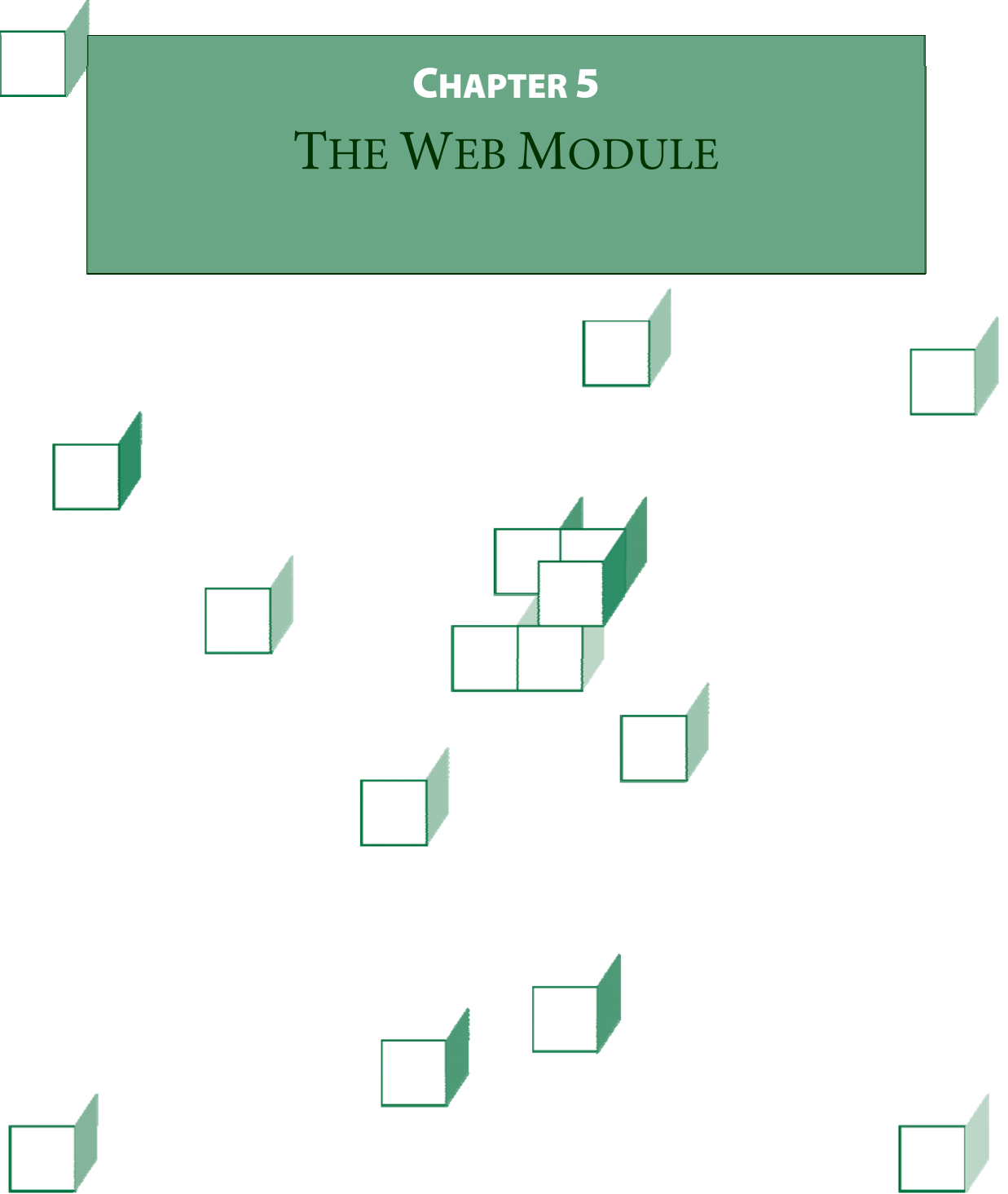




**CHAPTER 5**  
THE WEB MODULE



## OBJECTIVES

*After completing “The Web Module,” you will be able to:*

- Identify best practices and design patterns that have emerged in the years since Java EE was born, and explain how Spring facilitates these practices and patterns.
- Describe the lifecycle of an HTTP request/response roundtrip through a Spring web application: what components are involved in handling the request, carrying out work, presenting the next page, and handling errors.
- Refactor a traditional Java EE web application to use Spring.
- Describe the roles of key strategies in the Spring MVC cycle:
  - **HandlerMapping**
  - **Controller**
  - **ModelAndView**
  - **ViewResolver**
  - **View**

# Servlets and JSPs: What's Missing?

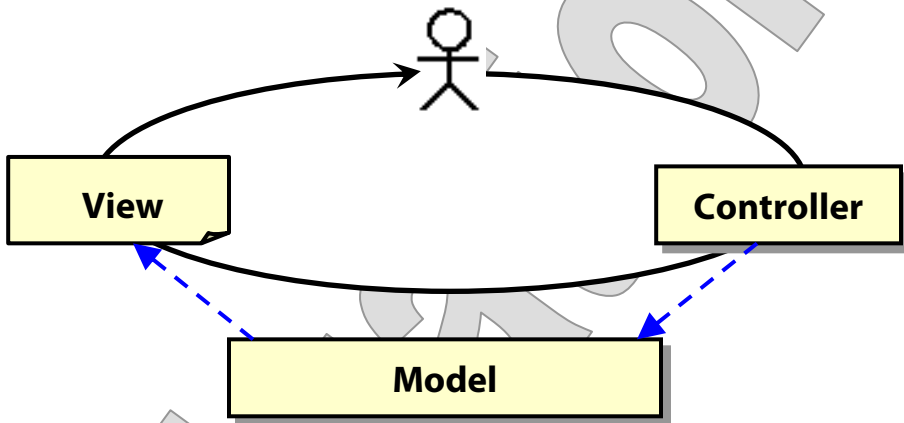
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- **Java servlets and JavaServer Pages (JSPs)** provide the basic means of responding to HTTP requests using Java code.
- There is a good deal of overlap in their capabilities, but each is best suited to a different sort of problem:
  - **Servlets** are Java classes and as such are strong on **processing**; producing HTML is possible but a bit awkward.
  - **JSPs** are more **presentation-oriented**, and best practice calls for all but true presentation logic to be deployed off-page and invoked using scriptlets, standard actions or custom tags.
- **Most Web applications are best developed to mix static HTML, JSPs, and servlets.**
  - The so-called **“Model 2”** architecture calls for servlets to implement business logic and then forward to JSPs to present the new information or system state as requested.
  - Thus servlets and JSPs each do what they're best at doing.
- **But the problem of how to coordinate these various components smoothly remains, and neither servlets nor JSP addresses this issue directly.**

# The Model/View/Controller Pattern

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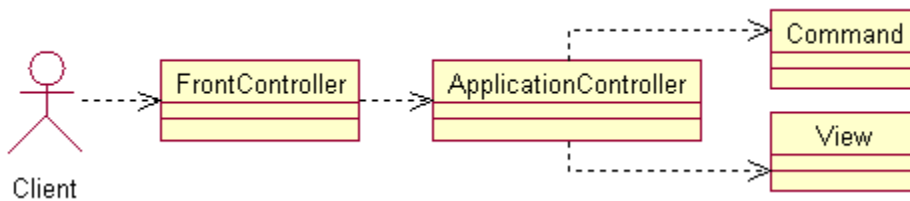
- As introduced in Chapter 1, MVC is a way of organizing any system – we’ll apply it to web applications specifically – into major roles **model**, **view**, and **controller**.



