TEAM: FAST TRACKERS MEMBERS:

AMRUTHA M NAIR 245138
JENSON MATHEW 245048
ANIRUDH G 245099
BLESSON JOHN ABRAHAM 245045

SPRING AOP AND SPRING MVC

SPRING AOP

Introduction

AOP is a programming paradigm that aims to increase modularity by allowing the separation of cross-cutting concerns. It does this by adding additional behaviour to existing code without modifying the code itself. Instead, we can declare the new code and the new behaviours separately. Spring's AOP framework helps us implement these cross-cutting concerns.

Aspect-Oriented Programming (AOP) complements Object-Oriented Programming (OOP) by providing another way of thinking about program structure. The key unit of modularity in OOP is the class, whereas in AOP the unit of modularity is the *aspect*. Aspects enable the modularization of concerns such as transaction management that cut across multiple types and objects. (Such concerns are often termed *crosscutting* concerns in AOP literature.)

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

AOP is used in the Spring Framework to...

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

AOP Concepts and Terminology

Let us begin by defining some central AOP concepts and terminology. These terms are not Spring-specific... unfortunately, AOP terminology is not particularly intuitive; however, it would be even more confusing if Spring used its own terminology.

- *Aspect*: a modularization of a concern that cuts across multiple classes. Transaction management is a good example of a crosscutting concern in J2EE applications. In Spring AOP, aspects are implemented using regular classes (the schema-based approach) or regular classes annotated with the @Aspect annotation (the @AspectJ style).
- *Join point*: a point during the execution of a program, such as the execution of a method or the handling of an exception. In Spring AOP, a join point *always* represents a method execution.
- *Advice*: action taken by an aspect at a particular join point. Different types of advice include "around," "before" and "after" advice. (Advice types are discussed below.) Many AOP frameworks, including Spring, model an advice as an *interceptor*, maintaining a chain of interceptors *around* the join point.
- *Pointcut*: a predicate that matches join points. Advice is associated with a pointcut expression and runs at any join point matched by the pointcut (for example, the execution of a method with a certain name). The concept of join points as matched by pointcut expressions is central to AOP, and Spring uses the AspectJ pointcut expression language by default.
- *Introduction*: declaring additional methods or fields on behalf of a type. Spring AOP allows you to introduce new interfaces (and a corresponding implementation) to any advised object. For example, you could use an introduction to make a bean implement an IsModified interface, to simplify caching. (An introduction is known as an inter-type declaration in the AspectJ community.)
- *Target object*: object being advised by one or more aspects. Also referred to as the *advised* object. Since Spring AOP is implemented using runtime proxies, this object will always be a *proxied* object.
- *AOP proxy*: an object created by the AOP framework in order to implement the aspect contracts (advise method executions and so on). In the Spring Framework, an AOP proxy will be a JDK dynamic proxy or a CGLIB proxy.

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

Types of advice:

- *Before advice*: Advice that executes before a join point, but which does not have the ability to prevent execution flow proceeding to the join point (unless it throws an exception).
- *After returning advice*: Advice to be executed after a join point completes normally: for example, if a method returns without throwing an exception.
- *After throwing advice*: Advice to be executed if a method exits by throwing an exception.
- *After (finally) advice*: Advice to be executed regardless of the means by which a join point exits (normal or exceptional return).
- *Around advice*: Advice that surrounds a join point such as a method invocation. This is the most powerful kind of advice. Around advice can perform custom behavior before and after the method invocation. It is also responsible for choosing whether to proceed to the join point or to shortcut the advised method execution by returning its own return value or throwing an exception.

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

In Spring 2.0, all advice parameters are statically typed, so that you work with advice parameters of the appropriate type (the type of the return value from a method execution for example) rather than Object arrays.

The concept of join points, matched by pointcuts, is the key to AOP which distinguishes it from older technologies offering only interception. Pointcuts enable advice to be targeted independently of the Object-Oriented hierarchy. For example, an around advice providing declarative transaction management

can be applied to a set of methods spanning multiple objects (such as all business operations in the service layer).

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 AOP currently supports only method execution join points (advising the execution of methods on Spring beans). Field interception is not implemented, although support for field interception could be added without breaking the core Spring AOP APIs. If you need to advise field access and update join points, consider a language such as AspectJ.

