

Web on Servlet Stack

Version 5.1.4.RELEASE

Table of Contents

1. Spring Web MVC	2
1.1. DispatcherServlet	2
1.1.1. Context Hierarchy	4
1.1.2. Special Bean Types	7
1.1.3. Web MVC Config	8
1.1.4. Servlet Config	9
1.1.5. Processing	11
1.1.6. Interception	13
1.1.7. Exceptions	13
Chain of Resolvers	14
Container Error Page	14
1.1.8. View Resolution	15
Handling	16
Redirecting	17
Forwarding	17
Content Negotiation	17
1.1.9. Locale	17
Time Zone	18
Header Resolver	18
Cookie Resolver	18
Session Resolver	19
Locale Interceptor	19
1.1.10. Themes	20
Defining a theme	20
Resolving Themes	21
1.1.11. Multipart Resolver	21
Apache Commons FileUpload	22
Servlet 3.0	22
1.1.12. Logging	22
Sensitive Data	23
1.2. Filters	24
1.2.1. Form Data	24
1.2.2. Forwarded Headers	24
1.2.3. Shallow ETag	24
1.2.4. CORS	25
1.3. Annotated Controllers	25
1.3.1. Declaration	26
AOP Proxies	27

1.3.2. Request Mapping	27
URI patterns	28
Pattern Comparison	29
Suffix Match	30
Suffix Match and RFD	30
Consumable Media Types	31
Producible Media Types	31
Parameters, headers	32
HTTP HEAD, OPTIONS	33
Custom Annotations	33
Explicit Registrations	34
1.3.3. Handler Methods	34
Method Arguments	34
Return Values	36
Type Conversion	38
Matrix Variables	38
@RequestParam	40
@RequestHeader	41
@CookieValue	42
@ModelAttribute	43
@SessionAttributes	45
@SessionAttribute	46
@RequestAttribute	47
Redirect Attributes	47
Flash Attributes	48
Multipart	49
@RequestBody	51
HttpEntity	52
@ResponseBody	52
ResponseEntity	53
Jackson JSON	53
1.3.4. Model	55
1.3.5. DataBinder	56
1.3.6. Exceptions	57
Method Arguments	59
Return Values	60
REST API exceptions	61
1.3.7. Controller Advice	62
1.4. URI Links	62
1.4.1. UriComponents	63
1.4.2. UriBuilder	64
1.4.3. URI Encoding	65
1.4.4. Relative Servlet Requests	67

1.4.5. Links to Controllers	67
1.4.6. Links in Views	69
1.5. Asynchronous Requests	70
1.5.1. DeferredResult	70
1.5.2. Callable	71
1.5.3. Processing	71
Exception Handling	72
Interception	73
Compared to WebFlux	73
1.5.4. HTTP Streaming	73
Objects	74
SSE	74
Raw Data	75
1.5.5. Reactive Types	75
1.5.6. Disconnects	76
1.5.7. Configuration	76
Servlet Container	77
Spring MVC	77
1.6. CORS	77
1.6.1. Introduction	77
1.6.2. Processing	78
1.6.3. @CrossOrigin	78
1.6.4. Global Configuration	80
Java Configuration	81
XML Configuration	81
1.6.5. CORS Filter	82
1.7. Web Security	82
1.8. HTTP Caching	83
1.8.1. CacheControl	83
1.8.2. Controllers	84
1.8.3. Static Resources	85
1.8.4. ETag Filter	85
1.9. View Technologies	85
1.9.1. Thymeleaf	86
1.9.2. FreeMarker	86
View Configuration	86
FreeMarker Configuration	87
Form Handling	88
1.9.3. Groovy Markup	94
Configuration	94
Example	95

1.9.4. Script Views	95
Requirements	96
Script Templates	96
1.9.5. JSP and JSTL	100
View Resolvers	100
JSPs versus JSTL	100
Spring's JSP Tag Library	100
Spring's form tag library	101
1.9.6. Tiles	116
Dependencies	116
Configuration	116
1.9.7. RSS and Atom	119
1.9.8. PDF and Excel	120
Introduction to Document Views	121
PDF Views	121
Excel Views	121
1.9.9. Jackson	122
Jackson-based JSON Views	122
Jackson-based XML Views	122
1.9.10. XML Marshalling	122
1.9.11. XSLT Views	122
Beans	123
Controller	123
Transformation	124
1.10. MVC Config	125
1.10.1. Enable MVC Configuration	126
1.10.2. MVC Config API	126
1.10.3. Type Conversion	127
1.10.4. Validation	128
1.10.5. Interceptors	130
1.10.6. Content Types	130
1.10.7. Message Converters	131
1.10.8. View Controllers	133
1.10.9. View Resolvers	134
1.10.10. Static Resources	135
1.10.11. Default Servlet	138
1.10.12. Path Matching	139
1.10.13. Advanced Java Config	140
1.10.14. Advanced XML Config	141
1.11. HTTP/2	141
2. REST Clients	143

2.1. RestTemplate	143
2.2. WebClient	143
3. Testing	144
4. WebSockets	145
4.1. Introduction to WebSocket	145
4.1.1. HTTP Versus WebSocket	146
4.1.2. When to Use WebSockets	146
4.2. WebSocket API	147
4.2.1. WebSocketHandler	147
4.2.2. WebSocket Handshake	149
4.2.3. Deployment	150
4.2.4. Server Configuration	152
4.2.5. Allowed Origins	155
4.3. SockJS Fallback	157
4.3.1. Overview	157
4.3.2. Enabling SockJS	158
4.3.3. IE 8 and 9	160
4.3.4. Heartbeats	161
4.3.5. Client Disconnects	161
4.3.6. SockJS and CORS	162
4.3.7. SockJsClient	162
4.4. STOMP	164
4.4.1. Overview	164
4.4.2. Benefits	166
4.4.3. Enable STOMP	166
4.4.4. WebSocket Server	169
4.4.5. Flow of Messages	170
4.4.6. Annotated Controllers	173
@MessageMapping	173
@SubscribeMapping	174
@MessageExceptionHandler	175
4.4.7. Sending Messages	176
4.4.8. Simple Broker	176
4.4.9. External Broker	177
4.4.10. Connecting to a Broker	179
4.4.11. Dots as Separators	180
4.4.12. Authentication	182
4.4.13. Token Authentication	183
4.4.14. User Destinations	184
4.4.15. Order of Messages	186
4.4.16. Events	187

4.4.17. Interception	188
4.4.18. STOMP Client	189
4.4.19. WebSocket Scope	191
4.4.20. Performance	192
4.4.21. Monitoring	195
4.4.22. Testing	197
5. Other Web Frameworks	199
5.1. Common Configuration	199
5.2. JSF	200
5.2.1. Spring Bean Resolver	201
5.2.2. Using FacesContextUtils	201
5.3. Apache Struts 2.x	201
5.4. Tapestry 5.x	202
5.5. Further Resources	202

This part of the documentation covers support for Servlet-stack web applications built on the Servlet API and deployed to Servlet containers. Individual chapters include [Spring MVC](#), [View Technologies](#), [CORS Support](#), and [WebSocket Support](#). For reactive-stack web applications, see [Web on Reactive Stack](#).

Chapter 1. Spring Web MVC

Spring Web MVC is the original web framework built on the Servlet API and has been included in the Spring Framework from the very beginning. The formal name, “Spring Web MVC,” comes from the name of its source module ([spring-webmvc](#)), but it is more commonly known as “Spring MVC”.

Parallel to Spring Web MVC, Spring Framework 5.0 introduced a reactive-stack web framework whose name, “Spring WebFlux,” is also based on its source module ([spring-webflux](#)). This section covers Spring Web MVC. The [next section](#) covers Spring WebFlux.

For baseline information and compatibility with Servlet container and Java EE version ranges, see the Spring Framework [Wiki](#).

1.1. DispatcherServlet

[Same as in Spring WebFlux](#)

Spring MVC, as many other web frameworks, is designed around the front controller pattern where a central [Servlet](#), the [DispatcherServlet](#), provides a shared algorithm for request processing, while actual work is performed by configurable delegate components. This model is flexible and supports diverse workflows.

The [DispatcherServlet](#), as any [Servlet](#), needs to be declared and mapped according to the Servlet specification by using Java configuration or in [web.xml](#). In turn, the [DispatcherServlet](#) uses Spring configuration to discover the delegate components it needs for request mapping, view resolution, exception handling, [and more](#).

The following example of the Java configuration registers and initializes the [DispatcherServlet](#), which is auto-detected by the Servlet container (see [Servlet Config](#)):

```
public class MyWebApplicationInitializer implements WebApplicationInitializer {  
  
    @Override  
    public void onStartup(ServletContext servletCxt) {  
  
        // Load Spring web application configuration  
        AnnotationConfigWebApplicationContext ac = new  
        AnnotationConfigWebApplicationContext();  
        ac.register(AppConfig.class);  
        ac.refresh();  
  
        // Create and register the DispatcherServlet  
        DispatcherServlet servlet = new DispatcherServlet(ac);  
        ServletRegistration.Dynamic registration = servletCxt.addServlet("app",  
        servlet);  
        registration.setLoadOnStartup(1);  
        registration.addMapping("/app/*");  
    }  
}
```



In addition to using the `ServletContext` API directly, you can also extend `AbstractAnnotationConfigDispatcherServletInitializer` and override specific methods (see the example under [Context Hierarchy](#)).

The following example of `web.xml` configuration registers and initializes the `DispatcherServlet`:

```

<web-app>

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

    <context-param>
        <param-name>contextConfigLocation</param-name>
        <param-value>/WEB-INF/app-context.xml</param-value>
    </context-param>

    <servlet>
        <servlet-name>app</servlet-name>
        <servlet-class>org.springframework.web.servlet.DispatcherServlet</servlet-
class>
        <init-param>
            <param-name>contextConfigLocation</param-name>
            <param-value></param-value>
        </init-param>
        <load-on-startup>1</load-on-startup>
    </servlet>

    <servlet-mapping>
        <servlet-name>app</servlet-name>
        <url-pattern>/app/*</url-pattern>
    </servlet-mapping>

</web-app>

```

 Spring Boot follows a different initialization sequence. Rather than hooking into the lifecycle of the Servlet container, Spring Boot uses Spring configuration to bootstrap itself and the embedded Servlet container. [Filter](#) and [Servlet](#) declarations are detected in Spring configuration and registered with the Servlet container. For more details, see the [Spring Boot documentation](#).

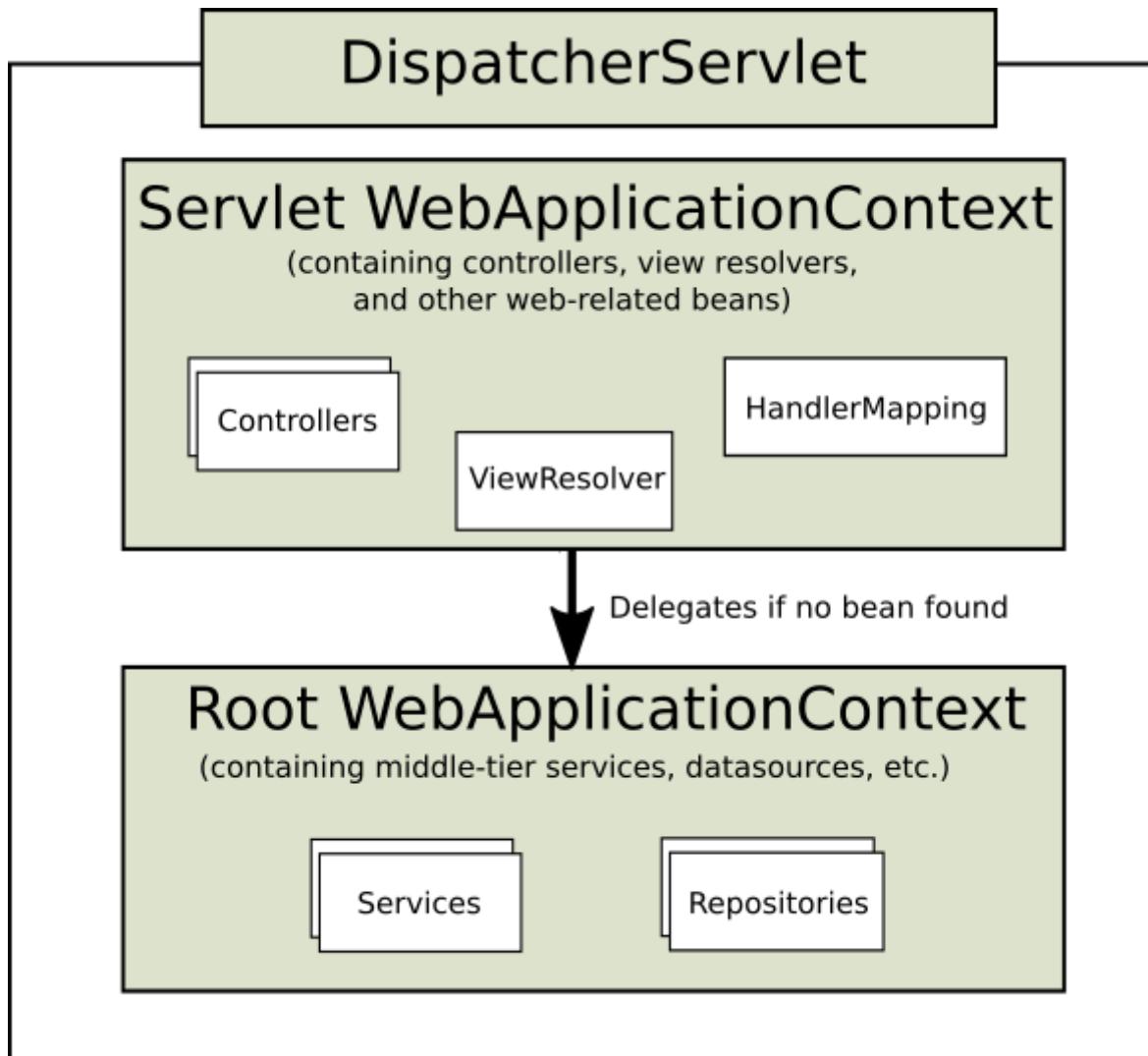
1.1.1. Context Hierarchy

`DispatcherServlet` expects a `WebApplicationContext` (an extension of a plain `ApplicationContext`) for its own configuration. `WebApplicationContext` has a link to the `ServletContext` and the `Servlet` with which it is associated. It is also bound to the `ServletContext` such that applications can use static methods on `RequestContextUtils` to look up the `WebApplicationContext` if they need access to it.

For many applications, having a single `WebApplicationContext` is simple and suffices. It is also possible to have a context hierarchy where one root `WebApplicationContext` is shared across multiple `DispatcherServlet` (or other `Servlet`) instances, each with its own child `WebApplicationContext` configuration. See [Additional Capabilities of the ApplicationContext](#) for more

on the context hierarchy feature.

The root `WebApplicationContext` typically contains infrastructure beans, such as data repositories and business services that need to be shared across multiple `Servlet` instances. Those beans are effectively inherited and can be overridden (that is, re-declared) in the Servlet-specific child `WebApplicationContext`, which typically contains beans local to the given `Servlet`. The following image shows this relationship:



The following example configures a `WebApplicationContext` hierarchy:

```
public class MyWebAppInitializer extends  
AbstractAnnotationConfigDispatcherServletInitializer {  
  
    @Override  
    protected Class<?>[] getRootConfigClasses() {  
        return new Class<?>[] { RootConfig.class };  
    }  
  
    @Override  
    protected Class<?>[] getServletConfigClasses() {  
        return new Class<?>[] { App1Config.class };  
    }  
  
    @Override  
    protected String[] getServletMappings() {  
        return new String[] { "/app1/*" };  
    }  
}
```



If an application context hierarchy is not required, applications can return all configuration through `getRootConfigClasses()` and `null` from `getServletConfigClasses()`.