- As a prescription for decoupling a complex system, MVC succeeds based on a clear definition of dependencies:
  - Both the controller and view depend on the model’s semantics.
  - The model never depends on controllers and views. Think of this in terms of multi-tier architecture, too: the model may span the presentation and business tiers, or live entirely in the business tier, while the controller and view are purely presentation components.
  - Neither should there be interdependencies between controllers and views.
- Observing these rules keeps a system neatly organized, allows iterative development, and the best adaptability to change.
  - Especially, it facilitates **many-to-many relationships**: primarily from controller-to-model and view-to-model.

# The Front Controller Pattern

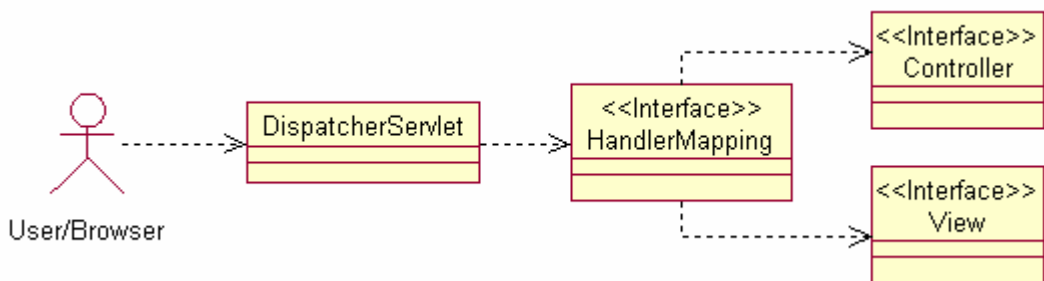
- A very popular Java EE design pattern is the **Front Controller**.
- This pattern recognizes the need for consistent pre-processing shared by many different request handlers – especially once they’ve been separated out according to MVC.
- This calls for a single controller at the front of the process – hence the pattern name – that can carry out the common pre-processing.



- This front controller is almost always linked to an **application controller**, which is responsible for dispatching to individual controllers, based on request URI or parameters, session attributes, or other variables.
  - Thus there is a **demultiplexing** of multiple request URIs to a front controller, and the application controller **re-multiplexes** to keep the control paths separate.

# The DispatcherServlet Class

- The entry point to the entire Spring Web module is the **DispatcherServlet**, which is often configured as the one and only servlet in a Spring web application.
  - Find this and most of the key Spring Web types in **org.springframework.web.servlet**, or subpackages thereof.
  - This servlet handles all control requests to the application, and then relies on a **HandlerMapping** implementation to dispatch to individual controllers. Does this diagram look familiar?

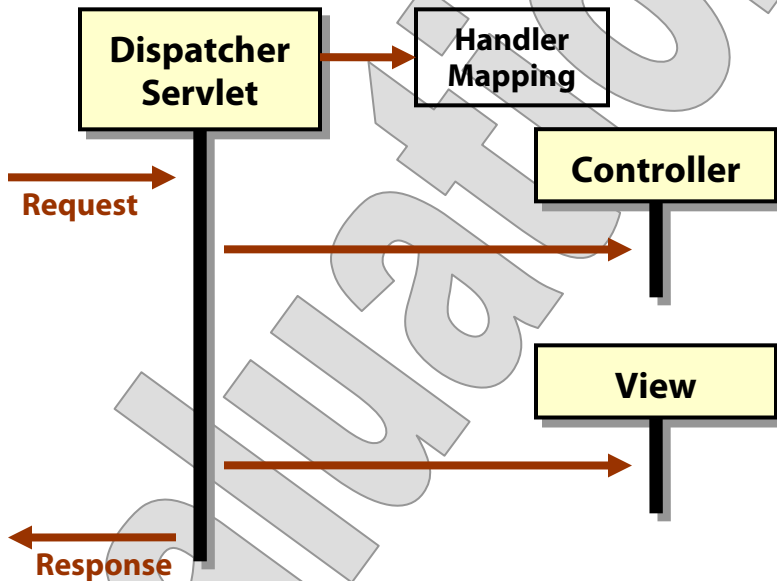


- There is not much public interface to show for this class.
- It handles HTTP requests via template methods **doService** and **processRequest**, which are called from its base class' implementations of **doGet**, **doPost**, etc.
- What's most interesting about **DispatcherServlet** is all the dependencies that don't show up as public methods.
  - It uses Spring IoC **autowiring by type** to find most of its delegate objects; we'll see more of this throughout the chapter.
  - It is also configurable through a few servlet initialization parameters – that is, via **web.xml**.

# A Spring Request/Response Cycle

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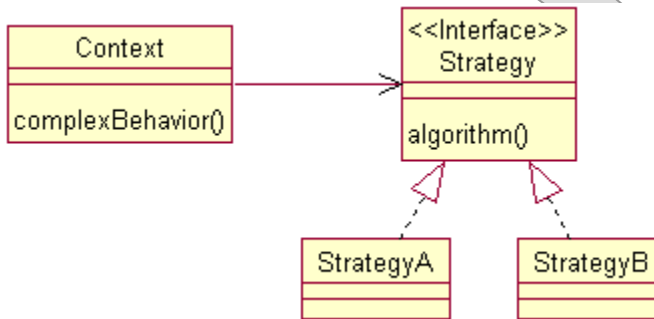
- So already we're getting an idea of the request/response cycle as implemented by the Spring Web module.
- We don't have the whole story yet, but we know this much:



- **DispatcherServlet** asks a **HandlerMapping** for a **Controller** and a **View**.
- It invokes the controller, and requested work is done there.
- It renders the view and hands it back to the user as the HTTP response.

# The Strategy Pattern

- The **Strategy** design pattern is a basic but often overlooked technique for factoring out pieces of a complex algorithm.



- The **Context** object (with its remarkably apt name for what we're doing) has a complicated job to do.
  - It could implement it, whole, but that would make for terrible maintenance characteristics.
  - It could define a big pile of virtual methods – **onThis** and **onThat** – allowing subclasses to hook into its process and customize it.
  - This is in fact the **Template Method** pattern, and it's useful but it has its limits, especially since each unique set of customizations would require a fresh subclass.
- **Strategy** calls for a separate interface for each piece of the larger process that can be made reasonably discrete.
  - Then subtypes can implement the strategy and plug in to the main processor.
- Does this sound familiar?

# JavaBeans as Web Components

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- Spring's Web MVC is stuffed full of Strategies.
- We've just seen one: the **HandlerMapping**, which can be implemented several different ways without even building your own subclass.
- **Controller** and **View** are strategies in themselves, at least the way Spring encapsulates them.
  - Most MVC implementations take a similar approach, but it's probably not accurate to say that Strategy is baked into MVC by definition.
- Indeed, Spring gets tremendous mileage out of this one pattern, factoring nearly all of the job of HTTP request handling into a handful of key roles and then allowing each of them to be played by a different actor.
  - We'll soon see the **ViewResolver** as another top-level strategy.
  - There will be more to come ...

# Configuring DispatcherServlet

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- Install a Spring application by the simple act of declaring the **DispatcherServlet** in **web.xml** and mapping some or all of your request URLs to it.