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

Thus, for example, the Spring Framework's AOP functionality is normally used in conjunction with the Spring IoC container. Aspects are configured using normal bean definition syntax (although this allows powerful "autoproxying" capabilities): this is a crucial difference from other AOP implementations. There are some things you cannot do easily or efficiently with Spring AOP, such as advise very fine-grained objects (such as domain objects typically): AspectJ is the best choice in such cases. However, our experience is that Spring AOP provides an excellent solution to most problems in J2EE applications that are amenable to AOP.

Spring AOP will never strive to compete with AspectJ to provide a comprehensive AOP solution. We believe that both proxy-based frameworks like Spring AOP and full-blown frameworks such as AspectJ are valuable, and that they are complementary, rather than in competition. Spring 2.0 seamlessly integrates Spring AOP and IoC with AspectJ, to enable all uses of AOP to be catered for within a consistent Spring-based application architecture. This integration does not affect the Spring AOP API or the AOP Alliance API: Spring AOP remains backward-compatible. See the following chapter for a discussion of the Spring AOP APIs.

@AspectJ support

@AspectJ refers to a style of declaring aspects as regular Java classes annotated with Java 5 annotations. The @AspectJ style was introduced by the AspectJ project as part of the AspectJ 5 release. Spring 2.0 interprets the same annotations as AspectJ 5, using a library supplied by AspectJ for pointcut parsing and matching. The AOP runtime is still pure Spring AOP though, and there is no dependency on the AspectJ compiler or weaver

Enabling @AspectJ Support

To use @AspectJ aspects in a Spring configuration you need to enable Spring support for configuring Spring AOP based on @AspectJ aspects, and *autoproxying* beans based on whether or not they are advised by those aspects. By autoproxying we mean that if Spring determines that a bean is advised by one or more aspects, it will automatically generate a proxy for that bean to intercept method invocations and ensure that advice is executed as needed.

The @AspectJ support is enabled by including the following element inside your spring configuration:

```
<aop:aspectj-autoproxy/>
```

You will also need two AspectJ libraries on the classpath of your application: aspectjweaver.jar and aspectjrt.jar. These libraries are available in the 'lib' directory of an AspectJ installation (version 1.5.1 or later required), or in the 'lib/aspectj' directory of the Spring-with-dependencies distribution.

Declaring an aspect

With the @AspectJ support enabled, any bean defined in your application context with a class that is an @AspectJ aspect (has the @Aspect annotation) will be automatically detected by Spring and used to configure Spring AOP. The following example shows the minimal definition required for a not-very-useful aspect:

A regular bean definition in the application context, pointing to a bean class that has the @Aspect annotation:

```
<bean id="myAspect" class="org.xyz.NotVeryUsefulAspect">
  <!-- configure properties of aspect here as normal -->
</bean>
```

And the NotVeryUsefulAspect class definition, annotated with org.aspectj.lang.annotation.Aspect annotation;

```
package org.xyz;
import org.aspectj.lang.annotation.Aspect;

@Aspect
public class NotVeryUsefulAspect {

}
```

Aspects (classes annotated with @Aspect) may have methods and fields just like any other class. They may also contain pointcut, advice, and introduction (inter-type) declarations.

Declaring a pointcut

Recall that pointcuts determine join points of interest, and thus enable us to control when advice executes. *Spring AOP only supports method execution join points for Spring beans*, so you can think of a pointcut as matching the execution of methods on Spring beans. A pointcut declaration has two parts: a signature comprising a name and any parameters, and a pointcut expression that determines *exactly* which method executions we are interested in. In the @AspectJ annotation-style of AOP, a pointcut signature is provided by a regular method definition, and the pointcut expression is indicated using the @Pointcut annotation (the method serving as the pointcut signature *must* have a void return type).