The following example shows the `web.xml` equivalent:

```

<web-app>

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

    <context-param>
        <param-name>contextConfigLocation</param-name>
        <param-value>/WEB-INF/root-context.xml</param-value>
    </context-param>

    <servlet>
        <servlet-name>app1</servlet-name>
        <servlet-class>org.springframework.web.servlet.DispatcherServlet</servlet-
class>
        <init-param>
            <param-name>contextConfigLocation</param-name>
            <param-value>/WEB-INF/app1-context.xml</param-value>
        </init-param>
        <load-on-startup>1</load-on-startup>
    </servlet>

    <servlet-mapping>
        <servlet-name>app1</servlet-name>
        <url-pattern>/app1/*</url-pattern>
    </servlet-mapping>

</web-app>

```



If an application context hierarchy is not required, applications may configure a “root” context only and leave the `contextConfigLocation` Servlet parameter empty.

1.1.2. Special Bean Types

Same as in Spring WebFlux

The `DispatcherServlet` delegates to special beans to process requests and render the appropriate responses. By “special beans” we mean Spring-managed `Object` instances that implement WebFlux framework contracts. Those usually come with built-in contracts, but you can customize their properties and extend or replace them.

The following table lists the special beans detected by the `DispatcherHandler`:

Bean type	Explanation
<code>HandlerMapping</code>	Map a request to a handler along with a list of <code>interceptors</code> for pre- and post-processing. The mapping is based on some criteria, the details of which vary by <code>HandlerMapping</code> implementation. The two main <code>HandlerMapping</code> implementations are <code>RequestMappingHandlerMapping</code> (which supports <code>@RequestMapping</code> annotated methods) and <code>SimpleUrlHandlerMapping</code> (which maintains explicit registrations of URI path patterns to handlers).
<code>HandlerAdapter</code>	Help the <code>DispatcherServlet</code> to invoke a handler mapped to a request, regardless of how the handler is actually invoked. For example, invoking an annotated controller requires resolving annotations. The main purpose of a <code>HandlerAdapter</code> is to shield the <code>DispatcherServlet</code> from such details.
<code>HandlerExceptionResolver</code>	Strategy to resolve exceptions, possibly mapping them to handlers, to HTML error views, or other targets. See Exceptions .
<code>ViewResolver</code>	Resolve logical <code>String</code> -based view names returned from a handler to an actual <code>View</code> with which to render to the response. See View Resolution and View Technologies .
<code>LocaleResolver</code> , <code>LocaleContextResolver</code>	Resolve the <code>Locale</code> a client is using and possibly their time zone, in order to be able to offer internationalized views. See Locale .
<code>ThemeResolver</code>	Resolve themes your web application can use — for example, to offer personalized layouts. See Themes .
<code>MultipartResolver</code>	Abstraction for parsing a multi-part request (for example, browser form file upload) with the help of some multipart parsing library. See Multipart Resolver .
<code>FlashMapManager</code>	Store and retrieve the “input” and the “output” <code>FlashMap</code> that can be used to pass attributes from one request to another, usually across a redirect. See Flash Attributes .

1.1.3. Web MVC Config

Same as in [Spring WebFlux](#)

Applications can declare the infrastructure beans listed in [Special Bean Types](#) that are required to process requests. The `DispatcherServlet` checks the `WebApplicationContext` for each special bean. If there are no matching bean types, it falls back on the default types listed in `DispatcherServlet.properties`.

In most cases, the [MVC Config](#) is the best starting point. It declares the required beans in either Java or XML and provides a higher-level configuration callback API to customize it.



Spring Boot relies on the MVC Java configuration to configure Spring MVC and provides many extra convenient options.

1.1.4. Servlet Config

In a Servlet 3.0+ environment, you have the option of configuring the Servlet container programmatically as an alternative or in combination with a `web.xml` file. The following example registers a `DispatcherServlet`:

```
import org.springframework.web.WebApplicationInitializer;

public class MyWebApplicationInitializer implements WebApplicationInitializer {

    @Override
    public void onStartup(ServletContext container) {
        XmlWebApplicationContext appContext = new XmlWebApplicationContext();
        appContext.setConfigLocation("/WEB-INF/spring/dispatcher-config.xml");

        ServletRegistration.Dynamic registration = container.addServlet(
            "dispatcher", new DispatcherServlet(appContext));
        registration.setLoadOnStartup(1);
        registration.addMapping("/");
    }
}
```

`WebApplicationInitializer` is an interface provided by Spring MVC that ensures your implementation is detected and automatically used to initialize any Servlet 3 container. An abstract base class implementation of `WebApplicationInitializer` named `AbstractDispatcherServletInitializer` makes it even easier to register the `DispatcherServlet` by overriding methods to specify the servlet mapping and the location of the `DispatcherServlet` configuration.

This is recommended for applications that use Java-based Spring configuration, as the following example shows:

```

public class MyWebAppInitializer extends
AbstractAnnotationConfigDispatcherServletInitializer {

    @Override
    protected Class<?>[] getRootConfigClasses() {
        return null;
    }

    @Override
    protected Class<?>[] getServletConfigClasses() {
        return new Class<?>[] { MyWebConfig.class };
    }

    @Override
    protected String[] getServletMappings() {
        return new String[] { "/" };
    }
}

```

If you use XML-based Spring configuration, you should extend directly from `AbstractDispatcherServletInitializer`, as the following example shows:

```

public class MyWebAppInitializer extends AbstractDispatcherServletInitializer {

    @Override
    protected WebApplicationContext createRootApplicationContext() {
        return null;
    }

    @Override
    protected WebApplicationContext createServletApplicationContext() {
        XmlWebApplicationContext ctxt = new XmlWebApplicationContext();
        ctxt.setConfigLocation("/WEB-INF/spring/dispatcher-config.xml");
        return ctxt;
    }

    @Override
    protected String[] getServletMappings() {
        return new String[] { "/" };
    }
}

```

`AbstractDispatcherServletInitializer` also provides a convenient way to add `Filter` instances and have them be automatically mapped to the `DispatcherServlet`, as the following example shows:

```

public class MyWebAppInitializer extends AbstractDispatcherServletInitializer {

    // ...

    @Override
    protected Filter[] getServletFilters() {
        return new Filter[] {
            new HiddenHttpMethodFilter(), new CharacterEncodingFilter() };
    }
}

```

Each filter is added with a default name based on its concrete type and automatically mapped to the `DispatcherServlet`.

The `isAsyncSupported` protected method of `AbstractDispatcherServletInitializer` provides a single place to enable async support on the `DispatcherServlet` and all filters mapped to it. By default, this flag is set to `true`.

Finally, if you need to further customize the `DispatcherServlet` itself, you can override the `createDispatcherServlet` method.

1.1.5. Processing

[Same as in Spring WebFlux](#)

The `DispatcherServlet` processes requests as follows:

- The `WebApplicationContext` is searched for and bound in the request as an attribute that the controller and other elements in the process can use. It is bound by default under the `DispatcherServlet.WEB_APPLICATION_CONTEXT_ATTRIBUTE` key.
- The locale resolver is bound to the request to let elements in the process resolve the locale to use when processing the request (rendering the view, preparing data, and so on). If you do not need locale resolving, you do not need the locale resolver.
- The theme resolver is bound to the request to let elements such as views determine which theme to use. If you do not use themes, you can ignore it.
- If you specify a multipart file resolver, the request is inspected for multipart. If multipart are found, the request is wrapped in a `MultipartHttpServletRequest` for further processing by other elements in the process. See [Multipart Resolver](#) for further information about multipart handling.
- An appropriate handler is searched for. If a handler is found, the execution chain associated with the handler (preprocessors, postprocessors, and controllers) is executed in order to prepare a model or rendering. Alternatively, for annotated controllers, the response can be rendered (within the `HandlerAdapter`) instead of returning a view.
- If a model is returned, the view is rendered. If no model is returned (maybe due to a preprocessor or postprocessor intercepting the request, perhaps for security reasons), no view

is rendered, because the request could already have been fulfilled.

The `HandlerExceptionResolver` beans declared in the `WebApplicationContext` are used to resolve exceptions thrown during request processing. Those exception resolvers allow customizing the logic to address exceptions. See [Exceptions](#) for more details.

The Spring `DispatcherServlet` also supports the return of the `last-modification-date`, as specified by the Servlet API. The process of determining the last modification date for a specific request is straightforward: The `DispatcherServlet` looks up an appropriate handler mapping and tests whether the handler that is found implements the `LastModified` interface. If so, the value of the `long getLastModified(request)` method of the `LastModified` interface is returned to the client.

You can customize individual `DispatcherServlet` instances by adding Servlet initialization parameters (`init-param` elements) to the Servlet declaration in the `web.xml` file. The following table lists the supported parameters:

Table 1. DispatcherServlet initialization parameters

Parameter	Explanation
<code>contextClass</code>	Class that implements <code>ConfigurableWebApplicationContext</code> , to be instantiated and locally configured by this Servlet. By default, <code>XmlWebApplicationContext</code> is used.
<code>contextConfigLocation</code>	String that is passed to the context instance (specified by <code>contextClass</code>) to indicate where contexts can be found. The string consists potentially of multiple strings (using a comma as a delimiter) to support multiple contexts. In the case of multiple context locations with beans that are defined twice, the latest location takes precedence.
<code>namespace</code>	Namespace of the <code>WebApplicationContext</code> . Defaults to <code>[servlet-name]-servlet</code> .
<code>throwExceptionIfNoHandlerFound</code>	Whether to throw a <code>NoHandlerFoundException</code> when no handler was found for a request. The exception can then be caught with a <code>HandlerExceptionResolver</code> (for example, by using an <code>@ExceptionHandler</code> controller method) and handled as any others. By default, this is set to <code>false</code> , in which case the <code>DispatcherServlet</code> sets the response status to 404 (NOT_FOUND) without raising an exception. Note that, if <code>default servlet handling</code> is also configured, unresolved requests are always forwarded to the default servlet and a 404 is never raised.

1.1.6. Interception

All `HandlerMapping` implementations support handler interceptors that are useful when you want to apply specific functionality to certain requests—for example, checking for a principal. Interceptors must implement `HandlerInterceptor` from the `org.springframework.web.servlet` package with three methods that should provide enough flexibility to do all kinds of pre-processing and post-processing:

- `preHandle(..)`: Before the actual handler is executed
- `postHandle(..)`: After the handler is executed
- `afterCompletion(..)`: After the complete request has finished

The `preHandle(..)` method returns a boolean value. You can use this method to break or continue the processing of the execution chain. When this method returns `true`, the handler execution chain continues. When it returns false, the `DispatcherServlet` assumes the interceptor itself has taken care of requests (and, for example, rendered an appropriate view) and does not continue executing the other interceptors and the actual handler in the execution chain.

See [Interceptors](#) in the section on MVC configuration for examples of how to configure interceptors. You can also register them directly by using setters on individual `HandlerMapping` implementations.

Note that `postHandle` is less useful with `@ResponseBody` and `ResponseEntity` methods for which the response is written and committed within the `HandlerAdapter` and before `postHandle`. That means it is too late to make any changes to the response, such as adding an extra header. For such scenarios, you can implement `ResponseBodyAdvice` and either declare it as an `Controller Advice` bean or configure it directly on `RequestMappingHandlerAdapter`.

1.1.7. Exceptions

Same as in Spring WebFlux

If an exception occurs during request mapping or is thrown from a request handler (such as a `@Controller`), the `DispatcherServlet` delegates to a chain of `HandlerExceptionResolver` beans to resolve the exception and provide alternative handling, which is typically an error response.

The following table lists the available `HandlerExceptionResolver` implementations:

Table 2. HandlerExceptionResolver implementations

<code>HandlerExceptionResolver</code>	<code>Description</code>
<code>SimpleMappingExceptionResolver</code>	A mapping between exception class names and error view names. Useful for rendering error pages in a browser application.
<code>DefaultHandlerExceptionResolver</code>	Resolves exceptions raised by Spring MVC and maps them to HTTP status codes. See also alternative <code>ResponseEntityExceptionHandler</code> and REST API exceptions.
<code>ResponseStatusExceptionResolver</code>	Resolves exceptions with the <code>@ResponseStatus</code> annotation and maps them to HTTP status codes based on the value in the annotation.

<code>HandlerExceptionResolver</code>	Description
<code>ExceptionHandlerExceptionResolver</code>	Resolves exceptions by invoking an <code>@ExceptionHandler</code> method in a <code>@Controller</code> or a <code>@ControllerAdvice</code> class. See <code>@ExceptionHandler</code> methods.

Chain of Resolvers

You can form an exception resolver chain by declaring multiple `HandlerExceptionResolver` beans in your Spring configuration and setting their `order` properties as needed. The higher the order property, the later the exception resolver is positioned.

The contract of `HandlerExceptionResolver` specifies that it can return:

- a `ModelAndView` that points to an error view.
- An empty `ModelAndView` if the exception was handled within the resolver.
- `null` if the exception remains unresolved, for subsequent resolvers to try, and, if the exception remains at the end, it is allowed to bubble up to the Servlet container.

The `MVC Config` automatically declares built-in resolvers for default Spring MVC exceptions, for `@ResponseStatus` annotated exceptions, and for support of `@ExceptionHandler` methods. You can customize that list or replace it.

Container Error Page

If an exception remains unresolved by any `HandlerExceptionResolver` and is, therefore, left to propagate or if the response status is set to an error status (that is, 4xx, 5xx), Servlet containers can render a default error page in HTML. To customize the default error page of the container, you can declare an error page mapping in `web.xml`. The following example shows how to do so:

```
<error-page>
    <location>/error</location>
</error-page>
```

Given the preceding example, when an exception bubbles up or the response has an error status, the Servlet container makes an ERROR dispatch within the container to the configured URL (for example, `/error`). This is then processed by the `DispatcherServlet`, possibly mapping it to a `@Controller`, which could be implemented to return an error view name with a model or to render a JSON response, as the following example shows:

```

@RestController
public class ErrorController {

    @RequestMapping(path = "/error")
    public Map<String, Object> handle(HttpServletRequest request) {
        Map<String, Object> map = new HashMap<String, Object>();
        map.put("status", request.getAttribute("javax.servlet.error.status_code"))
    );
        map.put("reason", request.getAttribute("javax.servlet.error.message"));
        return map;
    }
}

```



The Servlet API does not provide a way to create error page mappings in Java. You can, however, use both a `WebApplicationInitializer` and a minimal `web.xml`.

1.1.8. View Resolution

Same as in Spring WebFlux

Spring MVC defines the `ViewResolver` and `View` interfaces that let you render models in a browser without tying you to a specific view technology. `ViewResolver` provides a mapping between view names and actual views. `View` addresses the preparation of data before handing over to a specific view technology.

The following table provides more details on the `ViewResolver` hierarchy:

Table 3. ViewResolver implementations

ViewResolver	Description
<code>AbstractCachingViewResolver</code>	Sub-classes of <code>AbstractCachingViewResolver</code> cache view instances that they resolve. Caching improves performance of certain view technologies. You can turn off the cache by setting the <code>cache</code> property to <code>false</code> . Furthermore, if you must refresh a certain view at runtime (for example, when a FreeMarker template is modified), you can use the <code>removeFromCache(String viewName, Locale loc)</code> method.
<code>XmlViewResolver</code>	Implementation of <code>ViewResolver</code> that accepts a configuration file written in XML with the same DTD as Spring's XML bean factories. The default configuration file is <code>/WEB-INF/views.xml</code> .

ViewResolver	Description
ResourceBundleViewResolver	Implementation of ViewResolver that uses bean definitions in a ResourceBundle , specified by the bundle base name. For each view it is supposed to resolve, it uses the value of the property <code>[viewname].(class)</code> as the view class and the value of the property <code>[viewname].url</code> as the view URL. You can find examples in the chapter on View Technologies .
UrlBasedViewResolver	Simple implementation of the ViewResolver interface that affects the direct resolution of logical view names to URLs without an explicit mapping definition. This is appropriate if your logical names match the names of your view resources in a straightforward manner, without the need for arbitrary mappings.
InternalResourceViewResolver	Convenient subclass of UrlBasedViewResolver that supports InternalResourceView (in effect, Servlets and JSPs) and subclasses such as JstlView and TilesView . You can specify the view class for all views generated by this resolver by using <code>setViewClass(..)</code> . See the UrlBasedViewResolver javadoc for details.
FreeMarkerViewResolver	Convenient subclass of UrlBasedViewResolver that supports FreeMarkerView and custom subclasses of them.
ContentNegotiatingViewResolver	Implementation of the ViewResolver interface that resolves a view based on the request file name or Accept header. See Content Negotiation .

