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A. Spring's beans.dtd ...
Préface

Développer des applications est suffisamment dur même avec de bons outils et de bonnes technologies. Implémerter des applications en utilisant des plateformes qui promettent tout, peut s'avérer lourd, difficile à contrôler et pas très efficace durant les cycles de développement, peut devenir un cauchemar. Spring fournit une solution légère pour construire des applications prêtes à l'emploi pour les entreprises tout en supportant encore la possibilité d'utiliser la gestion des transactions déclaratives, l'accès distant à la logique applicative en utilisant RMI ou les services web, les facilités pour la messagerie et des possibilités variées pour persister vos données en base. Spring fournit un framework MVC, des manières transparentes pour intégrer l'AOP dans vos applications et une hiérarchie d'exceptions bien structurée incluant un mappage automatique à partir des hiérarchies d'exceptions propriétaires.

Spring peut être potentiellement une solution globale pour toutes les applications d'entreprises, cependant, Spring est modulaire, permettant ainsi d'utiliser des parties sans avoir à apporter le reste. Vous pouvez utiliser le conteneur de beans, avec Struts par dessus, mais vous pouvez également choisir de n'utiliser que l'intégration avec Hibernate ou la couche d'abstraction JDBC. Spring n'est pas intrusive, ce qui signifie qu'il n'y a aucune dépendance vis-à-vis du framework ou qu'elles sont réduites au minimum nécessaire suivant l'utilisation.

Ce document fournit un guide de référence pour les mécanismes de Spring. Puisque ce document est encore un travail en cours de réalisation, si vous avez des demandes ou des commentaires, veuillez les poster sur les listes de diffusion ou le forum sur la page du projet sur Sourceforge: http://www.sf.net/projects/springframework

Avant de poursuivre, quelques mots de gratitude: Chris Bauer (de l'équipe d'Hibernate) a préparé et adapté l'application DocBook-XSL pour permettre la création du manuel de référence d'Hibernate et nous permettant également de créer le notre.
Chapter 1. Introduction

1.1. Vue d'ensemble

Spring contient un grand nombre de fonctionnalités et de dispositifs, qui sont bien organisés dans sept modules comme décrit sur le diagramme suivant. Cette section décrit chaque module à tour de rôle.

Le package Core est la partie la plus fondamentale du framework et fournit la fonctionnalité Injection de Dépendance, vous permettant de gérer le conteneur de beans. Le concept de base ici est la BeanFactory qui fournit une implémentation dy pattern fabrique tout en supprimant la nécessité de programmer des singletons et permettent de découpler la configuration et la spécification des dépendances de la logique applicative elle-même.

Au sommet du package Core se trouve le package Context, fournissant un moyen d'accéder aux beans à la manière d'un framework ressemblant à un registre JNDI. Le package context hérite des fonctionnalités du package beans et ajoute le support des messages (i.e. "resource bundles"), la propagation d'événements, le chargement des ressourceset la création transparente de contextes, par exemple, par un conteneur de servlets.

Le package DAO fournit un niveau d'abstraction à JDBC qui supprime le besoin de code JDBC pénible et de gérer les codes erreurs spécifiques aux bases de données. De plus, le package JDBC fournit un moyen de gérer les transactions de manière déclarative ou par la programmation pas seulement pour les classes implémentant des interfaces spécifiques mais pour tous les POJOs (plain old java objects).

Le package ORM fournit des niveaux d'abstraction pour l'intégration des outils populaires de mappage objet-relationnel comme JDO, Hibernate et iBatis. En utilisant le package ORM, vous pouvez utiliser tous ces outils en combinaison de toutes les autres fonctionnalités qu'offre Spring, comme notamment la gestion déclarative des transactions mentionnée précédemment.

Le package AOP de Spring fournit une implémentation de la programmation orientée aspect conforme à AOP Alliance qui permet par exemple, de définir des intercepteurs de méthodes et des points de jonction en découplant proprement le code fonctionnel qui devrait être bien séparé. En utilisant les annotations au niveau
des sources, il est possible d'intégrer toute sorte d'informations dans le code, un peu comme avec les attributs .Net.

Le package Web de Spring fournit des fonctionnalités d'intégration de base pour les applications web comme la gestion des requêtes multipart, l'initialisation des contextes en utilisant les listeners des servlets et un contexte d'application orienté web. Pour utiliser Spring avec WebWork ou Struts, il est indispensable d'intégrer ce package.

Le package Web MVC de Spring fournit une implémentation Model-View-Controller pour les applications web. Spring MVC n'est pas une implémentation comme les autres, car elle fournit une séparation nette entre le code du modèle et les formulaires web et permet d'utiliser toutes les autres fonctionnalités du framework Spring comme la validation.

### 1.2. Scenarios d'utilisation

Avec les modules décrits ci-dessus, il est possible d'utiliser Spring dans toute sorte de scénarios allant des applets aux applications d'entreprise complexes utilisant la fonctionnalité de gestion des transaction de Spring et le framework web.

![Diagramme Spring Framework](image)

**Application web typique basée sur Spring**

Une application web typique utilise la plupart des fonctionnalités de Spring. En utilisant `TransactionProxyFactoryBeans`, l'application web est complètement transactionnelle comme elle l'aurait été en utilisant les transactions gérées par le conteneur des EJBs. Toute la logique métier peut être implémentée en utilisant des POJOs simples gérés par le conteneur d'Injection de Dépendance de Spring. Des services additionnels comme l'envoi de messages et la validation, indépendante de la couche web, permettent de choisir quand exécuter les règles de validation. Le support de Spring pour les ORMs est intégré avec Hibernate, JDO, iBatis. En utilisant, par exemple, `HibernateDaoSupport`, il est possible de réutiliser vos mappages existants. Les contrôleurs de formulaires s'intègrent de manière transparentes dans la couche web avec le modèle, supprimant de ce fait le besoin d'ActionForms ou d'autres classes transformant les paramètres HTTP en valeurs disponibles pour le modèle.
Le tier utilisant Spring et basé le framework web

Parfois, il arrive qu'il soit impossible de complètement changer de framework. Spring ne force en aucun cas, l'utilisation complète du framework; il ne s'agit pas d'une solution tout ou rien. Des frameworks de présentation utilisant WebWork, Struts, Tapestry ou autre peuvent être parfaitement intégrer avec un tier métier basé sur Spring et permettant ainsi d'utiliser les fonctionnalités transactionnelles offertes par Spring. La seule chose qui doit être faite, est de récupérer la logique métier en utilisant un ApplicationContext et de l'intégrer à la couche de présentation web en utilisant WebApplicationContext.

Scenario d'utilisation de la rupture de protocole

Quand il est nécessaire d'accéder à du code existant via des services web, il est possible d'utiliser les classes Hessian-, Burlap-, Rmi- or JaxRpcProxyFactory. Utiliser l'accès distant dans une application existante n'est pas plus difficile que cela.
Spring fournit également une couche d'accès et un niveau d'abstraction pour les EJBs, permettant d'utiliser les POJOs existants et de les envelopper dans des Beans Session sans Etat, pour un usage dans des applications web scalables et résistantes aux erreurs qui nécessitent de la sécurité déclarative.
Chapter 2. Problématique de fond

2.1. Inversion de Controle / Injection de Dépendance

Au début de 2004, Martin Fowler demanda aux lecteurs de son site: en parlant de l'Inversion de contrôle: "la question, est quel aspect de traitement ont-ils inversés?". Après avoir décrit le terme Inversion de Contrôle, Martin sugère de renommer le pattern, ou au moins lui donner un nom qui parle de lui-même et commence à utiliser le terme Injection de Dépendance. Son article continue d'expliquer les idées qui se cache derrière l'Inversion de Controle et l'Injection de Dépendance. Si vous avez besoin d'éclaircissement: http://martinfowler.com/articles/injection.html.
Chapter 3. Beans, BeanFactory et l'ApplicationContext

3.1. Introduction


En résumé, l'interface BeanFactory fournit la configuration du framework et de ses fonctionnalités de base, tandis que l'interface ApplicationContext ajoute des possibilités perfectionnées, dont certaines sont plus orientées J2EE et axées pour les applications d'entreprise. En général, un ApplicationContext est une surcouche complète d'un BeanFactory, et toutes les descriptions des possibilités d'un BeanFactory et comportement devraient être considérés comme appliquer aux ApplicationContexts eux-mêmes.

Parfois les utilisateurs ne sont pas sûrs laquelle des deux interfaces BeanFactory ou Application est bien adaptée pour un cas précis dans une situation particulière. Normalement pour la construction d'applications dans un environnement J2EE, la meilleure option est d'utiliser l'ApplicationContext, puisqu'il offre tous les dispositifs de BeanFactory et lui en ajoute d'autres tout en permettant également une approche déclarative pour l'utilisation de certaines fonctionnalités, qui est généralement souhaité. Le principal scénario d'utilisation où il est préférable d'utiliser BeanFactory, est quand la gestion de la mémoire est une grand préoccupation (comme dans le cas d'applets où chaque kilo octets compte), et tous les dispositifs de ApplicationContext sont nécessaires.

Ce chapitre est divisé en deux parties. La première couvre les principes basiques qui s'appliquent aussi bien à BeanFactory qu'à ApplicationContext. La seconde partie s'applique à des dispositifs qui ne s'appliquent qu'à ApplicationContext.

3.2. BeanFactory et BeanDefinitions - les bases

3.2.1. La BeanFactory

L'interface BeanFactory [http://www.springframework.org/docs/api/org/springframework/beans/factory/BeanFactory.html] est actuellement le conteneur qui instantie, configure et gère un ensemble de beans. Ces beans collaborent typiquement avec d'autres et ainsi ils ont des dépendances entre eux. Celles-ci sont reflétées dans la configuration utilisée par BeanFactory (bien que des dépendances peuvent ne pas être visible dans la configuration, elles peuvent plutôt être fonction d'intégrations réalisées par la programmation à l'exécution).

Une BeanFactory est représentée par l'interface org.springframework.beans.factory.BeanFactory pour
laquelle il existe plusieurs implémentations. La plus simple et la plus communément utilisée implémentation de BeanFactory est \texttt{org.springframework.beans.factory.xml.XmlBeanFactory}. (Il devrait être identifié que les ApplicationContexts sont des sous classes de BeanFactory et que la plupart des utilisateurs préfèrent finalement les variantes de ApplicationContext basées sur XML).

Bien que, pour la plupart des scénarios, presque tout le code géré par BeanFactory n'a pas besoin d'avoir conscience de celle-ci, la BeanFactory doit être instanciée. Cela se réalise explicitement avec un code similaire:

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

ou

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

ou

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

Dans beaucoup de scénarios d'utilisation, le code développé n'a pas à instancier la BeanFactory, puisque le framework Spring le fera. Par exemple, la couche web fournit un support pour charger un ApplicationContext Spring automatiquement en tant que partie intégrante du processus de démarrage d'une application web J2EE. La déclaration du processus est décrite ici:

Comme la manipulation par la programmation des BeanFactories sera décrite plus tard, les sections suivantes se concentrent sur la description de la configuration des BeanFactories.

Une configuration de BeanFactory consiste, au niveau le plus basique, à définir un ou plusieurs beans que la BeanFactory doit gérer. Dans une XmlBeanFactory, ceux-ci sont configurés en tant qu'éléments \texttt{bean} imbriqués dans un élément racine \texttt{beans}.

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

### 3.2.2. BeanDefinition

Les définitions des beans dans les variantes de DefaultListableBeanFactory (comme XmlBeanFactory) sont représentées en tant qu'objets BeanDefinition, qui contiennent (parmi d'autres informations) les détails suivants:

- un nom de classe: ceci est normalement la classe réelle d'implémentation du bean décrit dans la définition du bean. Cependant, si le bean est construit en appelant une méthode statique d'une \texttt{fabrique} au lieu d'un constructeur normal, ceci peut être le nom de la classe de la fabrique.
• les éléments de configuration du comportement du bean qui établisse comme le bean devrait se comporter dans le conteneur (i.e. prototype ou singleton, mode automatique de détection des dépendances, mode de vérification des dépendances, méthodes d'initialisation et de finalisation).
• les arguments du constructeur ou les valeurs des propriétés à positionner sur le bean nouvellement créé. Un exemple pourrait être le nombre de connexions à utiliser dans un bean qui gère un pool de connexions (aussi bien spécifié en tant que propriété ou argument d'un constructeur), ou la limite de taille du pool.
• les autres beans dont un bean a besoin pour réaliser ses traitements, i.e. collaborateurs (également spécifiés comme propriétés ou arguments du constructeur). Ceux-ci peuvent également être appelés dépendances.

Les concepts listés ci-dessus traduisent en un ensemble d'éléments la définition d'un bean. Quelques groupes d'éléments sont listés ci-dessous, avec un lien vers une documentation les décrivant.

<table>
<thead>
<tr>
<th>Fonctionalité</th>
<th>Plus d'information</th>
</tr>
</thead>
<tbody>
<tr>
<td>classe</td>
<td>Section 3.2.3, “La classe du bean”</td>
</tr>
<tr>
<td>identifiant et nom</td>
<td>Section 3.2.4, “Les identifiants d'un bean (id et name)”</td>
</tr>
<tr>
<td>singleton ou prototype</td>
<td>Section 3.2.5, “singleton ou pas singleton”</td>
</tr>
<tr>
<td>arguments du constructor</td>
<td>Section 3.3.1, “Positionnement des propriétés de beans et collaborateurs”</td>
</tr>
<tr>
<td>propriétés du bean</td>
<td>Section 3.3.1, “Positionnement des propriétés de beans et collaborateurs”</td>
</tr>
<tr>
<td>mode détection automatique</td>
<td>Section 3.3.6, “Autowiring collaborateurs”</td>
</tr>
<tr>
<td>mode de vérification des dépendences</td>
<td>Section 3.3.7, “Checking for dependencies”</td>
</tr>
<tr>
<td>méthode d'initialisation</td>
<td>Section 3.4.1, “Lifecycle interfaces”</td>
</tr>
<tr>
<td>méthode de finalisation</td>
<td>Section 3.4.1, “Lifecycle interfaces”</td>
</tr>
</tbody>
</table>

Il est à noter que la définition d'un bean est représenté par une réelle interface org.springframework.beans.factory.config.BeanDefinition, et ses divers sous interfaces et implémentations. Cependant, il est très peu probable que du code utilisateur ne travaille avec un BeanDefinition.

En outre les définitions des beans qui contiennent des informations sur la façon de créer un bean ou une fabrique de beans, peuvent de plus autoriser l'utilisation d'instances existantes de beans.

### 3.2.3. La classe du bean

L'attribut `class` est normalement obligatoire (voir Section 3.2.3.3, “Creation d'un bean via une méthode de fabrique d’instance” et Section 3.5, “Abstract and child bean definitions” pour les deux exceptions à la règle) et est utilisé pour un ou deux buts. Dans la plupart des cas classiques où la BeanFactory crée elle-même directement le bean en appelant son constructeur (équivalent à l'appel de `new`), l'attribut `class` spécifie la classe du bean à construire. Dans des cas moins fréquents où la BeanFactory appelle une méthode statique équivalente à une fabrique sur une classe pour créer le bean, l'attribut `class` spécifie la classe réelle contenant la méthode statique de fabrication. (le type du bean renvoyé par cette méthode peut être la même ou une autre classe, cela n'a aucune importance).
3.2.3.1. Création d'un bean via un constructeur

En créant un bean en utilisant l'approche basée sur le constructeur, toutes les classes normales sont utilisables par Spring et compatible avec ce framework. Cela signifie que la classe étant créée, n'a pas besoin d'implémenter aucune interface spécifique ou être développée d'une certaine manière. Le fait d'uniquement spécifier la classe du bean devrait suffir. Cependant, suivant le type d'IoC utilisé, il se peut d'un constructeur par défaut (vide) soit nécessaire.

De plus, la BeanFactory n'est uniquement limitée à gérer de véritable JavaBeans, elle est également capable de gérer pratiquement n'importe quelle classe voulue. La plupart des utilisateurs de Spring préfèrent avoir de vrais JavaBeans (ayant uniquement un constructeur par défaut (sans argument) et des accesseurs en lecture et écriture appropriés modélisés après les propriétés) dans la BeanFactory, mais il est également possible d'avoir, dans la BeanFactory, des classes plus exotiques n'adhérant pas au styles des beans. Si, par exemple, vous avez besoin d'utiliser un pool de connexion qui n'adhère pas à la spécification JavaBean, ne vous inquiétez pas, Spring peut quand même les gérer.

En utilisant XmlBeanFactory, la classe de votre bean peut être spécifiée de la manière suivante:

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

Le mécanisme pour positionner (optionnel) les arguments d'un constructeur ou les propriétés d'une instance d'un objet après que celui-ci ait été créé, sera décrit sous peu.

3.2.3.2. Création d'un bean via une méthode de fabrique statique

Au moment de définir un bean qui est créé en utilisant un méthode statique de fabrique, en parallèle de l'attribut class qui spécifie le nom de la classe la contenant, un autre attribut nommé factory-method est nécessaire pour déterminer le nom de la méthode de fabrique. Spring prévoit d'être capable de l'appeler (avec une liste optionelle d'arguments comme décrit plus tard) et de récupérer une instance qui pourra, à partir de ce moment, être traité comme s'il avait été créé normalement via un constructeur. Une des utilisations de ce type de définition est d'appeler des fabriques statiques dans du code.

L'exemple suivant décrit une définition de bean qui spécifie que celui-ci doit être créé en appelant une méthode fabrique. Il est à noter que la définition ne spécifie pas le type (classe) de retour de l'objet mais seulement la classe contenant la méthode. Dans cet exemple, createInstance doit être une méthode static.

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

Le mécanisme pour positionner (optionnel) les arguments d'un constructeur ou les propriétés d'une instance d'un objet après que celui-ci ait été créé, sera décrit sous peu.

3.2.3.3. Création d'un bean via une méthode de fabrique d'instance

La façon de créer un bean en utilisant une méthode de fabrique d'instance est similaire à celle pour une méthode statique, où une méthode d'un bean existant correspondant à une fabrique est appelé pour créer un nouveau bean.

Pour utiliser ce mécanisme, l'attribut class doit être laissé vide et l'attribut factory-bean doit spécifier le nom du bean une BeanFactory courante ou parente qui contient une méthode de fabrique. Celle-ci devrait encore elle-même être positionner via l'attribut factory-method.
Ce qui suit, illustre cela:

```xml
<!-- The factory bean, which contains a method called createInstance -->
<bean id="myFactoryBean"
     class="...">
     ...
</bean>

<!-- The bean to be created via the factory bean -->
<bean id="exampleBean"
     factory-bean="myFactoryBean"
     factory-method="createInstance"/>
```

Bien que les mécanismes pour positionner les propriétés des beans doivent être encore détaillés, une implication de cette approche est que la BeanFactory peut être gérée et configurée via l'Injection de Dépendence par le conteneur.

### 3.2.4. Les identifiants d'un bean (id et name)

Chaque bean possède un ou plusieurs ids (également appelés identifiants, ou noms; ces termes se réfèrent à la même chose). Ces ids doivent être unique dans la BeanFactory ou l'ApplicationContext où le bean se trouve. Un bean aura presque toujours un id, mais si un bean a plus d'un id, ceux supplémentaires seront considérés comme des alias.

Dans une XmlBeanFactory (incluant les variantes de ApplicationContext), les attributs id ou name sont utilisés pour spécifier l'(es) id(s) du bean et enfin un id doit être spécifié dans un ou les deux attributs. L'attribut id vous permet de spécifier un id, et comme cela est marqué dans la DTD XML (document de définition) comme un, le parseur est capable de faire quelques validations supplémentaires quand d'autres éléments pointent sur lui. En tant que tels, il s'agit de la manière recommandée de spécifier l'id d'un bean. Cependant, la spécification XML limite les caractères qui sont autorisés pour les IDs XML. Ce n'est pas habituellement une limitation, mais si vous devez utiliser l'un de ces caractères ou voulez ajouter d'autres alias au bean, vous pouvez également ou au lieu spécifier un ou plusieurs ids (séparés une virgule (,) ou un point virgule (;) avec l'attribut name.

### 3.2.5. singleton ou pas singleton

Les beans sont définis pour être déployés dans l'un des deux modes suivants: singleton ou non-singleton. (Le dernier est également appelé un prototype, bien que le terme ne soit pas tout à fait adéquat). Quand un bean est un singleton, seulement une instance partagée du bean sera gérée et toutes les requêtes sur les beans dont le ou les ids correspondent à cette définition utiliseront une instance spécifique retournée.

Le mode non-singleton ou prototype de déploiment d'un bean crée une nouvelle instance du bean à chaque fois qu'une requête sur un bean spécifique est faite. Ceci est idéal pour les situations où, par exemple, chaque utilisateur a besoin d'un objet indépendant de l'utilisateur ou une utilisation similaire.

Les beans sont déployés en mode singleton par défaut, à moins qu'il ne soit spécifié autre chose. Il faut garder à l'esprit qu'en changeant le type à non-singleton (prototype), chaque requête pour un bean resultera dans la création d'un bean nouvellement créé et ne sera pas peut-être ce qui est réellement voulu. De ce fait, changer le mode à prototype quand c'est absolument nécessaire.

Dans l'exemple ci-dessous, deux beans sont déclarés dont l'un est défini comme singleton, et l'autre est a non-singleton (prototype). exampleBean est créé à chaque fois qu'un client demande à la BeanFactory ce bean alors que yetAnotherExample est créé une seule fois; une référence à la même instance est retournée pour chaque requête sur le bean.
Note: quand a un bean est déployé dans le mode prototype, le cycle de vie du bean change légèrement. Par définition, Spring ne peut pas gérer le cycle complet de vie d'un bean de type non-singleton/prototype puisque, après qu'il soit créé, il est donné au client et le conteneur ne garde plus de trace de lui. Vous pouvez voir le rôle de Spring comme un remplacement de l'opération 'new'. Les aspects de cycle de vie doivent être gérés par le client. Le cycle de vie d'un bean dans la BeanFactory est décrit dans Section 3.4.1, “Lifecycle interfaces”.

3.3. Propriétés, collaborateurs, détection automatique et vérification de dépendance

3.3.1. Positionnement des propriétés de beans et collaborateurs

L'Inversion de Contrôle a déjà été désigné comme *Injection de Dépendance*. Le principe de base est que les beans définissent leurs dépendances (i.e. les autres objets avec lesquels ils travaillent) uniquement par le biais d'arguments de constructeurs, arguments d'une méthode de fabrique ou propriétés qui sont positionnées sur l'instance de l'objet qu'il ait été instancié ou retourné par une méthode de fabrique. Puis, le conteneur a réellement la responsabilité d'injecter ces dépendances au moment il crée le bean. Ceci est fondamentalement l'inversion (par conséquent le nom d'Inversion de Contrôle) de l'instanciation du bean ou de la localisation de ses dépendances par lui-même en utilisant l'instanciation direct de classes, ou un pattern comme le *Service de Localication*. ...

Comme cela a été abordé dans le précédent paragraphe, il existe deux variantes majeures de l'Inversion de Contrôle/Injection de Dépendance:

- L'injection de dépendance *basé sur le positionnement* est réalisée en appelant les méthodes de positionnement sur les beans après l'invocation d'un constructeur sans argument ou une méthode de fabrique statique sans argument pour instancier le bean. Les beans qui utilise ce type d'injection de dépendance sont de vrais JavaBeans. Spring recommande l'usage de ce type d'injection de dépendance, puisqu'un grand nombre d'arguments de constructeurs peut être difficile à manipuler, particulièrement quand certaines propriétés sont optionnelles.

- L'injection de dépendance *basé sur le constructeur* est réalisée en invoquant le constructeur avec un nombre d'arguments, chacun représentant un collaborateur ou une propriété. En plus, appeler une méthode de fabrique statique avec des arguments spécifiques, pour construire le bean, peut être considéré comme presque équivalent, et le reste de ce qui suit, considétera les arguments d'un constructeur et d'une méthode de fabrique statique comme similaire. Bien que Spring préconise l'utilisation de l'injection de dépendance basée sur le positionnement, il supporte complètement cette approche, puisqu'il peut que vous ayez à utiliser des beans pré-existants qui fournissent uniquement des constructeurs pour passer les arguments et aucune méthode pour les positionner. De plus, pour des beans plus simples, certaines personnes préfèrent l'approche constructeur comme un moyen de s'assurer que les beans ne puissent pas être dans un état invalides.

La interface BeanFactory supportent ces deux variantes pour injecter les dépendances dans les beans qu'elle gère. (En fait elle supporte également l'injection de dépendances basé sur le positionnement après que certaines dépendances aient été renseignées avec l'approche basée sur le constructeur.) La configuration des dépendances se réalise via une BeanDefinition, qui est utilisée de concert avec des PropertyEditors JavaBeans pour savoir comment convertir les propriétés d'un format à un autre. Les véritables valeurs passées, sont fournies sous la forme d'objets PropertyValue. Cependant, la plupart des utilisateurs de Spring n'auront pas à se
préoccuper de ces classes directement (i.e. par la programmation), mais utiliserons plutôt un fichier de définition XML qui sera converti en interne en des instances de ces classes, et utilisé pour charger une BeanFactory ou un ApplicationContext entier.

La résolution des dépendances d'un bean se produit généralement de la manière suivante:

1. La BeanFactory est créée et initialisée avec une configuration qui décrit tous les beans. La plupart des utilisateurs de Spring utilisent une variante de BeanFactory ou ApplicationContext qui supporte les fichiers de configuration au format XML.
2. Chaque bean a ses dépendances exprimés sous forme de propriétés, arguments de constructeur ou arguments d'une méthode de fabrique statique quand cela est utilisé au lieu du constructeur normal.
3. Chaque propriété ou argument de constructeur est soit une réelle définition d'une valeur à positionner, soit une référence à un autre bean dans la BeanFactory. Dans le cas de l'ApplicationContext, la référence peut être vers un ApplicationContext parent.
4. Chaque propriété ou argument de constructeur qui a une valeur doit pouvoir être converti de n'importe quel format spécifié vers le type réel de la propriété ou de l'argument. Par défaut Spring peut convertir une valeur fournie sous forme de chaînes de caractères dans n'importe quel type intégré, comme int, long, String, boolean, etc. De plus, quand on parle des variants de la BeanFactory basées sur XML (incluant les variantes d'ApplicationContext), il y a des supports intégrés pour les types de collection Lists, Maps, Sets, et Properties. Par ailleurs, Spring utilise les définitions de PropertyEditor des JavaBeans pour être capable de convertir des chaînes de caractères dans d'autres types de manière arbitraire. (Vous pouvez fournir à la BeanFactory vos propres définitions de PropertyEditor pour convertir vos propres types. Plus d'information à ce sujet et comment les ajouter manuellement peuvent être trouvées dans Section 3.9, “Registering additional custom PropertyEditors”). Quand une propriété d'un bean est une classe Java, Spring vous permettent de spécifier la valeur de cette propriété en tant que chaîne qui représente le nom de la classe et le PropertyEditor ClassEditor qui est intégré, et prend en charge la conversion du nom de la classe en une instance réelle de la classe.
5. Il est important d'être conscient que Spring validate la configuration de chaque bean de la BeanFactory quand celle-ci est créée, incluant la validation des propriétés qui font référence à des beans valides (i.e. les beans dont on fait référence, sont également définis dans la BeanFactory, ou dans le cas d'ApplicationContext, dans un contexte parent). Cependant, les propriétés elles-mêmes du bean ne sont pas positionnées jusqu'à ce que le bean soit réellement créé. Pour les beans qui sont des singletons et configurés pour être préinstanciés (comme les beans de type singleton dans un ApplicationContext), la création survient au moment où la BeanFactory est créée, mais autrement cela se produit uniquement quand le bean est demandé. Quand un bean doit réellement être créé, cela pourra potentiellement résulter dans un graph d'objets à créer comme les dépendances et les dépendances de ces dépendances (et ainsi de suite) doivent être créées et assignées.
6. Vous pouvez généralement avoir confiance en Spring pour faire le bon choix. Il ... les problèmes de configuration, incluant les beans qui n'existent pas and les dépendences circulaires au chargement de la BeanFactory. Il va réellement positionner les propriétés et résoudre les dépendences (i.e. créer ces dépendences si nécessaire) le plus tard possible c'est-à-dire quand le bean est réellement créé. Cela signifie qu'une BeanFactory qui s'est correctement chargée, peut par la suite générer une exception quand un bean est demandé, s'il y a un problème pour créer un bean ou une de ces dépendances. Cela peut arriver si le bean lève une exception en réponse à une propriété invalide ou manquante, par exemple. Cela retarde potentiellement la visibilité de ces problématiques de configuration et c'est pour cette raison que l'ApplicationContext pré-instantie par défaut les beans de type singleton. Au prix d'un surcout en terme de time et de mémoire pour créer ces beans avant d'en avoir besoin, vous découvrez les éventuels problèmes de configuration quand l'ApplicationContext est créé, pas après. Si vous le désirez, vous pouvez également surcharger ce comportement par défaut et spécifier n'importe quel de ces singletons d'être charger à la demande (lazy-load) (ils ne sont pas préinstanciés).

Quelques exemples:
Premièrement, voici un exemple d'utilisation de la BeanFactory pour une injection de dépendences basée sur le positionnement. En dessous se trouve une petite partie d'un fichier de configuration d'une XmlBeanFactory, spécifiant quelques définitions de beans. Ensuite se trouve le code du bean principal lui-même, montrant les méthodes de positionnement appropriées.

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

Comme vous pouvez le voir, les méthodes de positionnement ont été déclarées pour correspondre exactement aux propriétés spécifiées dans le fichier XML. (Les propriétés du fichier XML, font directement référence à l'objet PropertyValues de RootBeanDefinition).

Maintenant, voici un exemple de BeanFactory pour l'utilisation d'IoC type 3 (injection de dépendence basée sur les constructeurs). En dessous se trouve un extrait de la configuration XML qui spécifie les arguments du constructeur et le code réel du bean en montrant bien le constructeur:

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

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;
    }
}
```

Comme vous pouvez le voir, les arguments du constructeur spécifiés dans la définition du bean seront utilisés pour injecter des arguments au constructeur de la classe ExampleBean.
Désormais considérons une variante de cela où, au lieu d'utiliser un constructeur, on demande à Spring d'appeler une méthode de fabrique statique pour retourner une instance de l'objet:

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

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

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

  // a static factory method
  // the arguments to this method can be considered the dependencies of the bean that
  // is returned, regardless of how those arguments are actually used.
  public static ExampleBean createInstance(
      AnotherBean anotherBean, YetAnotherBean yetAnotherBean, int i) {
    ExampleBean eb = new ExampleBean(...);
    // some other operations
    ...
    return eb;
  }
}
```

Il est à noter que les arguments de la méthode de fabrique statique sont fournis via les éléments `constructor-arg` exactement de la même manière que si un constructeur avait été utilisé en réalité. Ces arguments sont optionnels. En outre, il est important de comprendre que les type de la classe retournée par cette méthode ne doit pas être obligatoirement du même type que la classe qui contient la méthode de fabrique statique, même si c'est le cas dans cet exemple. Une méthode de fabrique d'instance (non statique), mentionnée précédemment, serait utilisée essentiellement d'une manière identique (si ce n'est l'utilisation de l'attribut `factory-bean` à la place de l'attribut `class`), et ne sera donc pas détaillé ici.

### 3.3.2. Résolution des Arguments de Constructeur

La résolution des arguments du constructeur se réalise en utilisant leur type. Quand un autre bean est référencé, le type est connu et la correspondance peut être effectuée. Quand un type simple est utilisé, comme `<value>true</value>`, Spring ne peut déterminer le type correspondant à la valeur et ne peut donc pas faire la correspondance par type sans aide. Considérons la classe suivante, qui est utilisée dans les deux sections suivantes:

```java
package examples;

public class ExampleBean {  
  private int years;        //No. of years to the calculate the Ultimate Answer
  private String ultimateAnswer;  //The Answer to Life, the Universe, and Everything

  public ExampleBean(int years, String ultimateAnswer) {  
    this.years = years;
    this.ultimateAnswer = ultimateAnswer;
  }
}
```
3.3.2.1. Correspondance des Types des Arguments de Constructeur

Le scénario ci-dessus peut utiliser la correspondance de type avec des types simples en spécifiant explicitement le type des arguments du constructeur en utilisant l'attribut `type`. Par exemple:

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

3.3.2.2. Index des Arguments de Constructeur

Les arguments de constructeur peuvent avoir leur index spécifié explicitement en utilisant l'attribut `index`. Par exemple:

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

De la même manière qu'il résout l'ambiguité liée à de multiples valeurs simples, spécifier un index résoud également l'ambiguité quand un constructeur a deux arguments du même type. Il est à noter que l'index démarre à 0.

Spéciﬁer l'index d'un argument de constructeur est la façon recommandée pour réaliser l'IoC basée sur les constructeurs.

3.3.3. Les propriétés de bean et les arguments de constructeur détaillés

Comme mentionné dans la section précédente, les propriétés de bean et les arguments de construteur peuvent être définies comme étant soit des références à d'autres beans gérés par Spring (collaborateurs) ou des valeurs définies directement à ce niveau. La `XmlBeanFactory` supporte un grand nombre de types de sous-éléments dans ses éléments `property` et `constructor-arg` pour réaliser cela.

L'élément `value` spécifie une propriété ou un argument de constructeur dans sa représentation sous forme de chaînes de caractères (directement lisible). Comme mentionné en détail précédemment, les PropertyEditors JavaBeans sont utilisés pour convertir ces valeurs sous forme de chaînes d'un type `java.lang.String` vers le type réel de la propriété ou de l'arument.

```xml
<beans>
    <bean id="myDataSource" class="org.apache.commons.dbcp.BasicDataSource" destroy-method="close">
        <!-- results in a setDriverClassName(String) call -->
        <property name="driverClassName">
            <value>com.mysql.jdbc.Driver</value>
        </property>
        <property name="url">
            <value>jdbc:mysql://localhost:3306/mydb</value>
        </property>
        <property name="username">
            <value>root</value>
        </property>
    </bean>
</beans>
```

L'élément `null` est utilisé pour réaliser des valeurs nulles. Spring traite les arguments vides pour les propriétés comme des chaînes vides. La configuration suivante:

```xml
<bean class="ExampleBean">
    <property name="email"><value></value></property>
</bean>
```
dans la propriété email positionnée à "" est équivalente au code java: `exampleBean.setEmail("")`. L’élément spécial `<null>` peut être utilisé pour indiquer une valeur nulle et de ce fait:

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

est équivalent au code java: `exampleBean.setEmail(null)`.