An example will help make this distinction between a pointcut signature and a pointcut expression clear. The following example defines a pointcut named 'anyOldTransfer' that will match the execution of any method named 'transfer':

```
@Pointcut("execution(* transfer(..))")// the pointcut expression
private void anyOldTransfer() {}// the pointcut signature
```

Supported Pointcut Designators

Spring AOP supports the following AspectJ pointcut designators (PCD) for use in pointcut expressions:

- *execution* - for matching method execution join points, this is the primary pointcut designator you will use when working with Spring AOP

- *within* - limits matching to join points within certain types (simply the execution of a method declared within a matching type when using Spring AOP)
- *this* - limits matching to join points (the execution of methods when using Spring AOP) where the bean reference (Spring AOP proxy) is an instance of the given type
- *target* - limits matching to join points (the execution of methods when using Spring AOP) where the target object (application object being proxied) is an instance of the given type
- *args* - limits matching to join points (the execution of methods when using Spring AOP) where the arguments are instances of the given types
- *@target* - limits matching to join points (the execution of methods when using Spring AOP) where the class of the executing object has an annotation of the given type
- *@args* - limits matching to join points (the execution of methods when using Spring AOP) where the runtime type of the actual arguments passed have annotations of the given type(s)
- *@within* - limits matching to join points within types that have the given annotation (the execution of methods declared in types with the given annotation when using Spring AOP)
- *@annotation* - limits matching to join points where the subject of the join point (method being executed in Spring AOP) has the given annotation

Because Spring AOP limits matching to only method execution join points, the discussion of the pointcut designators above gives a narrower definition than you will find in the AspectJ programming guide. In addition, AspectJ itself has type-based semantics and at an execution join point both 'this' and 'target' refer to the same object - the object executing the method. Spring AOP is a proxy-based system and differentiates between the proxy object itself (bound to 'this') and the target object behind the proxy (bound to 'target').

Spring AOP also supports an additional PCD named 'bean'. This PCD allows you to limit the matching of join points to a particular named Spring bean, or to a set of named Spring beans (when using wildcards). The 'bean' PCD has the following form:

```
bean(idOrNameOfBean)
```

The 'idOrNameOfBean' token can be the name of any Spring bean: limited wildcard support using the '*' character is provided, so if you establish some naming conventions for your Spring beans you can quite easily write a 'bean'

PCD expression to pick them out. As is the case with other pointcut designators, the 'bean' PCD can be &&'ed, ||'ed, and ! (negated) too.

Combining pointcut expressions

Pointcut expressions can be combined using '&&', '||' and '!'. It is also possible to refer to pointcut expressions by name. The following example shows three pointcut expressions: anyPublicOperation (which matches if a method execution join point represents the execution of any public method); inTrading (which matches if a method execution is in the trading module), and tradingOperation (which matches if a method execution represents any public method in the trading module).

```
@Pointcut("execution(public * *(..))")
private void anyPublicOperation() {}

@Pointcut("within(com.xyz.someapp.trading..*)")
private void inTrading() {}

@Pointcut("anyPublicOperation() && inTrading()")
private void tradingOperation() {}
```

It is a best practice to build more complex pointcut expressions out of smaller named components as shown above. When referring to pointcuts by name, normal Java visibility rules apply (you can see private pointcuts in the same type, protected pointcuts in the hierarchy, public pointcuts anywhere and so on). Visibility does not affect pointcut *matching*.

Examples

Spring AOP users are likely to use the execution pointcut designator the most often. The format of an execution expression is:

```
execution(modifiers-pattern? ret-type-pattern declaring-type-pattern? name-pattern(param-pattern)
        throws-pattern?)
```

All parts except the returning type pattern (ret-type-pattern in the snippet above), name pattern, and parameters pattern are optional. The returning type pattern determines what the return type of the method must be in order for a join point to be matched. Most frequently you will use * as the returning type pattern, which matches any return type. A fully-qualified type name will match only when the method returns the given type. The name pattern matches the method name. You can use the * wildcard as all or part of a name pattern. The

parameters pattern is slightly more complex: () matches a method that takes no parameters, whereas (..) matches any number of parameters (zero or more). The pattern (*) matches a method taking one parameter of any type, (*,String) matches a method taking two parameters, the first can be of any type, the second must be a String. Consult the Language Semantics section of the AspectJ Programming Guide for more information.

Some examples of common pointcut expressions are given below.