Handling

[Same as in Spring WebFlux](#)

You can chain view resolvers by declaring more than one resolver bean and, if necessary, by setting the `order` property to specify ordering. Remember, the higher the order property, the later the view resolver is positioned in the chain.

The contract of a [ViewResolver](#) specifies that it can return null to indicate that the view could not be found. However, in the case of JSPs and [InternalResourceViewResolver](#), the only way to figure out if a JSP exists is to perform a dispatch through [RequestDispatcher](#). Therefore, you must always configure an [InternalResourceViewResolver](#) to be last in the overall order of view resolvers.

Configuring view resolution is as simple as adding [ViewResolver](#) beans to your Spring configuration. The [MVC Config](#) provides a dedicated configuration API for [View Resolvers](#) and for adding logic-less [View Controllers](#) which are useful for HTML template rendering without controller logic.

Redirecting

Same as in Spring WebFlux

The special `redirect:` prefix in a view name lets you perform a redirect. The `UrlBasedViewResolver` (and its subclasses) recognize this as an instruction that a redirect is needed. The rest of the view name is the redirect URL.

The net effect is the same as if the controller had returned a `RedirectView`, but now the controller itself can operate in terms of logical view names. A logical view name (such as `redirect:/myapp/some/resource`) redirects relative to the current Servlet context, while a name such as `redirect:http://myhost.com/some/arbitrary/path` redirects to an absolute URL.

Note that, if a controller method is annotated with the `@ResponseStatus`, the annotation value takes precedence over the response status set by `RedirectView`.

Forwarding

You can also use a special `forward:` prefix for view names that are ultimately resolved by `UrlBasedViewResolver` and subclasses. This creates an `InternalResourceView`, which does a `RequestDispatcher.forward()`. Therefore, this prefix is not useful with `InternalResourceViewResolver` and `InternalResourceView` (for JSPs), but it can be helpful if you use another view technology but still want to force a forward of a resource to be handled by the Servlet/JSP engine. Note that you may also chain multiple view resolvers, instead.

Content Negotiation

Same as in Spring WebFlux

`ContentNegotiatingViewResolver` does not resolve views itself but rather delegates to other view resolvers and selects the view that resembles the representation requested by the client. The representation can be determined from the `Accept` header or from a query parameter (for example, `"/path?format=pdf"`).

The `ContentNegotiatingViewResolver` selects an appropriate `View` to handle the request by comparing the request media types with the media type (also known as `Content-Type`) supported by the `View` associated with each of its `ViewResolvers`. The first `View` in the list that has a compatible `Content-Type` returns the representation to the client. If a compatible view cannot be supplied by the `ViewResolver` chain, the list of views specified through the `DefaultViews` property is consulted. This latter option is appropriate for singleton `Views` that can render an appropriate representation of the current resource regardless of the logical view name. The `Accept` header can include wildcards (for example `text/*`), in which case a `View` whose `Content-Type` is `text/xml` is a compatible match.

See [View Resolvers](#) under [MVC Config](#) for configuration details.

1.1.9. Locale

Most parts of Spring's architecture support internationalization, as the Spring web MVC framework does. `DispatcherServlet` lets you automatically resolve messages by 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 to set the locale. By using the `RequestContext.getLocale()` method, you can always retrieve the locale that was resolved by the locale resolver.

In addition to automatic locale resolution, you can also attach an interceptor to the handler mapping (see [Interception](#) for more information on handler mapping interceptors) to change the locale under specific circumstances (for example, based on a parameter in the request).

Locale resolvers and interceptors are defined in the `org.springframework.web.servlet.i18n` package and are configured in your application context in the normal way. The following selection of locale resolvers is included in Spring.

- [Time Zone](#)
- [Header Resolver](#)
- [Cookie Resolver](#)
- [Session Resolver](#)
- [Locale Interceptor](#)

Time Zone

In addition to obtaining the client's locale, it is often useful to know its time zone. The `LocaleContextResolver` interface offers an extension to `LocaleResolver` that lets resolvers provide a richer `LocaleContext`, which may include time zone information.

When available, the user's `TimeZone` can be obtained by using the `RequestContext.getTimeZone()` method. Time zone information is automatically used by any Date/Time `Converter` and `Formatter` objects that are registered with Spring's `ConversionService`.

Header Resolver

This locale resolver inspects the `accept-language` header in the request that was sent by the client (for example, a web browser). Usually, this header field contains the locale of the client's operating system. Note that this resolver does not support time zone information.

Cookie Resolver

This locale resolver inspects a `Cookie` that might exist on the client to see if a `Locale` or `TimeZone` is specified. If so, it uses the specified details. By using the properties of this locale resolver, you can specify the name of the cookie as well as the maximum age. The following example defines a `CookieLocaleResolver`:

```

<bean id="localeResolver" class=
"org.springframework.web.servlet.i18n.CookieLocaleResolver">

    <property name="cookieName" value="clientlanguage"/>

    <!-- in seconds. If set to -1, the cookie is not persisted (deleted when
        browser shuts down) -->
    <property name="cookieMaxAge" value="100000"/>

</bean>

```

The following table describes the properties `CookieLocaleResolver`:

Table 4. CookieLocaleResolver properties

Property	Default	Description
<code>cookieName</code>	classname + LOCALE	The name of the cookie
<code>cookieMaxAge</code>	Servlet container default	The maximum time a cookie persists on the client. If <code>-1</code> is specified, the cookie will not be persisted. It is available only until the client shuts down the browser.
<code>cookiePath</code>	/	Limits the visibility of the cookie to a certain part of your site. When <code>cookiePath</code> is specified, the cookie is visible only to that path and the paths below it.

Session Resolver

The `SessionLocaleResolver` lets you retrieve `Locale` and `TimeZone` from the session that might be associated with the user's request. In contrast to `CookieLocaleResolver`, this strategy stores locally chosen locale settings in the Servlet container's `HttpSession`. As a consequence, those settings are temporary for each session and are, therefore, lost when each session terminates.

Note that there is no direct relationship with external session management mechanisms, such as the Spring Session project. This `SessionLocaleResolver` evaluates and modifies the corresponding `HttpSession` attributes against the current `HttpServletRequest`.

Locale Interceptor

You can enable changing of locales by adding the `LocaleChangeInterceptor` to one of the `HandlerMapping` definitions. It detects a parameter in the request and changes the locale accordingly, calling the `setLocale` method on the `LocaleResolver` in the dispatcher's application context. The next example shows that calls to all `*.view` resources that contain a parameter named `siteLanguage` now changes the locale. So, for example, a request for the URL, `http://www.sf.net/home.view?siteLanguage=nl`, changes the site language to Dutch. The following example shows how to intercept the locale:

```

<bean id="localeChangeInterceptor"
      class="org.springframework.web.servlet.i18n.LocaleChangeInterceptor">
    <property name="paramName" value="siteLanguage"/>
</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 bean="localeChangeInterceptor"/>
    </list>
  </property>
  <property name="mappings">
    <value>/**/*.*.view=someController</value>
  </property>
</bean>

```

1.1.10. Themes

You can apply Spring Web MVC framework themes to set the overall look-and-feel of your application, thereby enhancing user experience. A theme is a collection of static resources, typically style sheets and images, that affect the visual style of the application.

Defining a theme

To use themes in your web application, you must set up an implementation of the `org.springframework.ui.context.ThemeSource` interface. The `WebApplicationContext` interface extends `ThemeSource` but delegates its responsibilities to a dedicated implementation. By default, the delegate is an `org.springframework.ui.context.support.ResourceBundleThemeSource` implementation that loads properties files from the root of the classpath. To use a custom `ThemeSource` implementation or to configure the base name prefix of the `ResourceBundleThemeSource`, you can register a bean in the application context with the reserved name, `themeSource`. The web application context automatically detects a bean with that name and uses it.

When you use the `ResourceBundleThemeSource`, a theme is defined in a simple properties file. The properties file lists the resources that make up the theme, as the following example shows:

```

styleSheet=/themes/cool/style.css
background=/themes/cool/img/coolBg.jpg

```

The keys of the properties are the names that refer to the themed elements from view code. For a

JSP, you typically do this using the `spring:theme` custom tag, which is very similar to the `spring:message` tag. The following JSP fragment uses the theme defined in the previous example to customize the look and feel:

```
<%@ taglib prefix="spring" uri="http://www.springframework.org/tags"%>
<html>
  <head>
    <link rel="stylesheet" href="
  </head>
  <body style="background=<spring:theme code='background' />">
  ...
</body>
</html>
```

By default, the `ResourceBundleThemeSource` uses an empty base name prefix. As a result, the properties files are loaded from the root of the classpath. Thus, you would put the `cool.properties` theme definition in a directory at the root of the classpath (for example, in `/WEB-INF/classes`). The `ResourceBundleThemeSource` uses the standard Java resource bundle loading mechanism, allowing for full internationalization of themes. For example, we could have a `/WEB-INF/classes/cool_nl.properties` that references a special background image with Dutch text on it.

Resolving Themes

After you define themes, as described in the preceding section, you decide which theme to use. The `DispatcherServlet` looks for a bean named `themeResolver` to find out which `ThemeResolver` implementation to use. A theme resolver works in much the same way as a `LocaleResolver`. It detects the theme to use for a particular request and can also alter the request's theme. The following table describes the theme resolvers provided by Spring:

Table 5. ThemeResolver implementations

Class	Description
<code>FixedThemeResolver</code>	Selects a fixed theme, set by using the <code>defaultThemeName</code> property.
<code>SessionThemeResolver</code>	The theme is maintained in the user's HTTP session. It needs to be set only once for each session but is not persisted between sessions.
<code>CookieThemeResolver</code>	The selected theme is stored in a cookie on the client.

Spring also provides a `ThemeChangeInterceptor` that lets theme changes on every request with a simple request parameter.

1.1.11. Multipart Resolver

Same as in Spring WebFlux

`MultipartResolver` from the `org.springframework.web.multipart` package is a strategy for parsing

multipart requests including file uploads. There is one implementation based on [Commons FileUpload](#) and another based on Servlet 3.0 multipart request parsing.

To enable multipart handling, you need to declare a `MultipartResolver` bean in your `DispatcherServlet` Spring configuration with a name of `multipartResolver`. The `DispatcherServlet` detects it and applies it to the incoming request. When a POST with content-type of `multipart/form-data` is received, the resolver parses the content and wraps the current `HttpServletRequest` as `MultipartHttpServletRequest` to provide access to resolved parts in addition to exposing them as request parameters.

Apache Commons FileUpload

To use Apache Commons `FileUpload`, you can configure a bean of type `CommonsMultipartResolver` with a name of `multipartResolver`. You also need to have `commons-fileupload` as a dependency on your classpath.

Servlet 3.0

Servlet 3.0 multipart parsing needs to be enabled through Servlet container configuration. To do so:

- In Java, set a `MultipartConfigElement` on the Servlet registration.
- In `web.xml`, add a "`<multipart-config>`" section to the servlet declaration.

The following example shows how to set a `MultipartConfigElement` on the Servlet registration:

```
public class AppInitializer extends
AbstractAnnotationConfigDispatcherServletInitializer {

    // ...

    @Override
    protected void customizeRegistration(ServletRegistration.Dynamic registration)
    {

        // Optionally also set maxFileSize, maxRequestSize, fileSizeThreshold
        registration.setMultipartConfig(new MultipartConfigElement("/tmp"));
    }

}
```

Once the Servlet 3.0 configuration is in place, you can add a bean of type `StandardServletMultipartResolver` with a name of `multipartResolver`.

1.1.12. Logging

Same as in Spring WebFlux

DEBUG-level logging in Spring MVC is designed to be compact, minimal, and human-friendly. It focuses on high-value bits of information that are useful over and over again versus others that are useful only when debugging a specific issue.

TRACE-level logging generally follows the same principles as DEBUG (and, for example, also should not be a fire hose) but can be used for debugging any issue. In addition, some log messages may show a different level of detail at TRACE versus DEBUG.

Good logging comes from the experience of using the logs. If you spot anything that does not meet the stated goals, please let us know.

Sensitive Data

Same as in Spring WebFlux

DEBUG and TRACE logging may log sensitive information. This is why request parameters and headers are masked by default and their logging in full must be enabled explicitly through the `enableLoggingRequestDetails` property on `DispatcherServlet`.

The following example shows how to do so by using Java configuration:

```
public class MyInitializer
    extends AbstractAnnotationConfigDispatcherServletInitializer {

    @Override
    protected Class<?>[] getRootConfigClasses() {
        return ... ;
    }

    @Override
    protected Class<?>[] getServletConfigClasses() {
        return ... ;
    }

    @Override
    protected String[] getServletMappings() {
        return ... ;
    }

    @Override
    protected void customizeRegistration(Dynamic registration) {
        registration.setInitParameter("enableLoggingRequestDetails", "true");
    }
}
```

1.2. Filters

Same as in Spring WebFlux

The `spring-web` module provides some useful filters:

- [Form Data](#)
- [Forwarded Headers](#)
- [Shallow ETag](#)
- [CORS](#)

1.2.1. Form Data

Browsers can submit form data only through HTTP GET or HTTP POST but non-browser clients can also use HTTP PUT, PATCH, and DELETE. The Servlet API requires `ServletRequest.getParameter*`() methods to support form field access only for HTTP POST.

The `spring-web` module provides `FormContentFilter` to intercept HTTP PUT, PATCH, and DELETE requests with a content type of `application/x-www-form-urlencoded`, read the form data from the body of the request, and wrap the `ServletRequest` to make the form data available through the `ServletRequest.getParameter*`() family of methods.

1.2.2. Forwarded Headers

Same as in Spring WebFlux

As a request goes through proxies (such as load balancers) the host, port, and scheme may change, and that makes it a challenge to create links that point to the correct host, port, and scheme from a client perspective.

RFC 7239 defines the `Forwarded` HTTP header that proxies can use to provide information about the original request. There are other non-standard headers, too, including `X-Forwarded-Host`, `X-Forwarded-Port`, `X-Forwarded-Proto`, `X-Forwarded-Ssl`, and `X-Forwarded-Prefix`.

`ForwardedHeaderFilter` is a Servlet filter that modifies the host, port, and scheme of the request, based on `Forwarded` headers, and then removes those headers.

There are security considerations for forwarded headers since an application cannot know if the headers were added by a proxy, as intended, or by a malicious client. This is why a proxy at the boundary of trust should be configured to remove untrusted `Forwarded` headers that come from the outside. You can also configure the `ForwardedHeaderFilter` with `removeOnly=true`, in which case it removes but does not use the headers.

1.2.3. Shallow ETag

The `ShallowEtagHeaderFilter` filter creates a “shallow” ETag by caching the content written to the response and computing an MD5 hash from it. The next time a client sends, it does the same, but it also compares the computed value against the `If-None-Match` request header and, if the two are

equal, returns a 304 (NOT_MODIFIED).

This strategy saves network bandwidth but not CPU, as the full response must be computed for each request. Other strategies at the controller level, described earlier, can avoid the computation. See [HTTP Caching](#).

This filter has a `writeWeakETag` parameter that configures the filter to write weak ETags similar to the following: `W/"02a2d595e6ed9a0b24f027f2b63b134d6"` (as defined in [RFC 7232 Section 2.3](#)).

1.2.4. CORS

[Same as in Spring WebFlux](#)

Spring MVC provides fine-grained support for CORS configuration through annotations on controllers. However, when used with Spring Security, we advise relying on the built-in `CorsFilter` that must be ordered ahead of Spring Security's chain of filters.

See the sections on [CORS](#) and the [CORS Filter](#) for more details.