Les éléments `list`, `set`, `map`, et `props` permettent définir et de positionner des propriétés et des arguments de type Java `list`, `set`, `map`, and `props` respectivement.

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

Il est à noter que la valeur d'une entrée dans une Map peut être n'importe lequel de ces éléments:

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

Un élément `bean` dans un élément `property` est utilisé pour définir un bean directement, au lieu de faire une référence déjà défini quelque part dans la BeanFactory. Cette définition ne nécessite de ne définir aucun attribut id.

```xml
<bean id="outer" class="...">
    <!-- Instead of using a reference to target, just use an inner bean -->
    <property name="target">
        <bean class="com.mycompany.PersonImpl">
            <property name="name"><value>Tony</value></property>
            <property name="age"><value>51</value></property>
        </bean>
    </property>
</bean>
```
L'élément idref est simplement un raccourci et un moyen infaillible pour positionner une propriété avec un id ou un name, sous forme de chaîne de caractères, d'un autre bean dans le conteneur.

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

Ceci est exactement équivalent à l'exécution à la configuration suivante;

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

La raison principale pour laquelle la première formulation est préférable, est que l'utilisation de la balise idref permet à Spring de valider au moment du déploiement que l'autre bean existe réellement. Dans la seconde forme, la classe qui a la propriété targetName est obligée de faire sa propre validation, ce qui se produira uniquement quand celle-ci sera réellement instanciée par Spring, probablement longtemps après que le conteneur ait été déployé.

De plus, si le bean référencé est dans le même fichier XML, et que le nom du bean est l'id du bean, l'attribut local peut être utilisé, ce qui permettra au parseur XML lui-même de valider le nom du bean au moment du parcours du document XML.

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

L'élément ref est le dernier élément autorisé dans une définition de l'élément property. Il est utilisé pour positionner la valeur de la propriété spécifiée comme étant une référence à un autre bean géré par le conteneur, un collaborateur, pour ainsi dire. Comme cela a été mentionné dans la précédente section, le bean referred-to est considéré comme étant une dépendance du bean dont la propriété a été positionné et sera initialisé à la demande quand cela sera nécessaire (s'il s'agit d'un singleton, il peut déjà avoir été initialisé par le conteneur) avant que la propriété soit positionnée. Toutes les références sont finalement uniquement une référence à un autre objet, mais il y a trois variantes sur la façon dont id/name de l'autre objet peuvent être spécifiés, ce qui déterminent la façon dont la portée et la validation sont prises en compte.

Spécifier le bean cible en utilisant l'attribut bean de la balise ref est la façon la plus courante, et permettra de créer une référence sur n'importe quel bean dans les mêmes BeanFactory/ApplicationContext (s'ils se trouvent ou non dans le même fichier XML), ou des BeanFactory/ApplicationContext parents. La valeur de l'attribut bean peut être le même que l'attribut id du bean cible, ou une des valeurs de l'attribut name de ce même bean.

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

Spécifier le bean cible en utilisant l'attribut local permet au parseur XML de valider les références des id XML dans le même fichier. La valeur de l'attribut local doit la même que l'attribut id du bean cible. Le parseur
XML remontera une erreur si aucun élément correspondant n'est trouvé dans le même fichier. De ce fait, utiliser local est le meilleur choix (pour connaître les erreurs le plus tôt possible) si le bean ciblé est dans le même fichier XML.

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

Spécifier le bean cible en utilisant l'attribut parent permet à une référence d'être créée sur un bean qui est dans une BeanFactory parente (ou ApplicationContext) de la BeanFactory courante (ou ApplicationContext). La valeur de l'attribut parent peut être le même que l'attribut id du bean cible, ou une des valeurs de l'attribut name de ce même bean, et le bean cible doit être dans une BeanFactory ou un ApplicationContext parent par rapport au courant. L'utilisation principale de cette variante de référence à un bean est quand il y a un besoin d'envelopper un bean existant dans un contexte parent avec des proxies (qui peuvent avoir le même nom que le parent), et ont besoin du l'objet original à cet effet.

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

### 3.3.4. Injection par Méthode

Pour la plupart des utilisateurs, la majorité des beans dans le conteneur seront des singletons. Quand un singleton a besoin de collaborer ou utiliser un autre singleton, ou un non-singleton a besoin avec un autre, l'approche typique et communément utilisée pour traiter cette dépendance en définissant un bean comme étant un propriété de l'autre, est appropriée. Il y a cependant un problème quand les cycles de vie des beans sont différent. Considérons un singleton A qui a besoin d'utiliser un non-singleton (prototype) B, peut-être sur chaque invocation de méthodes de A. Le conteneur créera seulement le singleton A une fois, et ainsi aura la possibilité de positionner ces propriétés une fois. Il n'y a pas de possibilité pour le conteneur de fournir une bean A avec une nouvelle instance de B à chaque fois qu'une nouvelle est nécessaire.

Une solution pour résoudre ce problème est de réonner à quelques inversions de contrôle. Le bean A peut être conscient du conteneur (comme décrit ici) en implémentant l'interface BeanFactoryAware, et utiliser la programmation (comme décrit here) pour demander directement au conteneur via l'appel getBean("B") un (nouveau) bean B chaque fois que A en a besoin. De manière générale, il ne s'agit pas d'une solution souhaitable puisque le code du bean est ensuite conscient et couplé à Spring.

L'Injection par méthode, un dispositif avancé de la BeanFactory, permet ce cas d'utilisation pour traiter d'une manière propre de même que d'autres scénarios.

#### 3.3.4.1. Injection par méthode de recherche

L'injection par méthode de recherche se réfère à la possibilité du conteneur de surcharger des méthodes abstraites ou concrètes sur des beans gérés par le conteneur, pour retourner le résultat d'une recherche d'une autre bean défini dans le conteneur. Cela se fera typiquement pour la recherche d'un non-singleton aussi bien que pour le scénario décrit précédemment (bien qu'il puisse également être un singleton). Spring implémente cela au moyen d'une sous-classe générée dynamiquement qui surcharge la méthode en utilisant la génération de bytecode via la bibliothèque CGLIB.

Dans la classe cliente contenant la méthode à injecter, la définition de la méthode doit être défini de manière abstraite (ou concrète) de cette manière:

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

Si la méthode n'est pas abstraite, Spring surchargera simplement l'implémentation existante. Dans le cas de
XmlBeanFactory, vous spécifiez à Spring pour injecter/surcharger la méthode retournant un bean particulier à partir du conteneur, en utilisant l'élément lookup-method dans la définition du bean. Par exemple:

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

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

Le bean identifié par myBean appellera sa propre méthode createSingleShotHelper toutes les fois qu'il aura besoin d'une nouvelle instance du bean singleShotHelper. Il est important de noter que la personne déployant les beans doit faire attention à déploier singleShotHelper comme un non-singleton (si c'est ce qui est voulu). S'il est déployé comme un singleton (soit explicitement, ou en comptant sur la valeur par défaut true pour ce paramètre), la même instance de singleShotHelper sera retournée à chaque fois!

Noter que la méthode d'injection par recherche peut être combinée avec l'Injection par Constructeur (fournissant des arguments optionnels au bean étant construit), et également avec l'Injection par Positionnement (positionnant les propriétés sur le bean étant construits).

### 3.3.4.2. Remplacement arbitraire de méthode

Une forme d'injection moins utilisée communément que l'Injection par Méthode de Recherche est la possibilité de remplacer arbitrairement des méthodes d'un bean par une autre implémentation de celle-ci. Les utilisateurs peuvent sans risque passer le reste de la section (qui décrit cette fonctionnalité avancée), à moins qu'il n'en ait réellement besoin.

Dans une XmlBeanFactory, l'élément replaced-method peut être utilisé pour remplacer une implémentation d'une méthode existante par une autre, pour un bean déployé. Considérons la classe suivante, avec une méthode computeValue, que l'on veut surcharger:

```java
public class MyValueCalculator {
  public String computeValue(String input) {
    ... some real code
  }
  ... some other methods
}
```

Une classe implémentant l'interface org.springframework.beans.factory.support.MethodReplacer est nécessaire pour fournir la définition de la nouvelle méthode.

```java
/** meant to be used to override the existing computeValue */
public class ReplacementComputeValue implements MethodReplacer {
  public Object reimplement(Object o, Method m, Object[] args) throws Throwable {
    // get the input value, work with it, and return a computed result
    String input = (String) args[0];
    ...
    return ...
  }
}
```

La définition dans la BeanFactory pour déployer la classe de base et spécifier la méthode à surcharger
Section 3.3.1, “Positionnement des propriétés de beans et collaborateurs”

```xml
<bean id="myValueCalculator" class="x.y.z.MyValueCalculator">
    <!-- arbitrary method replacement -->
    <replaced-method name="computeValue" replacer="replacementComputeValue">
        <arg-type>String</arg-type>
    </replaced-method>
</bean>

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

Un ou plusieurs sous-éléments arg-type de l'élément replaced-method peuvent être utilisés pour indiquer la signature de la méthode à surcharger. Noter que cette signature est seulement nécessaire réellement dans le cas où la méthode est réellement surchargée et qu'il y a plusieurs variantes dans la classe. Par convenance, la chaîne décrivant le type pour un argument peut être une sous-chaîne du nom complet du type. Par exemple, tous les formes suivantes correspondront à `java.lang.String`.

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

Puisque le nombre des arguments est parfois suffisant pour distinguer les différents choix possibles, ce raccourci peut alléger la définition en utilisant juste la plus courte chaîne correspondant à un type.

3.3.5. Using `depends-on`

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

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

Following is an example configuration:

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

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

3.3.6. Autowiring collaborators

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

¹See Section 3.3.1, “Positionnement des propriétés de beans et collaborateurs”
XmlBeanFactory, the autowire mode for a bean definition is specified by using the `autowire` attribute of the bean element. The following values are allowed.

### Table 3.2. Autowiring modes

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

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

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

### 3.3.7. Checking for dependencies

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

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

### Table 3.3. Dependency checking modes

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3.4. Customizing the nature of a bean

3.4.1. Lifecycle interfaces

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

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

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

3.4.1.1. InitializingBean / init-method

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

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

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

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

public class ExampleBean {
    public void init() {
```
Is exactly the same as:

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

3.4.1.2. DisposableBean / destroy-method

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

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

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

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

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

Is exactly the same as:

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

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

but does not couple the code to Spring.

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

```xml
"Beans, BeanFactory et l'ApplicationContext"
```

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3.4.2. Knowing who you are

3.4.2.1. BeanFactoryAware

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

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

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

3.4.2.2. BeanNameAware

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

3.4.3. FactoryBean

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

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

3.5. Abstract and child bean definitions

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

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

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

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

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

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

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

Note that in the example above, we have explicitly marked the parent bean definition as abstract by using the
abstract attribute. In the case that the parent definition does not specify a class:

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

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

the parent bean cannot get instantiated on its own since it is incomplete, and it's also considered abstract. When
a definition is considered abstract like this (explicitly or implicitly), it's usable just as a pure template or
abstract bean definition that will serve as parent definition for child definitions. Trying to use such an abstract
parent bean on its own (by referring to it as a ref property of another bean, or doing an explicit getBean() call
with the parent bean id, will result in an error. Similarly, the container's internal preInstantiateSingletons
method will completely ignore bean definitions which are considered abstract.

Important Note: Application contexts (but not simple bean factories) will by default pre-instantiate all
singletons. Therefore it is important (at least for singleton beans) that if you have a (parent) bean definition
which you intend to use only as a template, and this definition specifies a class, you must make sure to set the
abstract attribute to true, otherwise the application context will actually pre-instantiate it.

## 3.6. Interacting with the BeanFactory

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

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

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

- `boolean containsBean(String)`: returns true if the BeanFactory contains a bean definition or bean instance that matches the given name
- `Object getBean(String)`: returns an instance of the bean registered under the given name. Depending on how the bean was configured by the BeanFactory configuration, either a singleton and thus shared instance or a newly created bean will be returned. A BeansException will be thrown when either the bean could not be found (in which case it'll be a NoSuchBeanDefinitionException), or an exception occurred while instantiating and preparing the bean
- `Object getBean(String,Class)`: returns a bean, registered under the given name. The bean returned will be cast to the given Class. If the bean could not be cast, corresponding exceptions will be thrown (BeanNotOfRequiredTypeException). Furthermore, all rules of the getBean(String) method apply (see above)
- `boolean isSingleton(String)`: determines whether or not the bean definition or bean instance registered under the given name is a singleton or a prototype. If no bean corresponding to the given name could not be found, an exception will be thrown (NoSuchBeanDefinitionException)
- `String[] getAliases(String)`: Return the aliases for the given bean name, if any were defined in the bean definition

### 3.6.1. Obtaining a FactoryBean, not its product

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

### 3.7. Customizing beans with BeanPostprocessors

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

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

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

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

### 3.8. Customizing bean factories with BeanFactoryPostprocessors

A bean factory post-processor is a Java class which implements the `org.springframework.beans.factory.config.BeanFactoryPostProcessor` interface. It is executed manually (in the case of the BeanFactory) or automatically (in the case of the ApplicationContext) to apply changes of some sort to an entire BeanFactory, after it has been constructed. Spring includes a number of pre-existing bean factory post-processors, such as `PropertyResourceConfigurer` and `PropertyPlaceHolderConfigurer`, both described below, and `BeanNameAutoProxyCreator`, very useful for wrapping other beans transactionally or with any other kind of proxy, as described later in this manual. The BeanFactoryPostProcessor can be used to add custom editors (as also mentioned in Section 3.9, “Registering additional custom PropertyEditors”).

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

```java
XmlBeanFactory factory = new XmlBeanFactory(new FileSystemResource("beans.xml"));
// create placeholderconfigurer to bring in some property
// values from a Properties file
PropertyPlaceholderConfigurer cfg = new PropertyPlaceholderConfigurer();
cfg.setLocation(new FileSystemResource("jdbc.properties"));
// now actually do the replacement
cfg.postProcessBeanFactory(factory);
```

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

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

#### 3.8.1. The `PropertyPlaceholderConfigurer`

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

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

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

The actual values come from another file in Properties format:

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

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

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

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

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

### 3.8.2. The PropertyOverrideConfigurer

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

Note that the bean factory definition is not aware of being overridden, so it is not immediately obvious when looking at the XML definition file that the override configurer is being used. In case that there are multiple `PropertyOverrideConfigurers` that define different values for the same bean property, the last one will win (due to the overriding mechanism).

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

```
beanName.property=value
```
An example properties file could look like:

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

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

### 3.9. Registering additional custom PropertyEditors

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

If there is a need to register other custom PropertyEditors, there are several mechanisms available.

The most manual approach, which is not normally convenient or recommended, is to simply use the `registerCustomEditor()` method of the `ConfigurableBeanFactory` interface, assuming you have a BeanFactory reference.

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

Note that all bean factories and application contexts automatically use a number of built-in property editors, through their use of something called a BeanWrapper to handle property conversions. The standard property editors that the BeanWrapper registers are listed in the next chapter. Additionally, ApplicationContexts also override or add an additional 3 editors to handle resource lookups in a manner appropriate to the specific application context type. These are: `InputStreamEditor`, `ResourceEditor` and `URLEditor`.

### 3.10. Introduction to the ApplicationContext

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

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

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

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

### 3.11. Added functionality of the ApplicationContext

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

#### 3.11.1. Using the MessageSource

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

• `String getMessage (String code, Object[] args, String default, Locale loc)`: the basic method used to retrieve a message from the MessageSource. When no message is found for the specified locale, the default message is used. Any arguments passed in are used as replacement values, using the `MessageFormat` functionality provided by the standard library.
• `String getMessage (String code, Object[] args, Locale loc)`: essentially the same as the previous method, but with one difference: no default message can be specified; if the message cannot be found, a `NoSuchMessageException` is thrown.
• `String getMessage(MessageSourceResolvable resolvable, Locale locale)`: all properties used in the methods above are also wrapped in a class named `MessageSourceResolvable`, which you can use via this method.

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

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

```xml
<beans>
  <bean id="messageSource" class="org.springframework.context.support.ResourceBundleMessageSource">
    <property name="basenames">
      <list>
        <value>format</value>
        <value>exceptions</value>
        <value>windows</value>
      </list>
    </property>
  </bean>
</beans>
```
This assumes you have three resource bundles defined on your classpath called format, exceptions and windows. Using the JDK standard way of resolving messages through ResourceBundles, any request to resolve a message will be handled. TODO: SHOW AN EXAMPLE

### 3.11.2. Propagating events

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

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

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

```xml
<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:

```java
public class EmailBean implements ApplicationContextAware {
    /** the blacklist */
    private List blackList;

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

    // other methods...
}
```
public void setApplicationContext(ApplicationContext ctx) {
    this.ctx = ctx;
}

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

public class BlackListNotifier implements ApplicationListener {
    /** notification address */
    private String notificationAddress;

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

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

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

### 3.11.3. Using resources within Spring

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

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

<table>
<thead>
<tr>
<th>Method</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>getInputStream()</td>
<td>Opens an InputStream on the resource and returns it</td>
</tr>
<tr>
<td>exists()</td>
<td>Checks if the resource exists, returning false if it doesn’t</td>
</tr>
<tr>
<td>isOpen()</td>
<td>Will return true if 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</td>
</tr>
<tr>
<td>getDescription()</td>
<td>Returns a description of the resource, often the fully qualified file name or the actual URL</td>
</tr>
</tbody>
</table>

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

3.12. Customized behavior in the ApplicationContext

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

3.12.1. ApplicationContextAware marker interface

All marker interfaces available with BeanFactories still work. The ApplicationContext does add one extra marker interface which beans may implement, org.springframework.context.ApplicationContextAware. A bean which implements this interface and is deployed into the context will be called back on creation of the bean, using the interface's setApplicationContext() method, and provided with a reference to the context, which may be stored for later interaction with the context.

3.12.2. The BeanPostProcessor

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

3.12.3. The BeanFactoryPostProcessor

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

3.12.4. The PropertyPlaceholderConfigurer

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

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

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

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

```java
public class ExoticType {
    private String name;
    public ExoticType(String name) {
        this.name = name;
    }
}

public class DependsOnExoticType {
    private ExoticType type;
    public void setType(ExoticType type) {
        this.type = type;
    }
}
```

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

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

The PropertyEditor could look similar to this:

```java
// converts string representation to ExoticType object
public class ExoticTypeEditor extends PropertyEditorSupport {
    private String format;
    public void setFormat(String format) {
        this.format = format;
    }
    public void setAsText(String text) {
        if (format != null && format.equals("upperCase")) {
            text = text.toUpperCase();
        }
        ExoticType type = new ExoticType(text);
        setValue(type);
    }
}
```

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

```xml
<bean id="customEditorConfigurer" class="org.springframework.beans.factory.config.CustomEditorConfigurer">
    <property name="customEditors">
        <map>
            <entry key="example.ExoticType">
                <bean class="example.ExoticTypeEditor">
                    <property name="format">
                        <value>upperCase</value>
                    </property>
                </bean>
            </entry>
        </map>
    </property>
</bean>
```
3.14. Setting a bean property or constructor arg from a property expression

*PropertyPathFactoryBean* is a *FactoryBean* that evaluates a property path on a given target object. The target object can be specified directly or via a bean name. This value may then be used in another bean definition as a property value or constructor argument.

Here's an example where a path is used against another bean, by name:

```xml
// target bean to be referenced by name
<bean id="person" class="org.springframework.beans.TestBean" singleton="false">
  <property name="age"><value>10</value></property>
  <property name="spouse">
    <bean class="org.springframework.beans.TestBean">
      <property name="age"><value>11</value></property>
    </bean>
  </property>
</bean>

// will result in 11, which is the value of property 'spouse.age' of bean 'person'
<bean id="theAge" class="org.springframework.beans.factory.config.PropertyPathFactoryBean">
  <property name="targetBeanName"><value>person</value></property>
  <property name="propertyPath"><value>spouse.age</value></property>
</bean>
```

In this example, a path is evaluated against an inner bean:

```xml
// will result in 12, which is the value of property 'age' of the inner bean
<bean id="theAge" class="org.springframework.beans.factory.config.PropertyPathFactoryBean">
  <property name="targetObject">
    <bean class="org.springframework.beans.TestBean">
      <property name="age"><value>12</value></property>
    </bean>
  </property>
  <property name="propertyPath"><value>age</value></property>
</bean>
```

There is also a shortcut form, where the bean name is the property path.

```xml
// will result in 10, which is the value of property 'age' of bean 'person'
<bean id="person.age" class="org.springframework.beans.factory.config.PropertyPathFactoryBean"/>
```

This form does mean that there is no choice in the name of the bean, any reference to it will also have to use the same id, which is the path. Of course, if used as an inner bean, there is no need to refer to it at all:

```xml
<bean id="..." class="...">
  <property name="age">
    <bean id="person.age"
      class="org.springframework.beans.factory.config.PropertyPathFactoryBean"/>
  </property>
</bean>
```

The result type may be specifically set in the actual definition. This is not necessary for most use cases, but can be of use for some. Please see the JavaDocs for more info on this feature.

3.15. Setting a bean property or constructor arg from a field value
FileRetrievingFactoryBean is a FactoryBean which retrieves a static or non-static field value. It is typically used for retrieving public static final constants, which may then be used to set a property value or constructor arg for another bean.

Here's an example which shows how a static field is exposed, by using the staticField property:

```xml
<bean id="myField"
     class="org.springframework.beans.factory.config.FieldRetrievingFactoryBean">
  <property name="staticField"><value>java.sql.Connection.TRANSACTION_SERIALIZABLE</value></property>
</bean>
```

There's also a convenience usage form where the static field is specified as a bean name:

```xml
<bean id="java.sql.Connection.TRANSACTION_SERIALIZABLE"
     class="org.springframework.beans.factory.config.FieldRetrievingFactoryBean"/>
```

This means there is no longer any choice in what the bean id is (so any other bean that refers to it will also have to use this longer name), but this form is very concise to define, and very convenient to use as an inner bean since the id doesn't have to be specified for the bean reference:

```xml
<bean id="..." class="...">
  <property name="isolation">
    <bean id="java.sql.Connection.TRANSACTION_SERIALIZABLE"
         class="org.springframework.beans.factory.config.FieldRetrievingFactoryBean"/>
  </property>
</bean>
```

It's also possible to access a non-static field of another bean, as described in the JavaDocs.

### 3.16. Invoking another method and optionally using the return value.

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

We would however recommend that for the second use case, factory-methods, described previously, are a better all around choice.

An example (in an XML based BeanFactory definition) of a bean definition which uses this class to force some sort of static initialization:

```xml
<bean id="force-init" class="org.springframework.beans.factory.config.MethodInvokingFactoryBean">
  <property name="staticMethod"><value>com.example.MyClass.initialize</value></property>
</bean>

<bean id="bean1" class="..." depends-on="force-init">
  ...
</bean>
```

Note that the definition for bean1 has used the depends-on attribute to refer to the force-init bean, which will trigger initializing force-init first, and thus calling the static initializer method, when bean1 is first initialized.
Here's an example of a bean definition which uses this class to call a static factory method:

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

An example of calling a static method then an instance method to get at a Java System property. Somewhat verbose, but it works.

```xml
<bean id="sysProps" class="org.springframework.beans.factory.config.MethodInvokingFactoryBean">
  <property name="targetClass"><value>java.lang.System</value></property>
  <property name="targetMethod"><value>getProperties</value></property>
</bean>

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

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

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

### 3.17. Importing Bean Definitions from One File Into Another

It's often useful to split up container definitions into multiple XML files. One way to then load an application
context which is configured from all these XML fragments is to use the application context constructor which
takes multiple Resource locations. With a bean factory, a bean definition reader can be used multiple times to
read definitions from each file in turn.

Generally, the Spring team prefers the above approach, since it keeps container configurations files unaware of
the fact that they are being combined with others. However, an alternate approach is to from one XML bean
definition file, use one or more instances of the import element to load definitions from one or more other files.
Any import elements must be placed before bean elements in the file doing the importing. Let's look at a
sample:

```xml
<beans>
  <import resource="services.xml"/>
  <import resource="resources/messageSource.xml"/>
  <import resource="/resources/themeSource.xml"/>
  <bean id="bean1" class="..."/>
</beans>
```
In this example, external bean definitions are being loaded from 3 files, `services.xml`, `messageSource.xml`, and `themeSource.xml`. All location paths are considered relative to the definition file doing the importing, so `services.xml` in this case must be in the same directory or classpath location as the file doing the importing, while `messageSource.xml` and `themeSource.xml` must be in a `resources` location below the location of the importing file. As you can see, a leading slash is actually ignored, but given that these are considered relative paths, it is probably better form not to use the slash at all.

The contents of the files being imported must be fully valid XML bean definition files according to the DTD, including the top level `beans` element.

### 3.18. Creating an ApplicationContext from a web application

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

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

You can register an ApplicationContext using the `ContextLoaderListener` as follows:

```xml
<context-param>
    <param-name>contextConfigLocation</param-name>
    <param-value>/WEB-INF/daoContext.xml /WEB-INF/applicationContext.xml</param-value>
</context-param>

<listener>
    <listener-class>org.springframework.web.context.ContextLoaderListener</listener-class>
</listener>

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

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

### 3.19. Glue code and the evil singleton

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

As another example, in a complex J2EE apps with multiple layers (i.e. various JAR files, EJBs, and WAR files packaged as an EAR), with each layer having its own ApplicationContext definition (effectively forming a hierarchy), the preferred approach when there is only one web-app (WAR) in the top hierarchy is to simply create one composite ApplicationContext from the multiple XML definition files from each layer. All the ApplicationContext variants may be constructed from multiple definition files in this fashion. However, if there are multiple sibling web-apps at the top of the hierarchy, it is problematic to create an ApplicationContext for each web-app which consists of mostly identical bean definitions from lower layers, as there may be issues due to increased memory usage, issues with creating multiple copies of beans which take a long time to initialize (i.e. a Hibernate SessionFactory), and possible issues due to side-effects. As an alternative, classes such as ContextSingletonBeanFactoryLocator [???] or SingletonBeanFactoryLocator [http://www.springframework.org/docs/api/org/springframework/beans/factory/access/SingletonBeanFactoryLocator.html] may be used to demand load multiple hierarchical (i.e. one is a parent of another) BeanFactories or ApplicationContexts in an effectively singleton fashion, which may then be used as the parents of the web-app ApplicationContexts. The result is that bean definitions for lower layers are loaded only as needed, and loaded only once.

3.19.1. Using SingletonBeanFactoryLocator and ContextSingletonBeanFactoryLocator

You can see a detailed example of using SingletonBeanFactoryLocator [http://www.springframework.org/docs/api/org/springframework/beans/factory/access/SingletonBeanFactoryLocator.html] and ContextSingletonBeanFactoryLocator [???] by viewing their respective JavaDocs.

As mentioned in the chapter on EJBs, the Spring convenience base classes for EJBs normally use a non-singleton BeanFactoryLocator implementation, which is easily replaced by the use of SingletonBeanFactoryLocator and ContextSingletonBeanFactoryLocator if there is a need.
Chapter 4. PropertyEditors, data binding, validation and the BeanWrapper

4.1. Introduction

The big question is whether or not validation should be considered business logic. There are pros and cons for both answers, and Spring offers a design for validation (and data binding) that does not exclude either one of them. Validation should specifically not be tied to the web tier, should be easy to localize and it should be possible to plug in any validator available. Considering the above, Spring has come up with a Validator interface that’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.

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).

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 to query properties to determine if they are readable or writable. Also, the BeanWrapper offers support for nested properties, enabling the setting of properties on sub-properties to an unlimited depth. Then, the BeanWrapper 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.

See the beans chapter for more information
and the BeanFactory.

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

### 4.3.1. Setting and getting basic and nested properties

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

<table>
<thead>
<tr>
<th>Expression</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>name</code></td>
<td>Indicates the property name corresponding to the methods <code>getName()</code> or <code>isName()</code> and <code>setName()</code></td>
</tr>
<tr>
<td><code>account.name</code></td>
<td>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></td>
</tr>
<tr>
<td><code>account[2]</code></td>
<td>Indicates the third element of the indexed property <code>account</code>. Indexed properties can be of type array, list or other naturally ordered collection</td>
</tr>
<tr>
<td><code>account[COMPANYNAME]</code></td>
<td>Indicates the value of the map entry indexed by the key <code>COMPANYNAME</code> of the Map property <code>account</code></td>
</tr>
</tbody>
</table>

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

*Note: this part is not important to you if you're not planning to work with the BeanWrapper directly. If you're just using the DataBinder and the BeanFactory and their out-of-the-box implementation, you should skip ahead to the section about PropertyEditors.*

Consider the following two classes:

```java
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) {
    }
```

Spring Framework Version 1.1.4
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 or alternately in a specific Application Context as mentioned in the previous chapter, gives it the knowledge of how to convert properties to the desired type. Read more about PropertyEditors in the 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. Most, but not all (as indicated below), are registered by default by BeanWrapperImpl. Where the property editor is configurable in some fashion, you can of course still register your own variant to override the default one:

Table 4.2. Built-in PropertyEditors

<table>
<thead>
<tr>
<th>Class</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>ByteArrayPropertyEditor</td>
<td>Editor for byte arrays. Strings will simply be converted to their corresponding byte representations. Registered by default by BeanWrapperImpl.</td>
</tr>
<tr>
<td>ClassEditor</td>
<td>Parses Strings representing classes to actual classes and the other</td>
</tr>
<tr>
<td>Class</td>
<td>Explanation</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>CustomBooleanEditor</td>
<td>Customizable property editor for Boolean properties. Registered by default by BeanWrapperImpl, but, can be overridden by registering custom instance of it as custom editor.</td>
</tr>
<tr>
<td>CustomDateEditor</td>
<td>Customizable property editor for java.util.Date, supporting a custom DateFormat. NOT registered by default. Must be user registered as needed with appropriate format.</td>
</tr>
<tr>
<td>CustomNumberEditor</td>
<td>Customizable property editor for any Number subclass like Integer, Long, Float, Double. Registered by default by BeanWrapperImpl, but, can be overridden by registering custom instance of it as custom editor.</td>
</tr>
<tr>
<td>FileEditor</td>
<td>Capable of resolving Strings to File-objects. Registered by default by BeanWrapperImpl.</td>
</tr>
<tr>
<td>InputStreamEditor</td>
<td>One-way property editor, capable of taking a text string and producing (via an intermediate ResourceEditor and Resource) an InputStream, so InputStream properties may be directly setCapable of resolving Strings to File-objects. Note that the default usage will not close the InputStream for you!. Registered by default by BeanWrapperImpl.</td>
</tr>
<tr>
<td>LocaleEditor</td>
<td>Capable of resolving Strings to Locale-objects and vice versa (the String format is [language]<em>[country]</em>[variant], which is the same thing the toString() method of Locale provides. Registered by default by BeanWrapperImpl.</td>
</tr>
<tr>
<td>PropertiesEditor</td>
<td>Capable of converting Strings (formatted using the format as defined in the Javadoc for the java.lang.Properties class) to Properties-objects. Registered by default by BeanWrapperImpl.</td>
</tr>
<tr>
<td>StringArrayPropertyEditor</td>
<td>Capable of resolving a comma-delimited list of String to a String-array and vice versa. Registered by default by BeanWrapperImpl.</td>
</tr>
<tr>
<td>StringTrimmerEditor</td>
<td>Property editor that trims Strings. Optionally allows transforming an empty string into a null value. NOT registered by default. Must be user registered as needed.</td>
</tr>
<tr>
<td>URLEditor</td>
<td>Capable of resolving a String representation of a URL to an actual URL-object. Registered by default by BeanWrapperImpl.</td>
</tr>
</tbody>
</table>

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. Note also that the standard JavaBeans infrastructure will automatically discover PropertyEditors (without you having to register them) if they are in the same package as the class they handle, and have the same name as that class, with 'Editor' appended.
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 us begin by defining some central AOP concepts. These terms are not Spring-specific. Unfortunately, AOP terminology is not particularly intuitive. However, it would be even more confusing if Spring used its own terminology.

• Aspect: A modularization of a concern for which the implementation might otherwise cut across multiple objects. Transaction management is a good example of a crosscutting concern in J2EE applications. Aspects are implemented using Spring as Advisors or interceptors.

• Joinpoint: Point during the execution of a program, such as a method invocation or a particular exception being thrown. In Spring AOP, a joinpoint is always method invocation. Spring does not use the term joinpoint prominently; joinpoint information is accessible through methods on the MethodInvocation argument passed to interceptors, and is evaluated by implementations of the org.springframework.aop.Pointcut interface.

• Advice: Action taken by the AOP framework at a particular joinpoint. Different types of advice include "around," "before" and "throws" advice. Advice types are discussed below. Many AOP frameworks, including Spring, model an advice as an interceptor, maintaining a chain of interceptors "around" the joinpoint.
• **Pointcut**: A set of joinpoints specifying when an advice should fire. An AOP framework must allow developers to specify pointcuts: for example, using regular expressions.

• **Introduction**: Adding methods or fields to an advised class. Spring allows you to introduce new interfaces to any advised object. For example, you could use an introduction to make any object implement an `IsModified` interface, to simplify caching.

• **Target object**: Object containing the joinpoint. Also referred to as *advised* or *proxied* object.

• **AOP proxy**: Object created by the AOP framework, including advice. In Spring, an AOP proxy will be a JDK dynamic proxy or a CGLIB proxy.

• **Weaving**: Assembling aspects to create an advised object. This can be done at compile time (using the AspectJ compiler, for example), or at runtime. Spring, like other pure Java AOP frameworks, performs weaving at runtime.

Different advice types include:

• **Around advice**: Advice that surrounds a joinpoint such as a method invocation. This is the most powerful kind of advice. Around advices will perform custom behavior before and after the method invocation. They are responsible for choosing whether to proceed to the joinpoint or to shortcut executing by returning their own return value or throwing an exception.

• **Before advice**: Advice that executes before a joinpoint, but which does not have the ability to prevent execution flow proceeding to the joinpoint (unless it throws an exception).

• **Throws advice**: Advice to be executed if a method throws an exception. Spring provides strongly typed throws advice, so you can write code that catches the exception (and subclasses) you're interested in, without needing to cast from Throwable or Exception.

• **After returning advice**: Advice to be executed after a joinpoint completes normally: for example, if a method returns without throwing an exception.

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

As Spring, like AspectJ, provides a full range of advice types, we recommend that you use the least powerful advice type that can implement the required behavior. For example, if you need only to update a cache with the return value of a method, you are better off implementing an after returning advice than an around advice, although an around advice can accomplish the same thing. Using the most specific advice type provides a simpler programming model with less potential for errors. For example, you don't need to invoke the `proceed()` method on the MethodInvocation used for around advice, and hence can't fail to invoke it.

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

### 5.1.2. Spring AOP capabilities and goals

Spring AOP is implemented in pure Java. There is no need for a special compilation process. Spring AOP does not need to control the class loader hierarchy, and is thus suitable for use in a J2EE web container or application server.
Spring currently supports interception of method invocations. Field interception is not implemented, although support for field interception could be added without breaking the core Spring AOP APIs. 

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

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

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

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

Spring's approach to AOP differs from that of most other AOP frameworks. The aim is not to provide the most complete AOP implementation (although Spring AOP is quite capable); it is rather to provide a close integration between AOP implementation and Spring IoC to help solve common problems in enterprise applications.

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

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

### 5.1.3. AOP Proxies in Spring

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

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

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

### 5.2. Pointcuts in Spring
Let's look at how Spring handles the crucial pointcut concept.

### 5.2.1. Concepts

Spring's pointcut model enables pointcut reuse independent of advice types. It's possible to target different advice using the same pointcut.

The `org.springframework.aop.Pointcut` interface is the central interface, used to target advices to particular classes and methods. The complete interface is shown below:

```java
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:

```java
public interface ClassFilter {
    boolean matches(Class clazz);
}
```

The `MethodMatcher` interface is normally more important. The complete interface is shown below:

```java
public interface MethodMatcher {
    boolean matches(Method m, Class targetClass);
    boolean isRuntime();
    boolean matches(Method m, Class targetClass, Object[] args);
}
```

The `matches(Method, Class)` method is used to test whether this pointcut will ever match a given method on a target class. This evaluation can be performed when an AOP proxy is created, to avoid the need for a test on every method invocation. If the 2-argument matches method returns true for a given method, and the `isRuntime()` method for the `MethodMatcher` returns true, the 3-argument matches method will be invoked on every method invocation. This enables a pointcut to look at the arguments passed to the method invocation immediately before the target advice is to execute.