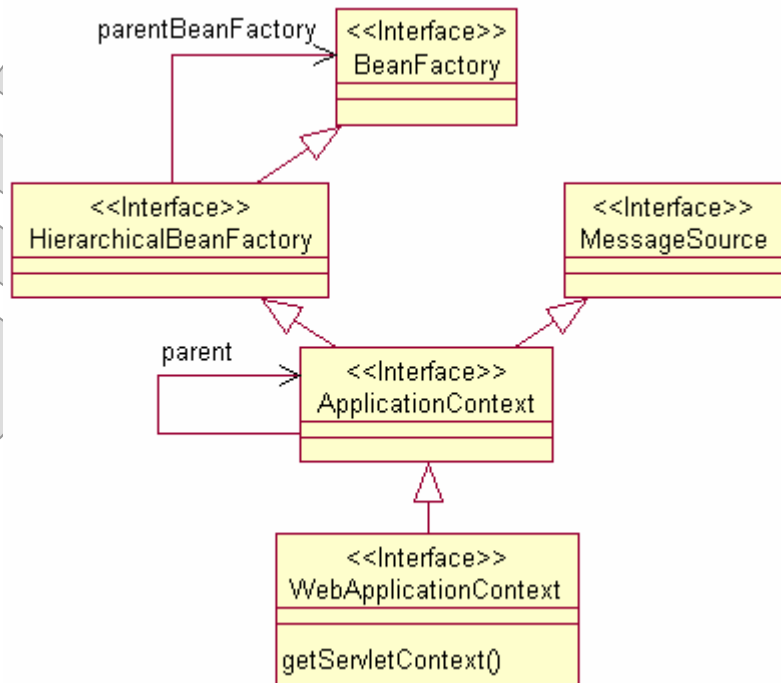
```
<servlet>
  <servlet-name>MyApplication</servlet-name>
  <servlet-class>
    org.springframework.web.servlet.DispatcherServlet
  </servlet-class>
  <load-on-startup>1</load-on-startup>
</servlet>
```

```
<servlet-mapping>
  <servlet-name>MyApplication</servlet-name>
  <url-pattern>*.do</url-pattern>
</servlet-mapping>
```

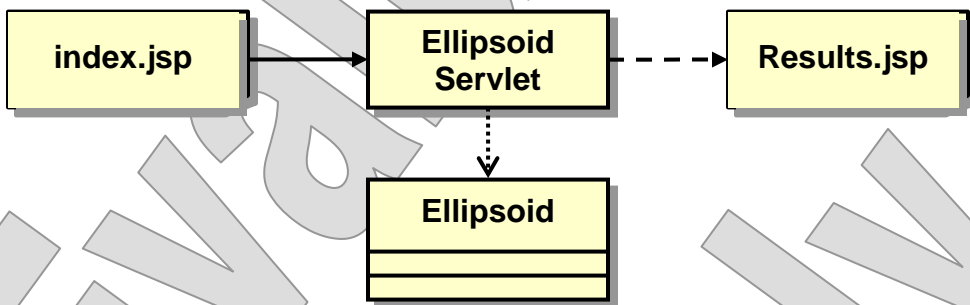
- Well, all right, there's a little more to do ...
  - Include at least **spring.jar** in your **WEB-INF/lib** directory.
  - If you want to use Spring's JSP custom tag library, include the **spring.tld** in **WEB-INF**.
- With this in place, everything else you do will be in the "Spring domain," so to speak, and the starting point for all such tasks is the Spring IoC container, which is specialized for web applications into a **web application context**.

# Web Application Contexts

- The Spring Web module relies heavily on the Core module, in particular on IoC containers.
- Every Spring web application has at least one **web application context**, which brings several of the behaviors we've already seen into a central position in the framework:
  - A web application context is a **bean factory** – so there's our primary IoC container capability.
  - It is also a **message source** – so we have internationalization
  - As an **application context**, it is **hierarchical**, meaning that a complex application can be organized into a tree or list of related modules.
  - By itself it adds the definition of a well-known name for a **root context** for the application, and our primary connection to the **servlet context**.
- Part of learning to develop in Spring is rethinking how you do familiar things – many of which you can do directly with Spring objects instead of requiring a path to a Servlets object.



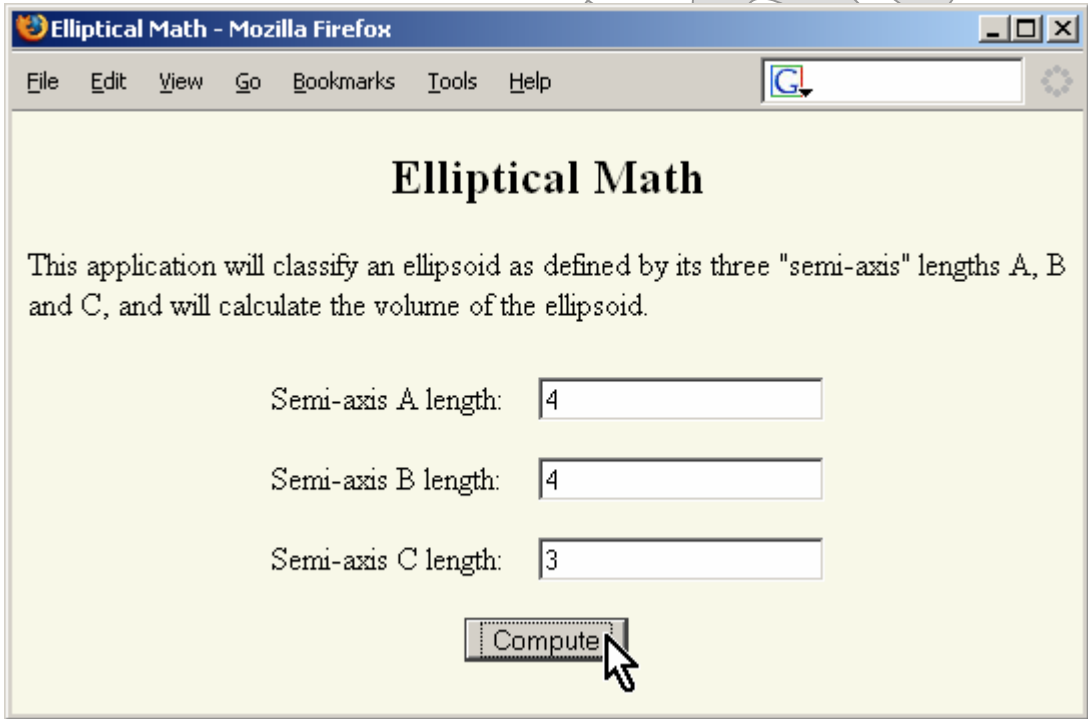
- As a next step in getting familiar with Spring, we'll carry out the process of refactoring an existing, simple web application.
  - The Ellipsoid application begins its life as a traditional servlet-and-JSP web application, with a JavaBean to capture useful state information and share it between components.
  - We'll gradually replace the standard Java EE workings with Spring components, and learn some new concepts along the way.
- We'll work in **Demos/SpringApp**.
  - The completed demo is in **Examples/Ellipsoid/Web/Step4**.
- Review the layout and code for the starter application.