1.3. Annotated Controllers

[Same as in Spring WebFlux](#)

Spring MVC provides an annotation-based programming model where `@Controller` and `@RestController` components use annotations to express request mappings, request input, exception handling, and more. Annotated controllers have flexible method signatures and do not have to extend base classes nor implement specific interfaces. The following example shows a controller defined by annotations:

```
@Controller
public class HelloController {

    @GetMapping("/hello")
    public String handle(Model model) {
        model.addAttribute("message", "Hello World!");
        return "index";
    }
}
```

In the preceding example, the method accepts a `Model` and returns a view name as a `String`, but many other options exist and are explained later in this chapter.



Guides and tutorials on [spring.io](#) use the annotation-based programming model described in this section.

1.3.1. Declaration

Same as in Spring WebFlux

You can define controller beans by using a standard Spring bean definition in the Servlet's `WebApplicationContext`. The `@Controller` stereotype allows for auto-detection, aligned with Spring general support for detecting `@Component` classes in the classpath and auto-registering bean definitions for them. It also acts as a stereotype for the annotated class, indicating its role as a web component.

To enable auto-detection of such `@Controller` beans, you can add component scanning to your Java configuration, as the following example shows:

```
@Configuration  
@ComponentScan("org.example.web")  
public class WebConfig {  
  
    // ...  
}
```

The following example shows the XML configuration equivalent of the preceding example:

```
<?xml version="1.0" encoding="UTF-8"?>  
<beans xmlns="http://www.springframework.org/schema/beans"  
       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"  
       xmlns:p="http://www.springframework.org/schema/p"  
       xmlns:context="http://www.springframework.org/schema/context"  
       xsi:schemaLocation="  
           http://www.springframework.org/schema/beans  
           http://www.springframework.org/schema/beans/spring-beans.xsd  
           http://www.springframework.org/schema/context  
           http://www.springframework.org/schema/context/spring-context.xsd">  
  
    <context:component-scan base-package="org.example.web"/>  
  
    <!-- ... -->  
  
</beans>
```

`@RestController` is a composed annotation that is itself meta-annotated with `@Controller` and `@ResponseBody` to indicate a controller whose every method inherits the type-level `@ResponseBody` annotation and, therefore, writes directly to the response body versus view resolution and rendering with an HTML template.

AOP Proxies

In some cases, you may need to decorate a controller with an AOP proxy at runtime. One example is if you choose to have `@Transactional` annotations directly on the controller. When this is the case, for controllers specifically, we recommend using class-based proxying. This is typically the default choice with controllers. However, if a controller must implement an interface that is not a Spring Context callback (such as `InitializingBean`, `*Aware`, and others), you may need to explicitly configure class-based proxying. For example, with `<tx:annotation-driven/>`, you can change to `<tx:annotation-driven proxy-target-class="true"/>`.

1.3.2. Request Mapping

Same as in Spring WebFlux

You can use the `@RequestMapping` annotation to map requests to controllers methods. It has various attributes to match by URL, HTTP method, request parameters, headers, and media types. You can use it at the class level to express shared mappings or at the method level to narrow down to a specific endpoint mapping.

There are also HTTP method specific shortcut variants of `@RequestMapping`:

- `@GetMapping`
- `@PostMapping`
- `@PutMapping`
- `@DeleteMapping`
- `@PatchMapping`

The shortcuts are [Custom Annotations](#) that are provided because, arguably, most controller methods should be mapped to a specific HTTP method versus using `@RequestMapping`, which, by default, matches to all HTTP methods. At the same, a `@RequestMapping` is still needed at the class level to express shared mappings.

The following example has type and method level mappings:

```

@RestController
@RequestMapping("/persons")
class PersonController {

    @GetMapping("/{id}")
    public Person getPerson(@PathVariable Long id) {
        // ...
    }

    @PostMapping
    @ResponseStatus(HttpStatus.CREATED)
    public void add(@RequestBody Person person) {
        // ...
    }
}

```

URI patterns

[Same as in Spring WebFlux](#)

You can map requests by using the following glob patterns and wildcards:

- `?` matches one character
- `*` matches zero or more characters within a path segment
- `**` match zero or more path segments

You can also declare URI variables and access their values with `@PathVariable`, as the following example shows:

```

@GetMapping("/owners/{ownerId}/pets/{petId}")
public Pet findPet(@PathVariable Long ownerId, @PathVariable Long petId) {
    // ...
}

```

You can declare URI variables at the class and method levels, as the following example shows:

```

@Controller
@RequestMapping("/owners/{ownerId}")
public class OwnerController {

    @GetMapping("/pets/{petId}")
    public Pet findPet(@PathVariable Long ownerId, @PathVariable Long petId) {
        // ...
    }
}

```

URI variables are automatically converted to the appropriate type, or `TypeMismatchException` is raised. Simple types (`int`, `long`, `Date`, and so on) are supported by default and you can register support for any other data type. See [Type Conversion](#) and [DataBinder](#).

You can explicitly name URI variables (for example, `@PathVariable("customId")`), but you can leave that detail out if the names are the same and your code is compiled with debugging information or with the `-parameters` compiler flag on Java 8.

The syntax `{varName:regex}` declares a URI variable with a regular expression that has syntax of `{varName:regex}`. For example, given URL `"/spring-web-3.0.5.jar"`, the following method extracts the name, version, and file extension:

```

@GetMapping("/{name:[a-z-]+}-{version:\d\.\d\.\d}{ext:\.[a-z]+}")
public void handle(@PathVariable String version, @PathVariable String ext) {
    // ...
}

```

URI path patterns can also have embedded `${...}` placeholders that are resolved on startup by using `PropertyPlaceholderConfigurer` against local, system, environment, and other property sources. You can use this, for example, to parameterize a base URL based on some external configuration.



Spring MVC uses the `PathMatcher` contract and the `AntPathMatcher` implementation from `spring-core` for URI path matching.

Pattern Comparison

Same as in Spring WebFlux

When multiple patterns match a URL, they must be compared to find the best match. This is done by using `AntPathMatcher.getPatternComparator(String path)`, which looks for patterns that are more specific.

A pattern is less specific if it has a lower count of URI variables and single wildcards counted as 1 and double wildcards counted as 2. Given an equal score, the longer pattern is chosen. Given the

same score and length, the pattern with more URI variables than wildcards is chosen.

The default mapping pattern (`/**`) is excluded from scoring and always sorted last. Also, prefix patterns (such as `/public/**`) are considered less specific than other pattern that do not have double wildcards.

For the full details, see [AntPatternComparator](#) in [AntPathMatcher](#) and also keep mind that you can customize the [PathMatcher](#) implementation. See [Path Matching](#) in the configuration section.

Suffix Match

By default, Spring MVC performs `.*` suffix pattern matching so that a controller mapped to `/person` is also implicitly mapped to `/person.*`. The file extension is then used to interpret the requested content type to use for the response (that is, instead of the `Accept` header)—for example, `/person.pdf`, `/person.xml`, and others.

Using file extensions in this way was necessary when browsers used to send `Accept` headers that were hard to interpret consistently. At present, that is no longer a necessity and using the `Accept` header should be the preferred choice.

Over time, the use of file name extensions has proven problematic in a variety of ways. It can cause ambiguity when overlain with the use of URI variables, path parameters, and URI encoding. Reasoning about URL-based authorization and security (see next section for more details) also become more difficult.

To completely disable the use of file extensions, you must set both of the following:

- `useSuffixPatternMatching(false)`, see [PathMatchConfigurer](#)
- `favorPathExtension(false)`, see [ContentNegotiationConfigurer](#)

URL-based content negotiation can still be useful (for example, when typing a URL in a browser). To enable that, we recommend a query parameter-based strategy to avoid most of the issues that come with file extensions. Alternatively, if you must use file extensions, consider restricting them to a list of explicitly registered extensions through the `mediaTypes` property of [ContentNegotiationConfigurer](#).

Suffix Match and RFD

A reflected file download (RFD) attack is similar to XSS in that it relies on request input (for example, a query parameter and a URI variable) being reflected in the response. However, instead of inserting JavaScript into HTML, an RFD attack relies on the browser switching to perform a download and treating the response as an executable script when double-clicked later.

In Spring MVC, `@ResponseBody` and `ResponseEntity` methods are at risk, because they can render different content types, which clients can request through URL path extensions. Disabling suffix pattern matching and using path extensions for content negotiation lower the risk but are not sufficient to prevent RFD attacks.

To prevent RFD attacks, prior to rendering the response body, Spring MVC adds a `Content-Disposition:inline;filename=f.txt` header to suggest a fixed and safe download file. This is done

only if the URL path contains a file extension that is neither whitelisted nor explicitly registered for content negotiation. However, it can potentially have side effects when URLs are typed directly into a browser.

Many common path extensions are whitelisted by default. Applications with custom `HttpMessageConverter` implementations can explicitly register file extensions for content negotiation to avoid having a `Content-Disposition` header added for those extensions. See [Content Types](#).

See [CVE-2015-5211](#) for additional recommendations related to RFD.

Consumable Media Types

[Same as in Spring WebFlux](#)

You can narrow the request mapping based on the `Content-Type` of the request, as the following example shows:

```
@PostMapping(path = "/pets", consumes = "application/json") ①
public void addPet(@RequestBody Pet pet) {
    // ...
}
```

① Using a `consumes` attribute to narrow the mapping by the content type.

The `consumes` attribute also supports negation expressions—for example, `!text/plain` means any content type other than `text/plain`.

You can declare a shared `consumes` attribute at the class level. Unlike most other request-mapping attributes, however, when used at the class level, a method-level `consumes` attribute overrides rather than extends the class-level declaration.



`MediaType` provides constants for commonly used media types, such as `APPLICATION_JSON_VALUE` and `APPLICATION_XML_VALUE`.

Producible Media Types

[Same as in Spring WebFlux](#)

You can narrow the request mapping based on the `Accept` request header and the list of content types that a controller method produces, as the following example shows:

```
@GetMapping(path = "/pets/{petId}", produces = "application/json;charset=UTF-8")  
①  
@ResponseBody  
public Pet getPet(@PathVariable String petId) {  
    // ...  
}
```

- ① Using a `produces` attribute to narrow the mapping by the content type.

The media type can specify a character set. Negated expressions are supported—for example, `!text/plain` means any content type other than "text/plain".



For the JSON content type, the UTF-8 charset should be specified even if [RFC7159](#) clearly states that “no charset parameter is defined for this registration”, because some browsers require it to correctly interpret UTF-8 special characters.

You can declare a shared `produces` attribute at the class level. Unlike most other request-mapping attributes, however, when used at the class level, a method-level `produces` attribute overrides rather than extends the class-level declaration.



`MediaType` provides constants for commonly used media types, such as `APPLICATION_JSON_UTF8_VALUE` and `APPLICATION_XML_VALUE`.

Parameters, headers

[Same as in Spring WebFlux](#)

You can narrow request mappings based on request parameter conditions. You can test for the presence of a request parameter (`myParam`), for the absence of one (`!myParam`), or for a specific value (`myParam=myValue`). The following example shows how to test for a specific value:

```
@GetMapping(path = "/pets/{petId}", params = "myParam=myValue") ①  
public void findPet(@PathVariable String petId) {  
    // ...  
}
```

- ① Testing whether `myParam` equals `myValue`.

You can also use the same with request header conditions, as the following example shows:

```
@GetMapping(path = "/pets", headers = "myHeader=myValue") ①
public void findPet(@PathVariable String petId) {
    // ...
}
```

① Testing whether `myHeader` equals `myValue`.



You can match `Content-Type` and `Accept` with the `headers` condition, but it is better to use `consumes` and `produces` instead.

HTTP HEAD, OPTIONS

Same as in Spring WebFlux

`@GetMapping` (and `@RequestMapping(method=HttpMethod.GET)`) support HTTP HEAD transparently for request mapping. Controller methods do not need to change. A response wrapper, applied in `javax.servlet.http.HttpServlet`, ensures a `Content-Length` header is set to the number of bytes written (without actually writing to the response).

`@GetMapping` (and `@RequestMapping(method=HttpMethod.GET)`) are implicitly mapped to and support HTTP HEAD. An HTTP HEAD request is processed as if it were HTTP GET except that, instead of writing the body, the number of bytes are counted and the `Content-Length` header is set.

By default, HTTP OPTIONS is handled by setting the `Allow` response header to the list of HTTP methods listed in all `@RequestMapping` methods that have matching URL patterns.

For a `@RequestMapping` without HTTP method declarations, the `Allow` header is set to `GET,HEAD,POST,PUT,PATCH,DELETE,OPTIONS`. Controller methods should always declare the supported HTTP methods (for example, by using the HTTP method specific variants: `@GetMapping`, `@PostMapping`, and others).

You can explicitly map the `@RequestMapping` method to HTTP HEAD and HTTP OPTIONS, but that is not necessary in the common case.

Custom Annotations

Same as in Spring WebFlux

Spring MVC supports the use of `composed annotations` for request mapping. Those are annotations that are themselves meta-annotated with `@RequestMapping` and composed to redeclare a subset (or all) of the `@RequestMapping` attributes with a narrower, more specific purpose.

`@GetMapping`, `@PostMapping`, `@PutMapping`, `@DeleteMapping`, and `@PatchMapping` are examples of composed annotations. They are provided because, arguably, most controller methods should be mapped to a specific HTTP method versus using `@RequestMapping`, which, by default, matches to all HTTP methods. If you need an example of composed annotations, look at how those are declared.

Spring MVC also supports custom request-mapping attributes with custom request-matching logic.

This is a more advanced option that requires subclassing `RequestMappingHandlerMapping` and overriding the `getCustomMethodCondition` method, where you can check the custom attribute and return your own `RequestCondition`.

Explicit Registrations

Same as in Spring WebFlux

You can programmatically register handler methods, which you can use for dynamic registrations or for advanced cases, such as different instances of the same handler under different URLs. The following example registers a handler method:

```
@Configuration
public class MyConfig {

    @Autowired
    public void setHandlerMapping(RequestMappingHandlerMapping mapping,
        UserHandler handler) ①
        throws NoSuchMethodException {

        RequestMappingInfo info = RequestMappingInfo
            .paths("/user/{id}").methods(RequestMethod.GET).build(); ②

        Method method = UserHandler.class.getMethod("getUser", Long.class); ③

        mapping.registerMapping(info, handler, method); ④
    }

}
```

- ① Inject the target handler and the handler mapping for controllers.
- ② Prepare the request mapping meta data.
- ③ Get the handler method.
- ④ Add the registration.

1.3.3. Handler Methods

Same as in Spring WebFlux

`@RequestMapping` handler methods have a flexible signature and can choose from a range of supported controller method arguments and return values.

Method Arguments

Same as in Spring WebFlux

The next table describes the supported controller method arguments. Reactive types are not

supported for any arguments.

JDK 8's `java.util.Optional` is supported as a method argument in combination with annotations that have a `required` attribute (for example, `@RequestParam`, `@RequestHeader`, and others) and is equivalent to `required=false`.

Controller method argument	Description
<code>WebRequest</code> , <code>NativeWebRequest</code>	Generic access to request parameters and request and session attributes, without direct use of the Servlet API.
<code>javax.servlet.ServletRequest</code> , <code>javax.servlet.ServletResponse</code>	Choose any specific request or response type — for example, <code>ServletRequest</code> , <code>HttpServletRequest</code> , or Spring's <code>MultipartRequest</code> , <code>MultipartHttpServletRequest</code> .
<code>javax.servlet.http.HttpSession</code>	Enforces the presence of a session. As a consequence, such an argument is never <code>null</code> . Note that session access is not thread-safe. Consider setting the <code>RequestMappingHandlerAdapter</code> instance's <code>synchronizeOnSession</code> flag to <code>true</code> if multiple requests are allowed to concurrently access a session.
<code>javax.servlet.http.PushBuilder</code>	Servlet 4.0 push builder API for programmatic HTTP/2 resource pushes. Note that, per the Servlet specification, the injected <code>PushBuilder</code> instance can be null if the client does not support that HTTP/2 feature.
<code>java.security.Principal</code>	Currently authenticated user — possibly a specific <code>Principal</code> implementation class if known.
<code>HttpMethod</code>	The HTTP method of the request.
<code>java.util.Locale</code>	The current request locale, determined by the most specific <code>LocaleResolver</code> available (in effect, the configured <code>LocaleResolver</code> or <code>LocaleContextResolver</code>).
<code>java.util.TimeZone</code> + <code>java.time.ZoneId</code>	The time zone associated with the current request, as determined by a <code>LocaleContextResolver</code> .
<code>java.io.InputStream</code> , <code>java.io.Reader</code>	For access to the raw request body as exposed by the Servlet API.
<code>java.io.OutputStream</code> , <code>java.io.Writer</code>	For access to the raw response body as exposed by the Servlet API.
<code>@PathVariable</code>	For access to URI template variables. See URI patterns .
<code>@MatrixVariable</code>	For access to name-value pairs in URI path segments. See Matrix Variables .
<code>@RequestParam</code>	For access to the Servlet request parameters, including multipart files. Parameter values are converted to the declared method argument type. See @RequestParam as well as Multipart . Note that use of <code>@RequestParam</code> is optional for simple parameter values. See "Any other argument", at the end of this table.
<code>@RequestHeader</code>	For access to request headers. Header values are converted to the declared method argument type. See @RequestHeader .
<code>@CookieValue</code>	For access to cookies. Cookies values are converted to the declared method argument type. See @CookieValue .