Most `MethodMatcher`s are static, meaning that their `isRuntime()` method returns false. In this case, the 3-argument matches method will never be invoked.

*If possible, try to make pointcuts static, allowing the AOP framework to cache the results of pointcut evaluation when an AOP proxy is created.*

### 5.2.2. Operations on pointcuts

Spring supports operations on pointcuts: notably, *union* and *intersection*.

Union means the methods that either pointcut matches.
Intersection means the methods that both pointcuts match.

Union is usually more useful.

Pointcuts can be composed using the static methods in the `org.springframework.aop.support.Pointcuts` class, or using the `ComposablePointcut` class in the same package.

5.2.3. Convenience pointcut implementations

Spring provides several convenient pointcut implementations. Some can be used out of the box; others are intended to be subclassed in application-specific pointcuts.

5.2.3.1. Static pointcuts

Static pointcuts are based on method and target class, and cannot take into account the method's arguments. Static pointcuts are sufficient—and best—for most usages. It's possible for Spring to evaluate a static pointcut only once, when a method is first invoked: after that, there is no need to evaluate the pointcut again with each method invocation.

Let's consider some static pointcut implementations included with Spring.

5.2.3.1.1. Regular expression pointcuts

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

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

The usage is shown below:

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

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

```
<bean id="settersAndAbsquatulateAdvisor"
    class="org.springframework.aop.support.RegexpMethodPointcutAdvisor">
    <ref local="beanNameOfAopAllianceInterceptor"/>
    <property name="patterns">
        <list>
            <value>.*get.*</value>
            <value>.*absquatulate</value>
        </list>
    </property>
</bean>
```
RegexpMethodPointcutAdvisor can be used with any Advice type. The RegexpMethodPointcut class requires the Jakarta ORO regular expression package.

5.2.3.1.2. Attribute-driven pointcuts

An important type of static pointcut is a metadata-driven pointcut. This uses the values of metadata attributes: typically, source-level metadata.

5.2.3.2. Dynamic pointcuts

Dynamic pointcuts are costlier to evaluate than static pointcuts. They take into account method arguments, as well as static information. This means that they must be evaluated with every method invocation; the result cannot be cached, as arguments will vary.

The main example is the control flow pointcut.

5.2.3.2.1. Control flow pointcuts

Spring control flow pointcuts are conceptually similar to AspectJ cflow pointcuts, although less powerful. (There is currently no way to specify that a pointcut executes below another pointcut.) A control flow pointcut matches the current call stack. For example, it might fire if the joinpoint was invoked by a method in the com.mycompany.web package, or by the SomeCaller class. Control flow pointcuts are specified using the org.springframework.aop.support.ControlFlowPointcut class.

Note

Control flow pointcuts are significantly more expensive to evaluate at runtime than even other dynamic pointcuts. In Java 1.4, the cost is about 5 times that of other dynamic pointcuts; in Java 1.3 more than 10.

5.2.4. Pointcut superclasses

Spring provides useful pointcut superclasses to help you to implement your own pointcuts.

Because static pointcuts are most useful, you'll probably subclass StaticMethodMatcherPointcut, as shown below. This requires implemented just one abstract method (although it's possible to override other methods to customize behavior):

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

There are also superclasses for dynamic pointcuts.

You can use custom pointcuts with any advice type in Spring 1.0 RC2 and above.

5.2.5. Custom pointcuts

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

_Later versions of Spring may offer support for "semantic pointcuts" as offered by JAC: for example, "all methods that change instance variables in the target object."_

### 5.3. Advice types in Spring

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

#### 5.3.1. Advice lifecycles

Spring advices can be shared across all advised objects, or unique to each advised object. This corresponds to _per-class_ or _per-instance_ advice.

Per-class advice is used most often. It is appropriate for generic advice such as transaction advisors. These do not depend on the state of the proxied object or add new state; they merely act on the method and arguments.

Per-instance advice is appropriate for introductions, to support mixins. In this case, the advice adds state to the proxied object.

It's possible to use a mix of shared and per-instance advice in the same AOP proxy.

#### 5.3.2. Advice types in Spring

Spring provides several advice types out of the box, and is extensible to support arbitrary advice types. Let us look at the basic concepts and standard advice types.

##### 5.3.2.1. Interception around advice

The most fundamental advice type in Spring is _interception around advice_.

Spring is compliant with the AOP Alliance interface for around advice using method interception. MethodInterceptors implementing around advice should implement the following interface:

```java
public interface MethodInterceptor extends Interceptor {
    Object invoke(MethodInvocation invocation) throws Throwable;
}
```

The _MethodInvocation_ argument to the _invoke()_ method exposes the method being invoked; the target joinpoint; the AOP proxy; and the arguments to the method. The _invoke()_ method should return the invocation's result: the return value of the joinpoint.

A simple _MethodInterceptor_ implementation looks as follows:

```java
public class DebugInterceptor implements MethodInterceptor {
    public Object invoke(MethodInvocation invocation) throws Throwable {
        System.out.println("Before: invocation=[" + invocation + "]");
        Object rval = invocation.proceed();
        System.out.println("Invocation returned");
        return rval;
    }
}
```
Note the call to the MethodInvocation's `proceed()` method. This proceeds down the interceptor chain towards the joinpoint. Most interceptors will invoke this method, and return its return value. However, a MethodInterceptor, like any around advice, can return a different value or throw an exception rather than invoke the proceed method. However, you don't want to do this without good reason! MethodInterceptors offer interoperability with other AOP Alliance-compliant AOP implementations. The other advice types discussed in the remainder of this section implement common AOP concepts, but in a Spring-specific way. While there is an advantage in using the most specific advice type, stick with MethodInterceptor around advice if you are likely to want to run the aspect in another AOP framework. Note that pointcuts are not currently interoperable between frameworks, and the AOP Alliance does not currently define pointcut interfaces.

### 5.3.2.2. Before advice

A simpler advice type is a **before advice**. This does not need a MethodInvocation object, since it will only be called before entering the method.

The main advantage of a before advice is that there is no need to invoke the `proceed()` method, and therefore no possibility of inadvertently failing to proceed down the interceptor chain.

The `MethodBeforeAdvice` interface is shown below. (Spring's API design would allow for field before advice, although the usual objects apply to field interception and it's unlikely that Spring will ever implement it).

```java
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 behavior before the joinpoint executes, but cannot change the return value. If a before advice throws an exception, this will abort further execution of the interceptor chain. The exception will propagate back up the interceptor chain. If it is unchecked, or on the signature of the invoked method, it will be passed directly to the client; otherwise it will be wrapped in an unchecked exception by the AOP proxy.

An example of a before advice in Spring, which counts all methods that return normally:

```java
public class CountingBeforeAdvice implements MethodBeforeAdvice {
    private int count;
    public void before(Method m, Object[] args, Object target) throws Throwable {
        ++count;
    }

    public int getCount() {
        return count;
    }
}
```

**Before advice can be used with any pointcut.**

### 5.3.2.3. Throws advice

**Throws advice** is invoked after the return of the joinpoint if the joinpoint threw an exception. Spring offers typed throws advice. Note that this means that the `org.springframework.aop.ThrowsAdvice` interface does not contain any methods: it is a tag interface identifying that the given object implements one or more typed throws advice methods. These should be of form `afterThrowing([Method], [args], [target], subclassOfThrowable)`.
Only the last argument is required. Thus there from one to four arguments, depending on whether the advice method is interested in the method and arguments. The following are examples of throws advices.

This advice will be invoked if a `RemoteException` is thrown (including subclasses):

```java
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:

```java
public static class ServletThrowsAdviceWithArguments implements ThrowsAdvice {
    public void afterThrowing(Method m, Object[] args, Object target, ServletException ex) {
        // Do something will 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.

```java
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 will all arguments
    }
}
```

Throws advice can be used with any pointcut.

### 5.3.2.4. After Returning advice

An after returning advice in Spring must implement the `org.springframework.aop.AfterReturningAdvice` interface, shown below:

```java
public interface AfterReturningAdvice extends Advice {
    void afterReturning(Object returnValue, Method m, Object[] args, Object target)
        throws Throwable;
}
```

An after returning advice has access to the return value (which it cannot modify), invoked method, methods arguments and target.

The following after returning advice counts all successful method invocations that have not thrown exceptions:

```java
public class CountingAfterReturningAdvice implements AfterReturningAdvice {
    private int count;
    public void afterReturning(Object returnValue, Method m, Object[] args, Object target) throws Throwable {
        ++count;
    }
    public int getCount() {
        return count;
    }
}
```
This advice doesn't change the execution path. If it throws an exception, this will be thrown up the interceptor chain instead of the return value.

*After returning advice can be used with any pointcut.*

### 5.3.2.5. Introduction advice

Spring treats introduction advice as a special kind of interception advice.

Introduction requires an `IntroductionAdvisor`, and an `IntroductionInterceptor`, implementing the following interface:

```java
public interface IntroductionInterceptor extends MethodInterceptor {
    boolean implementsInterface(Class intf);
}
```

The `invoke()` method inherited from the AOP Alliance `MethodInterceptor` interface must implement the introduction: that is, if the invoked method is on an introduced interface, the introduction interceptor is responsible for handling the method call—it cannot invoke `proceed()`.

Introduction advice cannot be used with any pointcut, as it applies only at class, rather than method, level. You can only use introduction advice with the `InterceptionIntroductionAdvisor`, which has the following methods:

```java
public interface InterceptionIntroductionAdvisor extends InterceptionAdvisor {
    ClassFilter getClassFilter();
    IntroductionInterceptor getIntroductionInterceptor();
    Class[] getInterfaces();
}
```

There is no `MethodMatcher`, and hence no `Pointcut`, associated with introduction advice. Only class filtering is logical.

The `getInterfaces()` method returns the interfaces introduced by this advisor.

Let's look at a simple example from the Spring test suite. Let's suppose we want to introduce the following interface to one or more objects:

```java
public interface Lockable {
    void lock();
    void unlock();
    boolean locked();
}
```

This illustrates a **mixin**. We want to be able to cast advised objects to `Lockable`, whatever their type, and call `lock` and `unlock` methods. If we call the `lock()` method, we want all setter methods to throw a `LockedException`. Thus we can add an aspect that provides the ability to make objects immutable, without them having any knowledge of it: a good example of AOP.

Firstly, we'll need an `IntroductionInterceptor` that does the heavy lifting. In this case, we extend the `org.springframework.aop.support.DelegatingIntroductionInterceptor` convenience class. We could...
implement IntroductionInterceptor directly, but using DelegatingIntroductionInterceptor is best for most cases.

The DelegatingIntroductionInterceptor is designed to delegate an introduction to an actual implementation of the introduced interface(s), concealing the use of interception to do so. The delegate can be set to any object using a constructor argument; the default delegate (when the no-arg constructor is used) is this. Thus in the example below, the delegate is the LockMixin subclass of DelegatingIntroductionInterceptor. Given a delegate (by default itself) a DelegatingIntroductionInterceptor instance looks for all interfaces implemented by the delegate (other than IntroductionInterceptor), and will support introductions against any of them. It’s possible for subclasses such as LockMixin to call the suppressInterface(Class intf) method to suppress interfaces that should not be exposed. However, no matter how many interfaces an IntroductionInterceptor is prepared to support, the IntroductionAdvisor used will control which interfaces are actually exposed. An introduced interface will conceal any implementation of the same interface by the target.

Thus LockMixin subclasses DelegatingIntroductionInterceptor and implements Lockable itself. The superclass automatically picks up that Lockable can be supported for introduction, so we don’t need to specify that. We could introduce any number of interfaces in this way.

Note the use of the locked instance variable. This effectively adds additional state to that held in the target object.

```java
public class LockMixin extends DelegatingIntroductionInterceptor
    implements Lockable {
    private boolean locked;

    public void lock() {
        this.locked = true;
    }

    public void unlock() {
        this.locked = false;
    }

    public boolean locked() {
        return this.locked;
    }

    public Object invoke(MethodInvocation invocation) throws Throwable {
        if (locked() && invocation.getMethod().getName().indexOf("set") == 0)
            throw new LockedException();
        return super.invoke(invocation);
    }
}
```

Often it isn’t necessary to override the invoke() method: the DelegatingIntroductionInterceptor implementation—which calls the delegate method if the method is introduced, otherwise proceeds towards the joinpoint—is usually sufficient. In the present case, we need to add a check: no setter method can be invoked if in locked mode.

The introduction advisor required is simple. All it needs to do is hold a distinct LockMixin instance, and specify the introduced interfaces—in this case, just Lockable. A more complex example might take a reference to the introduction interceptor (which would be defined as a prototype): in this case, there's no configuration relevant for a LockMixin, so we simply create it using new.

```java
public class LockMixinAdvisor extends DefaultIntroductionAdvisor {
    public LockMixinAdvisor() {
        super(new LockMixin(), Lockable.class);
    }
}
```
We can apply this advisor very simply: it requires no configuration. (However, it is necessary: It's impossible to use an IntroductionInterceptor without an IntroductionAdvisor.) As usual with introductions, the advisor must be per-instance, as it is stateful. We need a different instance of LockMixinAdvisor, and hence LockMixin, for each advised object. The advisor comprises part of the advised object's state.

We can apply this advisor programmatically, using the Advised.addAdvisor() method, or (the recommended way) in XML configuration, like any other advisor. All proxy creation choices discussed below, including "auto proxy creators," correctly handle introductions and stateful mixins.

5.4. Advisors in Spring

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

Apart from the special case of introductions, any advisor can be used with any advice. org.springframework.aop.support.DefaultPointcutAdvisor is the most commonly used advisor class. For example, it can be used with a MethodInterceptor, BeforeAdvice or ThrowsAdvice.

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

5.5. Using the ProxyFactoryBean to create AOP proxies

If you're using the Spring IoC container (an ApplicationContext or BeanFactory) for your business objects--and you should be!--you will want to use one of Spring's AOP FactoryBeans. (Remember that a factory bean introduces a layer of indirection, enabling it to create objects of a different type).

The basic way to create an AOP proxy in Spring is to use the org.springframework.aop.framework.ProxyFactoryBean. This gives complete control over the pointcuts and advice that will apply, and their ordering. However, there are simpler options that are preferable if you don't need such control.

5.5.1. Basics

The ProxyFactoryBean, like other Spring FactoryBean implementations, introduces a level of indirection. If you define a ProxyFactoryBean with name foo, what objects referencing foo see is not the ProxyFactoryBean instance itself, but an object created by the ProxyFactoryBean's implementation of the getObject() method. This method will create an AOP proxy wrapping a target object.

One of the most important benefits of using a ProxyFactoryBean or other IoC-aware class to create AOP proxies, is that it means that advices and pointcuts can also be managed by IoC. This is a powerful feature, enabling certain approaches that are hard to achieve with other AOP frameworks. For example, an advice may itself reference application objects (besides the target, which should be available in any AOP framework), benefiting from all the pluggability provided by Dependency Injection.
5.5.2. JavaBean properties

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

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

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

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

Other properties specific to ProxyFactoryBean include:

- proxyInterfaces: array of String interface names. If this isn't supplied, a CGLIB proxy for the target class will be used
- interceptorNames: String array of Advisor, interceptor or other advice names to apply. Ordering is significant. The names are bean names in the current factory, including bean names from ancestor factories.
- singleton: whether or not the factory should return a single object, no matter how often the getObject() method is called. Several FactoryBean implementations offer such a method. Default value is true. If you want to use stateful advice--for example, for stateful mixins--use prototype advices along with a singleton value of false.

5.5.3. Proxying interfaces

Let's look at a simple example of ProxyFactoryBean in action. This example involves:

- A target bean that will be proxied. This is the "personTarget" bean definition in the example below.
- An Advisor and an Interceptor used to provide advice.
• An AOP proxy bean definition specifying the target object (the personTarget bean) and the interfaces to proxy, along with the advices to apply.

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

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

<bean id="debugInterceptor" class="org.springframework.aop.interceptor.DebugInterceptor">
</bean>

<bean id="person" class="org.springframework.aop.framework.ProxyFactoryBean">
    <property name="proxyInterfaces"><value>com.mycompany.Person</value></property>
    <property name="target"><ref local="personTarget" /></property>
    <property name="interceptorNames">
        <list>
            <value>myAdvisor</value>
            <value>debugInterceptor</value>
        </list>
    </property>
</bean>
```

Note that the interceptorNames property takes a list of String: the bean names of the interceptor or advisors in the current factory. Advisors, interceptors, before, after returning and throws advice objects can be used. The ordering of advisors is significant.

You might be wondering why the list doesn't hold bean references. The reason for this is that if the ProxyFactoryBean's singleton property is set to false, it must be able to return independent proxy instances. If any of the advisors is itself a prototype, an independent instance would need to be returned, so it's necessary to be able to obtain an instance of the prototype from the factory; holding a reference isn't sufficient.

The "person" bean definition above can be used in place of a Person implementation, as follows:

```java
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:

```xml
<bean id="personUser" class="com.mycompany.PersonUser">
    <property name="person"><ref local="person" /></property>
</bean>
```

The PersonUser class in this example would expose a property of type Person. As far as it's concerned, the AOP proxy can be used transparently in place of a "real" person implementation. However, its class would be a dynamic proxy class. It would be possible to cast it to the Advised interface (discussed below).

It's possible to conceal the distinction between target and proxy using an anonymous inner bean, as follows. Only the ProxyFactoryBean definition is different; the advice is included only for completeness:
This has the advantage that there's only one object of type Person: useful if we want to prevent users of the application context obtaining a reference to the un-advised object, or need to avoid any ambiguity with Spring IoC autowiring. There's also arguably an advantage in that the ProxyFactoryBean definition is self-contained. However, there are times when being able to obtain the un-advised target from the factory might actually be an advantage: for example, in certain test scenarios.

5.5.4. Proxying classes

What if you need to proxy a class, rather than one or more interfaces?

Imagine that in our example above, there was no Person interface: we needed to advise a class called Person that didn't implement any business interface. In this case, you can configure Spring to use CGLIB proxying, rather than dynamic proxies. Simply set the proxyTargetClass property on the ProxyFactoryBean above to true. While it's best to program to interfaces, rather than classes, the ability to advise classes that don't implement interfaces can be useful when working with legacy code. (In general, Spring isn't prescriptive. While it makes it easy to apply good practices, it avoids forcing a particular approach.)

If you want to force the use of CGLIB in any case, even if you do have interfaces.

CGLIB proxying works by generating a subclass of the target class at runtime. Spring configures this generated subclass to delegate method calls to the original target: the subclass is used to implement the Decorator pattern, weaving in the advice.

CGLIB proxying should generally be transparent to users. However, there are some issues to consider:

- Final methods can't be advised, as they can't be overridden.
- You'll need the CGLIB 2 binaries on your classpath; dynamic proxies are available with the JDK

There's little performance difference between CGLIB proxying and dynamic proxies. As of Spring 1.0, dynamic proxies are slightly faster. However, this may change in the future. Performance should not be a decisive consideration in this case.

5.6. Convenient proxy creation
Often we don’t need the full power of the **ProxyFactoryBean**, because we’re only interested in one aspect: For example, transaction management.

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

### 5.6.1. TransactionProxyFactoryBean

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

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

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

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

```
<bean id="petStoreTarget" class="org.springframework.samples.jpetstore.domain.logic.PetStoreImpl">
  <property name="accountDao"><ref bean="accountDao"/></property>
</bean>

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

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

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

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

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

<property name="postInterceptors">
  <list>
    <ref local="myAdvisor"/>
  </list>
</property>
```
These properties could be added to the "petStore" bean definition above. A common usage is to combine transactionality with declarative security: a similar approach to that offered by EJB.

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

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

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

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

5.6.2. EJB proxies

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

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

5.7. Concise proxy definitions

Especially when defining transactional proxies, you may end up with many similar proxy definitions. The use of parent and child bean definitions, along with inner bean definitions, can result in much cleaner and more concise proxy definitions.

First a parent, template, bean definition is created for the proxy:

```xml
<bean id="txProxyTemplate" abstract="true"
     class="org.springframework.transaction.interceptor.TransactionProxyFactoryBean">
  <property name="transactionManager"><ref local="transactionManager"></ref></property>
  <property name="transactionAttributes">
    <prop key="*">PROPAGATION_REQUIRED</prop>
  </props>
</bean>
```

This will never be instantiated itself, so may actually be incomplete. Then each proxy which needs to be created is just a child bean definition, which to wraps the target of the proxy as an inner bean definition, since the target will never be used on its own anyways.

```xml
<bean id="myService" parent="txProxyTemplate">
  <property name="target">
    <bean class="org.springframework.samples.MyServiceImpl"/>
  </property>
</bean>
```
It is of course possible to override properties from the parent template, such as in this case, the transaction propagation settings:

```xml
<bean id="mySpecialService" parent="txProxyTemplate">
  <property name="target">
    <bean class="org.springframework.samples.MySpecialServiceImpl">
    </bean>
  </property>
  <property name="transactionAttributes">
    <props>
      <prop key="get*">PROPAGATION_REQUIRED,readOnly</prop>
      <prop key="find*">PROPAGATION_REQUIRED,readOnly</prop>
      <prop key="load*">PROPAGATION_REQUIRED,readOnly</prop>
      <prop key="store*">PROPAGATION_REQUIRED</prop>
    </props>
  </property>
</bean>
```

Note that in the example above, we have explicitly marked the parent bean definition as `abstract` by using the `abstract` attribute, as described previously, so that it may not actually ever be instantiated. Application contexts (but not simple bean factories) will by default pre-instantiate all singletons. Therefore it is important (at least for singleton beans) that if you have a (parent) bean definition which you intend to use only as a template, and this definition specifies a class, you must make sure to set the `abstract` attribute to `true`, otherwise the application context will actually try to pre-instantiate it.

5.8. Creating AOP proxies programmatically with the ProxyFactory

It’s easy to create AOP proxies programmatically using Spring. This enables you to use Spring AOP without dependency on Spring IoC.

The following listing shows creation of a proxy for a target object, with one interceptor and one advisor. The interfaces implemented by the target object will automatically be proxied:

```java
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.

5.9. 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:

```java
Advisor[] getAdvisors();
void addAdvice(Advice advice) throws AopConfigException;
void addAdvice(int pos, Advice advice)
    throws AopConfigException;
void addAdvisor(Advisor advisor) throws AopConfigException;
void addAdvisor(int pos, Advisor advisor) throws AopConfigException;
int indexOf(Advisor advisor);
boolean removeAdvisor(Advisor advisor) throws AopConfigException;
void removeAdvisor(int index) throws AopConfigException;
boolean replaceAdvisor(Advisor a, Advisor b) throws AopConfigException;
boolean isFrozen();
```

The `getAdvisors()` method will return an Advisor for every advisor, interceptor or other advice type that has been added to the factory. If you added an Advisor, the returned advisor at this index will be the object that you added. If you added an interceptor or other advice type, Spring will have wrapped this in an advisor with a pointcut that always returns true. Thus if you added a `MethodInterceptor`, the advisor returned for this index will be an `DefaultPointcutAdvisor` returning your `MethodInterceptor` and a pointcut that matches all classes and methods.

The `addAdvisor()` methods can be used to add any Advisor. Usually the advisor holding pointcut and advice will be the generic `DefaultPointcutAdvisor`, which can be used with any advice or pointcut (but not for introduction).

By default, it's possible to add or remove advisors or interceptors even once a proxy has been created. The only restriction is that it's impossible to add or remove an introduction advisor, as existing proxies from the factory will not show the interface change. (You can obtain a new proxy from the factory to avoid this problem.)

A simple example of casting an AOP proxy to the `Advised` interface and examining and manipulating its advice:

```java
Advised advised = (Advised) myObject;
Advisor[] advisors = advised.getAdvisors();
int oldAdvisorCount = advisors.length;
System.out.println(oldAdvisorCount + " advisors");

// Add an advice like an interceptor without a pointcut
// Will match all proxied methods
// Can use for interceptors, before, after returning or throws advice
advised.addAdvice(new DebugInterceptor());

// Add selective advice using a pointcut
advised.addAdvisor(new DefaultPointcutAdvisor(mySpecialPointcut, myAdvice));

assertEquals("Added two advisors",
    oldAdvisorCount + 2, advised.getAdvisors().length);
```

It's questionable whether it's advisable (no pun intended) to modify advice on a business object in production, although there are no doubt legitimate usage cases. However, it can be very useful in development: for example, in tests. I have sometimes found it very useful to be able to add test code in the form of an interceptor or other advice, getting inside a method invocation I want to test. (For example, the advice can get inside a
transaction created for that method: for example, to run SQL to check that a database was correctly updated, before marking the transaction for roll back.)

Depending on how you created the proxy, you can usually set a frozen flag, in which case the Advised
isFrozen() method will return true, and any attempts to modify advice through addition or removal will result
in an AopConfigException. The ability to freeze the state of an advised object is useful in some cases: For example, to prevent calling code removing a security interceptor. It may also be used in Spring 1.1 to allow aggressive optimization if runtime advice modification is known not to be required.

5.10. Using the "autoproxy" facility

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

Spring also allows us to use "autoproxy" bean definitions, which can automatically proxy selected bean
definitions. This is built on Spring "bean post processor" infrastructure, which enables modification of any bean
definition as the container loads.

In this model, you set up some special bean definitions in your XML bean definition file configuring the auto
proxy infrastructure. This allows you just to declare the targets eligible for autoproxying: you don't need to use
ProxyFactoryBean.

There are two ways to do this:

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

5.10.1. Autoproxy bean definitions

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

5.10.1.1. BeanNameAutoProxyCreator

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

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

As with ProxyFactoryBean, there is an interceptorNames property rather than a list of interceptor, to allow
correct behavior for prototype advisors. Named "interceptors" can be advisors or any advice type.

As with auto proxying in general, the main point of using BeanNameAutoProxyCreator is to apply the same
configuration consistently to multiple objects, and with minimal volume of configuration. It is a popular choice
for applying declarative transactions to multiple objects.
Bean definitions whose names match, such as "jdkMyBean" and "onlyJdk" in the above example, are plain old bean definitions with the target class. An AOP proxy will be created automatically by the `BeanNameAutoProxyCreator`. The same advice will be applied to all matching beans. Note that if advisors are used (rather than the interceptor in the above example), the pointcuts may apply differently to different beans.

### 5.10.1.2. DefaultAdvisorAutoProxyCreator

A more general and extremely powerful auto proxy creator is `DefaultAdvisorAutoProxyCreator`. This will automagically apply eligible advisors in the current context, without the need to include specific bean names in the autoproy proxy advisor's bean definition. It offers the same merit of consistent configuration and avoidance of duplication as `BeanNameAutoProxyCreator`.

Using this mechanism involves:

- Specifying a `DefaultAdvisorAutoProxyCreator` bean definition
- Specifying any number of Advisors in the same or related contexts. Note that these must be Advisors, not just interceptors or other advices. This is necessary because there must be a pointcut to evaluate, to check the eligibility of each advice to candidate bean definitions.

The `DefaultAdvisorAutoProxyCreator` will automatically evaluate the pointcut contained in each advisor, to see what (if any) advice it should apply to each business object (such as "businessObject1" and "businessObject2" in the example).

This means that any number of advisors can be applied automatically to each business object. If no pointcut in any of the advisors matches any method in a business object, the object will not be proxied. As bean definitions are added for new business objects, they will automatically be proxied if necessary.

Autoproxying in general has the advantage of making it impossible for callers or dependencies to obtain an un-advised object. Calling `getBean("businessObject1")` on this ApplicationContext will return an AOP proxy, not the target business object. (The "inner bean" idiom shown earlier also offers this benefit.)

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

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

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

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

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

The `DefaultAdvisorAutoProxyCreator` is very useful if you want to apply the same advice consistently to many business objects. Once the infrastructure definitions are in place, you can simply add new business objects without including specific proxy configuration. You can also drop in additional aspects very easily—for example, tracing or performance monitoring aspects—with minimal change to configuration.
The DefaultAdvisorAutoProxyCreator offers support for filtering (using a naming convention so that only certain advisors are evaluated, allowing use of multiple, differently configured, AdvisorAutoProxyCreators in the same factory) and ordering. Advisors can implement the `org.springframework.core.Ordered` interface to ensure correct ordering if this is an issue. The TransactionAttributeSourceAdvisor used in the above example has a configurable order value; default is unordered.

5.10.1.3. AbstractAdvisorAutoProxyCreator

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

5.10.2. Using metadata-driven auto-proxying

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

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

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

The /attributes directory of the jPetStore sample application shows the use of attribute-driven 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:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

### 5.11. Using TargetSources

Spring offers the concept of a TargetSource, expressed in the org.springframework.aop.TargetSource
interface. This interface is responsible for returning the "target object" implementing the joinpoint. The TargetSource implementation is asked for a target instance each time the AOP proxy handles a method invocation.

Developers using Spring AOP don't normally need to work directly with TargetSources, but this provides a powerful means of supporting pooling, hot swappable and other sophisticated targets. For example, a pooling TargetSource can return a different target instance for each invocation, using a pool to manage instances.

If you do not specify a TargetSource, a default implementation is used that wraps a local object. The same target is returned for each invocation (as you would expect).

Let's look at the standard target sources provided with Spring, and how you can use them. When using a custom target source, your target will usually need to be a prototype rather than a singleton bean definition. This allows Spring to create a new target instance when required.

5.11.1. Hot swappable target sources

The org.springframework.aop.target.HotSwappableTargetSource exists to allow the target of an AOP proxy to be switched while allowing callers to keep their references to it.

Changing the target source's target takes effect immediately. The HotSwappableTargetSource is threadsafe.

You can change the target via the swap() method on HotSwappableTargetSource as follows:

```java
HotSwappableTargetSource swapper = (HotSwappableTargetSource) beanFactory.getBean("swapper");
Object oldTarget = swapper.swap(newTarget);
```

The XML definitions required look as follows:

```xml
<bean id="initialTarget" class="mycompany.OldTarget">
</bean>

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

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

The above swap() call changes the target of the swappable bean. Clients who hold a reference to that bean will be unaware of the change, but will immediately start hitting the new target.

Although this example doesn't add any advice--and it's not necessary to add advice to use a TargetSource--of course any TargetSource can be used in conjunction with arbitrary advice.

5.11.2. Pooling target sources

Using a pooling target source provides a similar programming model to stateless session EJBs, in which a pool of identical instances is maintained, with method invocations going to free objects in the pool.
A crucial difference between Spring pooling and SLSB pooling is that Spring pooling can be applied to any POJO. As with Spring in general, this service can be applied in a non-invasive way.

Spring provides out-of-the-box support for Jakarta Commons Pool 1.1, which provides a fairly efficient pooling implementation. You'll need the commons-pool Jar on your application's classpath to use this feature. It's also possible to subclass org.springframework.aop.target.AbstractPoolingTargetSource to support any other pooling API.

Sample configuration is shown below:

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

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

<bean id="businessObject" class="org.springframework.aop.framework.ProxyFactoryBean">
    <property name="targetSource"><ref local="poolTargetSource"/></property>
    <property name="interceptorNames"><value>myInterceptor</value></property>
</bean>
```

Note that the target object--"businessObjectTarget" in the example--must be a prototype. This allows the PoolingTargetSource implementation to create new instances of the target to grow the pool as necessary. See the Javadoc for AbstractPoolingTargetSource and the concrete subclass you wish to use for information about it's 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:

```xml
<bean id="poolConfigAdvisor" class="org.springframework.beans.factory.config.MethodInvokingFactoryBean">
    <property name="targetObject"><ref local="poolTargetSource" /></property>
    <property name="targetMethod"><value>getPoolingConfigMixin</value></property>
</bean>
```

This advisor is obtained by calling a convenience method on the AbstractPoolingTargetSource class, hence the use of MethodInvokingFactoryBean. This advisor's name ("poolConfigAdvisor" here) must be in the list of interceptors names in the ProxyFactoryBean exposing the pooled object.