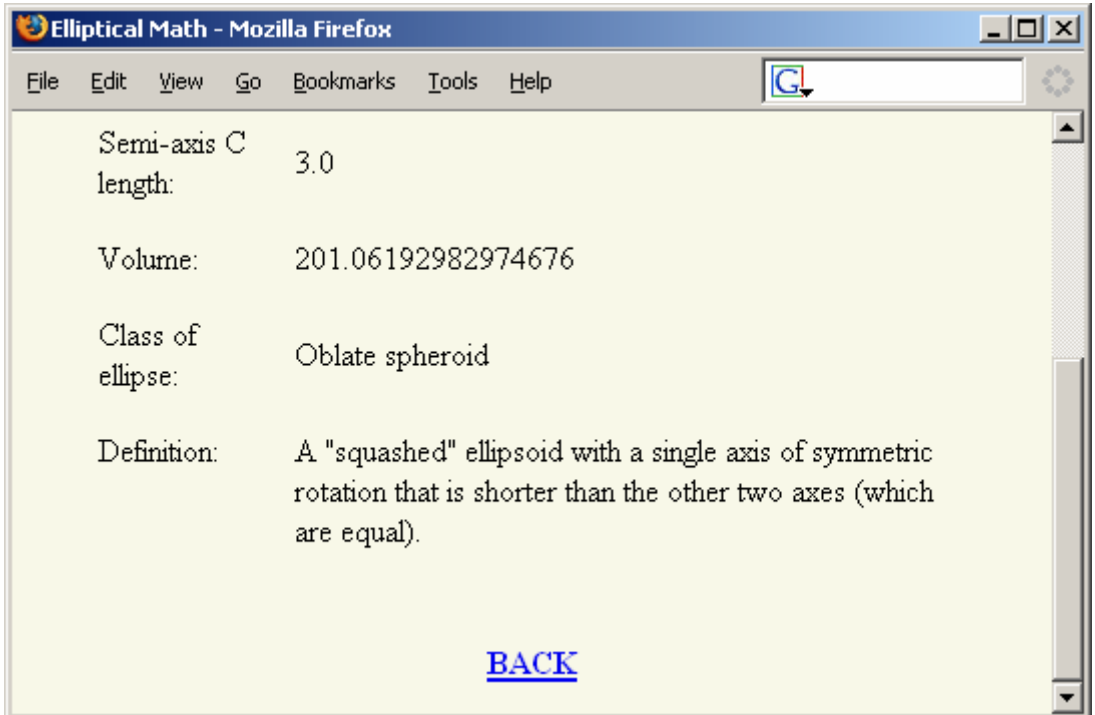


- **index.jsp** presents an HTML form that gathers three dimensions of a three-dimensional ellipsoid and places a request.
- **EllipsoidServlet** handles the request by creating and populating a JavaBean, **Ellipsoid**, with request parameters. It publishes the bean at request scope and forwards to **Results.jsp**.
- **Results.jsp** reads out the information in the JavaBean, including the request parameters and additional calculated properties: volume, classification, and description.

1. Build the starter application and test it out:  
**ant**

`http://localhost:8080/Ellipsoid`





2. Job one is to put Spring in place, so let's start by opening **docroot/WEB-INF/web.xml**.
3. Replace the mapping to **EllipsoidServlet** with a mapping to the **DispatcherServlet**. (The URL pattern can stay, since it's already set to **\*.do**, and we really only have one request path anyway.)

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

- This one change puts the incoming request on a completely different track, and brings new files into play that are already completed. Look at **docroot/WEB-INF/Ellipsoid-servlet.xml** for starters.
  - This is the primary context declaration for the web application – it plays the role of **web.xml** for a Spring application, using the vocabulary of the Spring beans configurations we've been working with so far.
  - Note that the name of the file is based on the declared name of the servlet in **web.xml**.

```
<bean
  class="org.springframework.web.servlet.handler
    .SimpleUrlHandlerMapping"
>
  <property name="mappings">
    <props>
      <prop key="/Compute.do" >
        EllipsoidController</prop>
      </props>
    </property>
  </bean>

<bean id="EllipsoidController"
  class="cc.math.EllipsoidController" />
```

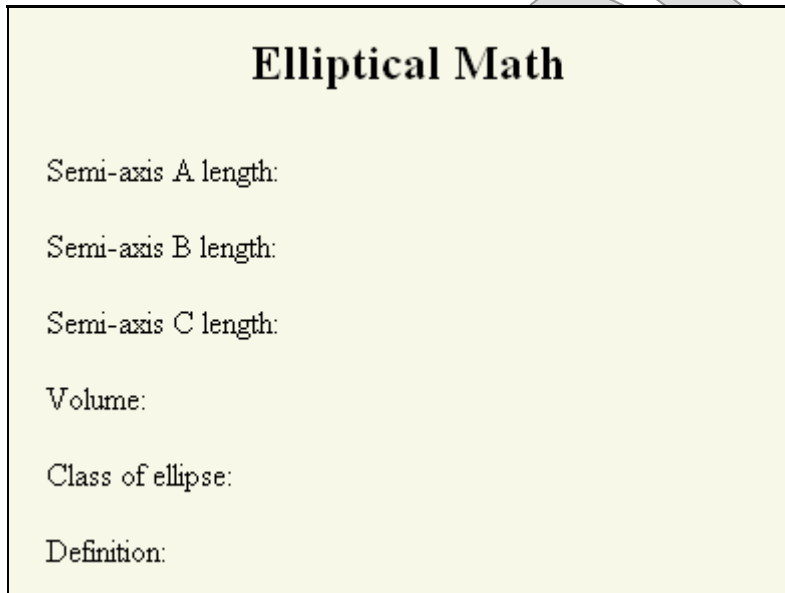
- This application's handler mapping uses an explicit map of URL keys and values that are interpreted as bean names.
- The only controller is **EllipsoidController** and this is mapped to the incoming **/Compute.do**.

5. Open `src/cc/math/EllipsoidController.java` and see the controller code. So far, the `handleRequest` method doesn't do much:

```
public class EllipsoidController
    implements Controller
{
    public ModelAndView handleRequest
        (HttpServletRequest request,
         HttpServletResponse response)
        throws Exception
    {
        System.out.println ("**Controller invoked.**");
        return new ModelAndView
            (new InternalResourceView ("Results.jsp"));
    }
}
```

- This **ModelAndView** is constructed to aggregate a prepared **InternalResourceView**, which is view implementation that simply wraps a browser-addressable resource within the application.

- Build, deploy, and test again to see two things.
  - The results page does appear, but it shows no values, only the static labels:



- We can see that the controller was invoked by looking in the Tomcat console:

```
INFO: Servlet 'Ellipsoid' configured successfully  
***** Controller invoked. *****
```

(This is the version in the example **Step2**.)

- Spring's authors have an unusual take on MVC, when it comes time to serve up the view: they suggest that the controller should decide on a view, and populate that view with a model.
  - That is, the controller “creates a model” for the view.
  - Traditionally, web MVC applications have treated the controller and view more as (perhaps unequal) partners, letting the view find the model information it would need, just as the controller would go to find the model for itself.
- The approaches are not so different in this case: the servlet was posting a bean at request scope, and this is just what Spring will do – when you pass the bean and name to a **ModelAndView** constructor.