Controller method argument	Description
<code>@RequestBody</code>	For access to the HTTP request body. Body content is converted to the declared method argument type by using <code>HttpMessageConverter</code> implementations. See @RequestBody .
<code>HttpEntity</code>	For access to request headers and body. The body is converted with an <code>HttpMessageConverter</code> . See HttpEntity .
<code>@RequestPart</code>	For access to a part in a <code>multipart/form-data</code> request, converting the part's body with an <code>HttpMessageConverter</code> . See Multipart .
<code>java.util.Map</code> , <code>org.springframework.ui.Model</code> , <code>org.springframework.ui.ModelMap</code>	For access to the model that is used in HTML controllers and exposed to templates as part of view rendering.
<code>RedirectAttributes</code>	Specify attributes to use in case of a redirect (that is, to be appended to the query string) and flash attributes to be stored temporarily until the request after redirect. See Redirect Attributes and Flash Attributes .
<code>@ModelAttribute</code>	For access to an existing attribute in the model (instantiated if not present) with data binding and validation applied. See @ModelAttribute as well as Model and DataBinder . Note that use of <code>@ModelAttribute</code> is optional (for example, to set its attributes). See “Any other argument” at the end of this table.
<code>Errors</code> , <code>BindingResult</code>	For access to errors from validation and data binding for a command object (that is, a <code>@ModelAttribute</code> argument) or errors from the validation of a <code>@RequestBody</code> or <code>@RequestPart</code> arguments. You must declare an <code>Errors</code> , or <code>BindingResult</code> argument immediately after the validated method argument.
<code>SessionStatus</code> + class-level <code>@SessionAttributes</code>	For marking form processing complete, which triggers cleanup of session attributes declared through a class-level <code>@SessionAttributes</code> annotation. See @SessionAttributes for more details.
<code>UriComponentsBuilder</code>	For preparing a URL relative to the current request's host, port, scheme, context path, and the literal part of the servlet mapping. See URI Links .
<code>@SessionAttribute</code>	For access to any session attribute, in contrast to model attributes stored in the session as a result of a class-level <code>@SessionAttributes</code> declaration. See @SessionAttribute for more details.
<code>@RequestAttribute</code>	For access to request attributes. See @RequestAttribute for more details.
Any other argument	If a method argument is not matched to any of the earlier values in this table and it is a simple type (as determined by <code>BeanUtils#isSimpleProperty</code>), it is resolved as a <code>@RequestParam</code> . Otherwise, it is resolved as a <code>@ModelAttribute</code> .

Return Values

Same as in Spring WebFlux

The next table describes the supported controller method return values. Reactive types are supported for all return values.

Controller method return value	Description
<code>@ResponseBody</code>	The return value is converted through <code>HttpMessageConverter</code> implementations and written to the response. See @ResponseBody .
<code>HttpEntity, ResponseEntity</code>	The return value that specifies the full response (including HTTP headers and body) is to be converted through <code>HttpMessageConverter</code> implementations and written to the response. See ResponseEntity .
<code>HttpHeaders</code>	For returning a response with headers and no body.
<code>String</code>	A view name to be resolved with <code>ViewResolver</code> implementations and used together with the implicit model — determined through command objects and <code>@ModelAttribute</code> methods. The handler method can also programmatically enrich the model by declaring a <code>Model</code> argument (see Explicit Registrations).
<code>View</code>	A <code>View</code> instance to use for rendering together with the implicit model — determined through command objects and <code>@ModelAttribute</code> methods. The handler method can also programmatically enrich the model by declaring a <code>Model</code> argument (see Explicit Registrations).
<code>java.util.Map, org.springframework.ui.Model</code>	Attributes to be added to the implicit model, with the view name implicitly determined through a <code>RequestToViewNameTranslator</code> .
<code>@ModelAttribute</code>	An attribute to be added to the model, with the view name implicitly determined through a <code>RequestToViewNameTranslator</code> . Note that <code>@ModelAttribute</code> is optional. See "Any other return value" at the end of this table.
<code>ModelAndView</code> object	The view and model attributes to use and, optionally, a response status.
<code>void</code>	A method with a <code>void</code> return type (or <code>null</code> return value) is considered to have fully handled the response if it also has a <code>ServletResponse</code> , an <code>OutputStream</code> argument, or an <code>@ResponseStatus</code> annotation. The same is also true if the controller has made a positive <code>ETag</code> or <code>lastModified</code> timestamp check (see Controllers for details). If none of the above is true, a <code>void</code> return type can also indicate "no response body" for REST controllers or a default view name selection for HTML controllers.
<code>DeferredResult<V></code>	Produce any of the preceding return values asynchronously from any thread — for example, as a result of some event or callback. See Asynchronous Requests and DeferredResult .
<code>Callable<V></code>	Produce any of the above return values asynchronously in a Spring MVC-managed thread. See Asynchronous Requests and Callable .

Controller method return value	Description
<code>ListenableFuture<V>, java.util.concurrent.CompletionStage<V>, java.util.concurrent.CompletableFuture<V></code>	Alternative to <code>DeferredResult</code> , as a convenience (for example, when an underlying service returns one of those).
<code>ResponseBodyEmitter, SseEmitter</code>	Emit a stream of objects asynchronously to be written to the response with <code>HttpMessageConverter</code> implementations. Also supported as the body of a <code>ResponseEntity</code> . See Asynchronous Requests and HTTP Streaming .
<code>StreamingResponseBody</code>	Write to the response <code>OutputStream</code> asynchronously. Also supported as the body of a <code>ResponseEntity</code> . See Asynchronous Requests and HTTP Streaming .
Reactive types — Reactor, RxJava, or others through <code>ReactiveAdapterRegistry</code>	<p>Alternative to <code>DeferredResult</code> with multi-value streams (for example, <code>Flux</code>, <code>Observable</code>) collected to a <code>List</code>.</p> <p>For streaming scenarios (for example, <code>text/event-stream</code>, <code>application/json+stream</code>), <code>SseEmitter</code> and <code>ResponseBodyEmitter</code> are used instead, where <code>ServletOutputStream</code> blocking I/O is performed on a Spring MVC-managed thread and back pressure is applied against the completion of each write.</p> <p>See Asynchronous Requests and Reactive Types.</p>
Any other return value	Any return value that does not match any of the earlier values in this table and that is a <code>String</code> or <code>void</code> is treated as a view name (default view name selection through <code>RequestToViewNameTranslator</code> applies), provided it is not a simple type, as determined by <code>BeanUtils#isSimpleProperty</code> . Values that are simple types remain unresolved.

Type Conversion

[Same as in Spring WebFlux](#)

Some annotated controller method arguments that represent `String`-based request input (such as `@RequestParam`, `@RequestHeader`, `@PathVariable`, `@MatrixVariable`, and `@CookieValue`) can require type conversion if the argument is declared as something other than `String`.

For such cases, type conversion is automatically applied based on the configured converters. By default, simple types (`int`, `long`, `Date`, and others) are supported. You can customize type conversion through a `WebDataBinder` (see `DataBinder`) or by registering `Formatters` with the `FormattingConversionService`. See [Spring Field Formatting](#).

Matrix Variables

[Same as in Spring WebFlux](#)

[RFC 3986](#) discusses name-value pairs in path segments. In Spring MVC, we refer to those as “matrix variables” based on an “[old post](#)” by Tim Berners-Lee, but they can be also be referred to as URI

path parameters.

Matrix variables can appear in any path segment, with each variable separated by a semicolon and multiple values separated by comma (for example, `/cars;color=red,green;year=2012`). Multiple values can also be specified through repeated variable names (for example, `color=red;color=green;color=blue`).

If a URL is expected to contain matrix variables, the request mapping for a controller method must use a URI variable to mask that variable content and ensure the request can be matched successfully independent of matrix variable order and presence. The following example uses a matrix variable:

```
// GET /pets/42;q=11;r=22

@GetMapping("/pets/{petId}")
public void findPet(@PathVariable String petId, @MatrixVariable int q) {

    // petId == 42
    // q == 11
}
```

Given that all path segments may contain matrix variables, you may sometimes need to disambiguate which path variable the matrix variable is expected to be in. The following example shows how to do so:

```
// GET /owners/42;q=11/pets/21;q=22

@GetMapping("/owners/{ownerId}/pets/{petId}")
public void findPet(
    @MatrixVariable(name="q", pathVar="ownerId") int q1,
    @MatrixVariable(name="q", pathVar="petId") int q2) {

    // q1 == 11
    // q2 == 22
}
```

A matrix variable may be defined as optional and a default value specified, as the following example shows:

```
// GET /pets/42

@GetMapping("/pets/{petId}")
public void findPet(@MatrixVariable(required=false, defaultValue="1") int q) {

    // q == 1
}
```

To get all matrix variables, you can use a `MultiValueMap`, as the following example shows:

```
// GET /owners/42;q=11;r=12/pets/21;q=22;s=23

@GetMapping("/owners/{ownerId}/pets/{petId}")
public void findPet(
    @MatrixVariable MultiValueMap<String, String> matrixVars,
    @MatrixVariable(pathVar="petId") MultiValueMap<String, String>
petMatrixVars) {

    // matrixVars: ["q" : [11,22], "r" : 12, "s" : 23]
    // petMatrixVars: ["q" : 22, "s" : 23]
}
```

Note that you need to enable the use of matrix variables. In the MVC Java configuration, you need to set a `UrlPathHelper` with `removeSemicolonContent=false` through `Path Matching`. In the MVC XML namespace, you can set `<mvc:annotation-driven enable-matrix-variables="true"/>`.

`@RequestParam`

Same as in Spring WebFlux

You can use the `@RequestParam` annotation to bind Servlet request parameters (that is, query parameters or form data) to a method argument in a controller.

The following example shows how to do so:

```

@Controller
@RequestMapping("/pets")
public class EditPetForm {

    // ...

    @GetMapping
    public String setupForm(@RequestParam("petId") int petId, Model model) { ①
        Pet pet = this.clinic.loadPet(petId);
        model.addAttribute("pet", pet);
        return "petForm";
    }

    // ...
}

}

```

① Using `@RequestParam` to bind `petId`.

By default, method parameters that use this annotation are required, but you can specify that a method parameter is optional by setting the `@RequestParam` annotation's `required` flag to `false` or by declaring the argument with an `java.util.Optional` wrapper.

Type conversion is automatically applied if the target method parameter type is not `String`. See [Type Conversion](#).

Declaring the argument type as an array or list allows for resolving multiple parameter values for the same parameter name.

When an `@RequestParam` annotation is declared as a `Map<String, String>` or `MultivalueMap<String, String>`, without a parameter name specified in the annotation, then the map is populated with the request parameter values for each given parameter name.

Note that use of `@RequestParam` is optional (for example, to set its attributes). By default, any argument that is a simple value type (as determined by `BeanUtils#isSimpleProperty`) and is not resolved by any other argument resolver, is treated as if it were annotated with `@RequestParam`.

`@RequestHeader`

[Same as in Spring WebFlux](#)

You can use the `@RequestHeader` annotation to bind a request header to a method argument in a controller.

Consider the following request, with headers:

Host	localhost:8080
Accept	text/html,application/xhtml+xml,application/xml;q=0.9
Accept-Language	fr,en-gb;q=0.7,en;q=0.3
Accept-Encoding	gzip,deflate
Accept-Charset	ISO-8859-1,utf-8;q=0.7,*;q=0.7
Keep-Alive	300

The following example gets the value of the `Accept-Encoding` and `Keep-Alive` headers:

```
@GetMapping("/demo")
public void handle(
    @RequestHeader("Accept-Encoding") String encoding, ①
    @RequestHeader("Keep-Alive") long keepAlive) { ②
    //...
}
```

① Get the value of the `Accept-Encoding` header.

② Get the value of the `Keep-Alive` header.

If the target method parameter type is not `String`, type conversion is automatically applied. See [Type Conversion](#).

When an `@RequestHeader` annotation is used on a `Map<String, String>`, `MultiValueMap<String, String>`, or `HttpHeaders` argument, the map is populated with all header values.



Built-in support is available for converting a comma-separated string into an array or collection of strings or other types known to the type conversion system. For example, a method parameter annotated with `@RequestHeader("Accept")` can be of type `String` but also `String[]` or `List<String>`.

`@CookieValue`

[Same as in Spring WebFlux](#)

You can use the `@CookieValue` annotation to bind the value of an HTTP cookie to a method argument in a controller.

Consider a request with the following cookie:

```
JSESSIONID=415A4AC178C59DACE0B2C9CA727CDD84
```

The following example shows how to get the cookie value:

```
@GetMapping("/demo")
public void handle(@CookieValue("JSESSIONID") String cookie) { ①
    //...
}
```

① Get the value of the `JSESSIONID` cookie.

if the target method parameter type is not `String`, type conversion is applied automatically. See [Type Conversion](#).

`@ModelAttribute`

[Same as in Spring WebFlux](#)

You can use the `@ModelAttribute` annotation on a method argument to access an attribute from the model or have it be instantiated if not present. The model attribute is also overlain with values from HTTP Servlet request parameters whose names match to field names. This is referred to as data binding, and it saves you from having to deal with parsing and converting individual query parameters and form fields. The following example shows how to do so:

```
@PostMapping("/owners/{ownerId}/pets/{petId}/edit")
public String processSubmit(@ModelAttribute Pet pet) { } ①
```

① Bind an instance of `Pet`.

The `Pet` instance above is resolved as follows:

- From the model if already added by using `Model`.
- From the HTTP session by using `@SessionAttributes`.
- From a URI path variable passed through a `Converter` (see the next example).
- From the invocation of a default constructor.
- From the invocation of a “primary constructor” with arguments that match to Servlet request parameters. Argument names are determined through JavaBeans `@ConstructorProperties` or through runtime-retained parameter names in the bytecode.

While it is common to use a `Model` to populate the model with attributes, one other alternative is to rely on a `Converter<String, T>` in combination with a URI path variable convention. In the following example, the model attribute name, `account`, matches the URI path variable, `account`, and the `Account` is loaded by passing the `String` account number through a registered `Converter<String, Account>`:

```
@PutMapping("/accounts/{account}")
public String save(@ModelAttribute("account") Account account) {
    // ...
}
```

After the model attribute instance is obtained, data binding is applied. The `WebDataBinder` class matches Servlet request parameter names (query parameters and form fields) to field names on the target `Object`. Matching fields are populated after type conversion is applied, where necessary. For more on data binding (and validation), see [Validation](#). For more on customizing data binding, see [DataBinder](#).

Data binding can result in errors. By default, a `BindException` is raised. However, to check for such errors in the controller method, you can add a `BindingResult` argument immediately next to the `@ModelAttribute`, as the following example shows:

```
@PostMapping("/owners/{ownerId}/pets/{petId}/edit")
public String processSubmit(@ModelAttribute("pet") Pet pet, BindingResult result)
{ ①
    if (result.hasErrors()) {
        return "petForm";
    }
    // ...
}
```

① Adding a `BindingResult` next to the `@ModelAttribute`.