- the execution of any public method:

```
execution(public * *(..))
```

- the execution of any method with a name beginning with "set":

```
execution(* set*(..))
```

- the execution of any method defined by the AccountService interface:

```
execution(* com.xyz.service.AccountService.*(..))
```

- the execution of any method defined in the service package:

```
execution(* com.xyz.service.*.*(..))
```

- the execution of any method defined in the service package or a sub-package:

```
execution(* com.xyz.service..*.*(..))
```

- any join point (method execution only in Spring AOP) within the service package:

```
within(com.xyz.service.*)
```

- any join point (method execution only in Spring AOP) within the service package or a sub-package:

```
within(com.xyz.service..*)
```

- any join point (method execution only in Spring AOP) where the proxy implements the AccountService interface:

```
this(com.xyz.service.AccountService)
```

'this' is more commonly used in a binding form :- see the following section on advice for how to make the proxy object available in the advice body.

- any join point (method execution only in Spring AOP) where the target object implements the AccountService interface:

```
target(com.xyz.service.AccountService)
```

'target' is more commonly used in a binding form :- see the following section on advice for how to make the target object available in the advice body.

- any join point (method execution only in Spring AOP) which takes a single parameter, and where the argument passed at runtime is Serializable:

```
args(java.io.Serializable)
```

'args' is more commonly used in a binding form :- see the following section on advice for how to make the method arguments available in the advice body.

Note that the pointcut given in this example is different to execution(* *(java.io.Serializable)): the args version matches if the argument passed at runtime is Serializable, the execution version matches if the method signature declares a single parameter of type Serializable.

- any join point (method execution only in Spring AOP) where the target object has an @Transactional annotation:

```
@target(org.springframework.transaction.annotation.Transactional)
```

'@target' can also be used in a binding form :- see the following section on advice for how to make the annotation object available in the advice body.

- any join point (method execution only in Spring AOP) where the declared type of the target object has an @Transactional annotation:

```
@within(org.springframework.transaction.annotation.Transactional)
```

'@within' can also be used in a binding form :- see the following section on advice for how to make the annotation object available in the advice body.

- any join point (method execution only in Spring AOP) where the executing method has an @Transactional annotation:

```
@annotation(org.springframework.transaction.annotation.Transactional
)
```

'@annotation' can also be used in a binding form :- see the following section on advice for how to make the annotation object available in the advice body.

- any join point (method execution only in Spring AOP) which takes a single parameter, and where the runtime type of the argument passed has the @Classified annotation:

```
@args(com.xyz.security.Classified)
```

'@args' can also be used in a binding form :- see the following section on advice for how to make the annotation object(s) available in the advice body.

- any join point (method execution only in Spring AOP) on a Spring bean named 'tradeService':

```
bean(tradeService)
```

- any join point (method execution only in Spring AOP) on Spring beans having names that match the wildcard expression '*Service':

```
bean(*Service)
```

Declaring advice

Advice is associated with a pointcut expression, and runs before, after, or around method executions matched by the pointcut. The pointcut expression may be either a simple reference to a named pointcut, or a pointcut expression declared in place.

Before advice

Before advice is declared in an aspect using the @Before annotation:

```
import org.aspectj.lang.annotation.Aspect;
import org.aspectj.lang.annotation.Before;

@Aspect
public class BeforeExample {

 @Before("com.xyz.myapp.SystemArchitecture.dataAccessOperation()")
 public void doAccessCheck() {
  // ...
 }
```

```
}
```

If using an in-place pointcut expression we could rewrite the above example as:

```
import org.aspectj.lang.annotation.Aspect;
import org.aspectj.lang.annotation.Before;

@Aspect
public class BeforeExample {

  @Before("execution(* com.xyz.myapp.dao.*.*(..))")
  public void doAccessCheck() {
    // ...
  }

}
```

After returning advice

After returning advice runs when a matched method execution returns normally. It is declared using the @AfterReturning annotation:

```
import org.aspectj.lang.annotation.Aspect;
import org.aspectj.lang.annotation.AfterReturning;

@Aspect
public class AfterReturningExample {


@AfterReturning("com.xyz.myapp.SystemArchitecture.dataAccessOperation()"
)
  public void doAccessCheck() {
    // ...
  }

}
```

Note: it is of course possible to have multiple advice declarations, and other members as well, all inside the same aspect. We're just showing a single advice declaration in these examples to focus on the issue under discussion at the time.