7. Copy code from the servlet source file to the controller to create an **Ellipsoid** object and to populate it using request parameters:

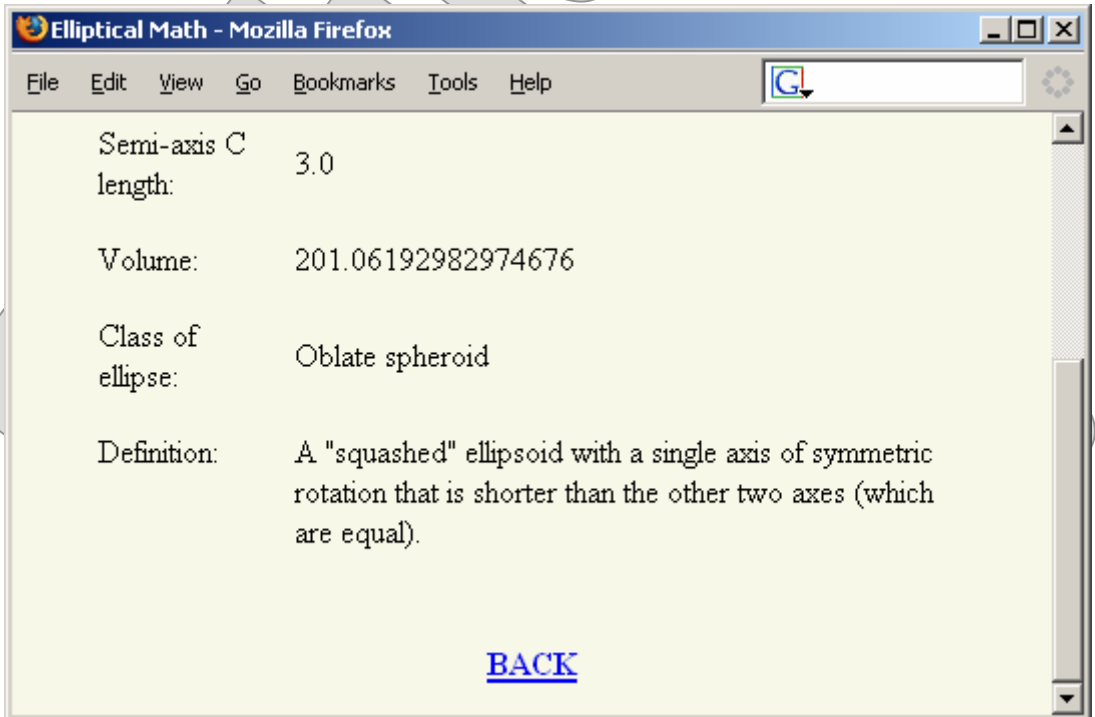
```
public ModelAndView handleRequest
    (HttpServletRequest request,
     HttpServletResponse response)
    throws Exception
{
    Ellipsoid delegate = new Ellipsoid ();
    delegate.setA (Double.parseDouble
        (request.getParameter ("a")));
    delegate.setB (Double.parseDouble
        (request.getParameter ("b")));
    delegate.setC (Double.parseDouble
        (request.getParameter ("c")));
    return new ModelAndView
        (new InternalResourceView ("Results.jsp"));
}
```

8. Still, so far our **ModelAndView** is really just a view. Add model information using a different constructor overload:

```
return new ModelAndView  
    (new InternalResourceView ("Results.jsp"),  
     "ellipsoid", delegate);
```

– **ModelAndView** can take a prepared **Map** with multiple keys and values, too, but we'll use this convenience constructor here.

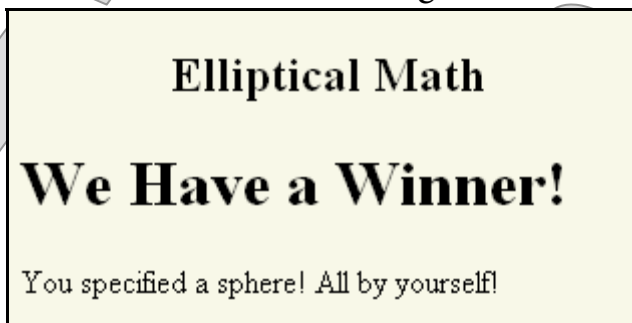
9. Build and retest to see that you again have correct functionality: the controller is now creating a bean, piping input to the bean, and making the bean itself available to the view so that the expressions in **Results.jsp** can read out the results.



(This is the version in the example **Step3**.)

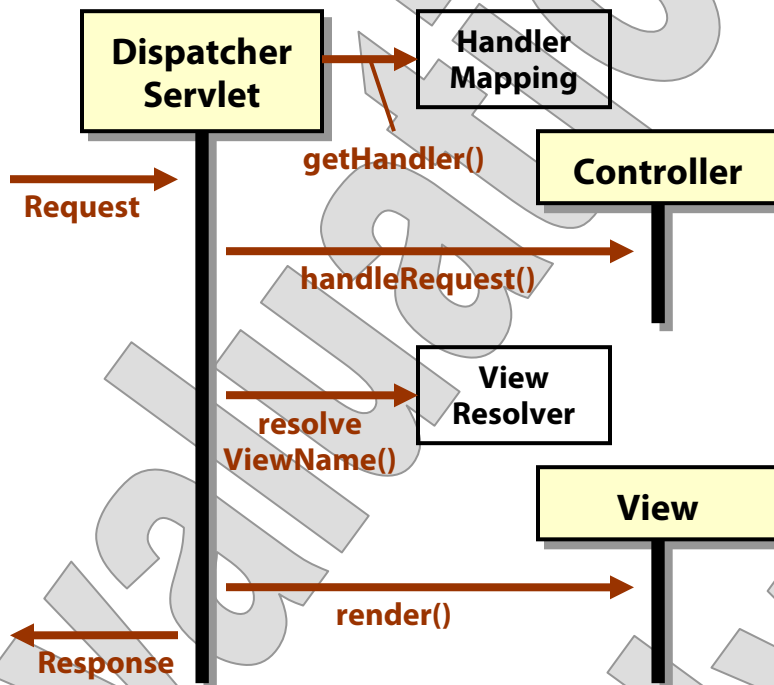
10. Now let's start taking advantage of a **view resolver**. See the rest of the context configuration file, which declares a **BeanNameViewResolver**. This class converts a requested view name to a **View**-implementing bean of a name that matches that view name.
11. See also the three beans defined to wrap three JSPs in the application, giving them simple names "Form", "NormalResult" and "SphereResult".
12. Modify the controller to choose between normal and sphere results – represented now as strings, not **View** objects – based on the results of **delegate.getType**:

```
return new ModelAndView  
    ((delegate.getType ().equals ("Sphere")  
     ? "SphereResult"  
     : "NormalResult"), "ellipsoid", delegate);
```
13. Build and test one last time. Now the view resolver is consulted with the string returned by the controller as part of the **ModelAndView** object. Try parameters you were using before, and then try using the same number for all three semi-axis lengths ...



(This is the final version in the example **Step4**.)

- With a few code changes, we've put the main body of Spring MVC to work for the application – here's our request-handling diagram again, with some new details gleaned from this demonstration:



- So **HandlerMapping** and **ViewResolver** are the next-level decision points after the servlet: one finds controllers and one finds views.
- Have you started wondering: how did the servlet find these two key objects?