In some cases, you may want access to a model attribute without data binding. For such cases, you can inject the `Model` into the controller and access it directly or, alternatively, set `@ModelAttribute(binding=false)`, as the following example shows:

```

@ModelAttribute
public AccountForm setUpForm() {
    return new AccountForm();
}

@ModelAttribute
public Account findAccount(@PathVariable String accountId) {
    return accountRepository.findOne(accountId);
}

@PostMapping("update")
public String update(@Valid AccountUpdateForm form, BindingResult result,
    @ModelAttribute(binding=false) Account account) { ①
    // ...
}

```

① Setting `@ModelAttribute(binding=false)`.

You can automatically apply validation after data binding by adding the `javax.validation.Valid` annotation or Spring's `@Validated` annotation (see [Bean validation](#) and [Spring validation](#)). The following example shows how to do so:

```

@PostMapping("/owners/{ownerId}/pets/{petId}/edit")
public String processSubmit(@Valid @ModelAttribute("pet") Pet pet, BindingResult
result) { ①
    if (result.hasErrors()) {
        return "petForm";
    }
    // ...
}

```

① Validate the `Pet` instance.

Note that using `@ModelAttribute` is optional (for example, to set its attributes). By default, any argument that is not a simple value type (as determined by `BeanUtils#isSimpleProperty`) and is not resolved by any other argument resolver is treated as if it were annotated with `@ModelAttribute`.

`@SessionAttributes`

[Same as in Spring WebFlux](#)

`@SessionAttributes` is used to store model attributes in the HTTP Servlet session between requests. It is a type-level annotation that declares the session attributes used by a specific controller. This typically lists the names of model attributes or types of model attributes that should be transparently stored in the session for subsequent requests to access.

The following example uses the `@SessionAttributes` annotation:

```
@Controller  
@SessionAttributes("pet") ①  
public class EditPetForm {  
    // ...  
}
```

① Using the `@SessionAttributes` annotation.

On the first request, when a model attribute with the name, `pet`, is added to the model, it is automatically promoted to and saved in the HTTP Servlet session. It remains there until another controller method uses a `SessionStatus` method argument to clear the storage, as the following example shows:

```
@Controller  
@SessionAttributes("pet") ①  
public class EditPetForm {  
    // ...  
  
    @PostMapping("/pets/{id}")  
    public String handle(Pet pet, BindingResult errors, SessionStatus status) {  
        if (errors.hasErrors) {  
            // ...  
        }  
        status.setComplete(); ②  
        // ...  
    }  
}
```

① Storing the `Pet` value in the Servlet session.

② Clearing the `Pet` value from the Servlet session.

`@SessionAttribute`

Same as in Spring WebFlux

If you need access to pre-existing session attributes that are managed globally (that is, outside the controller—for example, by a filter) and may or may not be present, you can use the `@SessionAttribute` annotation on a method parameter, as the following example shows:

```
@RequestMapping("/")
public String handle(@SessionAttribute User user) { ①
    // ...
}
```

① Using a `@SessionAttribute` annotation.

For use cases that require adding or removing session attributes, consider injecting `org.springframework.web.context.request.WebRequest` or `javax.servlet.http.HttpSession` into the controller method.

For temporary storage of model attributes in the session as part of a controller workflow, consider using `@SessionAttributes` as described in `@SessionAttributes`.

`@RequestAttribute`

Same as in Spring WebFlux

Similar to `@SessionAttribute`, you can use the `@RequestAttribute` annotations to access pre-existing request attributes created earlier (for example, by a Servlet `Filter` or `HandlerInterceptor`):

```
@GetMapping("/")
public String handle(@RequestAttribute Client client) { ①
    // ...
}
```

① Using the `@RequestAttribute` annotation.

Redirect Attributes

By default, all model attributes are considered to be exposed as URI template variables in the redirect URL. Of the remaining attributes, those that are primitive types or collections or arrays of primitive types are automatically appended as query parameters.

Appending primitive type attributes as query parameters can be the desired result if a model instance was prepared specifically for the redirect. However, in annotated controllers, the model can contain additional attributes added for rendering purposes (for example, drop-down field values). To avoid the possibility of having such attributes appear in the URL, a `@RequestMapping` method can declare an argument of type `RedirectAttributes` and use it to specify the exact attributes to make available to `RedirectView`. If the method does redirect, the content of `RedirectAttributes` is used. Otherwise, the content of the model is used.

The `RequestMappingHandlerAdapter` provides a flag called `ignoreDefaultModelOnRedirect`, which you can use to indicate that the content of the default `Model` should never be used if a controller method redirects. Instead, the controller method should declare an attribute of type `RedirectAttributes` or, if it does not do so, no attributes should be passed on to `RedirectView`. Both the MVC namespace and

the MVC Java configuration keep this flag set to `false`, to maintain backwards compatibility. However, for new applications, we recommend setting it to `true`.

Note that URI template variables from the present request are automatically made available when expanding a redirect URL, and you need explicitly add them through `Model` or `RedirectAttributes`. The following example shows how to define a redirect:

```
@PostMapping("/files/{path}")
public String upload(...) {
    // ...
    return "redirect:files/{path}";
}
```

Another way of passing data to the redirect target is by using flash attributes. Unlike other redirect attributes, flash attributes are saved in the HTTP session (and, hence, do not appear in the URL). See [Flash Attributes](#) for more information.

Flash Attributes

Flash attributes provide a way for one request to store attributes that are intended for use in another. This is most commonly needed when redirecting—for example, the Post-Redirect-Get pattern. Flash attributes are saved temporarily before the redirect (typically in the session) to be made available to the request after the redirect and are removed immediately.

Spring MVC has two main abstractions in support of flash attributes. `FlashMap` is used to hold flash attributes, while `FlashMapManager` is used to store, retrieve, and manage `FlashMap` instances.

Flash attribute support is always “on” and does not need to be enabled explicitly. However, if not used, it never causes HTTP session creation. On each request, there is an “input” `FlashMap` with attributes passed from a previous request (if any) and an “output” `FlashMap` with attributes to save for a subsequent request. Both `FlashMap` instances are accessible from anywhere in Spring MVC through static methods in `RequestContextUtils`.

Annotated controllers typically do not need to work with `FlashMap` directly. Instead, a `@RequestMapping` method can accept an argument of type `RedirectAttributes` and use it to add flash attributes for a redirect scenario. Flash attributes added through `RedirectAttributes` are automatically propagated to the “output” `FlashMap`. Similarly, after the redirect, attributes from the “input” `FlashMap` are automatically added to the `Model` of the controller that serves the target URL.

Matching requests to flash attributes

The concept of flash attributes exists in many other web frameworks and has proven to sometimes be exposed to concurrency issues. This is because, by definition, flash attributes are to be stored until the next request. However the very “next” request may not be the intended recipient but another asynchronous request (for example, polling or resource requests), in which case the flash attributes are removed too early.

To reduce the possibility of such issues, `RedirectView` automatically “stamps” `FlashMap` instances with the path and query parameters of the target redirect URL. In turn, the default `FlashMapManager` matches that information to incoming requests when it looks up the “input” `FlashMap`.

This does not entirely eliminate the possibility of a concurrency issue but reduces it greatly with information that is already available in the redirect URL. Therefore, we recommend that you use flash attributes mainly for redirect scenarios.

Multipart

Same as in Spring WebFlux

After a `MultipartResolver` has been `enabled`, the content of POST requests with `multipart/form-data` is parsed and accessible as regular request parameters. The following example accesses one regular form field and one uploaded file:

```
@Controller
public class FileUploadController {

    @PostMapping("/form")
    public String handleFormUpload(@RequestParam("name") String name,
                                   @RequestParam("file") MultipartFile file) {

        if (!file.isEmpty()) {
            byte[] bytes = file.getBytes();
            // store the bytes somewhere
            return "redirect:uploadSuccess";
        }
        return "redirect:uploadFailure";
    }
}
```

Declaring the argument type as a `List<MultipartFile>` allows for resolving multiple files for the same parameter name.

When the `@RequestParam` annotation is declared as a `Map<String, MultipartFile>` or `MultiValueMap<String, MultipartFile>`, without a parameter name specified in the annotation, then

the map is populated with the multipart files for each given parameter name.



With Servlet 3.0 multipart parsing, you may also declare `javax.servlet.http.Part` instead of Spring's `MultipartFile`, as a method argument or collection value type.

You can also use multipart content as part of data binding to a `command object`. For example, the form field and file from the preceding example could be fields on a form object, as the following example shows:

```
class MyForm {  
  
    private String name;  
  
    private MultipartFile file;  
  
    // ...  
}  
  
@Controller  
public class FileUploadController {  
  
    @PostMapping("/form")  
    public String handleFormUpload(MyForm form, BindingResult errors) {  
        if (!form.getFile().isEmpty()) {  
            byte[] bytes = form.getFile().getBytes();  
            // store the bytes somewhere  
            return "redirect:uploadSuccess";  
        }  
        return "redirect:uploadFailure";  
    }  
}
```

Multipart requests can also be submitted from non-browser clients in a RESTful service scenario. The following example shows a file with JSON:

```

POST /someUrl
Content-Type: multipart/mixed

--edt7Tfrdusa7r3lNQc79vXuhIIMlatb7PQg7Vp
Content-Disposition: form-data; name="meta-data"
Content-Type: application/json; charset=UTF-8
Content-Transfer-Encoding: 8bit

{
    "name": "value"
}
--edt7Tfrdusa7r3lNQc79vXuhIIMlatb7PQg7Vp
Content-Disposition: form-data; name="file-data"; filename="file.properties"
Content-Type: text/xml
Content-Transfer-Encoding: 8bit
... File Data ...

```

You can access the "meta-data" part with `@RequestParam` as a `String` but you'll probably want it deserialized from JSON (similar to `@RequestBody`). Use the `@RequestPart` annotation to access a multipart after converting it with an `HttpMessageConverter`:

```

@PostMapping("/")
public String handle(@RequestPart("meta-data") MetaData metadata,
                     @RequestPart("file-data") MultipartFile file) {
    // ...
}

```

You can use `@RequestPart` in combination with `javax.validation.Valid` or use Spring's `@Validated` annotation, both of which cause Standard Bean Validation to be applied. By default, validation errors cause a `MethodArgumentNotValidException`, which is turned into a 400 (BAD_REQUEST) response. Alternatively, you can handle validation errors locally within the controller through an `Errors` or `BindingResult` argument, as the following example shows:

```

@PostMapping("/")
public String handle(@Valid @RequestPart("meta-data") MetaData metadata,
                     BindingResult result) {
    // ...
}

```

`@RequestBody`

Same as in Spring WebFlux

You can use the `@RequestBody` annotation to have the request body read and deserialized into an `Object` through an `HttpMessageConverter`. The following example uses a `@RequestBody` argument:

```
@PostMapping("/accounts")
public void handle(@RequestBody Account account) {
    // ...
}
```

You can use the [Message Converters](#) option of the [MVC Config](#) to configure or customize message conversion.

You can use `@RequestBody` in combination with `javax.validation.Valid` or Spring's `@Validated` annotation, both of which cause Standard Bean Validation to be applied. By default, validation errors cause a `MethodArgumentNotValidException`, which is turned into a 400 (BAD_REQUEST) response. Alternatively, you can handle validation errors locally within the controller through an `Errors` or `BindingResult` argument, as the following example shows:

```
@PostMapping("/accounts")
public void handle(@Valid @RequestBody Account account, BindingResult result) {
    // ...
}
```

HttpEntity

[Same as in Spring WebFlux](#)

`HttpEntity` is more or less identical to using `@RequestBody` but is based on a container object that exposes request headers and body. The following listing shows an example:

```
@PostMapping("/accounts")
public void handle(HttpEntity<Account> entity) {
    // ...
}
```

@ResponseBody

[Same as in Spring WebFlux](#)

You can use the `@ResponseBody` annotation on a method to have the return serialized to the response body through an `HttpMessageConverter`. The following listing shows an example:

```
@GetMapping("/accounts/{id}")
@ResponseBody
public Account handle() {
    // ...
}
```

`@ResponseBody` is also supported at the class level, in which case it is inherited by all controller methods. This is the effect of `@RestController`, which is nothing more than a meta-annotation marked with `@Controller` and `@ResponseBody`.

You can use `@ResponseBody` with reactive types. See [Asynchronous Requests](#) and [Reactive Types](#) for more details.

You can use the [Message Converters](#) option of the [MVC Config](#) to configure or customize message conversion.

You can combine `@ResponseBody` methods with JSON serialization views. See [Jackson JSON](#) for details.

ResponseType

[Same as in Spring WebFlux](#)

`ResponseType` is like `@ResponseBody` but with status and headers. For example:

```
@GetMapping("/something")
public ResponseEntity<String> handle() {
    String body = ... ;
    String etag = ... ;
    return ResponseEntity.ok().eTag(etag).build(body);
}
```

Spring MVC supports using a single value [reactive type](#) to produce the `ResponseType` asynchronously, and/or single and multi-value reactive types for the body.

Jackson JSON

Spring offers support for the Jackson JSON library.

Jackson Serialization Views

[Same as in Spring WebFlux](#)

Spring MVC provides built-in support for [Jackson's Serialization Views](#), which allow rendering only a subset of all fields in an `Object`. To use it with `@ResponseBody` or `ResponseType` controller methods, you can use Jackson's `@JsonView` annotation to activate a serialization view class, as the following

example shows:

```
@RestController
public class UserController {

    @GetMapping("/user")
    @JsonView(User.WithoutPasswordView.class)
    public User getUser() {
        return new User("eric", "7!jd#h23");
    }
}

public class User {

    public interface WithoutPasswordView {};
    public interface WithPasswordView extends WithoutPasswordView {};

    private String username;
    private String password;

    public User() {}

    public User(String username, String password) {
        this.username = username;
        this.password = password;
    }

    @JsonView(WithoutPasswordView.class)
    public String getUsername() {
        return this.username;
    }

    @JsonView(WithPasswordView.class)
    public String getPassword() {
        return this.password;
    }
}
```



`@JsonView` allows an array of view classes, but you can specify only one per controller method. If you need to activate multiple views, you can use a composite interface.

For controllers that rely on view resolution, you can add the serialization view class to the model, as the following example shows:

```

@Controller
public class UserController extends AbstractController {

    @GetMapping("/user")
    public String getUser(Model model) {
        model.addAttribute("user", new User("eric", "7!jd#h23"));
        model.addAttribute(JsonView.class.getName(), User.WithoutPasswordView
.class);
        return "userView";
    }
}

```

1.3.4. Model

Same as in Spring WebFlux

You can use the `@ModelAttribute` annotation:

- On a `method argument` in `@RequestMapping` methods to create or access an `Object` from the model and to bind it to the request through a `WebDataBinder`.
- As a method-level annotation in `@Controller` or `@ControllerAdvice` classes that help to initialize the model prior to any `@RequestMapping` method invocation.
- On a `@RequestMapping` method to mark its return value is a model attribute.

This section discusses `@ModelAttribute` methods — the second item in the preceding list. A controller can have any number of `@ModelAttribute` methods. All such methods are invoked before `@RequestMapping` methods in the same controller. A `@ModelAttribute` method can also be shared across controllers through `@ControllerAdvice`. See the section on `Controller Advice` for more details.

`@ModelAttribute` methods have flexible method signatures. They support many of the same arguments as `@RequestMapping` methods, except for `@ModelAttribute` itself or anything related to the request body.

The following example shows a `@ModelAttribute` method:

```

@ModelAttribute
public void populateModel(@RequestParam String number, Model model) {
    model.addAttribute(accountRepository.findAccount(number));
    // add more ...
}

```

The following example adds only one attribute:

```
@ModelAttribute  
public Account addAccount(@RequestParam String number) {  
    return accountRepository.findAccount(number);  
}
```



When a name is not explicitly specified, a default name is chosen based on the `Object` type, as explained in the javadoc for [Conventions](#). You can always assign an explicit name by using the overloaded `addAttribute` method or through the `name` attribute on `@ModelAttribute` (for a return value).