Sometimes you need access in the advice body to the actual value that was returned. You can use the form of @AfterReturning that binds the return value for this:

```
import org.aspectj.lang.annotation.Aspect;
import org.aspectj.lang.annotation.AfterReturning;

@Aspect
public class AfterReturningExample {

  @AfterReturning(
    pointcut="com.xyz.myapp.SystemArchitecture.dataAccessOperation()",
    returning="retVal")
  public void doAccessCheck(Object retVal) {
    // ...
  }

}
```

The name used in the returning attribute must correspond to the name of a parameter in the advice method. When a method execution returns, the return value will be passed to the advice method as the corresponding argument value. A returning clause also restricts matching to only those method executions that return a value of the specified type (Object in this case, which will match any return value).

Please note that it is *not* possible to return a totally different reference when using after-returning advice.

After throwing advice

After throwing advice runs when a matched method execution exits by throwing an exception. It is declared using the @AfterThrowing annotation:

```
import org.aspectj.lang.annotation.Aspect;
import org.aspectj.lang.annotation.AfterThrowing;

@Aspect
public class AfterThrowingExample {


@AfterThrowing("com.xyz.myapp.SystemArchitecture.dataAccessOperation()"
)
```

```
  public void doRecoveryActions() {
   // ...
  }

}
```

Often you want the advice to run only when exceptions of a given type are thrown, and you also often need access to the thrown exception in the advice body. Use the throwing attribute to both restrict matching (if desired, use Throwable as the exception type otherwise) and bind the thrown exception to an advice parameter.

```
import org.aspectj.lang.annotation.Aspect;
import org.aspectj.lang.annotation.AfterThrowing;

@Aspect
public class AfterThrowingExample {

  @AfterThrowing(
    pointcut="com.xyz.myapp.SystemArchitecture.dataAccessOperation()",
    throwing="ex")
  public void doRecoveryActions(DataAccessException ex) {
   // ...
  }

}
```

The name used in the throwing attribute must correspond to the name of a parameter in the advice method. When a method execution exits by throwing an exception, the exception will be passed to the advice method as the corresponding argument value. A throwing clause also restricts matching to only those method executions that throw an exception of the specified type (DataAccessException in this case).

After (finally) advice

After (finally) advice runs however a matched method execution exits. It is declared using the @After annotation. After advice must be prepared to handle both normal and exception return conditions. It is typically used for releasing resources, etc.

```
import org.aspectj.lang.annotation.Aspect;
```

```
import org.aspectj.lang.annotation.After;

@Aspect
public class AfterFinallyExample {

  @After("com.xyz.myapp.SystemArchitecture.dataAccessOperation()")
  public void doReleaseLock() {
    // ...
  }

}
```

Around advice

The final kind of advice is around advice. Around advice runs "around" a matched method execution. It has the opportunity to do work both before and after the method executes, and to determine when, how, and even if, the method actually gets to execute at all. Around advice is often used if you need to share state before and after a method execution in a thread-safe manner (starting and stopping a timer for example). Always use the least powerful form of advice that meets your requirements (i.e. don't use around advice if simple before advice would do).

Around advice is declared using the @Around annotation. The first parameter of the advice method must be of type ProceedingJoinPoint. Within the body of the advice, calling proceed() on the ProceedingJoinPoint causes the underlying method to execute. The proceed method may also be called passing in an Object[] - the values in the array will be used as the arguments to the method execution when it proceeds.

The behavior of proceed when called with an Object[] is a little different than the behavior of proceed for around advice compiled by the AspectJ compiler. For around advice written using the traditional AspectJ language, the number of arguments passed to proceed must match the number of arguments passed to the around advice (not the number of arguments taken by the underlying join point), and the value passed to proceed in a given argument position supplants the original value at the join point for the entity the value was bound to (Don't worry if this doesn't make sense right now!). The approach taken by Spring is simpler and a better match to its proxy-based, execution only semantics. You only need to be aware of this difference if you are compiling @AspectJ aspects written for Spring and using proceed with arguments with

the AspectJ compiler and weaver. There is a way to write such aspects that is 100% compatible across both Spring AOP and AspectJ, and this is discussed in the following section on advice parameters.

```
import org.aspectj.lang.annotation.Aspect;
import org.aspectj.lang.annotation.Around;
import org.aspectj.lang.ProceedingJoinPoint;

@Aspect
public class AroundExample {

  @Around("com.xyz.myapp.SystemArchitecture.businessService()")
  public Object doBasicProfiling(ProceedingJoinPoint pjp) throws Throwable {
    // start stopwatch
    Object retVal = pjp.proceed();
    // stop stopwatch
    return retVal;
  }

}
```

The value returned by the around advice will be the return value seen by the caller of the method. A simple caching aspect for example could return a value from a cache if it has one, and invoke proceed() if it does not. Note that proceed may be invoked once, many times, or not at all within the body of the around advice, all of these are quite legal.