The cast will look as follows:

```java
PoolingConfig conf = (PoolingConfig) beanFactory.getBean("businessObject");
System.out.println("Max pool size is " + conf.getMaxSize());
```

Pooling stateless service objects is not usually necessary. We don't believe it should be the default choice, as most stateless objects are naturally thread safe, and instance pooling is problematic if resources are cached.
Simpler pooling is available using autoproxying. It's possible to set the TargetSources used by any autoproxy creator.

### 5.11.3. Prototype" target sources

Setting up a "prototype" target source is similar to a pooling TargetSource. In this case, a new instance of the target will be created on every method invocation. Although the cost of creating a new object isn't high in a modern JVM, the cost of wiring up the new object (satisfying its IoC dependencies) may be more expensive. Thus you shouldn't use this approach without very good reason.

To do this, you could modify the `poolTargetSource` definition shown above as follows. (I've also changed the name, for clarity.)

```xml
<bean id="prototypeTargetSource"
    class="org.springframework.aop.target.PrototypeTargetSource">
    <property name="targetBeanName">
        <value>businessObjectTarget</value>
    </property>
</bean>
```

There's only one property: the name of the target bean. Inheritance is used in the TargetSource implementations to ensure consistent naming. As with the pooling target source, the target bean must be a prototype bean definition.

### 5.12. Defining new Advice types

Spring AOP is designed to be extensible. While the interception implementation strategy is presently used internally, it is possible to support arbitrary advice types in addition to interception around advice, before, throws advice and after returning advice, which are supported out of the box.

The `org.springframework.aop.framework.adapter` package is an SPI package allowing support for new custom advice types to be added without changing the core framework. The only constraint on a custom Advice type is that it must implement the `org.aopalliance.aop.Advice` tag interface.

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

### 5.13. Further reading and resources

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

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

- The JPetStore's default configuration illustrates the use of the TransactionProxyFactoryBean for declarative transaction management
- The `/attributes` directory of the JPetStore illustrates the use of attribute-driven declarative transaction management

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

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

- **Performance improvements:** The creation of AOP proxies is handled by a factory via a Strategy interface. Thus we can support additional AopProxy types without impacting user code or the core implementation. Significant performance optimizations for CGLIB proxying are scheduled for the 1.0.3 release, with further optimizations by Spring 1.1 in cases where advice will not change at runtime. This should produce a significant reduction in the overhead of the AOP framework. Note, however, that the overhead of the AOP framework is not an issue in normal usage.

- **More expressive pointcuts:** Spring presently offers an expressive Pointcut interface, but we can add value through adding more Pointcut implementations. We are looking at an integration with AspectJ that will allow AspectJ pointcut expressions to be used in Spring configuration files. And if you wish to contribute a useful Pointcut, please do!

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

- Allowing AspectJ aspects to be configured using Spring IoC. This has the potential to integrate AspectJ aspects into applications where appropriate, in the same way as Spring aspects are integrated into application IoC contexts.

- Allowing the use of AspectJ pointcut expressions within Spring configuration to target Spring advice. This has significant benefits over devising our own pointcut expression language; AspectJ is both well thought out and well documented.

Both these integrations should be available in Spring 1.1.
Chapter 6. Intégration d'AspectJ

6.1. Vue d'ensemble

Le framework AOP de Spring basé sur les proxies est bien adapté pour résoudre beaucoup des problèmes génériques des middlewares et spécifiques des applications. Cependant, il arrive qu'une solution AOP plus puissante soit requise: par exemple, si des champs supplémentaires doivent être ajoutés à une classe, ou si des advices d'une granularité plus fines ne peuvent pas être créés avec le conteneur IoC de Spring.

Nous recommandons l'utilisation d'AspectJ dans ces cas précis puisque dans sa version 1.1, Spring offre une puissante intégration avec AspectJ.

6.2. Configuration des aspects d'AspectJ en utilisant le conteneur IoC de Spring

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

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

AspectJ aspects can expose JavaBean properties for Setter Injection, and even implement Spring lifecycle interfaces such as `BeanFactoryAware`. Note that AspectJ aspects cannot use Constructor Injection or Method Injection. This limitation is due to the fact that aspects do not have constructors that can be invoked like constructors of objects.

6.2.1. "Singleton" aspects

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

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

6.2.1.1. Example

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

The AspectJ code for the aspect (one of the Spring/AspectJ samples), is shown below. Note that the dependency on the `SecurityManager` interface is expressed in a JavaBean property:
public aspect BalanceChangeSecurityAspect {
    private SecurityManager securityManager;
    public void setSecurityManager(SecurityManager securityManager) {
        this.securityManager = securityManager;
    }
    private pointcut balanceChanged() :
        set(int Account.balance);
    before() : balanceChanged() {
        this.securityManager.checkAuthorizedToModify();
    }
}

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

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

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

6.2.1.2. Ordering issues
to be completed

6.2.2. Non-singleton aspects

** Complete material on pertarget etc.

6.2.3. Gotchas
to be completed
- Singleton issue

6.3. Using AspectJ pointcuts to target Spring advice

In a future release of Spring, we plan to provide the ability for AspectJ pointcut expressions to be used in Spring XML or other bean definition files, to target Spring advice. This will allow some of the power of the AspectJ pointcut model to be applied to Spring's proxy-based AOP framework. This will work in pure Java, and will not require the AspectJ compiler. Only the subset of AspectJ pointcuts relating to method invocation will be usable.
This feature is scheduled for Spring 1.2. It depends on AspectJ enhancements.

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

6.4. Spring aspects for AspectJ

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

This feature is probably of more interest to AspectJ users than Spring users.
Chapter 7. Transaction management

7.1. The Spring transaction abstraction

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

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

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

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

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

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

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

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

The key to the Spring transaction abstraction is the notion of a transaction strategy. This is captured in the `org.springframework.transaction.PlatformTransactionManager` interface, shown below:

```java
public interface PlatformTransactionManager {
    TransactionStatus getTransaction(TransactionDefinition definition) throws TransactionException;
    void commit(TransactionStatus status) throws TransactionException;
    void rollback(TransactionStatus status) throws TransactionException;
}
```

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

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

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

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

The `TransactionDefinition` interface specifies:

- **Transaction isolation**: The degree of isolation this transaction has from the work of other transactions. For example, can this transaction see uncommitted writes from other transactions?

- **Transaction propagation**: Normally all code executed within a transaction scope will run in that transaction. However, there are several options specifying behavior if a transactional method is executed when a transaction context already exists: For example, simply running in the existing transaction (the most common case); or suspending the existing transaction and creating a new transaction. Spring offers the transaction propagation options familiar from EJB CMT.

- **Transaction timeout**: How long this transaction may run before timing out (automatically being rolled back by the underlying transaction infrastructure).

- **Read-only status**: A read-only transaction does not modify any data. Read-only transactions can be a useful optimization in some cases (such as when using Hibernate).

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

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

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

```java
public interface TransactionStatus {
    boolean isNewTransaction();
    void setRollbackOnly();
    boolean isRollbackOnly();
}
```

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

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

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

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

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

The PlatformTransactionManager definition will look like this:

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

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

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

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

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

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

The DataSource bean definition will be similar to one of the above examples, and is not shown. (If it’s a container DataSource it should be non-transactional as Spring, rather than the container, will manage transactions.)
The "transactionManager" bean in this case is of class HibernateTransactionManager. In the same way as the DataSourceTransactionManager needs a reference to the DataSource, the HibernateTransactionManager needs a reference to the session factory.

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

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

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

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

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

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

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

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

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

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

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

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

Spring provides two means of programmatic transaction management:

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

We generally recommend the first approach.

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

### 7.3.1. Using the TransactionTemplate

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

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

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

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

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

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

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

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

### 7.3.2. Using the PlatformTransactionManager

You can also use the org.springframework.transaction.PlatformTransactionManager directly to manage your transaction. Simply pass the implementation of the PlatformTransactionManager you're using to your bean via a bean reference. Then, using the TransactionDefinition and TransactionStatus objects you can initiate transactions, rollback and commit.
DefaultTransactionDefinition def = new DefaultTransactionDefinition()
    .setPropagationBehavior(TransactionDefinition.PROPAGATION_REQUIRED);

TransactionStatus status = transactionManager.getTransaction(def);

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

7.4. Declarative transaction management

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

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

- Unlike EJB CMT, which is tied to JTA, Spring declarative transaction management works in any environment. It can work with JDBC, JDO, Hibernate or other transactions under the covers, with configuration changes only.

- Spring enables declarative transaction management to be applied to any POJO, not just special classes such as EJ Bs.

- Spring offers declarative rollback rules: a feature with no EJB equivalent, which we'll discuss below. Rollback can be controlled declaratively, not merely programmatically.

- Spring gives you an opportunity to customize transactional behavior, using AOP. For example, if you want to insert custom behavior in the case of transaction rollback, you can. You can also add arbitrary advice, along with the transactional advice. With EJB CMT, you have no way to influence the container's transaction management other than `setRollbackOnly()`.

- Spring does not support propagation of transaction contexts across remote calls, as do high-end application servers. If you need this feature, we recommend that you use EJB. However, don't use this feature lightly. Normally we don't want transactions to span remote calls.

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

While the EJB default behavior is for the EJB container to automatically roll back the transaction on a system exception (usually a runtime exception), EJB CMT does not roll back the transaction automatically on an application exception (checked exception other than `java.rmi.RemoteException`). While the Spring default behavior for declarative transaction management follows EJB convention (roll back is automatic only on
unchecked exceptions), it's often useful to customize this.

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

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

```
<!-- this example is in verbose form, see note later about concise 
     for multiple proxies! -->
<!-- the target bean to wrap transactionally -->
<bean id="petStoreTarget">
  ...
</bean>

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

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

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

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

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

Please see the chapter on AOP for more information and examples.
Note: Using TransactionProxyFactoryBean definitions in the form above can seem overly verbose when many almost identical transaction proxies need to be created. You will almost always want to take advantage of parent and child bean definitions, along with inner bean definitions, to significantly reduce the verbosity of your transaction proxy definitions, as described in Section 5.7, “Concise proxy definitions”.
You don’t need to be an AOP expert--or indeed, to know much at all about AOP--to use Spring’s declarative transaction management effectively. However, if you do want to become a "power user" of Spring AOP, you will find it easy to combine declarative transaction management with powerful AOP capabilities.

7.4.1. BeanNameAutoProxyCreator, another declarative approach

TransactionProxyFactoryBean is very useful, and gives you full control when wrapping objects with a transactional proxy. Used with parent/child bean definitions and inner beans holding the target, it is generally the best choice for transactional wrapping. In the case that you need to wrap a number of beans in a completely identical fashion (for example, a boilerplate, 'make all methods transactional', using a BeanFactoryPostProcessor called BeanNameAutoProxyCreator can offer an alternative approach which can end up being even less verbose for this simplified use case.

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

Let us consider a sample configuration:

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

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

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

Now that we have the transaction interceptor, we simply feed it to a BeanNameAutoProxyCreator instance we define, along with the names of 6 beans in the ApplicationContext that we want to wrap in an identical fashion. As you can see, the net result is significantly less verbose than it would have been to wrap 6 beans identically with TransactionProxyFactoryBean. Wrapping a 7th bean would add only one more line of config.

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

There is one thing to keep in mind, with regards to bean naming, when switching back and forth between the use of TransactionProxyFactoryBean, and BeanNameAutoProxyCreator. For the former, if the target bean is not defined as an inner bean, you normally give the target bean you want to wrap an id similar in form to myServiceTarget, and then give the proxy object an id of myService; then all users of the wrapped object simply refer to the proxy, i.e. myService. (These are just sample naming conventions, the point is that the target object has a different name than the proxy, and both are available from the ApplicationContext). However, when using BeanNameAutoProxyCreator, you name the target object something like myService. Then, when BeanNameAutoProxyCreator postprocesses the target object and create the proxy, it causes the proxy to be inserted into the Application context under the name of the original bean. From that point on, only the proxy (the wrapped object) is available from the ApplicationContext. When using TransactionProxyFactoryBean with the target specified as an inner bean, this naming issue is not a concern, since the inner bean is not normally given a name.

### 7.5. Choosing between programmatic and declarative transaction management

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

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

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

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

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

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

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

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

### 7.7. Common problems

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

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

If you are using global transactions, you must use the Spring

```
org.springframework.transaction.jta.JtaTransactionManager
```

for all your for all your transactional operations. Otherwise Spring will attempt to perform local transactions on resources such as container DataSources. Such local transactions don't make sense, and a good application server will treat them as errors.
Chapter 8. Source Level Metadata Support

8.1. Source-level metadata

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

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

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

We could add metadata to a method as follows:

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

Both these examples use Jakarta Commons Attributes syntax.

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

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

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

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

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

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

Such a facade adds value for several reasons:

- There is currently no standard metadata solution. Java 1.5 will provide one, but it is still in beta as of Spring 1.0. Furthermore, there will be a need for metadata support in 1.3 and 1.4 applications for at least two years. Spring aims to provide working solutions now; waiting for 1.5 is not an option in such an important area.

- Current metadata APIs, such as Commons Attributes (used by Spring 1.0) are hard to test. Spring provides a simple metadata interface that is much easier to mock.

- Even when Java 1.5 provides metadata support at language level, there will still be value in providing such an abstraction:

  - JSR-175 metadata is static. It is associated with a class at compile time, and cannot be changed in a deployed environment. There is a need for hierarchical metadata, providing the ability to override certain attribute values in deployment—for example, in an XML file.

  - JSR-175 metadata is returned through the Java reflection API. This makes it impossible to mock during test time. Spring provides a simple interface to allow this.

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

The `Spring Attributes` interface looks like this:

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

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

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

In most attribute providers, attribute classes will be configured via constructor arguments or `JavaBean`
properties. Commons Attributes supports both.

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

8.3. Integration with Jakarta Commons Attributes

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

Commons Attributes 2.1 (http://jakarta.apache.org/commons/attributes/) is a capable attributes solution. It supports attribute configuration via constructor arguments and JavaBean properties, which offers better self-documentation in attribute definitions. (Support for JavaBean properties was added at the request of the Spring team.)

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

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

Bean properties look as follows:

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

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

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

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

1. Copy the necessary library Jars to $ANT_HOME/lib. Four Jars are required, and all are distributed with Spring:
   - The Commons Attributes compiler Jar and API Jar
   - xjavadoc.jar, from XDoclet
   - commons-collections.jar, from Jakarta Commons

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

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

3. Next, define an attribute compilation task, which will use the Commons Attributes attribute-compiler task to "compile" the attributes in the source. This process results in the generation of additional sources, to a location specified by the destdir attribute. Here we show the use of a temporary directory:
The compile target that runs Javac over the sources should depend on this attribute compilation task, and must also compile the generated sources, which we output to our destination temporary directory. If there are syntax errors in your attribute definitions, they will normally be caught by the attribute compiler. However, if the attribute definitions are syntactically plausible, but specify invalid types or class names, the compilation of the generated attribute classes may fail. In this case, you can look at the generated classes to establish the cause of the problem.

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

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

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

```xml
<attribute-indexer jarFile="myCompiledSources.jar">
  <classpath refid="master-classpath"/>
</attribute-indexer>
```

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

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

### 8.4. Metadata and Spring AOP autoproxying

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

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

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

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

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

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

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

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

The basic concepts here should be familiar from the discussion of autoproxying in the AOP chapter. The most important bean definitions are those named `autoproxy` and `transactionAdvisor`. Note that the actual bean names are not important; what matters is their class.

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

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

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

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

### 8.4.2. Declarative transaction management

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

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

### 8.4.3. Pooling

Again, as with .NET, you can enable pooling behavior via class-level attributes. Spring can apply this behavior
to any POJO. You simply need to specify a pooling attribute, as follows, in the business object to be pooled:

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

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

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

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

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

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

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

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

### 8.4.4. Custom metadata

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

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

- Define your custom attribute class
- Define a Spring AOP Advisor with a pointcut that fires on the presence of this custom attribute.
- Add that Advisor as a bean definition to an application context with the generic autoproxy infrastructure in
  place.
- Add attributes to your POJOs.
There are several potential areas you might want to do this, such as custom declarative security, or possibly caching.

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

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

8.5. Using attributes to minimize MVC web tier configuration

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

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

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

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

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

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

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

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

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

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

```java
/**
 * Normal comments here
 * @author Rod Johnson
 * @org.springframework.web.servlet.handler.metadata.PathMap("/bar.cgi")
 */
public class BarController extends AbstractController {
```
private Cruncher cruncher;

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

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

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

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

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

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

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

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

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

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

This approach has the following benefits:
• Significantly reduced volume of configuration. Each time we add a controller we need add no XML
collection. As with attribute-driven transaction management, once the basic infrastructure is in place, it
is very easy to add more application classes.

• We retain much of the power of Spring IoC to configure controllers.

This approach has the following limitations:

• One-off cost in more complex build process. We need an attribute compilation step and an attribute
indexing step. However, once in place, this should not be an issue.

• Currently Commons Attributes only, although support for other attribute providers may be added in future.

• Only "autowiring by type" dependency injection is supported for such controllers. However, this still leaves
them far in advance of Struts Actions (with no IoC support from the framework) and, arguably, WebWork
Actions (with only rudimentary IoC support) where IoC is concerned.

• Reliance on automagical IoC resolution may be confusing.

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

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

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

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

8.6. Other uses of metadata attributes

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

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

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

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

*We expect to add support for Java 1.5 attributes--probably as an add-on to the Spring core--in Q2 2004.*
Chapter 9. DAO support

9.1. Introduction

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

9.2. Consistent Exception Hierarchy

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

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

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

The exception hierarchy that Spring uses is outlined in the following graph:
9.3. Consistent Abstract Classes for DAO Support

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

Dao Support classes:

- **JdbcDaoSupport** - super class for JDBC data access objects. Requires a DataSource to be set, providing a JdbcTemplate based on it to subclasses.

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

- **JdoDaoSupport** - super class for JDO data access objects. Requires a PersistenceManagerFactory to be set, providing a JdoTemplate based on it to subclasses.
Chapter 10. Data Access using JDBC

10.1. Introduction

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

The `org.springframework.jdbc.core` package contains the JdbcTemplate class and its various callback interfaces, plus a variety of related classes.

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

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

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

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

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

10.2.1. JdbcTemplate

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

Code using this class only need to implement callback interfaces, giving them a clearly defined contract. The PreparedStatementCreator callback interface creates a prepared statement given a Connection provided by this class, providing SQL and any necessary parameters. The same is true for the CallableStatementCreator interface which creates callable statement. The RowCallbackHandler interface extracts values from each row of a ResultSet.
This class can be used within a service implementation via direct instantiation with a DataSource reference, or get prepared in an application context and given to services as bean reference. Note: The DataSource should always be configured as a bean in the application context, in the first case given to the service directly, in the second case to the prepared template. Because this class is parameterizable by the callback interfaces and the SQLExceptionTranslator interface, it isn’t necessary to subclass it. All SQL issued by this class is logged.

### 10.2.2. DataSource

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

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

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

### 10.2.3. SQLExceptionTranslator

SQLExceptionTranslator is an interface to be implemented by classes that can translate between SQLExceptions and our data access strategy-agnostic org.springframework.dao.DataAccessException. Implementations can be generic (for example, using SQLState codes for JDBC) or proprietary (for example, using Oracle error codes) for greater precision.

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

The SQLErrorCodeSQLExceptionTranslator applies the following matching rules:

- Try custom translation implemented by any subclass. Note that this class is concrete and is typically used itself, in which case this rule doesn't apply.
Apply error code matching. Error codes are obtained from the SQLErrorCodesFactory by default. This looks up error codes from the classpath and keys into them from the database name from the database metadata.

Use the fallback translator. SQLStateSQLExceptionTranslator is the default fallback translator.

SQLErrorCodeSQLExceptionTranslator can be extended the following way:

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

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

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

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

### 10.2.4. Executing Statements

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

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

public class ExecuteAStatement { 
    private JdbcTemplate jt;
    private DataSource dataSource;
    
    public void doExecute() {
        jt = new JdbcTemplate(dataSource);
        jt.execute("create table mytable (id integer, name varchar(100))");
    }
    
    public void setDataSource(DataSource dataSource) {
        this.dataSource = dataSource;
    }
}
```

### 10.2.5. Running Queries

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

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

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

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

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

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

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

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

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

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

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

10.2.6. Updating the database

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

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

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

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

    public void setDataSource(DataSource dataSource) {
        this.dataSource = dataSource;
    }
}
```
10.3. Controlling how we connect to the database

10.3.1. DataSourceUtils

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

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

10.3.2. SmartDataSource

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

10.3.3. AbstractDataSource

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

10.3.4. SingleConnectionDataSource

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

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

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

10.3.5. DriverManagerDataSource

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

Useful for test or standalone environments outside of a J2EE container, either as a DataSource bean in a respective ApplicationContext, or in conjunction with a simple JNDI environment. Pool-assuming
Connection.close() calls will simply close the connection, so any DataSource-aware persistence code should work.

### 10.3.6. **DataSourceTransactionManager**

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

Application code is required to retrieve the JDBC connection via

```
DataSourceUtils.getConnection(DataSource) instead of J2EE's standard DataSource.getConnection.
```

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

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

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

### 10.4. Modeling JDBC operations as Java objects

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

#### 10.4.1. **SqlQuery**

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

#### 10.4.2. **MappingSqlQuery**

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

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

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

```java
private class CustomerMappingQuery extends MappingSqlQuery {
    public CustomerMappingQuery(DataSource ds) {
        super(ds, "SELECT id, name FROM customer WHERE id = ?");
        super.declareParameter(new SqlParameter("id", Types.INTEGER));
        compile();
    }
}
```
We provide a constructor for this customer query that takes the `DataSource` as the only parameter. In this constructor we call the constructor on the superclass with the `DataSource` and the SQL that should be executed to retrieve the rows for this query. This SQL will be used to create a `PreparedStatement` so it may contain place holders for any parameters to be passed in during execution. Each parameter must be declared using the `declareParameter` method passing in an `SqlParameter`. The `SqlParameter` takes a name and the JDBC type as defined in `java.sql.Types`. After all parameters have been defined we call the `compile` method so the statement can be prepared and later be executed.

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

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

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

**10.4.3. SqlUpdate**

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

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

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

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

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

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

```java
import java.sql.Types;
import java.util.HashMap;
import java.util.Iterator;
import java.util.Map;
import javax.sql.DataSource;
import org.springframework.jdbc.core.SqlOutParameter;
import org.springframework.jdbc.datasource.*;
import org.springframework.jdbc.object.StoredProcedure;

public class TestStoredProcedure {

    public static void main(String[] args) {
        TestStoredProcedure t = new TestStoredProcedure();
        t.test();
        System.out.println("Done!");
    }

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

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

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

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

10.4.5. SqlFunction

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

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

This is a concrete class, which there is normally no need to subclass. Code using this package can create an object of this type, declaring SQL and parameters, and then invoke the appropriate run method repeatedly to execute the function. Here is an example of retrieving the count of rows from a table:
Chapter 11. Data Access using O/R Mappers

11.1. Introduction

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

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

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

- **To avoid vendor lock-in, and allow mix-and-match implementation strategies.** While Hibernate is powerful, flexible, open source and free, it still uses a proprietary API. Furthermore one could argue that iBatis is a bit lightweight, although it's excellent for use in application that don't require complex O/R mapping strategies. Given the choice, it's usually desirable to implement major application functionality using standard or abstracted APIs, in case you need to switch to another implementation for reasons of functionality, performance, or any other concerns. For example, Spring's abstraction of Hibernate Transactions and Exceptions, along with its IoC approach which allows you to easily swap in mapper/DAO objects implementing data-access functionality, makes it easy to isolate all Hibernate-specific code in one area of your application, without sacrificing any of the power of Hibernate. Higher level service code dealing with the DAOs has no need to know anything about their implementation. This approach has the additional benefit of making it easy to intentionally implement data-access with a mix-and-match approach (i.e. some data-access performed using Hibernate, and some using JDBC, others using iBatis) in a non-intrusive fashion, potentially providing great benefits in terms of continuing to use legacy code or leveraging the strength of each technology.

- **Ease of testing.** Spring's inversion of control approach makes it easy to swap the implementations and locations of Hibernate session factories, datasources, transaction managers, and mapper object implementations (if needed). This makes it much easier to isolate and test each piece of persistence-related code in isolation.

- **General resource management.** Spring application contexts can handle the location and configuration of Hibernate SessionFactories, JDBC datasources, iBatis SQLMaps configuration objects, and other related resources. This makes these values easy to manage and change. Spring offers efficient, easy and safe handling of Hibernate Sessions. Related code using Hibernate generally needs to use the same Hibernate Session object for efficiency and proper transaction handling. Spring makes it easy to transparently create and bind a session to the current thread, using either a declarative, AOP method interceptor approach, or by using an explicit, template wrapper class at the Java code level. Thus Spring solves many of the usage issues that repeatedly arise on the Hibernate forums.

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

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

### 11.2. Hibernate

#### 11.2.1. Resource Management

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

#### 11.2.2. Resource Definitions in an Application Context

To avoid tying application objects to hard-coded resource lookups, Spring allows you to define resources like a JDBC `DataSource` or a Hibernate `SessionFactory` as beans in an application context. Application objects that need to access resources just receive references to such pre-defined instances via bean references (the DAO definition in the next section illustrates this). The following excerpt from an XML application context definition shows how to set up a JDBC `DataSource` and a Hibernate `SessionFactory` on top of it:
Note that switching from a JNDI-located DataSource to a locally defined one like a Jakarta Commons DBCP BasicDataSource is just a matter of configuration:

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

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

### 11.2.3. Inversion of Control: Template and Callback

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

```xml
<beans>
  <bean id="mySessionFactory" class="org.springframework.orm.hibernate.LocalSessionFactoryBean">
    <property name="mappingResources">
      <list>
        <value>product.hbm.xml</value>
      </list>
    </property>
    <property name="hibernateProperties">
      <props>
        <prop key="hibernate.dialect">net.sf.hibernate.dialect.MySQLDialect</prop>
      </props>
    </property>
    <property name="dataSource">
      <ref bean="myDataSource"/>
    </property>
  </bean>
  ...
</beans>
```
A callback implementation can effectively be used for any Hibernate data access. HibernateTemplate will ensure that Sessions are properly opened and closed, and automatically participate in transactions. The template instances are thread-safe and reusable, they can thus be kept as instance variables of the surrounding class. For simple single step actions like a single find, load, saveOrUpdate, or delete call, HibernateTemplate offers alternative convenience methods that can replace such one line callback implementations. Furthermore, Spring provides a convenient HibernateDaoSupport base class that provides a setSessionFactory method for receiving a SessionFactory, and getSessionFactory and getHibernateTemplate for use by subclasses. In combination, this allows for very simple DAO implementations for typical requirements:

```java
public class ProductDaoImpl implements ProductDao {
    private SessionFactory sessionFactory;

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

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

### 11.2.4. Applying an AOP Interceptor Instead of a Template

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

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

### 11.2.5. Programmatic Transaction Demarcation

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

Alternatively, one can use Spring’s AOP TransactionInterceptor, replacing the transaction demarcation code with an interceptor configuration in the application context. This allows you to keep business objects free of repetitive transaction demarcation code in each business method. Furthermore, transaction semantics like propagation behavior and isolation level can be changed in a configuration file and do not affect the business object implementations.
As with HibernateInterceptor, TransactionInterceptor allows any checked application exception to be thrown with the callback code, while TransactionTemplate is restricted to unchecked exceptions within the callback. TransactionTemplate will trigger a rollback in case of an unchecked application exception, or if the transaction has been marked rollback-only by the application (via TransactionStatus).

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

Both TransactionTemplate and TransactionInterceptor delegate the actual transaction handling to a PlatformTransactionManager instance, which can be a HibernateTransactionManager (for a single Hibernate SessionFactory, using a ThreadLocal Session under the hood) or a JtaTransactionManager (delegating to the JTA subsystem of the container) for Hibernate applications. You could even use a custom PlatformTransactionManager implementation. So switching from native Hibernate transaction management to JTA, i.e. when facing distributed transaction requirements for certain deployments of your application, is just a matter of configuration. Simply replace the Hibernate transaction manager with Spring’s JTA transaction implementation. Both transaction demarcation and data access code will work without changes, as they just use the generic transaction management APIs. For distributed transactions across multiple Hibernate session factories, simply combine JtaTransactionManager as a transaction strategy with multiple LocalSessionFactoryBean definitions. Each of your DAOs then gets one specific SessionFactory reference passed into its respective bean property. If all underlying JDBC data sources are transactional container ones, a business object can demarcate transactions across any number of DAOs and any number of session factories without special regard, as long as it is using JtaTransactionManager as the strategy.
Both HibernateTransactionManager and JtaTransactionManager allow for proper JVM-level cache handling with Hibernate - without container-specific transaction manager lookup or JCA connector (as long as not using EJB to initiate transactions). Additionally, HibernateTransactionManager can export the JDBC Connection used by Hibernate to plain JDBC access code. This allows for high level transaction demarcation with mixed Hibernate/JDBC data access completely without JTA, as long as just accessing one database!

Note, for an alternative approach to using TransactionProxyFactoryBean to declaratively demarcate transactions, please see Section 7.4.1, “BeanNameAutoProxyCreator, another declarative approach”.

11.2.8. Container Resources versus Local Resources
Spring's resource management allows for simple switching between a JNDI SessionFactory and a local one, same for a JNDI DataSource, without having to change a single line of application code. Whether to keep the resource definitions in the container or locally within the application, is mainly a matter of the transaction strategy being used. Compared to a Spring-defined local SessionFactory, a manually registered JNDI SessionFactory does not provide any benefits. If registered via Hibernate's JCA connector, there is the added value of transparently taking part in JTA transactions, especially within EJBs. An important benefit of Spring's transaction support is that it isn't bound to a container at all. Configured to any other strategy than JTA, it will work in a standalone or test environment too. Especially for the typical case of single-database transactions, this is a very lightweight and powerful alternative to JTA. When using local EJB Stateless Session Beans to drive transactions, you depend both on an EJB container and JTA - even if you just access a single database anyway, and just use SLSBs for declarative transactions via CMT. The alternative of using JTA programmatically requires a J2EE environment too. JTA does not just involve container dependencies in terms of JTA itself and of JNDI DataSources. For non-Spring JTA-driven Hibernate transactions, you have to use the Hibernate JCA connector, or extra Hibernate transaction code with JTATransaction being configured, for proper JVM-level caching. Spring-driven transactions can work with a locally defined Hibernate SessionFactory nicely, just like with a local JDBC DataSource - if accessing a single database, of course. Therefore you just have to fall back to Spring's JTA transaction strategy when actually facing distributed transaction requirements. Note that a JCA connector needs container-specific deployment steps, and obviously JCA support in the first place. This is far more hassle than deploying a simple web app with local resource definitions and Spring-driven transactions. And you often need the Enterprise Edition of your container, as e.g. WebLogic Express does not provide JCA. A Spring app with local resources and transactions spanning one single database will work in any J2EE web container (without JTA, JCA, or EJB) - like Tomcat, Resin, or even plain Jetty. Additionally, such a middle tier can be reused in desktop applications or test suites easily. All things considered: If you do not use EJB, stick with local SessionFactory setup and Spring's HibernateTransactionManager or JtaTransactionManager. You will get all benefits including proper transactional JVM-level caching and distributed transactions, without any container deployment hassle. JNDI registration of a Hibernate SessionFactory via the JCA connector only adds value for use within EJBs.

11.2.9. Samples

The Petclinic sample in the Spring distribution offers alternative DAO implementations and application context configurations for Hibernate, JDBC, and Apache OJB. Petclinic can therefore serve as working sample app that illustrates the use of Hibernate in a Spring web app. It also leverages declarative transaction demarcation with different transaction strategies.

11.3. JDO

ToDo

11.4. iBATIS

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

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

### Table 11.1. iBATIS SqlMaps supporting classes for 1.3 and 2.0

<table>
<thead>
<tr>
<th>Feature</th>
<th>1.3.x</th>
<th>2.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creation of SqlMap</td>
<td>SqlMapFactoryBean</td>
<td>SqlMapClientFactoryBean</td>
</tr>
<tr>
<td>Template-style helper class</td>
<td>SqlMapTemplate</td>
<td>SqlMapClientTemplate</td>
</tr>
<tr>
<td>Callback to use MappedStatement</td>
<td>SqlMapCallback</td>
<td>SqlMapClientCallback</td>
</tr>
<tr>
<td>Super class for DAOs</td>
<td>SqlMapDaoSupport</td>
<td>SqlMapClientDaoSupport</td>
</tr>
</tbody>
</table>

#### 11.4.2. Setting up the SqlMap

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

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

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

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

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

    public void setEmail(String email) {
        this.email = email;
    }
}
```

Suppose we would want to map this class. We'd have to create the following SqlMap. Using the query, we can later on retrieve users through their email addresses. `Account.xml`:

```xml
<sql-map name="Account">
    <result-map name="result" class="examples.Account">
        <property name="name" column="NAME" columnIndex="1"/>
        <property name="email" column="EMAIL" columnIndex="2"/>
    </result-map>

    <mapped-statement name="getAccountByEmail" result-map="result">
        select ACCOUNT.NAME,
              ACCOUNT.EMAIL
        from ACCOUNT
        where ACCOUNT.EMAIL = #value#
    </mapped-statement>

    <mapped-statement name="insertAccount">
        insert into ACCOUNT (NAME, EMAIL) values (#name#, #email#)
    </mapped-statement>
</sql-map>
```
After having defined the Sql Map, we have to create a configuration file for iBATIS (`sqlmap-config.xml`):

```xml
<sql-map-config>
  <sql-map resource="example/Account.xml"/>
</sql-map-config>
```

iBATIS loads resources from the classpath so be sure to add the Account.xml file to the classpath somewhere.