You can also use `@ModelAttribute` as a method-level annotation on `@RequestMapping` methods, in which case the return value of the `@RequestMapping` method is interpreted as a model attribute. This is typically not required, as it is the default behavior in HTML controllers, unless the return value is a `String` that would otherwise be interpreted as a view name. `@ModelAttribute` can also customize the model attribute name, as the following example shows:

```
@GetMapping("/accounts/{id}")  
@ModelAttribute("myAccount")  
public Account handle() {  
    // ...  
    return account;  
}
```

1.3.5. DataBinder

Same as in Spring WebFlux

`@Controller` or `@ControllerAdvice` classes can have `@InitBinder` methods that initialize instances of `WebDataBinder`, and those, in turn, can:

- Bind request parameters (that is, form or query data) to a model object.
- Convert String-based request values (such as request parameters, path variables, headers, cookies, and others) to the target type of controller method arguments.
- Format model object values as `String` values when rendering HTML forms.

`@InitBinder` methods can register controller-specific `java.bean.PropertyEditor` or Spring `Converter` and `Formatter` components. In addition, you can use the `MVC config` to register `Converter` and `Formatter` types in a globally shared `FormattingConversionService`.

`@InitBinder` methods support many of the same arguments that `@RequestMapping` methods do, except for `@ModelAttribute` (command object) arguments. Typically, they are declared with a `WebDataBinder` argument (for registrations) and a `void` return value. The following listing shows an example:

```

@Controller
public class FormController {

    @InitBinder ①
    public void initBinder(WebDataBinder binder) {
        SimpleDateFormat dateFormat = new SimpleDateFormat("yyyy-MM-dd");
        dateFormat.setLenient(false);
        binder.registerCustomEditor(Date.class, new CustomDateEditor(dateFormat,
false));
    }

    // ...
}

```

① Defining an `@InitBinder` method.

Alternatively, when you use a `Formatter`-based setup through a shared `FormattingConversionService`, you can re-use the same approach and register controller-specific `Formatter` implementations, as the following example shows:

```

@Controller
public class FormController {

    @InitBinder ①
    protected void initBinder(WebDataBinder binder) {
        binder.addCustomFormatter(new DateFormatter("yyyy-MM-dd"));
    }

    // ...
}

```

① Defining an `@InitBinder` method on a custom formatter.

1.3.6. Exceptions

Same as in Spring WebFlux

`@Controller` and `@ControllerAdvice` classes can have `@ExceptionHandler` methods to handle exceptions from controller methods, as the following example shows:

```
@Controller
public class SimpleController {

    // ...

    @ExceptionHandler
    public ResponseEntity<String> handle(IOException ex) {
        // ...
    }
}
```

The exception may match against a top-level exception being propagated (that is, a direct `IOException` being thrown) or against the immediate cause within a top-level wrapper exception (for example, an `IOException` wrapped inside an `IllegalStateException`).

For matching exception types, preferably declare the target exception as a method argument, as the preceding example shows. When multiple exception methods match, a root exception match is generally preferred to a cause exception match. More specifically, the `ExceptionDepthComparator` is used to sort exceptions based on their depth from the thrown exception type.

Alternatively, the annotation declaration may narrow the exception types to match, as the following example shows:

```
@ExceptionHandler({FileSystemException.class, RemoteException.class})
public ResponseEntity<String> handle(IOException ex) {
    // ...
}
```

You can even use a list of specific exception types with a very generic argument signature, as the following example shows:

```
@ExceptionHandler({FileSystemException.class, RemoteException.class})
public ResponseEntity<String> handle(Exception ex) {
    // ...
}
```

The distinction between root and cause exception matching can be surprising.

In the `IOException` variant shown earlier, the method is typically called with the actual `FileSystemException` or `RemoteException` instance as the argument, since both of them extend from `IOException`. However, if any such matching exception is propagated within a wrapper exception which is itself an `IOException`, the passed-in exception instance is that wrapper exception.



The behavior is even simpler in the `handle(Exception)` variant. This is always invoked with the wrapper exception in a wrapping scenario, with the actually matching exception to be found through `ex.getCause()` in that case. The passed-in exception is the actual `FileSystemException` or `RemoteException` instance only when these are thrown as top-level exceptions.

We generally recommend that you be as specific as possible in the argument signature, reducing the potential for mismatches between root and cause exception types. Consider breaking a multi-matching method into individual `@ExceptionHandler` methods, each matching a single specific exception type through its signature.

In a multi-`@ControllerAdvice` arrangement, we recommend declaring your primary root exception mappings on a `@ControllerAdvice` prioritized with a corresponding order. While a root exception match is preferred to a cause, this is defined among the methods of a given controller or `@ControllerAdvice` class. This means a cause match on a higher-priority `@ControllerAdvice` bean is preferred to any match (for example, root) on a lower-priority `@ControllerAdvice` bean.

Last but not least, an `@ExceptionHandler` method implementation can choose to back out of dealing with a given exception instance by rethrowing it in its original form. This is useful in scenarios where you are interested only in root-level matches or in matches within a specific context that cannot be statically determined. A rethrown exception is propagated through the remaining resolution chain, as though the given `@ExceptionHandler` method would not have matched in the first place.

Support for `@ExceptionHandler` methods in Spring MVC is built on the `DispatcherServlet` level, `HandlerExceptionResolver` mechanism.

Method Arguments

`@ExceptionHandler` methods support the following arguments:

Method argument	Description
Exception type	For access to the raised exception.
<code>HandlerMethod</code>	For access to the controller method that raised the exception.
<code>WebRequest</code> , <code>NativeWebRequest</code>	Generic access to request parameters and request and session attributes without direct use of the Servlet API.
<code>javax.servlet.ServletRequest</code> , <code>javax.servlet.ServletResponse</code>	Choose any specific request or response type (for example, <code>ServletRequest</code> or <code>HttpServletRequest</code> or or Spring's <code>MultipartRequest</code> or <code>MultipartHttpServletRequest</code>).

Method argument	Description
<code>javax.servlet.http.HttpSession</code>	Enforces the presence of a session. As a consequence, such an argument is never <code>null</code> . Note that session access is not thread-safe. Consider setting the <code>RequestMappingHandlerAdapter</code> instance's <code>synchronizeOnSession</code> flag to <code>true</code> if multiple requests are allowed to access a session concurrently.
<code>java.security.Principal</code>	Currently authenticated user — possibly a specific <code>Principal</code> implementation class if known.
<code>HttpMethod</code>	The HTTP method of the request.
<code>java.util.Locale</code>	The current request locale, determined by the most specific <code>LocaleResolver</code> available — in effect, the configured <code>LocaleResolver</code> or <code>LocaleContextResolver</code> .
<code>java.util.TimeZone</code> , <code>java.time.ZoneId</code>	The time zone associated with the current request, as determined by a <code>LocaleContextResolver</code> .
<code>java.io.OutputStream</code> , <code>java.io.Writer</code>	For access to the raw response body, as exposed by the Servlet API.
<code>java.util.Map</code> , <code>org.springframework.ui.Model</code> , <code>org.springframework.ui.ModelMap</code>	For access to the model for an error response. Always empty.
<code>RedirectAttributes</code>	Specify attributes to use in case of a redirect — (that is to be appended to the query string) and flash attributes to be stored temporarily until the request after the redirect. See Redirect Attributes and Flash Attributes .
<code>@SessionAttribute</code>	For access to any session attribute, in contrast to model attributes stored in the session as a result of a class-level <code>@SessionAttributes</code> declaration. See @SessionAttribute for more details.
<code>@RequestAttribute</code>	For access to request attributes. See @RequestAttribute for more details.

Return Values

`@ExceptionHandler` methods support the following return values:

Return value	Description
<code>@ResponseBody</code>	The return value is converted through <code>HttpMessageConverter</code> instances and written to the response. See @ResponseBody .
<code>HttpEntity</code> , <code>ResponseEntity</code>	The return value specifies that the full response (including the HTTP headers and the body) be converted through <code>HttpMessageConverter</code> instances and written to the response. See ResponseEntity .
<code>String</code>	A view name to be resolved with <code>ViewResolver</code> implementations and used together with the implicit model — determined through command objects and <code>@ModelAttribute</code> methods. The handler method can also programmatically enrich the model by declaring a <code>Model</code> argument (described earlier).

Return value	Description
<code>View</code>	A <code>View</code> instance to use for rendering together with the implicit model—determined through command objects and <code>@ModelAttribute</code> methods. The handler method may also programmatically enrich the model by declaring a <code>Model</code> argument (described earlier).
<code>java.util.Map<String, Object></code> <code>org.springframework.ui.Model</code>	Attributes to be added to the implicit model with the view name implicitly determined through a <code>RequestToViewNameTranslator</code> .
<code>@ModelAttribute</code>	<p>An attribute to be added to the model with the view name implicitly determined through a <code>RequestToViewNameTranslator</code>.</p> <p>Note that <code>@ModelAttribute</code> is optional. See “Any other return value” at the end of this table.</p>
<code>ModelAndView</code> object	The view and model attributes to use and, optionally, a response status.
<code>void</code>	<p>A method with a <code>void</code> return type (or <code>null</code> return value) is considered to have fully handled the response if it also has a <code>ServletResponse</code> an <code>OutputStream</code> argument, or a <code>@ResponseStatus</code> annotation. The same is also true if the controller has made a positive <code>ETag</code> or <code>lastModified</code> timestamp check (see Controllers for details).</p> <p>If none of the above is true, a <code>void</code> return type can also indicate “no response body” for REST controllers or default view name selection for HTML controllers.</p>
Any other return value	If a return value is not matched to any of the above and is not a simple type (as determined by <code>BeanUtils#isSimpleProperty</code>), by default, it is treated as a model attribute to be added to the model. If it is a simple type, it remains unresolved.

REST API exceptions

[Same as in Spring WebFlux](#)

A common requirement for REST services is to include error details in the body of the response. The Spring Framework does not automatically do this because the representation of error details in the response body is application-specific. However, a `@RestController` may use `@ExceptionHandler` methods with a `ResponseEntity` return value to set the status and the body of the response. Such methods can also be declared in `@ControllerAdvice` classes to apply them globally.

Applications that implement global exception handling with error details in the response body should consider extending `ResponseEntityExceptionHandler`, which provides handling for exceptions that Spring MVC raises and provides hooks to customize the response body. To make use of this, create a subclass of `ResponseEntityExceptionHandler`, annotate it with `@ControllerAdvice`, override the necessary methods, and declare it as a Spring bean.

1.3.7. Controller Advice

Same as in Spring WebFlux

Typically `@ExceptionHandler`, `@InitBinder`, and `@ModelAttribute` methods apply within the `@Controller` class (or class hierarchy) in which they are declared. If you want such methods to apply more globally (across controllers), you can declare them in a class marked with `@ControllerAdvice` or `@RestControllerAdvice`.

`@ControllerAdvice` is marked with `@Component`, which means such classes can be registered as Spring beans through `component scanning`. `@RestControllerAdvice` is also a meta-annotation marked with both `@ControllerAdvice` and `@ResponseBody`, which essentially means `@ExceptionHandler` methods are rendered to the response body through message conversion (versus view resolution or template rendering).

On startup, the infrastructure classes for `@RequestMapping` and `@ExceptionHandler` methods detect Spring beans of type `@ControllerAdvice` and then apply their methods at runtime. Global `@ExceptionHandler` methods (from a `@ControllerAdvice`) are applied *after* local ones (from the `@Controller`). By contrast, global `@ModelAttribute` and `@InitBinder` methods are applied *before* local ones.

By default, `@ControllerAdvice` methods apply to every request (that is, all controllers), but you can narrow that down to a subset of controllers by using attributes on the annotation, as the following example shows:

```
// Target all Controllers annotated with @RestController
@ControllerAdvice(annotations = RestController.class)
public class ExampleAdvice1 {}

// Target all Controllers within specific packages
@ControllerAdvice("org.example.controllers")
public class ExampleAdvice2 {}

// Target all Controllers assignable to specific classes
@ControllerAdvice(assignableTypes = {ControllerInterface.class,
AbstractController.class})
public class ExampleAdvice3 {}
```

The selectors in the preceding example are evaluated at runtime and may negatively impact performance if used extensively. See the `@ControllerAdvice` javadoc for more details.

1.4. URI Links

Same as in Spring WebFlux

This section describes various options available in the Spring Framework to work with URI's.

1.4.1. UriComponents

Spring MVC and Spring WebFlux

`UriComponentsBuilder` helps to build URI's from URI templates with variables, as the following example shows:

```
UriComponents uriComponents = UriComponentsBuilder
    .fromUriString("http://example.com/hotels/{hotel}") ①
    .queryParam("q", "{q}") ②
    .encode() ③
    .build(); ④

URI uri = uriComponents.expand("Westin", "123").toUri(); ⑤
```

- ① Static factory method with a URI template.
- ② Add or replace URI components.
- ③ Request to have the URI template and URI variables encoded.
- ④ Build a `UriComponents`.
- ⑤ Expand variables and obtain the `URI`.

The preceding example can be consolidated into one chain and shortened with `buildAndExpand`, as the following example shows:

```
URI uri = UriComponentsBuilder
    .fromUriString("http://example.com/hotels/{hotel}")
    .queryParam("q", "{q}")
    .encode()
    .buildAndExpand("Westin", "123")
    .toUri();
```

You can shorten it further by going directly to a URI (which implies encoding), as the following example shows:

```
URI uri = UriComponentsBuilder
    .fromUriString("http://example.com/hotels/{hotel}")
    .queryParam("q", "{q}")
    .build("Westin", "123");
```

You shorter it further still with a full URI template, as the following example shows:

```
URI uri = UriComponentsBuilder
    .fromUriString("http://example.com/hotels/{hotel}?q={q}")
    .build("Westin", "123");
```

1.4.2. UriBuilder

Spring MVC and Spring WebFlux

`UriComponentsBuilder` implements `UriBuilder`. You can create a `UriBuilder`, in turn, with a `UriBuilderFactory`. Together, `UriBuilderFactory` and `UriBuilder` provide a pluggable mechanism to build URIs from URI templates, based on shared configuration, such as a base URL, encoding preferences, and other details.

You can configure `RestTemplate` and `WebClient` with a `UriBuilderFactory` to customize the preparation of URIs. `DefaultUriBuilderFactory` is a default implementation of `UriBuilderFactory` that uses `UriComponentsBuilder` internally and exposes shared configuration options.

The following example shows how to configure a `RestTemplate`:

```
// import org.springframework.web.util.DefaultUriBuilderFactory.EncodingMode;

String baseUrl = "http://example.org";
DefaultUriBuilderFactory factory = new DefaultUriBuilderFactory(baseUrl);
factory.setEncodingMode(EncodingMode.TEMPLATE_AND_VARIABLES);

RestTemplate restTemplate = new RestTemplate();
restTemplate.setUriTemplateHandler(factory);
```

The following example configures a `WebClient`:

```
// import org.springframework.web.util.DefaultUriBuilderFactory.EncodingMode;

String baseUrl = "http://example.org";
DefaultUriBuilderFactory factory = new DefaultUriBuilderFactory(baseUrl);
factory.setEncodingMode(EncodingMode.TEMPLATE_AND_VARIABLES);

WebClient client = WebClient.builder().uriBuilderFactory(factory).build();
```

In addition, you can also use `DefaultUriBuilderFactory` directly. It is similar to using `UriComponentsBuilder` but, instead of static factory methods, it is an actual instance that holds configuration and preferences, as the following example shows:

```

String baseUrl = "http://example.com";
DefaultUriBuilderFactory uriBuilderFactory = new DefaultUriBuilderFactory(baseUrl
);

URI uri = uriBuilderFactory.uriString("/hotels/{hotel}")
    .queryParam("q", "{q}")
    .build("Westin", "123");

```

1.4.3. URI Encoding

Spring MVC and Spring WebFlux

`UriComponentsBuilder` exposes encoding options at two levels:

- `UriComponentsBuilder#encode()`: Pre-encodes the URI template first and then strictly encodes URI variables when expanded.
- `UriComponents#encode()`: Encodes URI components *after* URI variables are expanded.