# Autowiring in the DispatcherServlet

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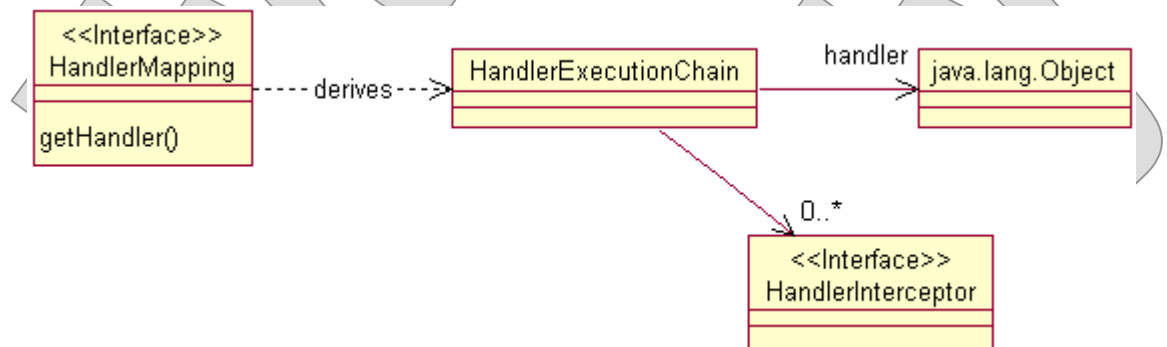
- The answer harks back to our study of Spring IoC in the previous chapter: **DispatcherServlet** finds these two delegates through beans autowiring by type.
- This isn't obvious, for the simple reason that the servlet isn't declared as a bean in the configuration itself.
- Also, it does what a declared bean could not do, which is choose to autowire by type, by name, or not at all, at a property level, rather than for the object as a whole.
- See the javadoc for this class for more on which delegates are found by what means – but an incomplete list, including several concepts we've yet to study, is here:
  - A **HandlerMapping** is wired by type
  - A **ViewResolver** is wired by type
  - A **MessageSource** is wired by the name “messageSource” – actually this is the web application context, not the servlet itself, doing the matching
  - A **HandlerExceptionResolver** is wired by type
  - A **MultipartResolver** is wired by the name “multipartResolver”
  - A **LocaleResolver** is wired by the name “localeResolver”
  - A **ThemeResolver** is wired by the name “themeResolver”

# The HandlerMapping Interface

- We've already seen the most important job that **HandlerMapping** does, which is help the dispatcher servlet decide on a controller for a given request.
- There is (how many times will we say this?) more to the story.
- The full responsibility of a **HandlerMapping** is to derive a **HandlerExecutionChain**.

```
public interface HandlerMapping
{
    public HandlerExecutionChain
        getHandler (HttpServletRequest request);
}
```

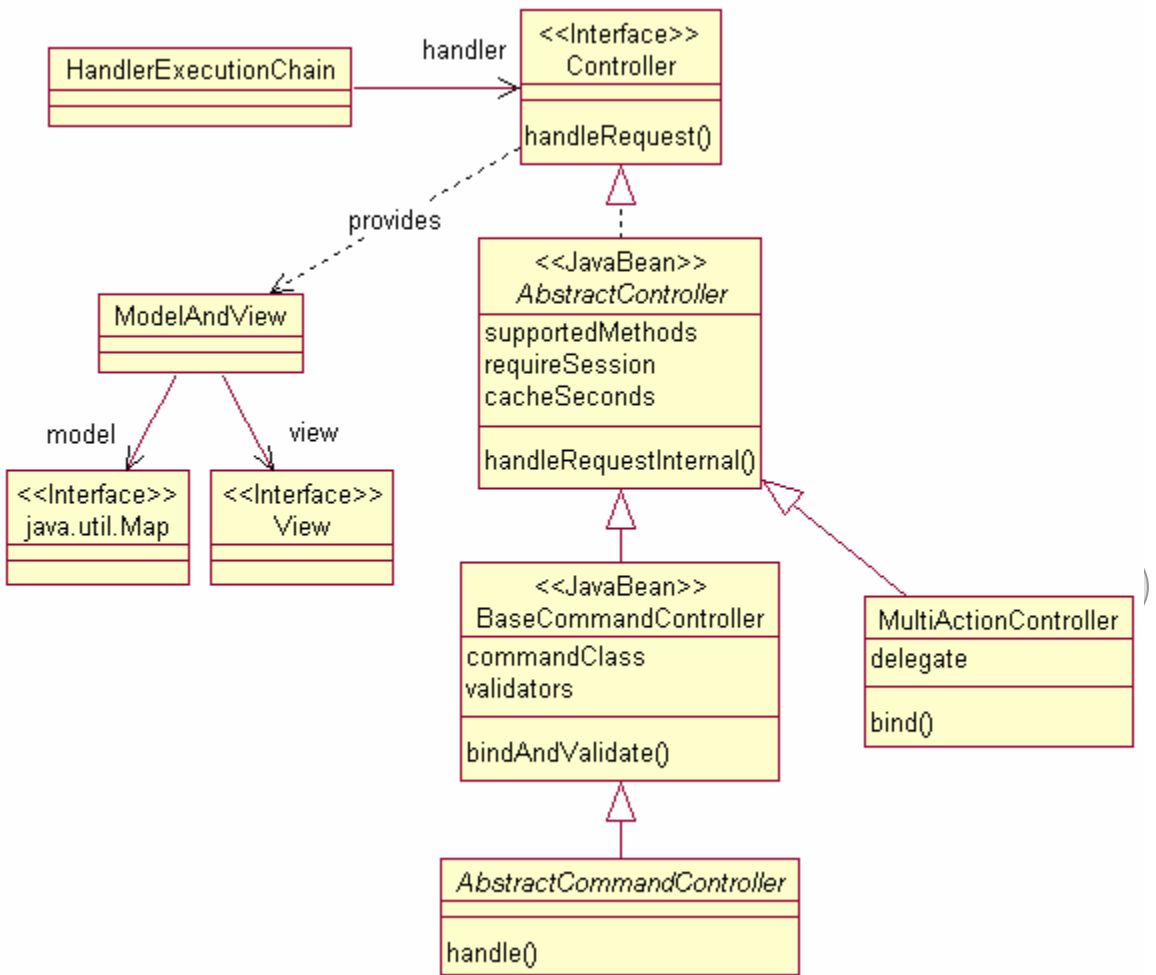
- This, in turn, navigates to one handler and any number of **HandlerInterceptors**.
- (We're still in **org.springframework.web.servlet** for all three of these types.)



- Interceptors implement the **Intercepting Filter** pattern for Spring; they are loosely analogous to servlet **Filters**.
  - We'll consider interceptors in more depth later in the course.

# The Controller Interface

- It all starts with the **HandlerMapping** ... but most of the real action is in the **Controller**.
- Though any object can technically be a Spring request handler, for HTTP requests all controllers will be implementations of the **Controller** interface.
  - All the controller types below are from the package **org.springframework.web.servlet.mvc**:



# Controller Responsibilities

---

- The Spring controller has an outsized role compared to the model and view: it really manages the remainder of the request-handling process.
- The basic job of a controller is to carry out the requested work and to serve up a view and a map of objects which the dispatcher servlet should make available to that view during its rendering.
- **AbstractController** is a convenient base type for controllers playing just this simple role.
- Other subtypes define – and then meet – additional responsibilities:
  - **MultiActionController** does additional dispatching to a delegate object, with additional strategy choices for deciding what methods to call for what request URIs and query strings.
  - **AbstractCommandController** formalizes the use of a **command object**: creating this JavaBean during request handling, binding request parameters to it, calling configured validators, and then making it available to controller and view components.
  - **AbstractFormController** goes further and encapsulates some of the concepts of the HTML form itself, managing form input, processing, and even redirecting flow back to the form when errors occur.
- We'll consider these different controller types in two later chapters.