Using Spring, we can now very easily set up the SqlMap, using the `SqlMapFactoryBean`:

```xml
<bean id="sqlMap" class="org.springframework.orm.ibatis.SqlMapFactoryBean">
  <property name="configLocation"><value>WEB-INF/sqlmap-config.xml</value></property>
</bean>
```

### 11.4.3. Using `SqlMapDaoSupport`

The `SqlMapDaoSupport` class offers a supporting class similar to the `HibernateDaoSupport` and the `JdbcDaoSupport` types. Let's implement a DAO:

```java
public class SqlMapAccountDao extends SqlMapDaoSupport implements AccountDao {
  public Account getAccount(String email) throws DataAccessException {
    return (Account) getSqlMapTemplate().executeQueryForObject("getAccountByEmail", email);
  }
  
  public void insertAccount(Account account) throws DataAccessException {
    getSqlMapTemplate().executeUpdate("insertAccount", account);
  }
}
```

As you can see, we're using the SqlMapTemplate to execute the query. Spring has initialized the SqlMap for us using the SqlMapFactoryBean and when setting up the SqlMapAccountDao as follows, you're all set to go:

```xml
<!-- for more information about using datasource, have a look at the JDBC chapter -->
<bean id="dataSource" class="org.apache.commons.dbcp.BasicDataSource" destroy-method="close">
  <property name="driverClassName"><value>${jdbc.driverClassName}</value></property>
  <property name="url"><value>${jdbc.url}</value></property>
  <property name="username"><value>${jdbc.username}</value></property>
  <property name="password"><value>${jdbc.password}</value></property>
</bean>

<bean id="accountDao" class="example.SqlMapAccountDao">
  <property name="dataSource"><ref local="dataSource"></ref></property>
  <property name="sqlMap"><ref local="sqlMap"></ref></property>
</bean>
```

### 11.4.4. Transaction management

It's pretty easy to add declarative transaction management to applications using iBATIS. Basically the only thing you need to do is adding a transaction manager to your application context and declaratively set your transaction boundaries using for example the `TransactionProxyFactoryBean`. More on this can be found in Chapter 7, *Transaction management*

TODO elaborate!
Chapter 12. Web framework

12.1. Introduction to the web framework

Spring's web framework is designed around a DispatcherServlet that dispatches requests to handlers, with configurable handler mappings, view resolution, locale and theme resolution as well support for upload files. The default handler is a very simple Controller interface, just offering a ModelAndView handleRequest(request, response) method. This can already be used for application controllers, but you will prefer the included implementation hierarchy, consisting of for example AbstractController, AbstractCommandController and SimpleFormController. Application controllers will typically be subclasses of those. Note that you can choose an appropriate base class: If you don't have a form, you don't need a FormController. This is a major difference to Struts.

You can take any object as command or form object: There's no need to implement an interface or derive from a base class. Spring's data binding is highly flexible, e.g. it treats type mismatches as validation errors that can be evaluated by the application, not as system errors. So you don't need to duplicate your business objects' properties as Strings in your form objects, just to be able to handle invalid submissions, or to convert the Strings properly. Instead, it's often preferable to bind directly to your business objects. This is another major difference to Struts which is built around required base classes like Action and ActionForm - for every type of action.

Compared to WebWork, Spring has more differentiated object roles: It supports the notion of a Controller, an optional command or form object, and a model that gets passed to the view. The model will normally include the command or form object but also arbitrary reference data. Instead, a WebWork Action combines all those roles into one single object. WebWork does allow you to use existing business objects as part of your form, but just by making them bean properties of the respective Action class. Finally, the same Action instance that handles the request gets used for evaluation and form population in the view. Thus, reference data needs to be modelled as bean properties of the Action too. These are arguably too many roles in one object.

Regarding views: Spring's view resolution is extremely flexible. A Controller implementation can even write a view directly to the response, returning null as ModelAndView. In the normal case, a ModelAndView instance consists of a view name and a model Map, containing bean names and corresponding objects (like a command or form, reference data, etc). View name resolution is highly configurable, either via bean names, via a properties file, or via your own ViewResolver implementation. The abstract model Map allows for complete abstraction of the view technology, without any hassle: Be it JSP, Velocity, or anything else - every renderer can be integrated directly. The model Map simply gets transformed into an appropriate format, like JSP request attributes or a Velocity template model.

12.1.1. Pluggability of MVC implementation

Many teams will try to leverage their investments in terms of know-how and tools, both for existing projects and for new ones. Concretely, there are not only a large number of books and tools for Struts but also a lot of developers that have experience with it. Thus, if you can live with Struts's architectural flaws, it can still be a viable choice for the web layer. The same applies to WebWork and other web frameworks.

If you don't want to use Spring's web MVC but intend to leverage other solutions that Spring offers, you can integrate the web framework of your choice with Spring easily. Simply start up a Spring root application context via its ContextLoaderListener, and access it via its ServletContext attribute (or Spring’s respective helper method) from within a Struts or WebWork action. Note that there aren't any "plugins" involved, therefore no dedicated integration: From the view of the web layer, you'll simply use Spring as a library, with
the root application context instance as entry point.

All your registered beans and all of Spring's services can be at your fingertips even without Spring's web MVC. Spring doesn't compete with Struts or WebWork in this usage, it just addresses the many areas that the pure web frameworks don't, from bean configuration to data access and transaction handling. So you are able to enrich your application with a Spring middle tier and/or data access tier, even if you just want to use e.g. the transaction abstraction with JDBC or Hibernate.

12.1.2. Features of Spring MVC

If just focusing on the web support, some of the Spring's unique features are:

- Clear separation of roles: controller vs validator vs command object vs form object vs model object, DispatcherServlet vs handler mapping vs view resolver, etc.
- Powerful and straightforward configuration of both framework and application classes as JavaBeans, including easy in-between referencing via an application context, e.g. from web controllers to business objects and validators.
- Adaptability, non-intrusiveness: Use whatever Controller subclass you need (plain, command, form, wizard, multi action, or a custom one) for a given scenario instead of deriving from Action/ActionForm for everything.
- Reusable business code, no need for duplication: You can use existing business objects as command or form objects instead of mirroring them in special ActionForm subclasses.
- Customizable binding and validation: type mismatches as application-level validation errors that keep the offending value, localized date and number binding, etc instead of String-only form objects with manual parsing and conversion to business objects.
- Customizable handler mapping, customizable view resolution: flexible model transfer via name/value Map, handler mapping and view resolution strategies from simple to sophisticated instead of one single way.
- Customizable locale and theme resolution, support for JSPs with and without Spring tag library, support for JSTL, support for Velocity without the need for extra bridges, etc.
- Simple but powerful tag library that avoids HTML generation at any cost, allowing for maximum flexibility in terms of markup code.

12.2. The DispatcherServlet

Spring's web framework is - like many other web frameworks - a request driven web framework, designed around a servlet that dispatches requests to controllers and offers other functionality facilitating the development of web applications. Spring's DispatcherServlet however, does more than just that. It is completely integrated with the Spring ApplicationContext and allows you to use every other feature Spring has.

Servlets are declared in the web.xml of your webapplication, so is the DispatcherServlet. Requests that you want the DispatcherServlet to handle, will have to be mapped, using a url-mapping in the same web.xml file.

```
<web-app>
  ...
  <servlet>
    <servlet-name>example</servlet-name>
    <servlet-class>org.springframework.web.servlet.DispatcherServlet</servlet-class>
    <load-on-startup>1</load-on-startup>
  </servlet>
  <servlet-mapping>
    <servlet-name>example</servlet-name>
    <url-pattern>*.form</url-pattern>
  </servlet-mapping>
</web-app>
```
In the example above, all requests ending with .form will be handled by the DispatcherServlet. Then, the DispatcherServlet needs to be configured. As illustrated in Section 3.10, “Introduction to the ApplicationContext”, ApplicationContexts in Spring can be scoped. In the web framework, each DispatcherServlet has its own WebApplicationContext, which contains the DispatcherServlet configuration beans. The default BeanFactory used by the DispatcherServlet is the XmlBeanFactory and the DispatcherServlet will on initialization look for a file named [servlet-name]-servlet.xml in the WEB-INF directory of your web application. The default values used by the DispatcherServlet can be modified by using the servlet initialization parameters (see below for more information).

The WebApplicationContext is just an ordinary ApplicationContext that has some extra features necessary for web applications. It differs from a normal ApplicationContext in that it is capable of resolving themes (see Section 12.7, “Using themes”), and that is 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>
<thead>
<tr>
<th>Expression</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>handler mapping(s)</td>
<td>(Section 12.4, “Handler mappings”) a list of pre- and postprocessors and controllers that will be executed if they match certain criteria (for instance a matching URL specified with the controller)</td>
</tr>
<tr>
<td>controller(s)</td>
<td>(Section 12.3, “Controllers”) the beans providing the actual functionality (or at least, access to the functionality) as part of the MVC triad</td>
</tr>
<tr>
<td>view resolver</td>
<td>(Section 12.5, “Views and resolving them”) capable of resolving view names and needed by the DispatcherServlet to resolves those views with</td>
</tr>
<tr>
<td>locale resolver</td>
<td>(Section 12.6, “Using locales”) capable of resolves the locale a client is using, in order to be able to offer internationalized views</td>
</tr>
<tr>
<td>theme resolver</td>
<td>(Section 12.7, “Using themes”) capable of resolving themes your webapplication can use e.g. to offer personalized layouts</td>
</tr>
<tr>
<td>multipart resolver</td>
<td>(Section 12.8, “Spring's multipart (fileupload) support”) offers functionality to process file uploads from HTML forms</td>
</tr>
<tr>
<td>handlerexception resolver</td>
<td>(Section 12.9, “Handling exceptions”) offers functionality to map exceptions to views or implement other more complex exception handling code</td>
</tr>
</tbody>
</table>

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
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.

Exceptions that might be thrown during processing of the request get picked up by any of the handlerexception resolvers that are declared in the `WebApplicationContext`. Using those exception resolvers you can define custom behavior in case such exceptions get thrown.

The Spring `DispatcherServlet` also has support for returning the `last-modification-date`, as specified by the Servlet API. The process of determining the last modification date for a specific request, is simple. The `DispatcherServlet` will first of all lookup an appropriate handler mapping and test if the handler that matched implements the interface `LastModified` and if so, the value 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 12.2. DispatcherServlet initialization parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>contextClass</code></td>
<td>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.</td>
</tr>
<tr>
<td><code>contextConfigLocation</code></td>
<td>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)</td>
</tr>
<tr>
<td><code>namespace</code></td>
<td>The namespace of the <code>WebApplicationContext</code>. Defaults to <code>[server-name]-servlet</code></td>
</tr>
</tbody>
</table>

### 12.3. Controllers

The notion of controller is part of the MVC design pattern. Controllers define application behavior, or at least provide users with access to the application behavior. Controllers interpret user input and transform the user input into a sensible model which will be represented to the user by the view. Spring has implemented the notion of a controller in a very abstract way enabling a wide variety of different kinds of controllers to be created. Spring contains formcontroller, commandcontroller, controllers that execute wizard-style logic and more.
Spring’s basis for the controller architecture is the `org.springframework.mvc.Controller` interface, which is listed below.

```java
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.

### 12.3.1. AbstractController and WebContentGenerator

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

#### Table 12.3. Features offered by the AbstractController

<table>
<thead>
<tr>
<th>Feature</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>supportedMethods</td>
<td>indicates what methods this controller should accept. Usually this is set to both <code>GET</code> and <code>POST</code>, 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 ServletException)</td>
</tr>
<tr>
<td>requiresSession</td>
<td>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 ServletException</td>
</tr>
<tr>
<td>synchronizeSession</td>
<td>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 handleRequestInternal method, which will be synchronized if you specify this variable</td>
</tr>
<tr>
<td>cacheSeconds</td>
<td>when you want a controller to generate caching directive in the HTTP response, specify a positive integer here. By default it is set to -1 so no caching directives will be included</td>
</tr>
<tr>
<td>useExpiresHeader</td>
<td>tweaking of your controllers specifying the HTTP 1.0 compatible &quot;Expires&quot; header. By default it's set to true, so you won't have to touch it</td>
</tr>
<tr>
<td>useCacheHeader</td>
<td>tweaking of your controllers specifying the HTTP 1.1 compatible &quot;Cache-Control&quot; header. By default this is set to true so you won't really have to touch it</td>
</tr>
</tbody>
</table>
When using the AbstractController as a baseclass for your controllers (which is not recommended since there are a lot of other controller that might already do the job for your) you only have to override the `handleRequestInternal(HttpServletRequest, HttpServletResponse)`-method and implement your logic code and return a `ModelAndView` object there. A short example consisting of a class and a declaration in the `webapplicationcontext`.

```java
package samples;

class SampleController extends AbstractController {
    public ModelAndView handleRequestInternal(HttpServletRequest request, HttpServletResponse response)
        throws Exception {
        ModelAndView mav = new ModelAndView("foo", new HashMap());
    }
}

<bean id="sampleController" class="samples.SampleController">
    <property name="cacheSeconds"><value>120</value></property>
</bean>
```

The class above and the declaration in the `webapplicationcontext` is all you need to do besides setting up a handler mapping (see Section 12.4, “Handler mappings”) to get this very simple controller working. This controller will generates caching directives telling the client to cache things for 2 minutes before rechecking. This controller furthermore returns an hard-coded view (hmm, not so nice), named index (see Section 12.5, “Views and resolving them” for more information about views).

### 12.3.2. Other simple controllers

Besides the AbstractController - which you could of course extend, although a more concrete controller might offer you more functionality - there are a couple of other simple controllers that might ease the pain of developing simple MVC applications. The `ParameterizableViewController` basically is the same as the one in the example above, except for the fact that you can specify its view name that it'll be returning in the `webapplicationcontext` (ahhh, no need to hard-code the viewname).

The `FileNameViewController` inspects the URL and retrieves the filename of the file request (the filename of `http://www.springframework.org/index.html` is `index`) and uses that as a viewname. Nothing more to it.

### 12.3.3. The `MultiActionController`

Spring offers a multi-action controller with which you aggregate multiple actions into one controller, grouping functionality together. The multi-action controller lives in a separate package - `org.springframework.web.mvc.multiaction` - and is capable of mapping requests to method names and then invoking the right method name. Using the multi-action controller is especially handy when you're having a lot of commons functionality in one controller, but want to have multiple entry points to the controller to tweak behavior for instance.

**Table 12.4. Features offered by the MultiActionController**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>delegate</td>
<td>there's two usage-scenarios for the MultiActionController. Either you subclass the MultiActionController and specify the methods that will be resolved by the</td>
</tr>
</tbody>
</table>
Feature | Explanation
--- | ---
MethodNameResolver on the subclass (in case you don't need this configuration parameter), or you define a delegate object, on which methods resolved by the Resolver will be invoked. If you choose to enter this scenario, you will have to define the delegate using this configuration parameter as a collaborator.

methodNameResolver | somehow, the MultiActionController will need to resolve the method it has to invoke, based on the request that came in. You can define a resolver that is capable of doing that using this configuration parameter.

Methods defined for a multi-action controller will need to conform to the following signature:

```java
// 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 form 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:

```java
// 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 (e.g., `/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 (e.g., `/testing.view` will result in a method `testing(HttpServletRequest, HttpServletResponse)` being called).
- **PropertiesMethodNameResolver** - uses a user-defined properties object with request URLs mapped to methodnames. When the properties contain `/index/welcome.html=doIt` and a request to `/index/welcome.html` comes in, the `doIt(HttpServletRequest, HttpServletResponse)` method is called. This method name resolver works with the PathMatcher (see Section 12.10.1, “A little story about the pathmatcher”) so if the properties contained `/**/welcome.html` it would also have worked!

A couple of examples. First of all one showing the ParameterMethodNameResolver and the delegate property, which will accept requests to urls with the parameter method included and set to retrieveIndex:

```xml
<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"/></ref>
</bean>

<bean id="sampleDelegate" class="samples.SampleDelegate"/>
```

## together with

```java
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:

```xml
<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>
</bean>
```

### 12.3.4. CommandControllers

Spring's CommandControllers are a fundamental part of the Spring MVC package. Command controllers provide a way to interact with dataobjects and dynamically bind parameters from the HttpServletRequest to the dataobject you're specifying. This compares to Struts's actionforms, where in Spring, you don't have to implement any interface 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 lets you specify in the controller itself what to do with the dataobject that has been filled with the parameters from the request.
- **AbstractFormController** - an abstract controller offering form submission support. Using this controller you can model forms and populate them using a dataobject you're retrieving in the controller. After a user has filled the form, the AbstractFormController binds the fields, validates and hands the object back to you - the controller - to take appropriate action. Supported features are invalid form submission (resubmission), validation, and the right workflow a form always has. What views you tie to your AbstractFormController you decide yourself. Use this controller if you need forms, but don't want to specify what views you're going to show the user in the 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 manipulation of dataobjects, which is extremely handy when large dataobjects come in

### 12.4. Handler mappings

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

12.4.1. **BeanNameUrlHandlerMapping**

A very simple, but very powerful handlermapping is the BeanNameUrlHandlerMapping, which maps incoming HTTP requests to names of beans, defined in the webapplicationcontext. Let’s say we want to enable a user to insert an account and we’ve already provided an appropriate FormController (see Section 12.3.4, “CommandControllers” for more information on Command- and FormControllers) and a JSP view (or Velocity template) that renders the form. When using the BeanNameUrlHandlerMapping, we could map the HTTP request with URL http://samples.com/editaccount.form to the appropriate FormController as follows:

```xml
<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.

```xml
<web-app>...
    <servlet>
        <servlet-name>sample</servlet-name>
        <servlet-class>org.springframework.web.servlet.DispatcherServlet</servlet-class>
        <load-on-startup>1</load-on-startup>
    </servlet>
    <!-- Maps the sample dispatcher to /*.form -->
    <servlet-mapping>
        <servlet-name>sample</servlet-name>
        <url-pattern>*.form</url-pattern>
    </servlet-mapping>
    ...
</web-app>
```

**NOTE:** if you want to use the BeanNameUrlHandlerMapping, you don’t necessarily have to define it in the webapplicationcontext (as indicated above). By default, if no handler mapping can be found in the context, the DispatcherServlet creates a BeanNameUrlHandlerMapping for you!
12.4.2. SimpleUrlHandlerMapping

Another - and much more powerful handler mapping - is the SimpleUrlHandlerMapping. This mapping is configurable in the application context and has Ant-style path matching capabilities (see Section 12.10.1, “A little story about the pathmatcher”). A couple of examples will probably make thing clear enough:

```xml
<web-app>
  ...
  <servlet>
    <servlet-name>sample</servlet-name>
    <servlet-class>org.springframework.web.servlet.DispatcherServlet</servlet-class>
    <load-on-startup>1</load-on-startup>
  </servlet>
  <!-- Maps the sample dispatcher to /*.form -->
  <servlet-mapping>
    <servlet-name>sample</servlet-name>
    <url-pattern>*.form</url-pattern>
  </servlet-mapping>
  <servlet-mapping>
    <servlet-name>sample</servlet-name>
    <url-pattern>*.html</url-pattern>
  </servlet-mapping>
  ...
</web-app>
```

Allows all requests ending with .html and .form to be handled by the sample dispatcherservlet.

```xml
<beans>
  <bean id="handlerMapping" class="org.springframework.web.servlet.handler.SimpleUrlHandlerMapping">
    <property name="mappings">
      <props>
        <prop key="/account.form">editAccountFormController</prop>
        <prop key="/editaccount.form">editAccountFormController</prop>
        <prop key="/ex/view*.html">someViewController</prop>
        <prop key="/**/help.html">helpController</prop>
      </props>
    </property>
  </bean>
  <bean id="someViewController" class="org.springframework.web.servlet.mvc.FilenameViewController"/>
  <bean id="editAccountFormController" class="org.springframework.web.servlet.mvc.SimpleFormController">
    <property name="formView"><value>account</value></property>
    <property name="successView"><value>account-created</value></property>
    <property name="commandName"><value>Account</value></property>
    <property name="commandClass"><value>samples.Account</value></property>
  </bean>
</beans>
```

This handler mapping first of all reroutes all requests in all directories for a file named help.html to the someViewController, which is a FilenameViewController (more about that can be found in Section 12.3, “Controllers”). Also, all requests for a resource beginning with view, ending with .html, in the directory ex, will be rerouted to that specific controller. Furthermore, two mappings have been defined that will match with the editAccountFormController.

12.4.3. Adding HandlerInterceptors

The handler mapping also has a notion of handler interceptors, that can be extremely useful when you want to apply specific functionality to all requests, for example the checking for a principal or something alike.

Interceptor located in the handler mapping must implement HandlerInterceptor from the org.springframework.web.servlet-package. This interface defines three methods, one that will be called
before the actual handler will be executed, one that will be called after the handler is executed, and one that is called after the complete request has finished. Those three methods should provide you with enough flexibility to do all kinds of pre- and post-processing.

The preHandle method has a boolean return value. Using this value, you can tweak the behavior of the execution chain. When returning true, the handler execution chain will continue, when returning false, the DispatcherServlet assumes the interceptor itself has taken care of requests (and for instance rendered an appropriate view) and does not continue with executing the other interceptors and the actual handler in the execution chain.

The following example provides an interceptor that intercepts all requests and reroutes the user to a specific page if the time is not between 9 a.m. and 6 p.m.

```xml
<beans>
  <bean id="handlerMapping"
    class="org.springframework.web.servlet.handler.SimpleUrlHandlerMapping">
    <property name="interceptors">
      <list>
        <ref bean="officeHoursInterceptor"/>
      </list>
    </property>
    <property name="mappings">
      <props>
        <prop key="/.*.form">editAccountFormController</prop>
        <prop key="/.*.view">editAccountFormController</prop>
      </props>
    </property>
  </bean>
  <bean id="officeHoursInterceptor"
    class="samples.TimeBasedAccessInterceptor">
    <property name="openingTime"><value>9</value></property>
    <property name="closingTime"><value>18</value></property>
  </bean>
</beans>

package samples;

public class TimeBasedAccessInterceptor extends HandlerInterceptorAdapter {
  private int openingTime;
  private int closingTime;
  public void setOpeningTime(int openingTime) {
    this.openingTime = openingTime;
  }
  public void setClosingTime(int closingTime) {
    this.closingTime = closingTime;
  }
  public boolean preHandle(
    HttpServletRequest request,
    HttpServletResponse response,
    Object handler)
    throws Exception {
    Calendar cal = Calendar.getInstance();
    int hour = cal.get(HOUR_OF_DAY);
    if (openingTime <= hour < closingTime) {
      return true;
    } else {
      response.sendRedirect("http://host.com/outsideOfficeHours.html");
      return false;
    }
  }
}
```

Any request coming in, will be intercepted by the TimeBasedAccessInterceptor, and if the current time is outside office hours, the user will be redirect to a static html file, saying for instance he can only access the website during office hours.

As you can see, Spring has an adapter to make it easy for you to extend the HandlerInterceptor.
12.5. Views and resolving them

No MVC framework for web applications is without a way to address views. Spring provides view resolvers, which enable you to render models in a browser without tying yourself to a specific view technology. Out-of-the-box, Spring enables you to use Java Server Pages, Velocity templates and XSLT views, for example. Chapter 13, *Integrating view technologies* has details of integrating various view technologies.

The two classes which are important to the way Spring handles views are the *ViewResolver* and the *View*. The *View* interface addresses the preparation of the request and hands the request over to one of the view technologies. The *ViewResolver* provides a mapping between view names and actual views.

### 12.5.1. ViewResolvers

As discussed before, all controllers in the SpringWeb framework, return a *ModelAndView* instance. Views in Spring are addressed by a view name and are resolved by a viewresolver. Spring comes with quite a few view resolvers. We’ll list most of them and then provide a couple of examples.

#### Table 12.5. View resolvers

<table>
<thead>
<tr>
<th>ViewResolver</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AbstractCachingViewResolver</td>
<td>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</td>
</tr>
<tr>
<td>ResourceBundleViewResolver</td>
<td>Implementation of ViewResolver that uses bean definitions in a ResourceBundle, specified by the bundle basename. The bundle is typically defined in a properties file, located in the classpath</td>
</tr>
<tr>
<td>UrlBasedViewResolver</td>
<td>Simple implementation of ViewResolver that allows for direct resolution of symbolic view names to URLs, without an explicit mapping definition. This is appropriate if your symbolic names match the names of your view resources in a straightforward manner, without the need for arbitrary mappings</td>
</tr>
<tr>
<td>InternalResourceViewResolver</td>
<td>Convenience subclass of UrlBasedViewResolver that supports InternalResourceView (i.e. Servlets and JSPs), and subclasses like JstlView and TilesView. The view class for all views generated by this resolver can be specified via setViewClass. See UrlBasedViewResolver's javadocs for details</td>
</tr>
<tr>
<td>VelocityViewResolver</td>
<td>Convenience subclass of UrlBasedViewResolver that supports VelocityView (i.e. Velocity templates) and custom subclasses of it</td>
</tr>
</tbody>
</table>

As an example, when using JSP for a view technology you can use the the UrlBasedViewResolver. This view resolver translates view names to a URL and hands the request over the RequestDispatcher to render the view.

```xml
<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 to render the view.
that'll send the request to /WEB-INF/jsp/test.jsp.

When mixing different view technologies in a web application, you can use the ResourceBundleViewResolver:

```xml
<bean id="viewResolver" class="org.springframework.web.servlet.view.ResourceBundleViewResolver">
  <property name="baseName"><value>views</value></property>
  <property name="defaultParentView"><value>parentView</value></property>
</bean>
```

A note on caching: subclasses of AbstractCachingViewResolver cache view instances they've resolved. This greatly improves performance when using certain view technology. It's possible to turn off the cache, by setting the cache property to false. Furthermore, if you have the requirement to be able to refresh a certain view at runtime (for example when a Velocity template has been modified), you can use the `removeFromCache(String viewName, Locale loc)` method.

### 12.6. Using locales

Most parts of Spring's architecture support internationalization, just as the Spring web framework does. SpringWEB enables you to automatically resolve messages using the client's locale. This is done with LocaleResolver objects.

When a request comes in, the DispatcherServlet looks for a locale resolver and if it finds one it tries to use it and set the locale. Using the `RequestContext.getLocale()` method, you can always retrieve the locale that was resolved by the locale resolver.

Besides the automatic locale resolution, you can also attach an interceptor to the handler mapping (see Section 12.4.3, “Adding HandlerInterceptors” for more info on that), to change the locale under specific circumstances, based on a parameter occurring in the request for example.

Locale resolvers and interceptors are all defined in the `org.springframework.web.servlet.i18n` package, and are configured in your application context in the normal way. Here is a selection of the locale resolvers included in Spring.

#### 12.6.1. AcceptHeaderLocaleResolver

This locale resolver 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.

#### 12.6.2. CookieLocaleResolver

This locale resolver inspects a Cookie that might exist on the client, to see if there's a locale specified. If so, it uses that specific locale. Using the properties of this locale resolver, you can specify the name of the cookie, as well as the maximum age.

```xml
<bean id="localeResolver">
  <property name="cookieName"><value>clientlanguage</value></property>
  <!-- in seconds. If set to -1, the cookie is not persisted (deleted when browser shuts down) -->
  <property name="cookieMaxAge"><value>100000</value></property>
</bean>
```

This is an example of defining a CookieLocaleResolver.

#### Table 12.6. Special beans in the WebApplicationContext
<table>
<thead>
<tr>
<th>Property</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>cookieName</td>
<td>classname + LOCALE</td>
<td>The name of the cookie</td>
</tr>
<tr>
<td>cookieMaxAge</td>
<td>Integer.MAX_INT</td>
<td>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</td>
</tr>
<tr>
<td>cookiePath</td>
<td>/</td>
<td>Using this parameter, you can limit the visibility of the cookie to a certain part of your site. When cookiePath is specified, the cookie will only be visible to that path, and the paths below</td>
</tr>
</tbody>
</table>

### 12.6.3. SessionLocaleResolver

The SessionLocaleResolver allows you to retrieve locales from the session that might be associated to the user’s request.

### 12.6.4. LocaleChangeInterceptor

You can build in changing of locales using the LocaleChangeInterceptor. This interceptor needs to be added to one of the handler mappings (see Section 12.4, “Handler mappings”) and it will detect a parameter in the request and change the locale (it calls setLocale() on the LocaleResolver that also exists in the context).

```xml
<bean id="localeChangeInterceptor" class="org.springframework.web.servlet.i18n.LocaleChangeInterceptor">
    <property name="paramName"><value>siteLanguage</value></property>
</bean>

<bean id="localeResolver" class="org.springframework.web.servlet.i18n.CookieLocaleResolver"/>

<bean id="urlMapping" class="org.springframework.web.servlet.handler.SimpleUrlHandlerMapping">
    <property name="interceptors">
        <list>
            <ref local="localeChangeInterceptor"/>
        </list>
    </property>
    <property name="mappings">
        <props>
            <prop key="/**/*.view">someController</prop>
        </props>
    </property>
</bean>
```

All calls to all *.view resources containing a parameter named siteLanguage will now change the locale. So a call to `http://www.sf.net/home.view?siteLanguage=nl` will change the site language to Dutch.

### 12.7. Using themes

Dummy paragraph

### 12.8. Spring's multipart (fileupload) support

#### 12.8.1. Introduction
Spring has built-in multipart support to handle file uploads in web applications. The design for the multipart support is done with pluggable `MultipartResolver` objects, defined in the `org.springframework.web.multipart` package. Out of the box, Spring provides `MultipartResolver` for use with Commons FileUpload (http://jakarta.apache.org/commons/fileupload) and COS FileUpload (http://www.servlets.com/cos). How uploading files is supported will be described in the rest of this chapter.

By default, no multipart handling will be done by Spring, as some developers will want to handle multiparts themselves. You'll have to enable it yourself by adding a multipart resolver to the web application's context. After you've done that, each request will be inspected for a multipart that it might contain. If no such multipart is found, the request will continue as expected. However, if a multipart is found in the request, the `MultipartResolver` that has been declared in your context will resolve. After that, the multipart attribute in your request will be treated as any other attributes.

### 12.8.2. Using the `MultipartResolver`

The following example shows how to use the `CommonsMultipartResolver`:

```xml
<bean id="multipartResolver"
 class="org.springframework.web.multipart.commons.CommonsMultipartResolver">
 <property name="maximumFileSize">
  <value>100000</value>
 </property>
</bean>
```

This is an example using the `CosMultipartResolver`:

```xml
<bean id="multipartResolver"
 class="org.springframework.web.multipart.cos.CosMultipartResolver">
 <property name="maximumFileSize">
  <value>100000</value>
 </property>
</bean>
```

Of course you need to stick the appropriate jars in your classpath for the multipart resolver to work. In the case of the `CommonsMultipartResolver`, you need to use `commons-fileupload.jar`, while in the case of the `CosMultipartResolver`, use `cos.jar`.

Now that you have seen how to set Spring up to handle multipart requests, let's talk about how to actually use it. When the Spring DispatcherServlet detects a Multipart request, it activates the resolver that has been declared in your context and hands over the request. What it basically does is wrap the current `HttpServletRequest` into a `MultipartHttpServletRequest` that has support for multiparts. Using the `MultipartHttpServletRequest` you can get information about the multiparts contained by this request and actually get the multiparts themselves in your controllers.

### 12.8.3. Handling a file upload in a form

After the `MultipartResolver` has finished doing its job, the request will be processed like any other. To use it, you create a form with an upload field, then let Spring bind the file on your form. Just as with any other property that's not automatically convertible to a String or primitive type, to be able to put binary data in your beans you have to register a custom editor with the `ServletRequestDataBinder`. There are a couple of editors available for handling files and setting the results on a bean. There's a `StringMultipartEditor` capable of converting files to Strings (using a user-defined character set) and there's a `ByteArrayMultipartEditor` which...
converts files to byte arrays. They function just as the `CustomDateEditor` does.

So, to be able to upload files using a form in a website, declare the resolver, a url mapping to a controller that will process the bean, and the controller itself.

```xml
<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

```java
// 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
        // ByteArrayMultipartFileEditor
        binder.registerCustomEditor(byte[].class, new ByteArrayMultipartFileEditor());
        // now Spring knows how to handle multipart object and convert them
    }
}
```

```java
// snippet from FileUploadBean
public class FileUploadBean {
    private byte[] file;

    public void setFile(byte[] file) {
        this.file = file;
    }

    public byte[] getFile() {
```
As you can see, the FileUploadBean has a property typed byte[] that holds the file. The controller registers a custom editor to let Spring know how to actually convert the multipart objects the resolver has found to properties specified by the bean. In these examples, nothing is done with the byte[] property of the bean itself, but in practice you can do whatever you want (save it in a database, mail it to somebody, etcetera).

But we're still not finished. To actually let the user upload something, we have to create a form:

```html
<html>
<head>
<title>Upload a file please</title>
</head>
<body>
<h1>Please upload a file</h1>
<form method="post" action="upload.form" enctype="multipart/form-data">
<input type="file" name="file"/>
<input type="submit"/>
</form>
</body>
</html>
```

As you can see, we've created a field named after the property of the bean that holds the byte[]. Furthermore we've added the encoding attribute which is necessary to let the browser know how to encode the multipart fields (don't forget this!). Right now everything should work.

### 12.9. Handling exceptions

Spring provides `HandlerExceptionResolvers` to ease the pain of unexpected exceptions occurring while your request is being handled by a controller which matched the request. `HandlerExceptionResolvers` somewhat resemble the exception-mappings you can define in the web application descriptor `web.xml`. However, they provide a more flexible way to handle exceptions. About what handler was executing when the exception was thrown. Furthermore, a programmatic way of handling exception gives you many more options for how to respond appropriately before the request is forwarded to another URL (the same end result as when using the servlet specific exception mappings).

Besides implementing the `ExceptionHandlerResolver`, which is only a matter of implementing the `resolveException(Exception, Handler)` method and returning a `ModelAndView`, you may also use the `SimpleMappingExceptionResolver`. This resolver enables you to take the class name of any exception that might be thrown and map it to a view name. This is functionally equivalent to the exception mapping feature from the servlet api, but it's also possible to implement more fine grained mappings of exception from different handlers.

### 12.10. Commonly used utilities

#### 12.10.1. A little story about the pathmatcher

ToDo
Chapter 13. Integrating view technologies

13.1. Introduction

One of the areas in which Spring excels is in the separation of view technologies from the rest of the MVC framework. For example, deciding to use Velocity or XSLT in place of an existing JSP is primarily a matter of configuration. This chapter covers the major view technologies that work with Spring and touches briefly on how to add new ones. This chapter assumes you are already familiar with Section 12.5, “Views and resolving them” which covers the basics of how views in general are coupled to the MVC framework.

13.2. JSP & JSTL

Spring provides a couple of out-of-the-box solutions for JSP and JSTL views. Using JSP or JSTL is done using a normal viewresolver defined in the WebApplicationContext. Furthermore, of course you need to write some JSPs that will actually render the view. This part describes some of the additional features Spring provides to facilitate JSP development.

13.2.1. View resolvers

Just as with any other view technology you're integrating with Spring, for JSPs you'll need a view resolver that will resolve your views. The most commonly used view resolvers when developing with JSPs are the InternalResourceViewResolver and the ResourceBundleViewResolver. Both are declared in the WebApplicationContext:

```xml
<bean id="viewResolver" class="org.springframework.web.servlet.view.ResourceBundleViewResolver">
    <property name="basename"><value>views</value></property>
</bean>

# And a sample properties file is uses (views.properties in WEB-INF/classes):
welcome.class=org.springframework.web.servlet.view.JstlView
welcome.url=/WEB-INF/jsp/welcome.jsp
productList.class=org.springframework.web.servlet.view.JstlView
productList.url=/WEB-INF/jsp/productlist.jsp
```

As you can see, the ResourceBundleViewResolver needs a properties file defining the view names mapped to 1) a class and 2) a URL. With a ResourceBundleViewResolver you can mix different types of views using only one resolver.