Choosing which AOP declaration style to use

Once you have decided that an aspect is the best approach for implementing a given requirement, how do you decide between using Spring AOP or AspectJ, and between the Aspect language (code) style, @AspectJ annotation style, or the Spring XML style? These decisions are influenced by a number of factors including application requirements, development tools, and team familiarity with AOP.

Spring AOP or full AspectJ?

Use the simplest thing that can work. Spring AOP is simpler than using full AspectJ as there is no requirement to introduce the AspectJ compiler / weaver into your development and build processes. If you only need to advise the execution of operations on Spring beans, then Spring AOP is the right choice. If you need to advise objects not managed by the Spring container (such as domain

objects typically), then you will need to use AspectJ. You will also need to use AspectJ if you wish to advise join points other than simple method executions (for example, field get or set join points, and so on).

When using AspectJ, you have the choice of the AspectJ language syntax (also known as the "code style") or the @AspectJ annotation style. Clearly, if you are not using Java 5+ then the choice has been made for you... use the code style. If aspects play a large role in your design, and you are able to use the AspectJ Development Tools (AJDT) plugin for Eclipse, then the AspectJ language syntax is the preferred option: it is cleaner and simpler because the language was purposefully designed for writing aspects. If you are not using Eclipse, or have only a few aspects that do not play a major role in your application, then you may want to consider using the @AspectJ style and sticking with a regular Java compilation in your IDE, and adding an aspect weaving phase to your build script.

@AspectJ or XML for Spring AOP?

If you have chosen to use Spring AOP, then you have a choice of @AspectJ or XML style. Clearly if you are not running on Java 5+, then the XML style is the appropriate choice; for Java 5 projects there are various tradeoffs to consider.

The XML style will be most familiar to existing Spring users. It can be used with any JDK level (referring to named pointcuts from within pointcut expressions does still require Java 5+ though) and is backed by genuine POJOs. When using AOP as a tool to configure enterprise services then XML can be a good choice (a good test is whether you consider the pointcut expression to be a part of your configuration you might want to change independently). With the XML style arguably it is clearer from your configuration what aspects are present in the system.

The XML style has two disadvantages. Firstly it does not fully encapsulate the implementation of the requirement it addresses in a single place. The DRY principle says that there should be a single, unambiguous, authoritative representation of any piece of knowledge within a system. When using the XML style, the knowledge of *how* a requirement is implemented is split across the declaration of the backing bean class, and the XML in the configuration file. When using the @AspectJ style there is a single module - the aspect - in which this information is encapsulated. Secondly, the XML style is slightly more limited in what it can express than the @AspectJ style: only the "singleton" aspect instantiation model is supported, and it is not possible to combine named pointcuts declared in XML. For example, in the @AspectJ style you can write something like:

Spring MVC

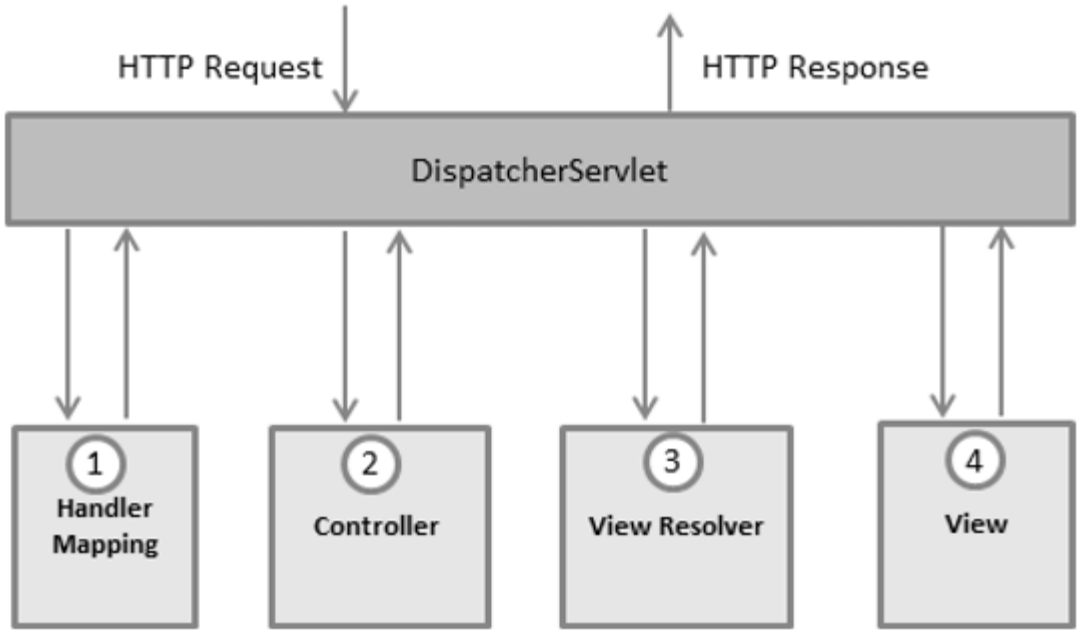
Introduction

The Spring Web MVC framework provides Model-View-Controller (MVC) architecture and ready components that can be used to develop flexible and loosely coupled web applications. The MVC pattern results in separating the different aspects of the application (input logic, business logic, and UI logic), while providing a loose coupling between these elements.

- The **Model** encapsulates the application data and in general they will consist of POJO.
- The **View** is responsible for rendering the model data and in general it generates HTML output that the client's browser can interpret.
- The **Controller** is responsible for processing user requests and building an appropriate model and passes it to the view for rendering.

The DispatcherServlet

The Spring Web model-view-controller (MVC) framework is designed around a *DispatcherServlet* that handles all the HTTP requests and responses. The request processing workflow of the Spring Web MVC *DispatcherServlet* is illustrated in the following diagram –



Following is the sequence of events corresponding to an incoming HTTP request to *DispatcherServlet* –

- After receiving an HTTP request, *DispatcherServlet* consults the *HandlerMapping* to call the appropriate *Controller*.
- The *Controller* takes the request and calls the appropriate service methods based on used GET or POST method. The service method will set model data based on defined business logic and returns view name to the *DispatcherServlet*.
- The *DispatcherServlet* will take help from *ViewResolver* to pickup the defined view for the request.
- Once view is finalized, The *DispatcherServlet* passes the model data to the view which is finally rendered on the browser.

All the above-mentioned components, i.e. HandlerMapping, Controller, and ViewResolver are parts of *WebApplicationContext* which is an extension of the plain*ApplicationContext* with some extra features necessary for web applications.

Required Configuration

You need to map requests that you want the *DispatcherServlet* to handle, by using a URL mapping in the **web.xml** file. The following is an example to show declaration and mapping for **HelloWeb** *DispatcherServlet* example –

```
<web-app id = "WebApp_ID" version = "2.4"
  xmlns = "http://java.sun.com/xml/ns/j2ee"
  xmlns:xsi = "http://www.w3.org/2001/XMLSchema-instance"
  xsi:schemaLocation = "http://java.sun.com/xml/ns/j2ee
  http://java.sun.com/xml/ns/j2ee/web-app_2_4.xsd">

  <display-name>Spring MVC Application</display-name>

  <servlet>
    <servlet-name>HelloWeb</servlet-name>
    <servlet-class>
      org.springframework.web.servlet.DispatcherServlet
    </servlet-class>
    <load-on-startup>1</load-on-startup>
  </servlet>

  <servlet-mapping>
    <servlet-name>HelloWeb</servlet-name>
    <url-pattern>*.jsp</url-pattern>
  </servlet-mapping>

</web-app>
```

The **web.xml** file will be kept in the WebContent/WEB-INF directory of your web application. Upon initialization of **HelloWeb** DispatcherServlet, the framework will try to load the application context from a file named **[servlet-name]-servlet.xml** located in the application's WebContent/WEB-INF directory. In this case, our file will be **HelloWebservlet.xml**.

Next, <servlet-mapping> tag indicates what URLs will be handled by which DispatcherServlet. Here all the HTTP requests ending with **.jsp** will be handled by the **HelloWeb** DispatcherServlet.