# The ModelAndView Class

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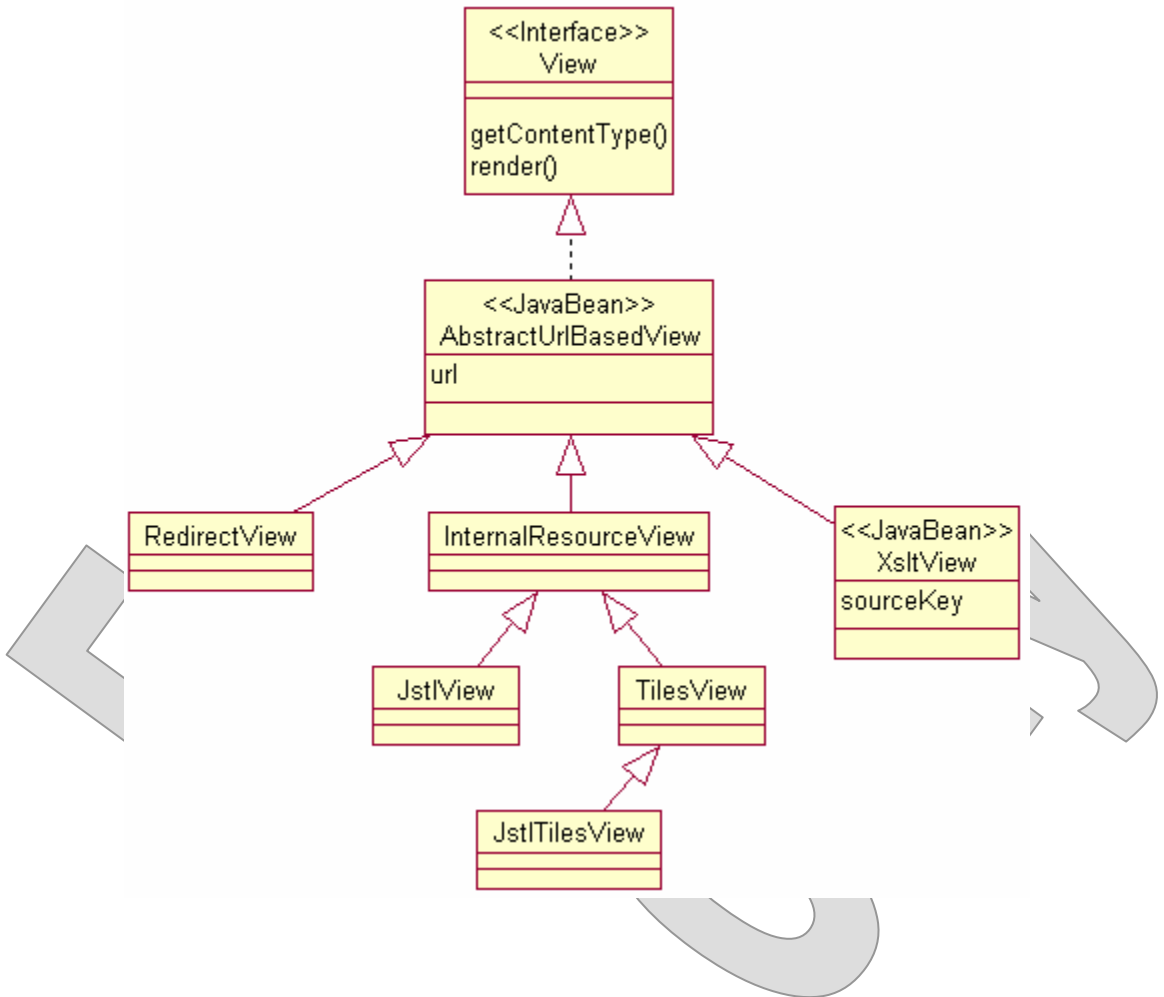
- **ModelAndView** is a simple aggregation of a **View** object and a “model” – which in this context means a map of keys and objects that might be useful to view rendering, and not the overall state model of the MVC application.

```
public class ModelAndView extends Object
{
    public ModelAndView (View view);
    public ModelAndView (View view, Map model);
    public ModelAndView (View view,
        String oneKey, Object oneValue);
    public ModelAndView (String viewName);
    public ModelAndView (String viewName, Map model);
    public ModelAndView (String viewName,
        String oneKey, Object oneValue);
    ...
}
```

- **Overloads of its constructor allow for various usages:**
  - Provide a **View** instance or a name to be passed to a **ViewResolver**.
  - Provide no model, a single key/value pair (surprisingly useful and common), or a full-fledged map.
- Its public methods are mostly called by framework code, so we won't delve into those too deeply.

# The View Interface

- A **View** is simply a component that can render a response in the appropriate content type.
- There are over two dozen view types implemented in Spring.
- Just a handful support most Spring development – here are some of the most common types:



# The ViewResolver Interface

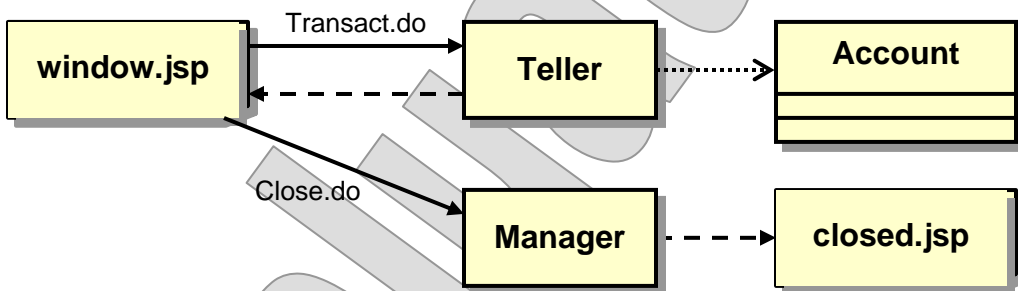
---

- Once a controller has done its work, it will report back to the dispatcher servlet with a **ModelAndView** object.
- For complex applications, this will usually carry the name of a desired view for the servlet to render to the HTTP response.
- Translating, or **resolving**, this name to an actual **View** object is the responsibility of a configured **ViewResolver**:

```
public interface ViewResolver
{
    public View resolveViewName
        (String name, Locale locale);
}
```

- The one method on this interface, **resolveViewName**, illustrates the simplicity of the job description.
- It also points up one of the more compelling reasons to use view resolvers, which is the built-in internationalization support.
- If a controller builds or finds its own view, any i18n support will have to come from the controller's own logic – and that gets old pretty quick when you're writing tens or scores or hundreds of controllers.

- Let's use another example application as a way of reviewing the control paths that make Spring's MVC work.
  - We'll trace the flow of control all the way from the receipt of the incoming HTTP request around to the rendering of the response.
- See **Examples/Bank/Web** for a two-page web application that allows the user to make transactions on a preconfigured bank account:



- From **window.jsp** the user actually has three options:
  - **Deposit** and **Withdraw** buttons request the **Transact.do** URL.
  - A link to **close this account** requests **Close.do**.

- Let's build and run the application first – so we know what it does, before asking how it does it.

- Run **ant** and visit the following URL:

`http://localhost:8080/Bank`

**Online Banking**

Current account balance is 500.0.