```xml
<bean id="viewResolver" class="org.springframework.web.servlet.view.InternalResourceViewResolver">
    <property name="viewClass"><value>org.springframework.web.servlet.view.JstlView</value></property>
    <property name="prefix"><value>/WEB-INF/jsp/</value></property>
    <property name="suffix"><value>.jsp</value></property>
</bean>
```

The InternalResourceBundleViewResolver can be configured for using JSPs as described above. As a best practice, we strongly encourage placing your JSP files in a a directory under the WEB-INF directory, so there can be no direct access by clients.

13.2.2. 'Plain-old' JSPs versus JSTL
When using Java Standard Tag Library you must use a special view class, the JstlView, as JSTL needs some preparation before things such as the i18N features will work.

### 13.2.3. Additional tags facilitating development

Spring provides data binding of request parameters to command objects as described in earlier chapters. To facilitate the development of JSP pages in combination with those data binding features, Spring provides a few tags that make things even easier. All Spring tags have *html escaping* features to enable or disable escaping of characters.

The tag library descriptor (TLD) is included in the spring.jar as well in the distribution itself. More information about the individual tags can be found online: http://www.springframework.org/docs/taglib/index.html.

### 13.3. Tiles

It is possible to integrate Tiles - just as any other view technology - in web applications using Spring. The following describes in a broad way how to do this.

#### 13.3.1. Dependencies

To be able to use Tiles you have to have a couple of additional dependencies included in your project. The following is the list of dependencies you need.

- struts version 1.1
- commons-beanutils
- commons-digester
- commons-logging
- commons-lang

The dependencies are all available in the Spring distribution.

#### 13.3.2. How to integrate Tiles

To be able to use Tiles, you have to configure it using files containing definitions (for basic information on definitions and other Tiles concepts, please have a look at http://jakarta.apache.org/struts). In Spring this is done using the TilesConfigurer. Have a look at the following piece of example ApplicationContext configuration:

```xml
<bean id="tilesConfigurer" class="org.springframework.web.servlet.view.tiles.TilesConfigurer">
    <property name="factoryClass">
        <value>org.apache.struts.tiles.xmlDefinition.I18nFactorySet</value>
    </property>
    <property name="definitions">
        <list>
            <value>/WEB-INF/defs/general.xml</value>
            <value>/WEB-INF/defs/widgets.xml</value>
            <value>/WEB-INF/defs/administrator.xml</value>
            <value>/WEB-INF/defs/customer.xml</value>
            <value>/WEB-INF/defs/templates.xml</value>
        </list>
    </property>
</bean>
```
As you can see, there are five files containing definitions, which are all located in the WEB-INF/defs directory. At initialization of the WebApplicationContext, the files will be loaded and the definitionsfactory defined by the factoryClass-property is initialized. After that has been done, the tiles includes in the definition files can be used as views within your Spring web application. To be able to use the views you have to have a ViewResolver just as with any other view technology used with Spring. Below you can find two possibilities, the InternalResourceViewResolver and the ResourceBundleViewResolver.

### 13.3.2.1. InternalResourceViewResolver

The InternalResourceViewResolver instantiates the given viewClass for each view it has to resolve.

```xml
<bean id="viewResolver" class="org.springframework.web.servlet.view.InternalResourceViewResolver">
    <property name="requestContextAttribute"><value>requestContext</value></property>
    <property name="viewClass">
        <value>org.springframework.web.servlet.view.tiles.TilesView</value>
    </property>
</bean>
```

### 13.3.2.2. ResourceBundleViewResolver

The ResourceBundleViewResolver has to be provided with a property file containing viewnames and viewclasses the resolver can use:

```xml
<bean id="viewResolver" class="org.springframework.web.servlet.view.ResourceBundleViewResolver">
    <property name="basename"><value>views</value></property>
</bean>
```

```xml
... welcomeView.class=org.springframework.web.servlet.view.tiles.TilesView
welcomeView.url=welcome (<b>this is the name of a definition</b>)

vetsView.class=org.springframework.web.servlet.view.tiles.TilesView
vetsView.url=vetsView (<b>again, this is the name of a definition</b>)

findOwnersForm.class=org.springframework.web.servlet.view.JstlView
findOwnersForm.url=/WEB-INF/jsp/findOwners.jsp
...```

As you can see, when using the ResourceBundleViewResolver, you can mix view using different view technologies.

### 13.4. Velocity & FreeMarker

Velocity [http://jakarta.apache.org/velocity] and FreeMarker [http://www.freemarker.org] are two templating languages that can both be used as view technologies within Spring MVC applications. The languages are quite similar and serve similar needs and so are considered together in this section. For semantic and syntactic differences between the two languages, see the FreeMarker [http://www.freemarker.org] web site.

#### 13.4.1. Dependencies

Your web application will need to include velocity-1.x.x.jar or freemarker-2.x.jar in order to work with Velocity or FreeMarker respectively and commons-collections.jar needs also to be available for Velocity. Typically they are included in the WEB-INF/lib folder where they are 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, freemarker and commons collections jars are supplied
with the Spring framework and can be copied from the relevant /lib/ sub-directories. If you make use of Spring’s dateToolAttribute or numberToolAttribute in your Velocity views, you will also need to include the velocity-tools-generic-1.x.jar

13.4.2. Context configuration

A suitable configuration is initialized by adding the relevant configurer bean definition to your *.servlet.xml as shown below:

```xml
<!-- This bean sets up the Velocity environment for us based on a root path for templates. Optionally, a properties file can be specified for more control over the Velocity environment, but the defaults are pretty sane for file based template loading. -->
<bean id="velocityConfig"
    class="org.springframework.web.servlet.view.velocity.VelocityConfigurer">
    <property name="resourceLoaderPath"><value>/WEB-INF/velocity/</value></property>
</bean>

<!-- View resolvers can also be configured with ResourceBundles or XML files. If you need different view resolving based on Locale, you have to use the resource bundle resolver. -->
<bean id="viewResolver"
    class="org.springframework.web.servlet.view.velocity.VelocityViewResolver">
    <property name="cache"><value>true</value></property>
    <property name="prefix"><value></value></property>
    <property name="suffix"><value>.vm</value></property>
</bean>
```

```xml
<!-- freemarker config -->
<bean id="freemarkerConfig"
    class="org.springframework.web.servlet.view.freemarker.FreeMarkerConfigurer">
    <property name="templateLoaderPath"><value>/WEB-INF/freemarker/</value></property>
</bean>

<!-- View resolvers can also be configured with ResourceBundles or XML files. If you need different view resolving based on Locale, you have to use the resource bundle resolver. -->
<bean id="viewResolver"
    class="org.springframework.web.servlet.view.freemarker.FreeMarkerViewResolver">
    <property name="cache"><value>true</value></property>
    <property name="prefix"><value></value></property>
    <property name="suffix"><value>.ftl</value></property>
</bean>
```

NB: For non web-apps add a VelocityConfigurationFactoryBean or a FreeMarkerConfigurationFactoryBean to your application context definition file.

13.4.3. Creating templates

Your templates need to be stored in the directory specified by the *Configurer bean shown above in Section 13.4.2, “Context configuration” This document does not cover details of creating templates for the two languages - please see their relevant websites for information. If you use the view resolvers highlighted, then the logical view names relate to the template file names in similar fashion to InternalResourceViewResolver for JSPs. So if your controller returns a ModelAndView object containing a view name of "welcome" then the resolvers will look for the /WEB-INF/freemarker/welcome.ftl or /WEB-INF/velocity/welcome.vm template as appropriate.
13.4.4. Advanced configuration

The basic configurations highlighted above will be suitable for most application requirements, however additional configuration options are available for when unusual or advanced requirements dictate.

13.4.4.1. velocity.properties

This file is completely optional, but if specified, contains the values that are passed to the Velocity runtime in order to configure velocity itself. Only required for advanced configurations, if you need this file, specify its location on the VelocityConfigurer bean definition above.

```xml
<bean
    id="velocityConfig"
    class="org.springframework.web.servlet.view.velocity.VelocityConfigurer">
    <property name="configLocation">
        <value>/WEB-INF/velocity.properties</value>
    </property>
</bean>
```

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.

```xml
<bean
    id="velocityConfig"
    class="org.springframework.web.servlet.view.velocity.VelocityConfigurer">
    <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>
</bean>
```

Refer to the API documentation [http://www.springframework.org/docs/api/org/springframework/ui/velocity/VelocityEngineFactory.html] for Spring configuration of Velocity, or the Velocity documentation for examples and definitions of the velocity.properties file itself.

13.4.4.2. FreeMarker

FreeMarker 'Settings' and 'SharedVariables' can be passed directly to the FreeMarker Configuration object managed by Spring by setting the appropriate bean properties on the FreeMarkerConfigurer bean. The freemarkerSettings property requires a java.util.Properties object and the freemarkerVariables property requires a java.util.Map.

```xml
<bean
    id="freemarkerConfig"
    class="org.springframework.web.servlet.view.freemarker.FreeMarkerConfigurer">
    <property name="templateLoaderPath"><value>/WEB-INF/freemarker/</value></property>
    <property name="freemarkerVariables">
        <map>
            <entry key="xml_escape"><ref local="fmXmlEscape"/></entry>
        </map>
    </property>
</bean>
```

```xml
<bean id="fmXmlEscape" class="freemarker.template.utility.XmlEscape"/>
```
See the FreeMarker documentation for details of settings and variables as they apply to the Configuration object.

## 13.4.5. Bind support and 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 values from form backing objects and to show the results of failed validations from a `Validator` in the web or business tier. From version 1.1, Spring now has support for the same functionality in both Velocity and FreeMarker, with additional convenience macros for generating form input elements themselves.

### 13.4.5.1. the bind macros

A standard set of macros are maintained within the `spring.jar` file for both languages, so they are always available to a suitably configured application. However they can only be used if your view sets the bean property `exposeSpringMacroHelpers` to `true`. The same property can be set on `VelocityViewResolver` or `FreeMarkerViewResolver` too if you happen to be using it, in which case all of your views will inherit the value from it. Note that this property is **not required** for any aspect of HTML form handling except where you wish to take advantage of the Spring macros. Below is an example of a view.properties file showing correct configuration of such a view for either language:

```properties
personFormV.class=org.springframework.web.servlet.view.velocity.VelocityView
personFormV.url=personForm.vm
personFormV.exposeSpringMacroHelpers=true

personFormF.class=org.springframework.web.servlet.view.freemarker.FreeMarkerView
personFormF.url=personForm.ftl
personFormF.exposeSpringMacroHelpers=true
```

Some of the macros defined in the Spring libraries are considered internal (private) but no such scoping exists in the macro definitions making all macros visible to calling code and user templates. The following sections concentrate only on the macros you need to be directly calling from within your templates. If you wish to view the macro code directly, the files are called `spring.vm` / `spring.ftl` and are in the packages `org.springframework.web.servlet.view.velocity` or `org.springframework.web.servlet.view.freemarker` respectively.

### 13.4.5.2. simple binding

In your html forms (vm / ftl templates) that act as the 'formView' for a Spring form controller, you can use code similar to the following to bind to field values and display error messages for each input field in similar fashion to the JSP equivalent. Note that the name of the command object is "command" by default, but can be overridden in your MVC configuration by setting the 'commandName' bean property on your form controller. Example code is shown below for the `personFormV` and `personFormF` views configured earlier:

```html
<!-- velocity macros are automatically available -->
<html>
...<form action="" method="POST">
Name: #springBind( "command.name" )
<input type="text"
    name="${status.expression}" value="$!status.value" /><br>
#foreach($error in $status.errorMessages) <b>$error</b> <br> #end
<br>
...<input type="submit" value="submit"/>
```
#springBind / @spring.bind> requires a 'path' argument which consists of the name of your command object (it will be 'command' unless you changed it in your FormController properties) followed by a period and the name of the field on the command object you wish to bind to. Nested fields can be used too such as "command.address.street". The bind macro assumes the default HTML escaping behavior specified by the ServletContext parameter defaultHtmlEscape in web.xml.

The optional form of the macro called #springBindEscaped / @spring.bindEscaped> takes a second argument and explicitly specifies whether HTML escaping should be used in the status error messages or values. Set to true or false as required. Additional form handling macros simplify the use of HTML escaping and these macros should be used wherever possible. They are explained in the next section.

### 13.4.5.3. form input generation macros

Additional convenience macros for both languages simplify both binding and form generation (including validation error display). It is never necessary to use these macros to generate form input fields, and they can be mixed and matched with simple HTML or calls direct to the spring bind macros highlighted previously.

The following table of available macros show the VTL and FTL definitions and the parameter list that each takes.

<table>
<thead>
<tr>
<th>macro</th>
<th>VTL definition</th>
<th>FTL definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>formInput (standard input field for gathering user input)</td>
<td>#springFormInput($path $attributes)</td>
<td>&lt;@spring.formInput path, attributes/&gt;</td>
</tr>
<tr>
<td>formTextarea (large text field for gathering long, freeform text input)</td>
<td>#springFormTextarea($path $attributes)</td>
<td>&lt;@spring.formTextarea path, attributes/&gt;</td>
</tr>
<tr>
<td>formSingleSelect (drop down box of options allowing a single required value to be selected)</td>
<td>#springFormSingleSelect($path $options $attributes)</td>
<td>&lt;@spring.formSingleSelect path, options, attributes/&gt;</td>
</tr>
<tr>
<td>formMultiSelect (a list box of options allowing the user to select 0 or more values)</td>
<td>#springFormMultiSelect($path $options $attributes)</td>
<td>&lt;@spring.formMultiSelect path, options, attributes/&gt;</td>
</tr>
</tbody>
</table>
The parameters to any of the above macros have consistent meanings:

- **path**: the name of the field to bind to (ie "command.name")

- **options**: a Map of all the available values that can be selected from in the input field. The keys to the map represent the values that will be POSTed back from the form and bound to the command object. Map objects stored against the keys are the labels displayed on the form to the user and may be different from the corresponding values posted back by the form. Usually such a map is supplied as reference data by the controller. Any Map implementation can be used depending on required behavior. For strictly sorted maps, a **SortedMap** such as a **TreeMap** with a suitable Comparator may be used and for arbitrary Maps that should return values in insertion order, use a **LinkedHashMap** or a **LinkedMap** from commons-collections.

- **separator**: where multiple options are available as discreet elements (radio buttons or checkboxes), the sequence of characters used to separate each one in the list (ie "<br>").

- **attributes**: an additional string of arbitrary tags or text to be included within the HTML tag itself. This string is echoed literally by the macro. For example, in a text area field you may supply attributes as 'rows="5" cols="60"' or you could pass style information such as 'style="border:1px solid silver"'.

- **classOrStyle**: for the showErrors macro, the name of the CSS class that the span tag wrapping each error will use. If no information is supplied (or the value is empty) then the errors will be wrapped in <b></b> tags.

Examples of the macros are outlined below some in FTL and some in VTL. Where usage differences exist between the two languages, they are explained in the notes.

### 13.4.5.3.1. Input Fields

```vtemplate
<!-- the Name field example from above using form macros in VTL -->
...
Name:
#springFormInput("command.name" "")<br>
#springShowErrors("<br>" "")<br>
```

The formInput macro takes the path parameter (command.name) and an additional attributes parameter which is empty in the example above. The macro, along with all other form generation macros, performs an implicit spring bind on the path parameter. The binding remains valid until a new bind occurs so the showErrors macro doesn't need to pass the path parameter again - it simply operates on whichever field a bind was last created for.
The `showErrors` macro takes a separator parameter (the characters that will be used to separate multiple errors on a given field) and also accepts a second parameter, this time a class name or style attribute. Note that FreeMarker is able to specify default values for the attributes parameter, unlike Velocity, and the two macro calls above could be expressed as follows in FTL:

```ftl
<@spring.formInput "command.name"/>
<@spring.showErrors "<br/>
```

Output is shown below of the form fragment generating the name field, and displaying a validation error after the form was submitted with no value in the field. Validation occurs through Spring’s Validation framework.

The generated HTML looks like this:

```html
Name:
<input type="text" name="name" value="">
<br>
<b>required</b>
<br>
<br>
```

The `formTextarea` macro works the same way as the `formInput` macro and accepts the same parameter list. Commonly, the second parameter (attributes) will be used to pass style information or rows and cols attributes for the textarea.

### 13.4.5.3.2. Selection Fields

Four selection field macros can be used to generate common UI value selection inputs in your HTML forms.

- `formSingleSelect`
- `formMultiSelect`
- `formRadioButtons`
- `formCheckboxes`

Each of the four macros accepts a Map of options containing the value for the form field, and the label corresponding to that value. The value and the label can be the same.

An example of radio buttons in FTL is below. The form backing object specifies a default value of 'London' for this field and so no validation is necessary. When the form is rendered, the entire list of cities to choose from is supplied as reference data in the model under the name 'cityMap'.

```ftl
...:
<Town:
<@spring.formRadioButtons "command.address.town", cityMap, "" /><br><br>
```

This renders a line of radio buttons, one for each value in `cityMap` using the separator ".". No additional attributes are supplied (the last parameter to the macro is missing). The `cityMap` uses the same String for each key-value pair in the map. The map's keys are what the form actually submits as POSTed request parameters, map values are the labels that the user sees. In the example above, given a list of three well known cities and a default value in the form backing object, the HTML would be

```html
Town:
<input type="radio" name="address.town" value="London"
```
If your application expects to handle cities by internal codes for example, the map of codes would be created with suitable keys like the example below.

```java
protected Map referenceData(HttpServletRequest request) throws Exception {
    Map cityMap = new LinkedHashMap();
    cityMap.put("LDN", "London");
    cityMap.put("PRS", "Paris");
    cityMap.put("NYC", "New York");

    Map m = new HashMap();
    m.put("cityMap", cityMap);
    return m;
}
```

The code would now produce output where the radio values are the relevant codes but the user still sees the more user friendly city names.

```html
Town:
<input type="radio" name="address.town" value="LDN">
London
<input type="radio" name="address.town" value="PRS" checked="checked">
Paris
<input type="radio" name="address.town" value="NYC">
New York
```

13.4.5.4. overriding HTML escaping and making tags XHTML compliant

Default usage of the form macros above will result in HTML tags that are HTML 4.01 compliant and that use the default value for HTML escaping defined in your web.xml as used by Spring's bind support. In order to make the tags XHTML compliant or to override the default HTML escaping value, you can specify two variables in your template (or in your model where they will be visible to your templates). The advantage of specifying them in the templates is that they can be changed to different values later in the template processing to provide different behavior for different fields in your form.

To switch to XHTML compliance for your tags, specify a value of 'true' for a model/context variable named xhtmlCompliant:

```
## for Velocity..
#set($springXhtmlCompliant = true)

<#-- for FreeMarker -->
<#assign xhtmlCompliant = true in spring>
```

Any tags generated by the Spring macros will now be XHTML compliant after processing this directive.

In similar fashion, HTML escaping can be specified per field:
13.5. XSLT

XSLT is a transformation language for XML and is popular as a view technology within web applications. XSLT can be a good choice as a view technology if your application naturally deals with XML, or if your model can easily be converted to XML. The following section shows how to produce an XML document as model data and have it transformed with XSLT in a Spring application.

13.5.1. My First Words

This example is a trivial Spring application that creates a list of words in the Controller and adds them to the model map. The map is returned along with the view name of our XSLT view. See Section 12.3, “Controllers” for details of Spring Controllers. The XSLT view will turn the list of words into a simple XML document ready for transformation.

13.5.1.1. 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.

```xml
<bean id="homeController" class="xslt.HomeController"/>
```

..that implements our word generation 'logic'.

13.5.1.2. Standard MVC controller code

The controller logic is encapsulated in a subclass of AbstractController, with the handler method being defined like so.

```java
protected ModelAndView handleRequestInternal(
    HttpServletRequest req,
    HttpServletResponse resp) throws Exception {
    Map map = new HashMap();
    List wordList = new ArrayList();

    wordList.add("hello");
    wordList.add("world");

    map.put("wordList", wordList);
    return new ModelAndView("home", map);
}
```

So far we've done nothing that's XSLT specific. The model data has been created in the same way as you would for any other Spring MVC application. Depending on the configuration of the application now, that list of words could be rendered by JSP/JSTL by having them added as request attributes, or they could be handled by Velocity by adding the object to the VelocityContext. In order to have XSLT render them, they of course have...
to be converted into an XML document somehow. There are software packages available that will automatically ‘domify’ an object graph, but within Spring, you have complete flexibility to create the DOM from your model in any way you choose. This prevents the transformation of XML playing too great a part in the structure of your model data which is a danger when using tools to manage the domification process.

13.5.1.3. 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.

```java
package xslt;

// imports omitted for brevity

public class HomePage extends AbstractXsltView {
    protected Node createDomNode(
            Map model, String rootName, HttpServletRequest req, HttpServletResponse res
    ) throws Exception {
        Element root = new Element(rootName);
        doc.setRootElement(root);

        List words = (List) model.get("wordList");
        for (Iterator it = words.iterator(); it.hasNext();)
        {
            String nextWord = (String) it.next();
            Element e = new Element("word");
            e.setText(nextWord);
            root.addContent(e);
        }

        // convert JDOM doc to a W3C Node and return
        return new DOMOutputter().output( doc );
    }
}
```

13.5.1.3.1. Adding stylesheet parameters

A series of parameter name/value pairs can optionally be defined by your subclass which will be added to the transformation object. The parameter names must match those defined in your XSLT template declared with 

```xml
<xsl:param name="myParam">defaultValue</xsl:param>
```

To specify the parameters, override the method getParameters() from AbstractXsltView and return a map of the name/value pairs. If your parameters need to derive information from the current request, you can (from version 1.1) override the getParameters(HttpServletRequest request) method instead.

13.5.1.3.2. Formatting dates and currency

Unlike JSTL and Velocity, XSLT has relatively poor support for locale based currency and date formatting. In recognition of the fact, Spring provides a helper class that you can use from within your createDomNode() methods to get such support. See the javadocs for org.springframework.web.servlet.view.xslt.FormatHelper

13.5.1.4. Defining the view properties
The views.properties file (or equivalent xml definition if you're using an XML based view resolver as we did in the Velocity examples above) looks like this for the one-view application that is 'My First Words'.

| home.class=xslt.HomePage |
| home.stylesheetLocation=/WEB-INF/xsl/home.xslt |
| home.root=words |

Here, you can see how the view is tied in with the HomePage class just written which handles the model domification in the first property `.class`. The stylesheetLocation property obviously points to the XSLT file which will handle the XML transformation into HTML for us and the final property `.root` is the name that will be used as the root of the XML document. This gets passed to the HomePage class above in the second parameter to the createDomNode method.

### 13.5.1.5. 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
<?xml version="1.0"?>
<xsl:stylesheet version="1.0" xmlns:xsl="http://www.w3.org/1999/XSL/Transform">
  <xsl:output method="text/html" omit-xml-declaration="yes"/>
  <xsl:template match="/">
    <html>
      <head><title>Hello!</title></head>
      <body>
        <h1>My First Words</h1>
        <xsl:for-each select="wordList/word">
          <xsl:value-of select="."/><br />
        </xsl:for-each>
      </body>
    </html>
  </xsl:template>
</xsl:stylesheet>
```

### 13.5.2. 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
```

Integrating view technologies

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You will also need to ensure that an XML parser and an XSLT engine are available on the classpath. JDK 1.4 provides them by default, and most J2EE containers will also make them available by default, but it's a possible source of errors to be aware of.

13.6. Document views (PDF/Excel)

13.6.1. Introduction

Returning an HTML page isn't always the best way for the user to view the model output, and Spring makes it simple to generate a PDF document or an Excel spreadsheet dynamically from the model data. The document is the view and will be streamed from the server with the correct content type to (hopefully) enable the client PC to run their spreadsheet or PDF viewer application in response.

In order to use Excel views, you need to add the 'poi' library to your classpath, and for PDF generation, the iText.jar. Both are included in the main Spring distribution.

13.6.2. Configuration and setup

Document based views are handled in an almost identical fashion to XSLT views, and the following sections build upon the previous one by demonstrating how the same controller used in the XSLT example is invoked to render the same model as both a PDF document and an Excel spreadsheet (which can also be viewed or manipulated in Open Office).

13.6.2.1. 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..

```text
home.class=xslt HomePage
home.stylesheetLocation=/WEB-INF/xsl/home.xslt
home.root=words
xl.class=excel HomePage
pdf.class=pdf HomePage
```

If you want to start with a template spreadsheet to add your model data to, specify the location as the 'url' property in the view definition.

13.6.2.2. Controller code

The controller code we'll use remains exactly the same from the XSLT example earlier other than to change the name of the view to use. Of course, you could be clever and have this selected based on a URL parameter or some other logic - proof that Spring really is very good at decoupling the views from the controllers!

13.6.2.3. Subclassing for Excel views

Exactly as we did for the XSLT example, we'll subclass suitable abstract classes in order to implement custom behavior 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.

```java
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 `xl` as the name of the view (`return new ModelAndView("xl", map);`) and run your application again, you should find that the Excel spreadsheet is created and downloaded automagically when you request the same page as before.

### 13.6.2.4. 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..

```java
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 `return new ModelAndView("pdf", map);` and reload the URL in your application. This time a PDF document should appear listing each of the words in the model map.

### 13.7. Tapestry

Tapestry is a powerful, component-oriented web application framework from Apache's Jakarta project (http://jakarta.apache.org/tapestry). While Spring has its own powerful web UI layer, there are a number of unique advantages to building a J2EE application using a combination of Tapestry for the web UI, and the Spring container for the lower layers. This document attempts to detail a few best practices for combining these two frameworks. It is expected that you are relatively familiar with both Tapestry and Spring Framework basics, so they will not be explained here. General introductory documentation for both Tapestry and Spring Framework are available on their respective web sites.

#### 13.7.1. Architecture

A typical layered J2EE application built with Tapestry and Spring will consist of a top UI layer built with Tapestry, and a number of lower layers, hosted out of one or more Spring Application Contexts.

- **User Interface Layer:**
  - concerned with the user interface
  - contains some application logic
  - provided by Tapestry

  - aside from providing UI via Tapestry, code in this layer does its work via objects which implement interfaces from the Service Layer. The actual objects which implement these service layer interfaces are obtained from a Spring Application Context.

- **Service Layer:**
  - application specific 'service' code

  - works with domain objects, and uses the Mapper API to get those domain objects into and out of some sort of repository (database)

  - hosted in one or more Spring contexts

  - code in this layer manipulates objects in the domain model, in an application specific fashion. It does its work via other code in this layer, and via the Mapper API. An object in this layer is given the specific mapper implementations it needs to work with, via the Spring context.

  - since code in this layer is hosted in the Spring context, it may be transactionally wrapped by the Spring context, as opposed to managing its own transactions

- **Domain Model:**
  - domain specific object hierarchy, which deals with data and logic specific to this domain

  - although the domain object hierarchy is built with the idea that it is persisted somehow and makes some general concessions to this (for example, bidirectional relationships), it generally has no knowledge of other
layers. As such, it may be tested in isolation, and used with different mapping implementations for production vs. testing.

- these objects may be standalone, or used in conjunction with a Spring application context to take advantage of some of the benefits of the context, e.g., isolation, inversion of control, different strategy implementations, etc.

• **Data Source Layer:**

  - Mapper API (also called Data Access Objects): an API used to persist the domain model to a repository of some sort (generally a DB, but could be the filesystem, memory, etc.)

  - Mapper API implementations: one or more specific implementations of the Mapper API, for example, a Hibernate-specific mapper, a JDO-specific mapper, JDBC-specific mapper, or a memory mapper.

  - mapper implementations live in one or more Spring Application Contexts. A service layer object is given the mapper objects it needs to work with via the context.

• **Database, filesystem, or other repositories:**

  - objects in the domain model are stored into one or more repositories via one or more mapper implementations

  - a repository may be very simple (e.g. filesystem), or may have its own representation of the data from the domain model (i.e. a schema in a db). It does not know about other layers however.

### 13.7.2. Implementation

The only real question (which needs to be addressed by this document), is how Tapestry pages get access to service implementations, which are simply beans defined in an instance of the Spring Application Context.

#### 13.7.2.1. Sample application context

Assume we have the following simple Application Context definition, in xml form:

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

<!-- ========================= GENERAL DEFINITIONS ========================= -->

<!-- ========================= PERSISTENCE DEFINITIONS ========================= -->

<!-- the DataSource -->
<bean id="dataSource" class="org.springframework.jndi.JndiObjectFactoryBean">
  <property name="jndiName"><value>java:DefaultDS</value></property>
  <property name="resourceRef"><value>false</value></property>
</bean>

<!-- define a Hibernate Session factory via a Spring LocalSessionFactoryBean -->
<bean id="hibSessionFactory" class="org.springframework.orm.hibernate.LocalSessionFactoryBean">
  <property name="dataSource"><ref bean="dataSource"/></property>
</bean>

<!-- - Defines a transaction manager for usage in business or data access objects. -->
<!-- - No special treatment by the context, just a bean instance available as reference -->
<!-- - for business objects that want to handle transactions, e.g. via TransactionTemplate. -->
```

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Inside the Tapestry application, we need to load this application context, and allow Tapestry pages to get the authenticationService and userService beans, which implement the AuthenticationService and UserService interfaces, respectively.

### 13.7.2.2. Obtaining beans in Tapestry pages

At this point, the application context is available to a web application by calling Spring's static utility function `WebApplicationContextUtils.getApplicationContext(servletContext)`, where `servletContext` is the standard `ServletContext` from the J2EE Servlet specification. As such, one simple mechanism for a page to get an instance of the UserService, for example, would be with code such as:

```java
WebApplicationContext appContext = WebApplicationContextUtils.getApplicationContext(
    getRequestCycle().getRequestContext().getServlet().getServletContext());
UserService userService = (UserService) appContext.getBean("userService");
...
```

This mechanism does work. It can be made a lot less verbose by encapsulating most of the functionality in a method in the base class for the page or component. However, in some respects it goes against the Inversion of Control approach which Spring encourages, which is being used in other layers of this app, in that ideally you would like the page to not have to ask the context for a specific bean by name, and in fact, the page would ideally not know about the context at all.
Luckily, there is a mechanism to allow this. We rely upon the fact that Tapestry already has a mechanism to declaratively add properties to a page, and it is in fact the preferred approach to manage all properties on a page in this declarative fashion, so that Tapestry can properly manage their lifecycle as part of the page and component lifecycle.

13.7.2.3. Exposing the application context to Tapestry

First we need to make the ApplicationContext available to the Tapestry page or Component without having to have the ServletContext; this is because at the stage in the page's/component's lifecycle when we need to access the ApplicationContext the ServletContext won't be easily available to the page, so we can't use WebApplicationContextUtils.getApplicationContext(servletContext) directly. One way is by defining a custom version of the Tapestry IEngine which exposes this for us:

```java
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:

```xml
file: xportal.application:

<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE application PUBLIC
 "-//Apache Software Foundation//Tapestry Specification 3.0//EN"
 "http://jakarta.apache.org/tapestry/dtd/Tapestry_3_0.dtd">
<application
    name="Whatever xPortal"
    engine-class="com.whatever.web.xportal.MyEngine">
</application>
```

13.7.2.4. 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:

```xml
<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">
```

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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
<?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>
```

13.7.2.5. 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:

```java
// 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:

```java
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 {
```
public static final String USER_KEY = "user";

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).
 */
13.7.3. Summary

In this example, we’ve managed to allow service beans defined in the Spring ApplicationContext to be provided to the page in a declarative fashion. The page class does not know where the service implementations are coming from, and in fact it is easy to slip in another implementation, for example, during testing. This inversion of control is one of the prime goals and benefits of the Spring Framework, and we have managed to extend it all the way up the J2EE stack in this Tapestry application.

13.8. JasperReports

JasperReports (http://jasperreports.sourceforge.net) is a powerful, open-source reporting engine that supports the creation of report designs using an easily understood XML file formats. JasperReports is capable of rendering reports output into four different formats: CSV, Excel, HTML and PDF.

13.8.1. Dependencies

Your application will need to include the latest release of JasperReports, which at the time of writing was 0.6.1. JasperReports itself depends on the following projects:
BeanShell
Commons BeanUtils
Commons Collections
Commons Digester
Commons Logging
iText
POI

JasperReports also requires a JAXP compliant XML parser.

13.8.2. Configuration

To configure JasperReports views in your ApplicationContext you have to define a ViewResolver to map view names to the appropriate view class depending on which format you want your report rendered in.