If you do not want to go with default filename as *[servlet-name]-servlet.xml* and default location as *WebContent/WEB-INF*, you can customize this file name and location by adding the servlet listener *ContextLoaderListener* in your web.xml file as follows –

```
<web-app...>

  <!-------- DispatcherServlet definition goes here----->
  ....
  <context-param>
    <param-name>contextConfigLocation</param-name>
    <param-value>/WEB-INF/HelloWeb-servlet.xml</param-value>
  </context-param>

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

</web-app>
```

Now, let us check the required configuration for **HelloWeb-servlet.xml** file, placed in your web application's *WebContent/WEB-INF* directory –

```
<beans xmlns = "http://www.springframework.org/schema/beans"
  xmlns:context = "http://www.springframework.org/schema/context"
  xmlns:xsi = "http://www.w3.org/2001/XMLSchema-instance"
  xsi:schemaLocation = "http://www.springframework.org/schema/beans
  http://www.springframework.org/schema/beans/spring-beans-3.0.xsd
  http://www.springframework.org/schema/context
  http://www.springframework.org/schema/context/spring-context-
3.0.xsd">

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

```
  <bean class =
"org.springframework.web.servlet.view.InternalResourceViewResolver">
    <property name = "prefix" value = "/WEB-INF/jsp/" />
    <property name = "suffix" value = ".jsp" />
  </bean>

</beans>
```

Following are the important points about **HelloWeb-servlet.xml** file –

- The *[servlet-name]-servlet.xml* file will be used to create the beans defined, overriding the definitions of any beans defined with the same name in the global scope.
- The *<context:component-scan...>* tag will be use to activate Spring MVC annotation scanning capability which allows to make use of annotations like @Controller and @RequestMapping etc.
- The *InternalResourceViewResolver* will have rules defined to resolve the view names. As per the above defined rule, a logical view named **hello** is delegated to a view implementation located at */WEB-INF/jsp/hello.jsp* .

The following section will show you how to create your actual components, i.e., Controller, Model, and View.

Defining a Controller

The DispatcherServlet delegates the request to the controllers to execute the functionality specific to it. The **@Controller** annotation indicates that a particular class serves the role of a controller. The **@RequestMapping** annotation is used to map a URL to either an entire class or a particular handler method.

```
@Controller
@RequestMapping("/hello")
public class HelloController {
  @RequestMapping(method = RequestMethod.GET)
  public String printHello(ModelMap model) {
    model.addAttribute("message", "Hello Spring MVC Framework!");
```

```
    return "hello";
  }
}
```

The **@Controller** annotation defines the class as a Spring MVC controller. Here, the first usage of **@RequestMapping** indicates that all handling methods on this controller are relative to the **/hello** path. Next annotation **@RequestMapping(method = RequestMethod.GET)** is used to declare the printHello() method as the controller's default service method to handle HTTP GET request. You can define another method to handle any POST request at the same URL.

You can write the above controller in another form where you can add additional attributes in *@RequestMapping* as follows –

```
@Controller
public class HelloController {
  @RequestMapping(value = "/hello", method = RequestMethod.GET)
  public String printHello(ModelMap model) {
    model.addAttribute("message", "Hello Spring MVC Framework!");
    return "hello";
  }
}
```

The **value** attribute indicates the URL to which the handler method is mapped and the **method** attribute defines the service method to handle HTTP GET request. The following important points are to be noted about the controller defined above –

- You will define required business logic inside a service method. You can call another method inside this method as per requirement.
- Based on the business logic defined, you will create a model within this method. You can use setter different model attributes and these attributes will be accessed by the view to present the final result. This example creates a model with its attribute "message".

- A defined service method can return a String, which contains the name of the **view** to be used to render the model. This example returns "hello" as logical view name.

Creating JSP Views

Spring MVC supports many types of views for different presentation technologies. These include - JSPs, HTML, PDF, Excel worksheets, XML, Velocity templates, XSLT, JSON, Atom and RSS feeds, JasperReports, etc. But most commonly we use JSP templates written with JSTL.

Let us write a simple **hello** view in /WEB-INF/hello/hello.jsp –

```
<html>
  <head>
    <title>Hello Spring MVC</title>
  </head>

  <body>
    <h2>${message}</h2>
  </body>
</html>
```

Here **${message}** is the attribute which we have set up inside the Controller. You can have multiple attributes to be displayed inside your view.