Amount:

You may [close this account](#) at any time.

- Make a deposit ...

**Online Banking**

Current account balance is 598.5.

Amount:

You may [close this account](#) at any time.

- ... and close the account:

**Online Banking**

The account has been closed.

- Consider a request to make a deposit – what happens from the moment the user clicks the **Deposit** button?

1. The server receives an HTTP request for this resource:

`http://localhost:8080/Bank/Transact.do`

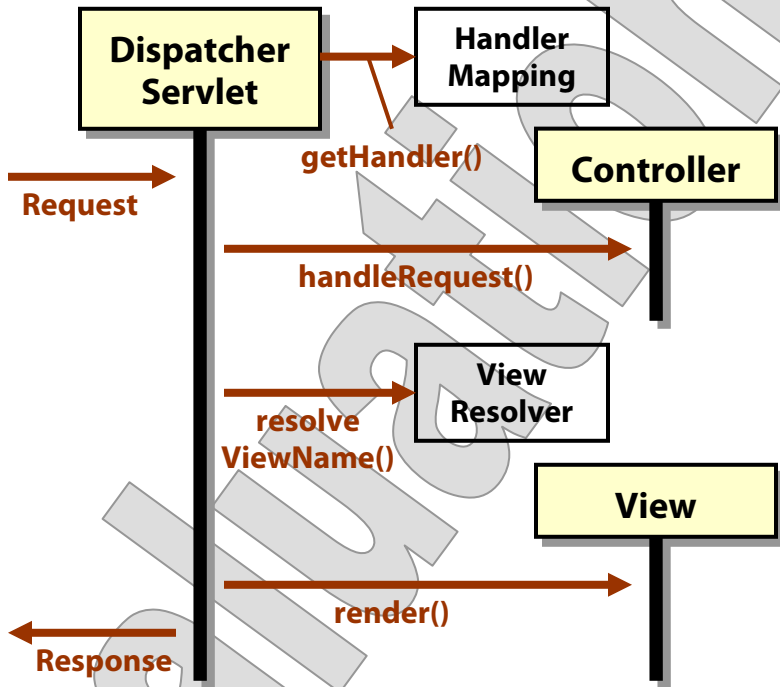
2. This is fielded by the web container, which (a) determines the correct web application by searching its index of deployed applications and their context URLs, and (b) consults the **web.xml** file for a possible servlet mapping.

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

```
<servlet-mapping>
  <servlet-name>Bank</servlet-name>
  <url-pattern>*.do</url-pattern>
</servlet-mapping>
```

3. The application says all requests ending in **.do** go to the Spring **DispatcherServlet**, and the container dispatches the request there and waits for request handling and response rendering.
4. The **DispatcherServlet** has been initialized based on the servlet name given by **web.xml** and so knows to configure itself from a file **Bank-servlet.xml**.

5. Based on those bean declarations, it will now carry out the process diagrammed earlier:



6. So, first it looks for a **HandlerMapping**, and finds one:

```
<bean
  class="org.springframework.web.servlet.handler
    .SimpleUrlHandlerMapping"
>
  <property name="mappings">
    <props>
      <prop key="/Approach.do" >Teller</prop>
      <prop key="/Transact.do" >Teller</prop>
      <prop key="/Close.do" >Manager</prop>
    </props>
  </property>
</bean>
```

7. The **SimpleUrlHandlerMapping** tells the servlet that a request to **Transact.do** should be handled by an instance of the **Teller** bean:

```
<bean id="Teller" class="cc.bank.Teller"
      autowire="byType" />
```

8. Thus comes a call to the **handleRequest** method on **cc.bank.Teller**. This singleton bean has a dependency on a bank account (specifically, Spring sees the method **setAccount**) auto-wired to the only **Account** instance in the configuration:

```
<bean class="cc.bank.CheckingAccount" >
  <constructor-arg type="double" value="500" />
</bean>
```

9. **handleRequest** then looks at request parameters and either deposits or withdraws the requested amount:

```
double amount = Double.parseDouble (amountParam);
if (request.getParameter ("deposit") != null)
    account.deposit (amount);
if (request.getParameter ("withdraw") != null)
    account.withdraw (amount);
```

10. Then it returns instructions to the **DispatcherServlet** in the form of a **ModelAndView** object that says two things: (a) put a bean called “account” at request scope so the view can see it, and (b) resolve to a view identified as “window”.

```
return new ModelAndView
    ("window", "account", account);
```

11. The **DispatcherServlet** finds (actually, has already found) its **ViewResolver** in the configuration:

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

12. The **InternalResourceViewResolver** maps the view name to the location of an internal resource: the **window.jsp**.

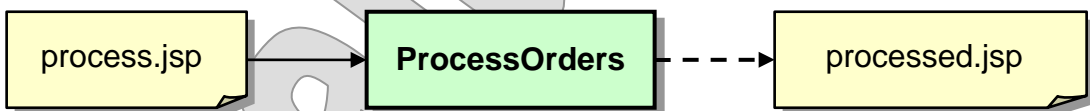
13. It wraps this resource in an **InternalResourceView** object and hands that back to the **DispatcherServlet**.

14. The **DispatcherServlet** then asks this view object to **render** the HTTP response – this occurs as usual for a JSP, no real Spring intervention in the process – and then returns control to the web container.

## Suggested time: 60 minutes

In this lab you will implement a partial version of the Wholesale application, now retooled for the web. This will provide some challenging exercise in building Spring applications from scratch; it's not a refactoring exercise, as we've had plenty of those by now. In general this case study will offer opportunities to build new functionality "the right way" right off the bat.

The domain model is largely intact from earlier chapters – a few tweaks – and for this exercise you'll implement a simple page flow that will demonstrate end-to-end connectivity in processing prepared sales feeds at the direction of the operator.

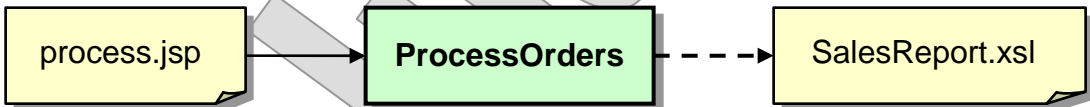


Detailed instructions are found at the end of the chapter.

## Suggested time: 30 minutes

In this lab you will improve on the response provided by the Wholesale application after it processes a batch of orders. We have a good XSLT transform already defined that can produce HTML from the XML sales report. What we need to do is integrate this XSLT into a Spring request/response cycle.

It turns out there's a **View** class for that! You'll instantiate **XsltView** and inform it with the XML source and XSLT transform locations, resulting in a modified page flow:



Detailed instructions are found at the end of the chapter.

## SUMMARY

- The Spring Web module is meant to simplify the development of complex web applications – but it is quite a complex system in and of itself.
- Still, there is an elegance to the kernel of the module: the request-handling process carried out by the dispatcher servlet.
  - It's extrapolated from MVC, with **Controller** and **View** interfaces at the heart of the system.
  - Each of these actors is chosen by an agent: **HandlerMapping** for **Controller**, **ViewResolver** for **View**.
  - Each of these four roles is plugged in to the dispatcher servlet via the Strategy design pattern.
  - Each has multiple subtypes, which can be mixed, matched, combined, and extended.
- The whole system sits on top of one or more Spring IoC containers.
  - Bean configurations, autowiring, dependencies, and collections – all these Core techniques are now folded into the declarative side of Spring Web development.