13.8.2.1. Configuring the ViewResolver

Typically, you will use the ResourceBundleViewResolver to map view names to view classes and files in a properties file

```xml
<bean id="viewResolver" class="org.springframework.web.servlet.view.ResourceBundleViewResolver">
    <property name="basename">
        <value>views</value>
    </property>
</bean>
```

Here we've configured an instance of ResourceBundleViewResolver which will look for view mappings in the resource bundle with base name `views`. The exact contents of this file is described in the next section.

13.8.2.2. Configuring the Views

Spring contains four different View implementations for JasperReports each of which corresponds to one of the four output formats supported by JasperReports:

Table 13.2. JasperReports View Classes

<table>
<thead>
<tr>
<th>Class Name</th>
<th>Render Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>JasperReportsCsvView</td>
<td>CSV</td>
</tr>
<tr>
<td>JasperReportsHtmlView</td>
<td>HTML</td>
</tr>
<tr>
<td>JasperReportsPdfView</td>
<td>PDF</td>
</tr>
<tr>
<td>JasperReportsXlsView</td>
<td>Microsoft Excel</td>
</tr>
</tbody>
</table>

Mapping one of these classes to a view name and a report file is simply a matter of adding the appropriate entries into the resource bundle configured in the previous section as shown here:
Here you can see that the view with name, `simpleReport`, is mapped to the `JasperReportsPdfView` class. This will cause the output of this report to be rendered in PDF format. The `url` property of the view is set to the location of the underlying report file.

### 13.8.2.3. About Report Files

JasperReports has two distinct types of report file: the design file, which has a `.jrxml` extension, and the compiled report file, which has a `.jasper` extension. Typically, you use the JasperReports Ant task to compile your `.jrxml` design file into a `.jasper` file before deploying it into your application. With Spring you can map either of these files to your report file and Spring will take care of compiling the `.jrxml` file on the fly for you. You should note that after a `.jrxml` file is compiled by Spring, the compiled report is cached for the life of the application. To make changes to the file you will need to restart your application.

### 13.8.3. Populating the `ModelAndView`

In order to render your report correctly in the format you have chosen, you must supply Spring with all of the data needed to populate your report. For JasperReports this means you must pass in all report parameters along with the report datasource. Report parameters are simple name/value pairs and can be added be to the `Map` for your model as you would add any name/value pair.

When adding the datasource to the model you have two approaches to choose from. The first approach is to add an instance of `JRDataSource` or `Collection` to the model `Map` under any arbitrary key. Spring will then locate this object in the model and treat it as the report datasource. For example, you may populate your model like this:

```java
private Map getModel() {
    Map model = new HashMap();
    Collection beanData = getBeanData();
    model.put("myBeanData", beanData);
    return model;
}
```

The second approach is to add the instance of `JRDataSource` or `Collection` under a specific key and then configure this key using the `reportDataKey` property of the view class. In both cases Spring will instances of `Collection` in a `JRBeanCollectionDataSource` instance. For example:

```java
private Map getModel() {
    Map model = new HashMap();
    Collection beanData = getBeanData();
    Collection someData = getSomeData();
    model.put("myBeanData", beanData);
    model.put("someData", someData);
    return model;
}
```

Here you can see that two `Collection` instances are being added to the model. To ensure that the correct one is used, we simply modify our view configuration as appropriate:
Be aware that when using the first approach, Spring will use the first instance of `JRDataSource` or `Collection` that it encounters. If you need to place multiple instances of `JRDataSource` or `Collection` into the model then you need to use the second approach.
Chapter 14. JMS

14.1. Introduction

Spring fournit un framework qui permet de s'abstraire de JMS et simplifie l'utilisation de cette API. Il permet également de masquer à l'utilisateur les différences entre les APIs JMS en version 1.0.2 et 1.1.

Spring peut être divisé en deux types de fonctionnalités, production et consommation de messages. En J2EE, la possibilité de consommer des messages de manière asynchrone est réalisée grâce aux EJBs "Message-Driven" (MDB) alors que, dans une application autonome, cette fonctionnalité est permise par la création de MessageListeners ou de ConnectionConsumers.

Le package org.springframework.jms.core fournit les fonctionnalités de base pour utiliser JMS. Il comprend la classe template JMS qui simplifie l'utilisation de JMS en se chargeant de la création et de la libération des ressources de la même manière que la classe JdbcTemplate le réalise pour JDBC. Le point commun dans la conception des classes de template de Spring est de fournir des méthodes facilitant l'exécution des opérations communes...

Le package org.springframework.jms.support fournit la fonctionnalité de translation des exceptions JMSException. Celui-ci convertit la hiérarchie des exceptions checkées dans une hiérarchie correspondante d'exceptions non checkées. Si un fournisseur a des sous exceptions spécifiques de la classe javax.jms.JMSException, celles-ci seront encapsulées dans l'exception non checkée UncategorizedJmsException. Le package org.springframework.jms.support.converter fournit une abstraction MessageConverter pour convertir des objets java en messages JMS. Le package org.springframework.jms.support.destination fournit différentes stratégies pour gérer les destinations JMS en fournissant, par exemple, un service de localisation des destinations stockées dans JNDI.

Pour finir, le package org.springframework.jms.connection fournit une implémentation de l'interface ConnectionFactory utilisable dans les applications autonomes. Il contient également une implémentation de l'interface de Spring, PlatformTransactionManager, pour JMS. Cela permet l'intégration de JMS en tant que ressource transactionnelle dans les mécanismes de gestions des transactions de Spring.

14.2. Unification des domaines

La spécification JMS a deux versions majeures: 1.0.2 et 1.1. La version 1.0.2 définit deux domaines de messages, point à point (queue) et publication/souscription (sujet). L'API en version 1.0.2 reflète ces deux aspects de messages en fournissant des classes similaires pour chaque domaine. De ce fait, une application cliente est spécifique à un domaine lors de l'utilisation de l'API JMS. JMS en version 1.1 introduit une unification des domaines qui minimise aussi bien les différences fonctionnelles que les différences au niveau de l'API cliente JMS entre les deux domaines. Pour illustrer ceci, si vous utilisez un fournisseur supportant la version 1.1 de JMS, vous pouvez dans une même transaction récupérer un message d'un domaine et en produire un autre dans un autre domaine tout en utilisant la même Session.

La version 1.1 de la spécification JMS a été publiée en avril 2002 et ajoutée à J2EE en novembre 2003. De ce fait, beaucoup de serveurs d'application communément utilisés ne supportent que la version 1.0.2 de JMS.

14.3. JmsTemplate

Deux implémentations de JmsTemplate sont fournies. La classe JmsTemplate utilise l'API JMS version 1.1 et la
sous classe JmsTemplate102 l'utilise en version 1.0.2.

Le code utilisant JmsTemplate doit seulement implémenter des interfaces de rappel qui ont des contrats clairement définis. L'interface MessageCreator crée un message à partir d'une Session fourni par le code appelant de JmsTemplate. Afin de permettre une utilisation plus complexe de l'API JMS, l'interface SessionCallback fournit à l'utilisateur une Session JMS et l'interface ProducerCallback, une Session et un MessageProducer.

L'API JMS fournit deux types de méthodes d'envoi, une qui prend des paramètres de qualité de service tels que le mode de livraison la priorité et la durée de vie (QOS) et une qui n'en prend aucun et se base sur les valeurs par défaut. Puisque la classe JmsTemplate fournit plusieurs méthodes d'envoi, la configuration des paramètres de qualité de service a été permise par le biais des propriétés de beans pour éviter les duplications. De la même manière, la valeur de délai d'expiration (timeout) pour les appels synchrones est positionné avec la propriété setReceiveTimeout.

Certains fournisseurs JMS permettent la configuration des valeurs par défaut de la qualité de service administrativement via la configuration de la ConnectionFactory. Cela implique que l'appel de la méthode send(Destination destination, Message message) de la classe MessageProducer utilisera des valeurs par défaut différentes de celles de la spécification JMS. De plus, pour garantir une gestion conforme des valeurs de qualité de service, la classe JmsTemplate doit être spécifiquement activé pour pouvoirs utiliser ses propres valeurs en spécifiant à vrai (true) la valeur de la propriété isExplicitQosEnabled.

14.3.1. ConnectionFactory

L'utilisation de JmsTemplate nécessite une référence à une ConnectionFactory. L'interface ConnectionFactory fait partie intégrante de la spécification JMS. Elle est utilisée par l'application client comme une fabrique pour créer des connexions avec le fournisseur JMS et encapsuler les différents paramètres de configuration, dont beaucoup sont spécifiques à celui-ci comme ceux de la configuration de SSL.

Pour utiliser JMS dans un EJB, le vendeur fournit des implémentations pour les interfaces JMS et, de ce fait, celles-ci peuvent participer dans une gestion transactionnelle déclarative et réaliser un pooling de connexions et de sessions. Pour utiliser cette implémentation, les conteneurs J2EE imposent typiquement la déclaration de la fabrique de connexion JMS en tant que resource-ref dans les descripteurs de déploiement des EJBs et servlets. Pour utiliser cette fonctionnalité avec JmsTemplate dans un EJB, l'application client devrait vérifier qu'il référence bien une implémentation managée de la ConnectionFactory.

Spring fournit une implémentation de l'interface ConnectionFactory, SingleConnectionFactory, qui retourne toujours la même connexion sur tous les appels à createConnection et ignore ceux sur close.. Cela est très utile pour tester et également dans les environnements autonomes, puisque cette même connexion peut être partagée par différents appels à JmsTemplate.

14.3.2. Gestion des transactions

Spring fournit une classe JmsTransactionManager qui gère les transactions pour une unique ConnectionFactory JMS. Cela permet aux applications JMS d'utiliser les possibilités de Spring en matière de gestion des transactions comme décrit dans le chapitre 7. La classe JmsTransactionManager associe la paire Connection/Session d'une ConnectionFactory à un thread. Cependant, dans un environnement J2EE, les ConnectionFactory peuvent gérer des pools de connexions et de sessions, et de ce fait, les instances associées au thread dépendent du comportement du pool. Dans un environnement autonome, utiliser SingleConnectionFactory entraînera l'utilisation d'une unique connexion JMS et chaque transaction aura sa propre session. La classe JmsTemplate peut également être utilisée avec la classe JtaTransactionManager et une ConnectionFactory JMS supportant le protocole XA pour effectuer des transactions globales.
Réutiliser du code sur des environnements autonomes et non autonomes, peut être source de confusion lors de la création d’une Session à partir d’une Connection. Cela vient du fait que l’API JMS a une fabrique unique pour créer une Session et elle nécessite des paramètres pour les modes transactionnel et d’acquittement. Dans un environnement non autonome, positionner ces valeurs... Quand la classe JmsTemplate est utilisée dans un environnement non autonome, il est possible de spécifier ces valeurs par le biais de l'utilisation des propriétés SessionTransacted et SessionAcknowledgeMode. Quand est utilisé une implémentation de PlatformTransactionManager avec la classe JmsTemplate, le template recevra toujours une session JMS transactionnelle.

14.3.3. Gestion des destinations

Les destinations, comme les ConnectionFactory, sont des objets JMS administrés qui peuvent être stockés et récupérés dans JNDI. Au moment de configurer un contexte d'application dans Spring, il est possible d'utiliser la classe de fabrique JndiObjectFactoryBean pour réaliser de l'injection de dépendance sur les références d'objets avec des destinations JMS. Cependant, cette façon de faire est déconseillée s'il y a un grand nombre de destinations dans l'application ou s'il y a des fonctionnalités avancées spécifiques au fournisseur JMS pour la gestion des destinations. Un exemple de gestion de ce type serait la création de destinations dynamiques ou le support d'espaces de nommage hiérarchique pour les destinations. La classe JmsTemplate déléguera la résolution du nom de la destination d'un objet JMS à une implémentation de l'interface DestinationResolver. DynamicDestinationResolver est l'implémentation par défaut utilisée par la classe JmsTemplate et qui permet de résoudre les destinations dynamiques. Une classe JndiDestinationResolver est également fournie pour jouer le rôle de service de localisation des destinations contenues dans JNDI et peut également rebasculer sur le comportement de DynamicDestinationResolver.

Très souvent, les destinations utilisées dans une application JMS ne sont connues uniquement qu'au moment de l'exécution et, de ce fait, ne peuvent pas être créées administrativement quand l'application est déployée. Ceci est dû au fait que la logique applicative est partagée par les composants intéragissant dans le système qui créent des destinations au moment de l'exécution en suivant une convention de nommage bien définie et connue. Même si la création dynamique de destinations ne fait pas partie de la spécification JMS, la plupart des fournisseurs offrent cette fonctionnalité. Les destinations dynamiques sont créées avec un nom défini par l'utilisateur, ce qui les différencient des destinations temporaires et ne sont parfois pas mises dans JNDI. L’API utilisée pour les créer varie d'un fournisseur à l'autre puisque les propriétés associées lui sont spécifiques. Cependant un choix simple d'implémentation qui est souvent fait par les fournisseurs, est de négliger les mises en garde de la spécification JMS et d'utiliser la méthode createTopic(String topicName) de l'interface TopicSession ou la méthode createQueue(String queueName) de l'interface QueueSession pour créer une nouvelle destination avec les propriétés par défaut des destinations. Suivant l'implémentation du vendeur, DynamicDestinationResolver peut aussi créer une destination physique ay lieu de seulement la résoudre.

La propriété bouléenne PubSubDomain est utilisée pour configurer la classe JmsTemplate en ayant la connaissance du domaine. Par défaut, la valeur de cette propriété est fausse (false) indiquant ainsi que le domaine point à point sera utilisé. Dans l'implémentation relative à la version 1.0.2, la valeur de cette propriété détermine si les opérations d'envoi de JmsTemplate enverront un message à une queue ou une matière. Ce champ n'a aucun effet sur les opérations d'envoi pour l'implémentation relative à la version 1.1. Cependant, dans les deux implémentations, cette propriété détermine le comportement pour la résolution dynamique des destinations via les implémentations de la méthode createTopic(String topicName) de l'interface DestinationResolver.

Il est possible de configurer également la classe JmsTemplate avec une destination par défaut au moyen de la propriété DefaultDestination. Celle-ci sera utilisée avec les opérations d'envoi et de réception qui ne se réfèrent pas à de destinations spécifiques.
14.4. Utilisation de JmsTemplate

Pour débuter avec JmsTemplate, il faut choisir l'implémentation JmsTemplate102 pour la version 1.0.2 ou JmsTemplate pour la version 1.1. Interroger votre fournisseur JMS pour déterminer quelle version est supportée.

14.4.1. Envoi d’un message

La classe JmsTemplate contient beaucoup de méthodes intéressantes pour envoyer un message. Il y a des méthodes d’envoi qui permettent de spécifier la destination en utilisant un objet javax.jms.Destination et celles qui la spécifient en utilisant une chaîne de caractères pour effectuer une recherche JNDI. La méthode d’envoi qui ne prend aucune destination utilise celle par défaut. Voici un exemple qui envoie un message à une queue en utilisant l’implémentation relative à la version 1.0.2 de JMS.

```java
import javax.jms.ConnectionFactory;
import javax.jms.JMSException;
import javax.jms.Message;
import javax.jms.Queue;
import javax.jms.Session;
import org.springframework.jms.core.JmsTemplate;
import org.springframework.jms.core.JmsTemplate102;
import org.springframework.jms.core.MessageCreator;

public class JmsQueueSender {
    private JmsTemplate jt;
    private ConnectionFactory connFactory;
    private Queue queue;

    public void simpleSend() {
        jt = new JmsTemplate102(connFactory, false);
        jt.send(queue, new MessageCreator() {
            public Message createMessage(Session session) throws JMSException {
                return session.createTextMessage("hello queue world");
            }
        });
    }

    public void setConnectionFactory(ConnectionFactory cf) {
        connFactory = cf;
    }

    public void setQueue(Queue q) {
        queue = q;
    }
}
```

Cette exemple utilise l'interface de rappel MessageCreator pour créer un message de type texte à partir d'une session fournie. JmsTemplate est construit avec une référence à une ConnectionFactory et un bouléen spécifiant le domaine de messagerie. Un constructeur sans argument et une méthode setConnectionFactory/Queue est aussi fournie et peut être utilisée égalemnet pour construire un instance en utilisant un BeanFactory. La méthode simpleSend modifiée pour envoyer sur une matière plutôt que sur une queue est montrée ci-dessous:

```java
public void simpleSend() {
    jt = new JmsTemplate102(connFactory, true);
    jt.send(topic, new MessageCreator() {
        public Message createMessage(Session session) throws JMSException {
            return session.createTextMessage("hello topic world");
        }
    });
}
```

Spring Framework Version 1.1.4
Au moment de configurer le version 1.0.2 dans une contexte d'application, il est important de ne pas oublier de positionner la propriété bouléenne PubSubDomain pour indiquer quelle destination utiliser, queues ou matière.

La méthode send(String destinationName, MessageCreator c) permet d'envoyer un message en utilisant le nom d'une destination. Si ces noms existent dans JNDI, la propriété du template DestinationResolver doit être positionnée avec une instance de JndiDestinationResolver.

Si vous avez créé une classe JmsTemplate et lui avez spécifié un destination par défaut, la méthode send(MessageCreator c) envoie un message à celle-ci.

### 14.4.2. Réception synchrone

Bien que JMS soit typiquement associé avec de la messagerie asynchrone, il est possible de consommer les messages de manière synchrone. Les méthodes surchargées receive offre cette fonctionnalité. Durant la réception synchrone, le thread réalisant l'appel se bloque jusqu'à ce qu'un message devienne disponible. Cela peut s'avérer être une opération dangereuse ce thread peut potentiellement être bloqué indéfiniment. La propriété receiveTimeout spécifie la durée au cours de laquelle le receveur doit attendre avant de mettre de continuer.

### 14.4.3. Utilisation des Message Converters

Afin de faciliter l'envoi d'objets de domaine, la classe JmsTemplate a différentes méthodes qui prennent des objets Java en arguments pour les données du message. Les méthodes surchargées convertAndSend et receiveAndConvert de la classe JmsTemplate déléguent le traitement de conversion à une instance de l’interface MessageConverter. Cette interface définit un contrat simple pour convertir les objets Java en messages JMS (et inversement). L’implémentation par défaut, SimpleMessageConverter, supporte les conversions entre String et TextMessage, byte[] et BytesMessage, et java.util.Map et MapMessage. En utilisant le convertisseur, le code de l'application peut se focaliser sur l'objet métier qui va être envoyé ou reçu via JMS et ne plus se soucier des détails de sa représentation en tant que message JMS.

La "sandbox" (bac à sable) contient actuellement une classe MapMessageConverter qui utilise la réflexion pour convertir un JavaBean en MapMessage (et réciproquement). D'autres choix populaires d'implémentations sont les convertisseurs tels que des packages existants de sérialisation XML comme JAXB, Castor, XMLBeans, ou XStream, pour créer un TextMessage représentant l'objet.

Pour faciliter le positionnement des propriétés, entêtes et corps du message qui ne peuvent pas être encapsulés de manière générique dans une classe de conversion, l’interface MessagePostProcessor donne accès au message après qu’il ait été converti mais qu’il ne soit envoyé. L’exemple ci-dessous montre comment modifier une propriété et une entête de message après qu’il ait été converti à partir d'une java.util.Map.

```java
public void sendWithConversion() {
    Map m = new HashMap();
    m.put("Name", "Mark");
    m.put("Age", new Integer(35));
    jt.convertAndSend("testQueue", m, new MessagePostProcessor() {
        public Message postProcessMessage(Message message)
            throws JMSException {
                message.setIntProperty("AccountID", 1234);
                message.setJMSCorrelationID("123-00001");
                return message;
        }
    });
}
```
Le message résultat sera de la forme

```java
MapMessage={
    Header={
        ... standard headers ...
        CorrelationID={123-00001}
    }
    Properties={
        AccountID={Integer:1234}
    }
    Fields={
        Name={String:Mark}
        Age={Integer:35}
    }
}
```

14.4.4. SessionCallback et ProducerCallback

Bien que les opérations d'envoi couvre beaucoup de scénarios d'utilisation, il y a des cas où de multiples opérations doivent être exécutées sur une session JMS ou un MessageProducer. Les interfaces `SessionCallback` et `ProducerCallback` exposent respectivement la session JMS et la paire `Session/MessageProducer`. Les méthodes `execute()` de `JmsTemplate` exécutent ces méthodes de rappel.
Chapter 15. Accessing and implementing EJBs

As a lightweight container, Spring is often considered an EJB replacement. We do believe that for many if not most applications and use cases, Spring as a container, combined with its rich supporting functionality in the area of transactions, ORM and JDBC access, is a better choice than implementing equivalent functionality via an EJB container and EJBs.

However, it is important to note that using Spring does not prevent you from using EJBs. In fact, Spring makes it much easier to access EJBs and implement EJBs and functionality within them. Additionally, using Spring to access services provided by EJBs allows the implementation of those services to later transparently be switched between local EJB, remote EJB, or POJO (plain java object) variants, without the client code client code having to be changed.

In this chapter, we look at how Spring can help you access and implement EJBs. Spring provides particular value when accessing stateless session beans (SLSBs), so we'll begin by discussing this.

15.1. Accessing EJBs

15.1.1. Concepts

To invoke a method on a local or remote stateless session bean, client code must normally perform a JNDI lookup to obtain the (local or remote) EJB Home object, then use a 'create' method call on that object to obtain the actual (local or remote) EJB object. One or more methods are then invoked on the EJB.

To avoid repeated low-level code, many EJB applications use the Service Locator and Business Delegate patterns. These are better than spraying JNDI lookups throughout client code, but their usual implementations have significant disadvantages. For example:

- Typically code using EJBs depends on Service Locator or Business Delegate singletons, making it hard to test
- In the case of the Service Locator pattern used without a Business Delegate, application code still ends up having to invoke the create() method on an EJB home, and deal with the resulting exceptions. Thus it remains tied to the EJB API and the complexity of the EJB programming model.
- Implementing the Business Delegate pattern typically results in significant code duplication, where we have to write numerous methods that simply call the same method on the EJB.

The Spring approach is to allow the creation and use of proxy objects, normally configured inside a Spring ApplicationContext or BeanFactory, which act as code-less business delegates. You do not need to write another Service Locator, another JNDI lookup, or duplicate methods in a hand-coded Business Delegate unless you're adding real value.

15.1.2. Accessing local SLSBs

Assume that we have a web controller that needs to use a local EJB. We'll follow best practice and use the EJB Business Methods Interface pattern, so that the EJB's local interface extends a non EJB-specific business methods interface. Let's call this business methods interface MyComponent.

```java
public interface MyComponent {
    ...
}
```
(One of the main reasons to the Business Methods Interface pattern is to ensure that synchronization between method signatures in local interface and bean implementation class is automatic. Another reason is that it later makes it much easier for us to switch to a POJO (plain java object) implementation of the service if it makes sense to do so) Of course we'll also need to implement the local home interface and provide a bean implementation class that implements SessionBean and the MyComponent business methods interface. Now the only Java coding we'll need to do to hook up our web tier controller to the EJB implementation is to expose a setter method of type MyComponent on the controller. This will save the reference as an instance variable in the controller:

```java
private MyComponent myComponent;

public void setMyComponent(MyComponent myComponent) {
    this.myComponent = myComponent;
}
```

We can subsequently use this instance variable in any business method in the controller. Now assuming we are obtaining our controller object out of a Spring ApplicationContext or BeanFactory, we can in the same context configure a `LocalStatelessSessionProxyFactoryBean` instance, which will be EJB proxy object. The configuration of the proxy, and setting of the `myComponent` property of the controller is done with a configuration entry such as:

```xml
<bean id="myComponent"
    class="org.springframework.ejb.access.LocalStatelessSessionProxyFactoryBean">
    <property name="jndiName"><value>myComponent</value></property>
    <property name="businessInterface"><value>com.mycom.MyComponent</value></property>
</bean>

<bean id="myController" class = "com.mycom.myController">
    <property name="myComponent"><ref bean="myComponent"/></property>
</bean>
```

There's a lot of magic happening behind the scenes, courtesy of the Spring AOP framework, although you aren't forced to work with AOP concepts to enjoy the results. The `myComponent` bean definition creates a proxy for the EJB, which implements the business method interface. The EJB local home is cached on startup, so there's only a single JNDI lookup. Each time the EJB is invoked, the proxy invokes the create() method on the local EJB and invokes the corresponding business method on the EJB.

The `myController` bean definition sets the `myComponent` property of the controller class to this proxy.

This EJB access mechanism delivers huge simplification of application code: The web tier code (or other EJB client code) has no dependence on the use of EJB. If we want to replace this EJB reference with a POJO or a mock object or other test stub, we could simply change the `myComponent` bean definition without changing a line of Java code. Additionally, we haven't had to write a single line of JNDI lookup or other EJB plumbing code as part of our application.

Benchmarks and experience in real applications indicate that the performance overhead of this approach (which involves reflective invocation of the target EJB) is minimal, and undetectable in typical use. Remember that we don't want to make fine-grained calls to EJBs anyway, as there's a cost associated with the EJB infrastructure in the application server.

There is one caveat with regards to the JNDI lookup. In a bean container, this class is normally best used as a singleton (there simply is no reason to make it a prototype). However, if that bean container pre-instantiates singletons (as do the XML ApplicationContext variants) you may have a problem if the bean container is loaded before the EJB container loads the target EJB. That is because the JNDI lookup will be performed in the
init method of this class and cached, but the EJB will not have been bound at the target location yet. The solution is to not pre-instantiate this factory object, but allow it to be created on first use. In the XML containers, this is controlled via the lazy-init attribute.

Although this will not be of interest to the majority of Spring users, those doing programmatic AOP work with EJBs may want to look at LocalSlsbInvokerInterceptor.

15.1.3. Accessing remote SLSBs

Accessing remote EJBs is essentially identical to accessing local EJBs, except that the SimpleRemoteStatelessSessionProxyFactoryBean is used. Of course, with or without Spring, remote invocation semantics apply; a call to a method on an object in another VM in another computer does sometimes have to be treated differently in terms of usage scenarios and failure handling.

Spring's EJB client support adds one more advantage over the non-Spring approach. Normally it is problematic for EJB client code to be easily switched back and forth between calling EJBs locally or remotely. This is because the remote interface methods must declare that they throw RemoteException, and client code must deal with this, while the local interface methods don't. Client code written for local EJBs which needs to be moved to remote EJBs typically has to be modified to add handling for the remote exceptions, and client code written for remote EJBs which needs to be moved to local EJBs, can either stay the same but do a lot of unnecessary handling of remote exceptions, or needs to be modified to remove that code. With the Spring remote EJB proxy, you can instead not declare any thrown RemoteException in your Business Method Interface and implementing EJB code, have a remote interface which is identical except that it does throw RemoteException, and rely on the proxy to dynamically treat the two interfaces as if they were the same. That is, client code does not have to deal with the checked RemoteException class. Any actual RemoteException that is thrown during the EJB invocation will be re-thrown as the non-checked RemoteAccessException class, which is a subclass of RuntimeException. The target service can then be switched at will between a local EJB or remote EJB (or even plain Java object) implementation, without the client code knowing or caring. Of course, this is optional; there is nothing stopping you from declaring RemoteExceptions in your business interface.

15.2. Using Spring convenience EJB implementation classes

Spring also provides convenience classes to help you implement EJBs. These are designed to encourage the good practice of putting business logic behind EJBs in POjos, leaving EJBs responsible for transaction demarcation and (optionally) remoting.

To implement a Stateless or Stateful session bean, or Message Driven bean, you derive your implementation class from AbstractStatelessSessionBean, AbstractStatefulSessionBean, and AbstractMessageDrivenBean/AbstractJmsMessageDrivenBean, respectively.

Consider an example Stateless Session bean which actually delegates the implementation to a plain java service object. We have the business interface:

```java
public interface MyComponent {
    public void myMethod(...);
    ...
}
```

We have the plain java implementation object:

```java
public class MyComponentImpl implements MyComponent {
    public String myMethod(...) {
        ...
    }
}
```
And finally the Stateless Session Bean itself:

```java
class MyComponentEJB implements AbstractStatelessSessionBean {  
    MyComponent _myComp;  
    /**  
    * Obtain our POJO service object from the BeanFactory/ApplicationContext  
    * @see org.springframework.ejb.support.AbstractStatelessSessionBean#onEjbCreate()  
    */  
    protected void onEjbCreate() throws CreateException {  
        _myComp = (MyComponent) getBeanFactory().getBean(
                ServicesConstants.CONTEXT_MYCOMP_ID);  
    }  
    // for business method, delegate to POJO service impl.  
    public String myMethod(...) {  
        return _myComp.myMethod(...);  
    }  
    ...
```

The Spring EJB support base classes will by default create and load a BeanFactory (or in this case, its ApplicationContext subclass) as part of their lifecycle, which is then available to the EJB (for example, as used in the code above to obtain the POJO service object). The loading is done via a strategy object which is a subclass of BeanFactoryLocator. The actual implementation of BeanFactoryLocator used by default is ContextJndiBeanFactoryLocator, which creates the ApplicationContext from a resource locations specified as a JNDI environment variable (in the case of the EJB classes, at java:comp/env/ejb/BeanFactoryPath). If there is a need to change the BeanFactory/ApplicationContext loading strategy, the default BeanFactoryLocator implementation used may be overridden by calling the setBeanFactoryLocator() method, either in setSessionContext(), or in the actual constructor of the EJB. Please see the JavaDocs for more details.

As described in the JavaDocs, Stateful Session beans expecting to be passivated and reactivated as part of their lifecycle, and which use a non-serializable BeanFactory/ApplicationContext instance (which is the normal case) will have to manually call unloadBeanFactory() and loadBeanFactory from ejbPassivate and ejbActivate, respectively, to unload and reload the BeanFactory on passivation and activation, since it can not be saved by the EJB container.

The default usage of ContextJndiBeanFactoryLocator to load an ApplicationContext for the use of the EJB is adequate for some situations. However, it is problematic when the ApplicationContext is loading a number of beans, or the initialization of those beans is time consuming or memory intensive (such as a Hibernate SessionFactory initialization, for example), since every EJB will have their own copy. In this case, the user may want to override the default ContextJndiBeanFactoryLocator usage and use another BeanFactoryLocator variant, such as ContextSingletonBeanFactoryLocator, which can load and use a shared BeanFactory or ApplicationContext to be used by multiple EJBs or other clients. Doing this is relatively simple, by adding code similar to this to the EJB:

```java
/**  
 * Override default BeanFactoryLocator implementation  
 */  
@see javax.ejb.SessionBean#setSessionContext javax.ejb.SessionContext  
*/
public void setSessionContext(SessionContext sessionContext) {  
    super.setSessionContext(sessionContext);  
    setBeanFactoryLocator(ContextSingletonBeanFactoryLocator.getInstance());  
    setBeanFactoryLocatorKey(ServicesConstants.PRIMARY_CONTEXT_ID);  
}  
```
Please see the respective JavaDocs for `BeanFactoryLocator` and `ContextSingletonBeanFactoryLocator` for more information on their usage.
Chapter 16. Remoting and web services using Spring

16.1. Introduction

Spring features integration classes for remoting support using various technologies. The remoting support eases the development of remote-enabled services, implemented by your usual (Spring) POJOs. Currently, Spring supports four remoting technologies:

- **Remote Method Invocation (RMI).** Through the use of the `RmiProxyFactoryBean` and the `RmiServiceExporter` Spring supports both traditional RMI (with `java.rmi.Remote` interfaces and `java.rmi.RemoteException`) and transparent remoting via RMI invokers (with any Java interface).
- **Spring’s HTTP invoker.** Spring provides a special remoting strategy which allows for Java serialization via HTTP, supporting any Java interface (just like the RMI invoker). The corresponding support classes are `HttpInvokerProxyFactoryBean` and `HttpInvokerServiceExporter`.
- **Hessian.** By using the `HessianProxyFactoryBean` and the `HessianServiceExporter` you can transparently expose your services using the lightweight binary HTTP-based protocol provided by Caucho.
- **Burlap.** Burlap is Caucho’s XML-based alternative for Hessian. Spring provides support classes such as `BurlapProxyFactoryBean` and `BurlapServiceExporter`.
- **JAX RPC (TODO).**
- **JMS (TODO).**

While discussing the remoting capabilities of Spring, we'll use the following domain model and corresponding services:

```java
// Account domain object
public class Account implements Serializable{
    private String name;

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

// Account service
public interface AccountService {
    public void insertAccount(Account acc);
    public List getAccounts(String name);
}

// ... and corresponding implement doing nothing at the moment
public class AccountServiceImpl implements AccountService {
    public void insertAccount(Account acc) {
        // do something
    }

    public List getAccounts(String name) {
        // do something
    }
}
```
We will start exposing the service to a remote client by using RMI and talk a bit about the drawbacks of using RMI. We'll then continue to show an example for Hessian.

### 16.2. Exposing services using RMI

Using Spring's support for RMI, you can transparently expose your services through the RMI infrastructure. After having this set up, you basically have a configuration similar to remote EJBs, except for the fact that there is no standard support for security context propagation or remote transaction propagation. Spring does provide hooks for such additional invocation context when using the RMI invoker, so you can for example plug in security frameworks or custom security credentials here.

#### 16.2.1. Exporting the service using the `RmiServiceExporter`

Using the `RmiServiceExporter`, we can expose the interface of our `AccountService` object as RMI object. The interface can be accessed by using `RmiProxyFactoryBean`, or via plain RMI in case of a traditional RMI service. The `RmiServiceExporter` explicitly supports the exposing of any non-RMI services via RMI invokers.

Of course, we first have to set up our service in the Spring BeanFactory:

```xml
<bean id="accountService" class="example.AccountServiceImpl">
  <!-- any additional properties, maybe a DAO? -->
</bean>
```

Next we'll have to expose our service using the `RmiServiceExporter`:

```xml
<bean class="org.springframework.remoting.rmi.RmiServiceExporter">
  <!-- does not necessarily have to be the same name as the bean to be exported -->
  <property name="serviceName"><value>AccountService</value></property>
  <property name="service"><ref bean="accountService"></property>
  <property name="serviceInterface"><value>example.AccountService</value></property>
  <property name="registryPort"><value>1199</value></property>
</bean>
```

As you can see, we're overriding the port for the RMI registry. Often, your application server also maintains an RMI registry and it is wise to not interfere with that one. Furthermore, the service name is used to bind the service under. So right now, the service will be bound at `rmi://HOST:1199/AccountService`. We'll use the URL later on to link in the service at the client side.

*Note: We've left out one property, i.e. the `servicePort` property, which is 0 by default. This means an anonymous port will be used to communicate with the service. You can specify a different port if you like.*

#### 16.2.2. Linking in the service at the client

Our client is a simple object using the `AccountService` to manage accounts:

```java
public class SimpleObject {
  private AccountService accountService;
  public void setAccountService(AccountService accountService) {
    this.accountService = accountService;
  }
}
```
To link in the service on the client, we'll create a separate bean factory, containing the simple object and the service linking configuration bits:

```xml
<bean class="example.SimpleObject">
    <property name="accountService"><ref bean="accountService"/></property>
</bean>

<bean id="accountService" class="org.springframework.remoting.rmi.RmiProxyFactoryBean">
    <property name="serviceUrl"><value>rmi://HOST:1199/AccountService</value></property>
    <property name="serviceInterface"><value>example.AccountService</value></property>
</bean>
```

That's all we need to do to support the remote account service on the client. Spring will transparently create an invoker and remotely enable the account service through the RmiServiceExporter. At the client we're linking it in using the RmiProxyFactoryBean.

### 16.3. Using Hessian or Burlap to remotely call services via HTTP

Hessian offers a binary HTTP-based remoting protocol. It's created by Caucho and more information about Hessian itself can be found at http://www.caucho.com.

#### 16.3.1. Wiring up the DispatcherServlet for Hessian

Hessian communicates via HTTP and does so using a custom servlet. Using Spring's DispatcherServlet principles, you can easily wire up such a servlet exposing your services. First we'll have to create a new servlet in your application (this an excerpt from `web.xml`):

```xml
<servlet>
    <servlet-name>remote</servlet-name>
    <servlet-class>org.springframework.web.servlet.DispatcherServlet</servlet-class>
    <load-on-startup>1</load-on-startup>
</servlet>
```

You're probably familiar with Spring's DispatcherServlet principles and if so, you know that know you'll have to create an application context named `remote-servlet.xml` (after the name of your servlet) in the `WEB-INF` directory. The application context will be used in the next section.

#### 16.3.2. Exposing your beans by using the HessianServiceExporter

In the newly created application context called `remote-servlet.xml` we'll create a HessianServiceExporter exporting your services:

```xml
<bean id="accountService" class="example.AccountServiceImpl">
    <!-- any additional properties, maybe a DAO? -->
</bean>

<bean name="/AccountService" class="org.springframework.remoting.caucho.HessianServiceExporter">
    <property name="service"><ref bean="accountService"/></property>
</bean>
```
Now we're ready to link in the service at the client. No handler mapping is specified mapping requests (urls) onto services and that's why the BeanNameUrlHandlerMapping will be used, hence the service will be exported at the URL http://HOST:8080/AccountService.

16.3.3. Linking in the service on the client

Using the HessianProxyFactoryBean we can link in the service at the client. The same principles apply as with the RMI example. We'll create a separate bean factory or application context and mention the following beans where the SimpleObject is using the AccountService to manage accounts:

```
<bean class="example.SimpleObject">
    <property name="accountService"><ref bean="accountService"/></property>
</bean>

<bean id="accountService" class="org.springframework.remoting.caucho.HessianProxyFactoryBean">
    <property name="serviceUrl"><value>http://remotehost:8080/AccountService</value></property>
    <property name="ServiceInterface"><value>example.AccountService</value></property>
</bean>
```

That's all there is to it.

16.3.4. Using Burlap

We won't discuss Burlap, the XML-based equivalent of Hessian, in detail here, since it is configured and set up in exactly the same way as the Hessian variant explained above. Just replace the word Hessian with Burlap and you're all set to go.

16.3.5. Applying HTTP basic authentication to a service exposed through Hessian or Burlap

One of the advantages of Hessian and Burlap is that we can easily apply HTTP basic authentication, because both protocols are HTTP-based. Your normal HTTP server security mechanism can easily be applied through using the web.xml security features, for example. Usually, you don't use per-user security credentials here, but rather shared credentials defined at the Hessian/BurlapProxyFactoryBean level (similar to a JDBC DataSource).

```
<bean class="org.springframework.web.servlet.handler.BeanNameUrlHandlerMapping">
    <property name="interceptors">
        <list>
            <ref bean="authorizationInterceptor"/>
        </list>
    </property>
</bean>

<bean id="authorizationInterceptor" class="org.springframework.web.servlet.handler.UserRoleAuthorizationInterceptor">
    <property name="authorizedRoles">
        <list>
            <value>administrator</value>
            <value>operator</value>
        </list>
    </property>
</bean>
```
This an example where we explicitly mention the BeanNameUrlHandlerMapping and set an interceptor allowing only administrators and operators to call the beans mentioned in this application context.

Note: Of course, this example doesn't show a flexible kind of security infrastructure. For more options as far as security is concerned, have a look at the Acegi Security System for Spring, to be found at http://acegisecurity.sourceforge.net.

16.4. Exposing services using HTTP invokers

As opposed to Burlap and Hessian, which are both lightweight protocols using their own slim serialization mechanisms, Spring Http invokers use the standard Java serialization mechanism to expose services through HTTP. This has a huge advantage if your arguments and return types are complex types that cannot be serialized using the serialization mechanisms Hessian and Burlap use (refer to the next section for more considerations when choosing a remoting technology).

Under the hood, Spring uses either the standard facilities provided by J2SE to perform HTTP calls or Commons HttpClient. Use the latter if you need more advanced and easy-to-use functionality. Refer to jakarta.apache.org/commons/httpclient for more info.

16.4.1. Exposing the service object

Setting up the HTTP invoker infrastructure for a service objects much resembles the way you would do using Hessian or Burlap. Just as Hessian support provides the HessianServiceExporter, Spring Http invoker support provides the so-called org.springframework.remoting.httpinvoker.HttpInvokerServiceExporter. To expose the AccountService (mentioned above), the following configuration needs to be in place:

```xml
<bean name="/AccountService" class="org.springframework.remoting.httpinvoker.HttpInvokerServiceExporter">
    <property name="service"><ref bean="accountService"/></property>
    <property name="serviceInterface">
        <value>example.AccountService</value>
    </property>
</bean>
```

16.4.2. Linking in the service at the client

Again, linking in the service from the client much resembles the way you would do it when using Hessian or Burlap. Using a proxy, Spring will be able to translate your calls to HTTP POST requests to the URL pointing to the exported service.

```xml
<bean id="httpInvokerProxy" class="org.springframework.remoting.httpinvoker.HttpInvokerProxyFactoryBean">
    <property name="serviceUrl">
        <value>http://remotehost:8080/AccountService</value>
    </property>
    <property name="serviceInterface">
        <value>example.AccountService</value>
    </property>
</bean>
```

As mentioned before, you can choose what HTTP client you want to use. By default, the HttpInvokerProxy
uses the J2SE HTTP functionality, but you can also use the Commons HttpClient by setting the `httpInvokerRequestExecutor` property:

```
<property name="httpInvokerRequestExecutor">
  <bean class="org.springframework.remoting.httpinvoker.CommonsHttpInvokerRequestExecutor"/>
</property>
```

### 16.5. Considerations when choosing a technology

Each and every technology presented here has its drawbacks. You should carefully consider you needs, the services your exposing and the objects you'll be sending over the wire when choosing a technology.

When using RMI, it's not possible to access the objects through the HTTP protocol, unless you're tunneling the RMI traffic. RMI is a fairly heavy-weight protocol in that it support full-object serialization which is important when using a complex data model that needs serialization over the wire. However, RMI-JRMP is tied to Java clients: It is a Java-to-Java remoting solution.

Spring's HTTP invoker is a good choice if you need HTTP-based remoting but also rely on Java serialization. It shares the basic infrastructure with RMI invokers, just using HTTP as transport. Note that HTTP invokers are not only limited to Java-to-Java remoting but also to Spring on both the client and server side. (The latter also applies to Spring's RMI invoker for non-RMI interfaces.)

Hessian and/or Burlap might provide significant value when operating in a heterogeneous environment, because they explicitly allow for non-Java clients. However, non-Java support is still limited. Known problems include the serialization of Hibernate objects in combination with lazily initializing collections. If you have such a data model, consider using RMI or HTTP invokers instead of Hessian.

JMS can be useful for providing clusters of services and allowing the JMS broker to take care of load balancing, discovery and auto-failover. By default Java serialization is used when using JMS remoting but the JMS provider could use a different mechanism for the wire formatting, such as XStream to allow servers to be implemented in other technologies.

Last but not least, EJB has an advantage over RMI in that it supports standard role-based authentication and authorization and remote transaction propagation. It is possible to get RMI invokers or HTTP invokers to support security context propagation as well, although this is not provided by core Spring: There are just appropriate hooks for plugging in third-party or custom solutions here.
Chapter 17. Sending Email with Spring mail abstraction layer

17.1. Introduction

Spring provides a higher level of abstraction for sending electronic mail which shields the user from the specifics of underlying mailing system and is responsible for a low level resource handling on behalf of the client.

17.2. Spring mail abstraction structure

The main package of Spring mail abstraction layer is org.springframework.mail package. It contains central interface for sending emails called MailSender and the value object which encapsulates properties of a simple mail such as from, to, cc, subject, text called SimpleMailMessage. This package also contains a hierarchy of checked exceptions which provide a higher level of abstraction over the lower level mail system exceptions with the root exception being MailException. Please refer to JavaDocs for more information on mail exception hierarchy.

Spring also provides a sub-interface 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:

```java
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:

```java
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.
     */
    public void send(MimeMessage message) throws MailException;
}
```
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;

}

17.3. Using Spring mail abstraction

Let's assume there is a business interface called OrderManager

public interface OrderManager {

void placeOrder(Order order);

}

and there is a use case that says that an email message with order number would need to be generated and sent to a customer placing that order. So for this purpose we want to use MailSender and SimpleMailMessage

Please note that as usual, we work with interfaces in the business code and let Spring IoC container take care of wiring of all the collaborators for us.

Here is the implementation of OrderManager

import org.springframework.mail.MailException;
import org.springframework.mail.MailSender;
import org.springframework.mail.SimpleMailMessage;

Spring Framework Version 1.1.4
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 thread safe "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:

```xml
<bean id="mailSender"
    class="org.springframework.mail.javamail.JavaMailSenderImpl">
    <property name="host"><value>mail.mycompany.com</value></property>
</bean>

<bean id="mailMessage"
    class="org.springframework.mail.SimpleMailMessage">
    <property name="from"><value>customerservice@mycompany.com</value></property>
    <property name="subject"><value>Your order</value></property>
</bean>

<bean id="orderManager"
    class="com.mycompany.businessapp.support.OrderManagerImpl">
    <property name="mailSender"><ref bean="mailSender"/></property>
    <property name="message"><ref bean="mailMessage"/></property>
</bean>
```

Here is the implementation of OrderManager using MimeMessagePreparator callback interface. Please note that the mailSender property is of type JavaMailSender in this case in order to be able to use JavaMail MimeMessage:

```java
import javax.mail.Message;
import javax.mail.MessagingException;
import javax.mail.internet.InternetAddress;
import javax.mail.internet.MimeMessage;
import java.util.Properties;

public class OrderManagerImpl implements OrderManager {
    private JavaMailSender mailSender;

    public void setMailSender(JavaMailSender mailSender) {
        this.mailSender = mailSender;
    }

    public void placeOrder(Order order) {
        //... * Do the business calculations....
        //... * Call the collaborators to persist the order
        //Create a thread safe "sandbox" of the message
        MimeMessage msg = new MimeMessage(this.mailSender.getJavaMailSender());
        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());
        }
    }
}
```

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public void setMailSender(JavaMailSender mailSender) {
    this.mailSender = mailSender;
}

public void placeOrder(final Order order) {
    //... * Do the business calculations....
    //... * Call the collaborators to persist the order

    MimeMessagePreparator preparator = new MimeMessagePreparator() {
        public void prepare(MimeMessage mimeMessage) throws MessagingException {
            mimeMessage.setRecipient(Message.RecipientType.TO,
                new InternetAddress(order.getCustomer().getEmailAddress()));
            mimeMessage.setFrom(new InternetAddress("mail@mycompany.com"));
            mimeMessage.setText("Dear 
                + order.getCustomer().getFirstName()
                + order.getCustomer().getLastName()
                + ", thank you for placing order. Your order number is 
                + order.getOrderNumber();
        }
    };
    try{
        mailSender.send(preparator);
    } catch(MailException ex) {
        //log it and go on
        System.err.println(ex.getMessage());
    }
}

If you want to use JavaMail MimeMessage to the full power, the MimeMessagePreparator is available at your fingertips.

Please note that the mail code is a crosscutting concern and is a perfect candidate for refactoring into a custom Spring AOP advice, which then could easily be applied to OrderManager target. Please see the AOP chapter.

17.3.1. Pluggable MailSender implementations

Spring comes with two MailSender implementations out of the box - the JavaMail implementation and the implementation on top of Jason Hunter's MailMessage class that's included in http://servlets.com/cos (com.oreilly.servlet). Please refer to JavaDocs for more information.

17.4. Using the JavaMail MimeMessageHelper

One of the components that comes in pretty handy when dealing with JavaMail messages is the org.springframework.mail.javamail.MimeMessageHelper. It prevents you from having to use the nasty APIs the javax.mail.internet classes. A couple of possible scenarios:

17.4.1. Creating a simple MimeMessage and sending it

Using the MimeMessageHelper it's pretty easy to setup and send a MimeMessage:

// of course you would setup the mail sender using
// DI in any real-world cases
JavaMailSenderImpl sender = new JavaMailSenderImpl();
sender.setHost("mail.host.com");

MimeMessage message = sender.createMimeMessage();
MimeMessageHelper helper = new MimeMessageHelper(message);
17.4.2. Sending attachments and inline resources

Email allow for attachments, but also for inline resources in multipart messages. Inline resources could for example be images or stylesheet you want to use in your message, but don't want displayed as attachment. The following shows you how to use the MimeMessageHelper to send an email along with an inline image.

```
JavaMailSenderImpl sender = new JavaMailSenderImpl();
sender.setHost("mail.host.com");

MimeMessage message = sender.createMimeMessage();

// use the true flag to indicate you need a multipart message
MimeMessageHelper helper = new MimeMessageHelper(message, true);
helper.setTo("test@host.com");

// use the true flag to indicate the text included is HTML
helper.setText("<html><body><img src='cid:identifier1234'></body></html>", true);

// let's include the infamous windows Sample file (this time copied to c:/)
FileSystemResource res = new FileSystemResource(new File("c:/Sample.jpg"));
helper.addInline("identifier1234", res);

// if you would need to include the file as an attachment, use
// addAttachment() methods on the MimeMessageHelper
sender.send(message);
```

*Inline resources are added to the mime message using the Content-ID specified as you've seen just now (`identifier1234` in this case). The order in which you're adding the text and the resource are VERY important. First add the text and after that the resources. If you're doing it the other way around, it won't work!*
Chapter 18. Scheduling jobs using Quartz or Timer

18.1. Introduction

Spring features integration classes for scheduling support. Currently, Spring supports the Timer, built in the JDK since 1.3 and the Quartz Scheduler (http://www.quartzscheduler.org). Both schedulers are set up using a FactoryBean with optional references to Timers or Triggers, respectively. Furthermore, a convenience class for both the Quartz Scheduler and the Timer is available that allows you to invoke a method on a target object that you can specify yourself (analogous to normal MethodInvokingFactoryBeans).

18.2. Using the OpenSymphony Quartz Scheduler

Quartz uses Triggers, Jobs and JobDetail to realize scheduling of all kinds of jobs. For the basic concepts behind Quartz, have a look at http://www.opensymphony.com/quartz. For convenience purposes, Spring offers a couple of classes that simplify usage of Quartz within Spring-based applications.

18.2.1. Using the JobDetailBean

JobDetail objects contain all information needed to run a job. Spring provides a so-called JobDetailBean that makes the JobDetail more of an actual JavaBean with sensible defaults. Let's have a look at an example:

```xml
<bean name="exampleJob" class="org.springframework.scheduling.quartz.JobDetailBean">
    <property name="jobClass">
        <value>example.ExampleJob</value>
    </property>
    <property name="jobDataAsMap">
        <map>
            <entry key="timeout"><value>5</value></entry>
        </map>
    </property>
</bean>
```

The job detail bean has all information it needs to run the job (ExampleJob). The timeout is specified as the job data map. The job data map is available through the JobExecutionContext (passed to you at execution time), but the JobDetailBean also maps the properties from the job data map to properties of the actual job. So in this case, if the ExampleJob contains a property named timeout, the JobDetailBean will automatically apply it:

```java
package example;
public class ExampleJob extends QuartzJobBean {
    private int timeout;
    
    /**
     * Setter called after the ExampleJob is instantiated
     * with the value from the JobDetailBean (5)
     */
    public void setTimeout(int timeout) {
        this.timeout = timeout;
    }

    protected void executeInternal(JobExecutionContext ctx)
        throws JobExecutionException {
        // do the actual work
    }
}
```
All additional settings from the job detail bean are by the way available to you as well.

*Note: Using the *name* and *group* properties, you can modify in which group the job runs and using what name. By default the name of the job equals the bean name of the job detail bean (in the example above this is exampleJob).*

### 18.2.2. Using the MethodInvokingJobDetailFactoryBean

Often times, you just need to invoke a method on a specific object. Using the `MethodInvokingJobDetailFactoryBean` you can do exactly this:

```xml
<bean id="methodInvokingJobDetail"
      class="org.springframework.scheduling.quartz.MethodInvokingJobDetailFactoryBean">
  <property name="targetObject"><ref bean="exampleBusinessObject"/></property>
  <property name="targetMethod"><value>doIt</value></property>
</bean>
```

The above example will result in the `doIt` being called on the `exampleBusinessObject` (see below):

```java
public class BusinessObject {
    // properties and collaborators

    public void doIt() {
        // do the actual work
    }
}
```

```xml
<bean id="exampleBusinessObject" class="examples.ExampleBusinessObject"/>
```

Using the `MethodInvokingJobDetailFactoryBean` you don't need to create one-line jobs that just invoke a method, and you only need to create the actual business object and wire up the detail object.

By default, Quartz Jobs are stateless, resulting in the possibility of jobs interfering with each other. If you specify two triggers for the same JobDetail, it might be possible that before the first job has finished, the second one will start. If JobDetail objects implement the Stateful interface, this won't happen. The second job will not start before the first one has finished. To make jobs resulting from the `MethodInvokingJobDetailFactoryBean` non-concurrent, set the `concurrent` flag to false.

```xml
<bean id="methodInvokingJobDetail"
      class="org.springframework.scheduling.quartz.MethodInvokingJobDetailFactoryBean">
  <property name="targetObject"><ref bean="exampleBusinessObject"/></property>
  <property name="targetMethod"><value>doIt</value></property>
  <property name="concurrent"><value>false</value></property>
</bean>
```

*Note: By default, jobs will run in a concurrent fashion.*
18.2.3. Wiring up jobs using triggers and the SchedulerFactoryBean

We’ve created job details, jobs and we’ve reviewed the convenience bean that allows you to invoke a method on a specific object. Of course we still need to schedule the jobs themselves. This is done using triggers and a SchedulerFactoryBean. Several triggers are available within Quartz. Spring offers two subclassed triggers, the CronTriggerBean and the SimpleTriggerBean.

Triggers need to be scheduled. Spring offers a SchedulerFactoryBean exposing properties to set the triggers. The SchedulerFactoryBean schedules the actual triggers.

A couple of examples:

```xml
<bean id="simpleTrigger" class="org.springframework.scheduling.quartz.SimpleTriggerBean">
  <property name="jobDetail">
    <!-- see the example of method invoking job above -->
    <ref bean="methodInvokingJobDetail"/>
  </property>
  <property name="startDelay">
    <!-- 10 seconds -->
    <value>10000</value>
  </property>
  <property name="repeatInterval">
    <!-- repeat every 50 seconds -->
    <value>50000</value>
  </property>
</bean>

<bean id="cronTrigger" class="org.springframework.scheduling.quartz.CronTriggerBean">
  <property name="jobDetail">
    <ref bean="exampleJob"/>
  </property>
  <property name="cronExpression">
    <!-- run every morning at 6 am -->
    <value>0 6 * * 1</value>
  </property>
</bean>
```

Ok, now we’ve set up two triggers, one running every 50 seconds with a starting delay of 10 seconds and one every morning at 6. To finalize everything we need to set up the SchedulerFactoryBean:

```xml
<bean class="org.springframework.scheduling.quartz.SchedulerFactoryBean">
  <property name="triggers">
    <list>
      <ref local="cronTrigger"/>
      <ref local="simpleTrigger"/>
    </list>
  </property>
</bean>
```

More properties are available for the SchedulerFactoryBean for you to set, such as the Calendars used by the job details, properties to customize Quartz with, etcetera. Have a look at the JavaDoc (http://www.springframework.org/docs/api/org/springframework/scheduling/quartz/SchedulerFactoryBean.html) for more information.

18.3. Using JDK Timer support

The other way to schedule jobs is using the JDK Timer objects. More information about Timers themselves can be found at http://java.sun.com/docs/books/tutorial/essential/threads/timer.html. The concepts discussed above
also apply to the Timer support. You can create custom timers or use the timer that invokes methods. Wiring timers has to be done using the TimerFactoryBean.

18.3.1. Creating custom timers

Using the TimerTask you can create customer timer tasks, similar to Quartz jobs:

```java
public class CheckEmailAddresses extends TimerTask {
    private List emailAddresses;
    public void setEmailAddresses(List emailAddresses) {
        this.emailAddresses = emailAddresses;
    }
    public void run() {
        // iterate over all email addresses and archive them
    }
}
```

Wiring it up is simple:

```xml
<bean id="checkEmail" class="examples.CheckEmailAddress">
    <property name="emailAddresses">
        <list>
            <value>test@springframework.org</value>
            <value>foo@bar.com</value>
            <value>john@doe.net</value>
        </list>
    </property>
</bean>

<bean id="scheduledTask" class="org.springframework.scheduling.timer.ScheduledTimerTask">
    <!-- wait 10 seconds before starting repeated execution -->
    <property name="delay">
        <value>10000</value>
    </property>
    <!-- run every 50 seconds -->
    <property name="period">
        <value>50000</value>
    </property>
    <property name="timerTask">
        <ref local="checkEmail"/>
    </property>
</bean>
```

18.3.2. Using the MethodInvokingTimerTaskFactoryBean

Similar to the Quartz support, the Timer support also features a component that allows you to periodically invoke a method:

```xml
<bean id="methodInvokingTask" class="org.springframework.scheduling.timer.MethodInvokingTimerTaskFactoryBean">
    <property name="targetObject">
        <ref bean="exampleBusinessObject"/>
    </property>
    <property name="targetMethod">
        <value>doIt</value>
    </property>
</bean>
```

The above example will result in the doIt being called on the exampleBusinessObject (see below):

```java
public class BusinessObject {
}
```
Changing the reference of the above example in which the ScheduledTimerTask is mentioned to the `methodInvokingTask` will result in this task being executed.

### 18.3.3. Wrapping up: setting up the tasks using the TimerFactoryBean

The TimerFactoryBean is similar to the Quartz SchedulerFactoryBean in that it serves the same purpose: setting up the actual scheduling. The TimerFactoryBean sets up an actual Timer and schedules the tasks it has references to. You can specify whether or not daemon threads should be used.

```xml
<bean id="timerFactory" class="org.springframework.scheduling.timer.TimerFactoryBean">
  <property name="scheduledTimerTasks">
    <!-- see the example above -->
    <list>
      <ref local="scheduledTask"/>
    </list>
  </property>
</bean>
```

That's all!
Appendix A. Spring's beans.dtd

<?xml version="1.0" encoding="UTF-8"?>
<!--
Spring XML Beans DTD
Authors: Rod Johnson, Juergen Hoeller, Alef Arendsen, Colin Sampaleanu

This defines a simple and consistent way of creating a namespace
of JavaBeans objects, configured by a Spring BeanFactory, read by
a DefaultXmlBeanDefinitionReader.

This document type is used by most Spring functionality, including
web application contexts, which are based on bean factories.

Each "bean" element in this document defines a JavaBean.
Typically the bean class is specified, along with JavaBean properties
and/or constructor arguments.

Bean instances can be "singletons" (shared instances) or "prototypes"
(independent instances). Further scopes are supposed to be built on top
of the core BeanFactory infrastructure and are therefore not part of it.

References among beans are supported, i.e. setting a JavaBean property
or a constructor argument to refer to another bean in the same factory
(or an ancestor factory).

As alternative to bean references, "inner bean definitions" can be used.
Singleton flags of such inner bean definitions are effectively ignored:
Inner beans are typically anonymous prototypes.

There is also support for lists, sets, maps, and java.util.Properties
as bean property types respectively constructor argument types.

As the format is simple, a DTD is sufficient, and there's no need
for a schema at this point.

XML documents that conform to this DTD should declare the following doctype:

<!DOCTYPE beans PUBLIC "-/SPRING/DTD BEAN//EN"
"http://www.springframework.org/dtd/spring-beans.dtd">
$Id: dtd.xml,v 1.9 2005/01/01 20:04:48 colins Exp $
-->

<!--
The document root. A document can contain bean definitions only,
imports only, or a mixture of both (typically with imports first).
-->
<!ELEMENT beans (description?,
import*,
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">

<!--
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)>

<!--
Specifies an XML bean definition resource to import.
-->

The relative resource location of the XML bean definition file to import, for example "myImport.xml" or "includes/myImport.xml" or ".../myImport.xml".

Defines a single named bean.

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 is given, the bean class name is used as id (with an appended counter like "#2" if there is already a bean with that name).

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.

Each bean definition must specify the fully qualified name of the class, except if it purely serves as parent for child bean definitions.

Optionally specify a parent bean definition.

Will use the bean class of the parent if none specified, but can also override it. In the latter case, the child bean class must be compatible with the parent, i.e. accept the parent's property values and constructor argument values, if any.

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

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

Is this bean "abstract", i.e. not meant to be instantiated itself but rather just serving as parent for concrete child bean definitions. Default is false. Specify true to tell the bean factory to not try to instantiate that particular bean in any case.

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.
<!-- 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: -->

<!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. -->

<!ATTLIST bean dependency-check (none | objects | simple | all | default) "default">

<!-- The names of the beans that this bean depends on being initialized. 
The bean factory will guarantee that these beans get initialized before. 
Note that dependencies are normally expressed through bean properties or 
constructor arguments. This property should just be necessary for other kinds 
of dependencies like statics (*ugh*) or database preparation on startup. -->

<!ATTLIST bean depends-on CDATA #IMPLIED>

<!-- Optional attribute for the name of the custom initialization method 
to invoke after setting bean properties. The method must have no arguments, 
but may throw any exception. -->

<!ATTLIST bean init-method CDATA #IMPLIED>
<!-- Optional attribute for the name of the custom destroy method to invoke on bean factory shutdown. The method must have no arguments, but may throw any exception. Note: Only invoked on singleton beans! -->

<!ATTLIST bean destroy-method CDATA #IMPLIED>

<!-- Optional attribute specifying the name of a factory method to use to create this object. Use constructor-arg elements to specify arguments to the factory method, if it takes arguments. Autowiring does not apply to factory methods. 

If the "class" attribute is present, the factory method will be a static method on the class specified by the "class" attribute on this bean definition. Often this will be the same class as that of the constructed object - for example, when the factory method is used as an alternative to a constructor. However, it may be on a different class. In that case, the created object will "not" be of the class specified in the "class" attribute. This is analogous to FactoryBean behavior. 

If the "factory-bean" attribute is present, the "class" attribute is not used, and the factory method will be an instance method on the object returned from a getBean call with the specified bean name. The factory bean may be defined as a singleton or a prototype. 

The factory method can have any number of arguments. Autowiring is not supported. Use indexed constructor-arg elements in conjunction with the factory-method attribute. 

Setter Injection can be used in conjunction with a factory method. Method Injection cannot, as the factory method returns an instance, which will be used when the container creates the bean. -->

<!ATTLIST bean factory-method CDATA #IMPLIED>

<!-- Alternative to class attribute for factory-method usage. If this is specified, no class attribute should be used. This should be set to the name of a bean in the current or ancestor factories that contains the relevant factory method. This allows the factory itself to be configured using Dependency Injection, and an instance (rather than static) method to be used. -->

<!ATTLIST bean factory-bean CDATA #IMPLIED>

<!-- Bean definitions can specify zero or more constructor arguments. This is an alternative to "autowire constructor". Arguments correspond to either a specific index of the constructor argument list or are supposed to be matched generically by type. Note: A single generic argument value will just be used once, rather than potentially matched multiple times (as of Spring 1.1). constructor-arg elements are also used in conjunction with the factory-method element to construct beans using static or instance factory methods. -->

<!ELEMENT constructor-arg (description?, (bean | ref | idref | list | set | map | props | value | null))>

<!-- The constructor-arg tag can have an optional index attribute, to specify the exact index in the constructor argument list. Only needed to avoid ambiguities, e.g. in case of 2 arguments of the same type. 

NOTE: it is highly recommended to use the index attribute, in Spring up to and including 1.1. The constructor matcher is extremely greedy in matching args without an index, to the point of duplicating supplied args to fill in unspecified constructor args, if they are compatible (i.e. one single String arg will match a constructor with two String args, etc.). The matcher should be less aggressive in a future version. -->

<!ATTLIST constructor-arg index CDATA #IMPLIED>

<!-- The constructor-arg tag can have an optional type attribute, -->
to specify the exact type of the constructor argument. Only needed to avoid ambiguities, e.g. in case of 2 single argument constructors that can both be converted from a String.

--> <!ATTLIST constructor-arg type CDATA #IMPLIED>

<!-- Bean definitions can have zero or more properties. Property elements correspond to JavaBean setter methods exposed by the bean classes. Spring supports primitives, references to other beans in the same or related factories, lists, maps and properties. -->

<!ELEMENT property (description?, (bean | ref | idref | list | set | map | props | value | null))>

<!-- The property name attribute is the name of the JavaBean property. This follows JavaBean conventions: a name of "age" would correspond to setAge()/optional getAge() methods. -->

<!ATTLIST property name CDATA #REQUIRED>

<!-- A lookup method causes the IoC container to override the given method and return the bean with the name given in the bean attribute. This is a form of Method Injection. It's particularly useful as an alternative to implementing the BeanFactoryAware interface, in order to be able to make getBean() calls for non-singleton instances at runtime. In this case, Method Injection is a less invasive alternative. -->

<!ELEMENT lookup-method EMPTY>

<!-- Name of a lookup method. This method should take no arguments. -->

<!ATTLIST lookup-method name CDATA #IMPLIED>

<!-- Similar to the lookup method mechanism, the replaced-method element is used to control IoC container method overriding: Method Injection. This mechanism allows the overriding of a method with arbitrary code. -->

<!ELEMENT replaced-method (arg-type)>

<!-- Name of the method whose implementation should be replaced by the IoC container. If this method is not overloaded, there's no need to use arg-type sub-elements. If this method is overloaded, arg-type sub-elements must be used for all override definitions for the method. -->

<!ATTLIST replaced-method name CDATA #IMPLIED>

<!ELEMENT replaced-method replacer CDATA #IMPLIED>

<!-- Bean name of an implementation of the MethodReplacer interface in the current or ancestor factories. This may be a singleton or prototype bean. If it's a prototype, a new instance will be used for each method replacement. Singleton usage is the norm. -->

<!ATTLIST replaced-method replacer CDATA #IMPLIED>

<!-- Sub-element of replaced-method identifying an argument for a replaced method in the event of method overloading. -->

<!ELEMENT arg-type (#PCDATA)>

<!-- Specification of the type of an overloaded method argument as a String. For convenience, this may be a substring of the FQN. E.g. all the following would match "java.lang.String":
- java.lang.String
- String
- Str -->
As the number of arguments will be checked also, this convenience can often be used to save typing.

```
<!ATTLIST arg-type match CDATA #IMPLIED>
```

Name of the bean in the current or ancestor factories that the lookup method should resolve to. Often this bean will be a prototype, in which case the lookup method will return a distinct instance on every invocation. This is useful for single-threaded objects.

```
<!ATTLIST lookup-method bean CDATA #IMPLIED>
```

Defines a reference to another bean in this factory or an external factory (parent or included factory).

```
<!ELEMENT ref EMPTY>
```

References must specify a name of the target bean. The "bean" attribute can reference any name from any bean in the context, to be checked at runtime. Local references, using the "local" attribute, have to use bean ids; they can be checked by this DTD, thus should be preferred for references within the same bean factory XML file.

```
<!ATTLIST ref bean CDATA #IMPLIED>
<!ATTLIST ref local IDREF #IMPLIED>
<!ATTLIST ref parent CDATA #IMPLIED>
```

Defines a string property value, which must also be the id of another bean in this factory or an external factory (parent or included factory). While a regular 'value' element could instead be used for the same effect, using idref in this case allows validation of local bean ids by the xml parser, and name completion by helper tools.

```
<!ELEMENT idref EMPTY>
```

ID refs must specify a name of the target bean. The "bean" attribute can reference any name from any bean in the context, potentially to be checked at runtime by bean factory implementations. Local references, using the "local" attribute, have to use bean ids; they can be checked by this DTD, thus should be preferred for references within the same bean factory XML file.

```
<!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 the BeanFactory.

```
<!ELEMENT list (bean | ref | idref | list | set | map | props | value | null)*
```

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 | null)*
```

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.

Each map element must specify its key.

Props elements differ from map elements in that values must be strings. Props may be empty.

Element content is the string value of the property. Note that whitespace is trimmed off to avoid unwanted whitespace caused by typical XML formatting.

Contains a string representation of a property value. The property may be a string, or may be converted to the required type using the JavaBeans PropertyEditor machinery. This makes it possible for application developers to write custom PropertyEditor implementations that can convert strings to objects.

Note that this is recommended for simple objects only. Configure more complex objects by populating JavaBean properties with references to other beans.

Denotes a Java null value. Necessary because an empty "value" tag will resolve to an empty String, which will not be resolved to a null value unless a special PropertyEditor does so.