Both options replace non-ASCII and illegal characters with escaped octets. However, the first option also replaces characters with reserved meaning that appear in URI variables.



Consider ";", which is legal in a path but has reserved meaning. The first option replaces ";" with "%3B" in URI variables but not in the URI template. By contrast, the second option never replaces ";", since it is a legal character in a path.

For most cases, the first option is likely to give the expected result, because it treats URI variables as opaque data to be fully encoded, while option 2 is useful only if URI variables intentionally contain reserved characters.

The following example uses the first option:

```

URI uri = UriComponentsBuilder.fromPath("/hotel list/{city}")
    .queryParam("q", "{q}")
    .encode()
    .buildAndExpand("New York", "foo+bar")
    .toUri();

// Result is "/hotel%20list/New%20York?q=foo%2Bbar"

```

You can shorten the preceding example by going directly to the URI (which implies encoding), as the following example shows:

```
URI uri = UriComponentsBuilder.fromPath("/hotel list/{city}")
    .queryParam("q", "{q}")
    .build("New York", "foo+bar")
```

You can shorten it further still with a full URI template, as the following example shows:

```
URI uri = UriComponentsBuilder.fromPath("/hotel list/{city}?q={q}")
    .build("New York", "foo+bar")
```

The `WebClient` and the `RestTemplate` expand and encode URI templates internally through the `UriBuilderFactory` strategy. Both can be configured with a custom strategy, as the following example shows:

```
String baseUrl = "http://example.com";
DefaultUriBuilderFactory factory = new DefaultUriBuilderFactory(baseUrl)
factory.setEncodingMode(EncodingMode.TEMPLATE_AND_VALUES);

// Customize the RestTemplate..
RestTemplate restTemplate = new RestTemplate();
restTemplate.setUriTemplateHandler(factory);

// Customize the WebClient..
WebClient client = WebClient.builder().uriBuilderFactory(factory).build();
```

The `DefaultUriBuilderFactory` implementation uses `UriComponentsBuilder` internally to expand and encode URI templates. As a factory, it provides a single place to configure the approach to encoding, based on one of the below encoding modes:

- **TEMPLATE_AND_VALUES**: Uses `UriComponentsBuilder#encode()`, corresponding to the first option in the earlier list, to pre-encode the URI template and strictly encode URI variables when expanded.
- **VALUES_ONLY**: Does not encode the URI template and, instead, applies strict encoding to URI variables through `UriUtils#encodeUriVariables` prior to expanding them into the template.
- **URI_COMPONENTS**: Uses `UriComponents#encode()`, corresponding to the second option in the earlier list, to encode URI component value *after* URI variables are expanded.
- **NONE**: No encoding is applied.

The `RestTemplate` is set to `EncodingMode.URI_COMPONENTS` for historic reasons and for backwards compatibility. The `WebClient` relies on the default value in `DefaultUriBuilderFactory`, which was changed from `EncodingMode.URI_COMPONENTS` in 5.0.x to `EncodingMode.TEMPLATE_AND_VALUES` in 5.1.

1.4.4. Relative Servlet Requests

You can use `ServletUriComponentsBuilder` to create URIs relative to the current request, as the following example shows:

```
HttpServletRequest request = ...  
  
// Re-uses host, scheme, port, path and query string...  
  
ServletUriComponentsBuilder ucb = ServletUriComponentsBuilder.fromRequest(request)  
    .replaceQueryParam("accountId", "{id}").build()  
    .expand("123")  
    .encode();
```

You can create URIs relative to the context path, as the following example shows:

```
// Re-uses host, port and context path...  
  
ServletUriComponentsBuilder ucb = ServletUriComponentsBuilder.fromContextPath  
(request)  
    .path("/accounts").build()
```

You can create URIs relative to a Servlet (for example, `/main/*`), as the following example shows:

```
// Re-uses host, port, context path, and Servlet prefix...  
  
ServletUriComponentsBuilder ucb = ServletUriComponentsBuilder.fromServletMapping  
(request)  
    .path("/accounts").build()
```



As of 5.1, `ServletUriComponentsBuilder` ignores information from the `Forwarded` and `X-Forwarded-*` headers, which specify the client-originated address. Consider using the `ForwardedHeaderFilter` to extract and use or to discard such headers.

1.4.5. Links to Controllers

Spring MVC provides a mechanism to prepare links to controller methods. For example, the following MVC controller allows for link creation:

```
@Controller  
@RequestMapping("/hotels/{hotel}")  
public class BookingController {  
  
    @GetMapping("/bookings/{booking}")  
    public ModelAndView getBooking(@PathVariable Long booking) {  
        // ...  
    }  
}
```

You can prepare a link by referring to the method by name, as the following example shows:

```
UriComponents uriComponents = MvcUriComponentsBuilder  
    .fromMethodName(BookingController.class, "getBooking", 21).buildAndExpand(42);  
  
URI uri = uriComponents.encode().toUri();
```

In the preceding example, we provide actual method argument values (in this case, the long value: 21) to be used as a path variable and inserted into the URL. Furthermore, we provide the value, 42, to fill in any remaining URI variables, such as the hotel variable inherited from the type-level request mapping. If the method had more arguments, we could supply null for arguments not needed for the URL. In general, only `@PathVariable` and `@RequestParam` arguments are relevant for constructing the URL.

There are additional ways to use `MvcUriComponentsBuilder`. For example, you can use a technique akin to mock testing through proxies to avoid referring to the controller method by name, as the following example shows (the example assumes static import of `MvcUriComponentsBuilder.on`):

```
UriComponents uriComponents = MvcUriComponentsBuilder  
    .fromMethodCall(on(BookingController.class).getBooking(21)).buildAndExpand(42)  
;  
  
URI uri = uriComponents.encode().toUri();
```



Controller method signatures are limited in their design when they are supposed to be usable for link creation with `fromMethodCall`. Aside from needing a proper parameter signature, there is a technical limitation on the return type (namely, generating a runtime proxy for link builder invocations), so the return type must not be `final`. In particular, the common `String` return type for view names does not work here. You should use `ModelAndView` or even plain `Object` (with a `String` return value) instead.

The earlier examples use static methods in `MvcUriComponentsBuilder`. Internally, they rely on `ServletUriComponentsBuilder` to prepare a base URL from the scheme, host, port, context path, and servlet path of the current request. This works well in most cases. However, sometimes, it can be insufficient. For example, you may be outside the context of a request (such as a batch process that prepares links) or perhaps you need to insert a path prefix (such as a locale prefix that was removed from the request path and needs to be re-inserted into links).

For such cases, you can use the static `fromXxx` overloaded methods that accept a `UriComponentsBuilder` to use a base URL. Alternatively, you can create an instance of `MvcUriComponentsBuilder` with a base URL and then use the instance-based `withXxx` methods. For example, the following listing uses `withMethodCall`:

```
UriComponentsBuilder base = ServletUriComponentsBuilder.fromCurrentContextPath()
    .path("/en");
MvcUriComponentsBuilder builder = MvcUriComponentsBuilder.relativeTo(base);
builder.withMethodCall(on(BookingController.class).getBooking(21)).buildAndExpand(
    42);

URI uri = uriComponents.encode().toUri();
```



As of 5.1, `MvcUriComponentsBuilder` ignores information from the `Forwarded` and `X-Forwarded-*` headers, which specify the client-originated address. Consider using the `ForwardedHeaderFilter` to extract and use or to discard such headers.

1.4.6. Links in Views

In views such as Thymeleaf, FreeMarker, or JSP, you can build links to annotated controllers by referring to the implicitly or explicitly assigned name for each request mapping.

Consider the following example:

```
@RequestMapping("/people/{id}/addresses")
public class PersonAddressController {

    @RequestMapping("/{country}")
    public ResponseEntity getAddress(@PathVariable String country) { ... }
}
```

Given the preceding controller, you can prepare a link from a JSP, as follows:

```
<%@ taglib uri="http://www.springframework.org/tags" prefix="s" %>
...
<a href="${s:mvcUrl('PAC#getAddress').arg(0,'US').buildAndExpand('123')}">Get
Address</a>
```

The preceding example relies on the `mvcUrl` function declared in the Spring tag library (that is, META-INF/spring.tld), but it is easy to define your own function or prepare a similar one for other templating technologies.

Here is how this works. On startup, every `@RequestMapping` is assigned a default name through `HandlerMethodMappingNamingStrategy`, whose default implementation uses the capital letters of the class and the method name (for example, the `getThing` method in `ThingController` becomes "TC#getThing"). If there is a name clash, you can use `@RequestMapping(name="..")` to assign an explicit name or implement your own `HandlerMethodMappingNamingStrategy`.

1.5. Asynchronous Requests

[Compared to WebFlux](#)

Spring MVC has an extensive integration with Servlet 3.0 asynchronous request [processing](#):

- `DeferredResult` and `Callable` return values in controller methods and provide basic support for a single asynchronous return value.
- Controllers can `stream` multiple values, including `SSE` and `raw data`.
- Controllers can use reactive clients and return `reactive types` for response handling.

1.5.1. DeferredResult

[Compared to WebFlux](#)

Once the asynchronous request processing feature is [enabled](#) in the Servlet container, controller methods can wrap any supported controller method return value with `DeferredResult`, as the following example shows:

```

@GetMapping("/quotes")
@ResponseBody
public DeferredResult<String> quotes() {
    DeferredResult<String> deferredResult = new DeferredResult<String>();
    // Save the deferredResult somewhere...
    return deferredResult;
}

// From some other thread...
deferredResult.setResult(data);

```

The controller can produce the return value asynchronously, from a different thread—for example, in response to an external event (JMS message), a scheduled task, or other event.

1.5.2. Callable

[Compared to WebFlux](#)

A controller can wrap any supported return value with `java.util.concurrent.Callable`, as the following example shows:

```

@PostMapping
public Callable<String> processUpload(final MultipartFile file) {

    return new Callable<String>() {
        public String call() throws Exception {
            // ...
            return "someView";
        }
    };
}

```

The return value can then be obtained by running the the given task through the [configured TaskExecutor](#).

1.5.3. Processing

[Compared to WebFlux](#)

Here is a very concise overview of Servlet asynchronous request processing:

- A `ServletRequest` can be put in asynchronous mode by calling `request.startAsync()`. The main effect of doing so is that the Servlet (as well as any filters) can exit, but the response remains open to let processing complete later.

- The call to `request.startAsync()` returns `AsyncContext`, which you can use for further control over asynchronous processing. For example, it provides the `dispatch` method, which is similar to a forward from the Servlet API, except that it lets an application resume request processing on a Servlet container thread.
- The `ServletRequest` provides access to the current `DispatcherType`, which you can use to distinguish between processing the initial request, an asynchronous dispatch, a forward, and other dispatcher types.

`DeferredResult` processing works as follows:

- The controller returns a `DeferredResult` and saves it in some in-memory queue or list where it can be accessed.
- Spring MVC calls `request.startAsync()`.
- Meanwhile, the `DispatcherServlet` and all configured filters exit the request processing thread, but the response remains open.
- The application sets the `DeferredResult` from some thread, and Spring MVC dispatches the request back to the Servlet container.
- The `DispatcherServlet` is invoked again, and processing resumes with the asynchronously produced return value.

`Callable` processing works as follows:

- The controller returns a `Callable`.
- Spring MVC calls `request.startAsync()` and submits the `Callable` to a `TaskExecutor` for processing in a separate thread.
- Meanwhile, the `DispatcherServlet` and all filters exit the Servlet container thread, but the response remains open.
- Eventually the `Callable` produces a result, and Spring MVC dispatches the request back to the Servlet container to complete processing.
- The `DispatcherServlet` is invoked again, and processing resumes with the asynchronously produced return value from the `Callable`.

For further background and context, you can also read [the blog posts](#) that introduced asynchronous request processing support in Spring MVC 3.2.

Exception Handling

When you use a `DeferredResult`, you can choose whether to call `setResult` or `setErrorResult` with an exception. In both cases, Spring MVC dispatches the request back to the Servlet container to complete processing. It is then treated either as if the controller method returned the given value or as if it produced the given exception. The exception then goes through the regular exception handling mechanism (for example, invoking `@ExceptionHandler` methods).

When you use `Callable`, similar processing logic occurs, the main difference being that the result is returned from the `Callable` or an exception is raised by it.

Interception

`HandlerInterceptor` instances can be of type `AsyncHandlerInterceptor`, to receive the `afterConcurrentHandlingStarted` callback on the initial request that starts asynchronous processing (instead of `postHandle` and `afterCompletion`).

`HandlerInterceptor` implementations can also register a `CallableProcessingInterceptor` or a `DeferredResultProcessingInterceptor`, to integrate more deeply with the lifecycle of an asynchronous request (for example, to handle a timeout event). See `AsyncHandlerInterceptor` for more details.

`DeferredResult` provides `onTimeout(Runnable)` and `onCompletion(Runnable)` callbacks. See the [javadoc of `DeferredResult`](#) for more details. `Callable` can be substituted for `WebAsyncTask` that exposes additional methods for timeout and completion callbacks.

Compared to WebFlux

The Servlet API was originally built for making a single pass through the Filter-Servlet chain. Asynchronous request processing, added in Servlet 3.0, lets applications exit the Filter-Servlet chain but leave the response open for further processing. The Spring MVC asynchronous support is built around that mechanism. When a controller returns a `DeferredResult`, the Filter-Servlet chain is exited, and the Servlet container thread is released. Later, when the `DeferredResult` is set, an `ASYNC` dispatch (to the same URL) is made, during which the controller is mapped again but, rather than invoking it, the `DeferredResult` value is used (as if the controller returned it) to resume processing.

By contrast, Spring WebFlux is neither built on the Servlet API, nor does it need such an asynchronous request processing feature, because it is asynchronous by design. Asynchronous handling is built into all framework contracts and is intrinsically supported through all stages of request processing.

From a programming model perspective, both Spring MVC and Spring WebFlux support asynchronous and [Reactive Types](#) as return values in controller methods. Spring MVC even supports streaming, including reactive back pressure. However, individual writes to the response remain blocking (and are performed on a separate thread), unlike WebFlux, which relies on non-blocking I/O and does not need an extra thread for each write.

Another fundamental difference is that Spring MVC does not support asynchronous or reactive types in controller method arguments (for example, `@RequestBody`, `@RequestPart`, and others), nor does it have any explicit support for asynchronous and reactive types as model attributes. Spring WebFlux does support all that.

1.5.4. HTTP Streaming

[Same as in Spring WebFlux](#)

You can use `DeferredResult` and `Callable` for a single asynchronous return value. What if you want to produce multiple asynchronous values and have those written to the response? This section describes how to do so.

Objects

You can use the `ResponseBodyEmitter` return value to produce a stream of objects, where each object is serialized with an `HttpMessageConverter` and written to the response, as the following example shows:

```
@GetMapping("/events")
public ResponseBodyEmitter handle() {
    ResponseBodyEmitter emitter = new ResponseBodyEmitter();
    // Save the emitter somewhere..
    return emitter;
}

// In some other thread
emitter.send("Hello once");

// and again later on
emitter.send("Hello again");

// and done at some point
emitter.complete();
```

You can also use `ResponseBodyEmitter` as the body in a `ResponseEntity`, letting you customize the status and headers of the response.

When an `emitter` throws an `IOException` (for example, if the remote client went away), applications are not responsible for cleaning up the connection and should not invoke `emitter.complete` or `emitter.completeWithError`. Instead, the servlet container automatically initiates an `AsyncListener` error notification, in which Spring MVC makes a `completeWithError` call. This call, in turn, performs one final `ASYNC` dispatch to the application, during which Spring MVC invokes the configured exception resolvers and completes the request.

SSE

`SseEmitter` (a subclass of `ResponseBodyEmitter`) provides support for `Server-Sent Events`, where events sent from the server are formatted according to the W3C SSE specification. To produce an SSE stream from a controller, return `SseEmitter`, as the following example shows:

```

@GetMapping(path="/events", produces=MediaType.TEXT_EVENT_STREAM_VALUE)
public SseEmitter handle() {
    SseEmitter emitter = new SseEmitter();
    // Save the emitter somewhere..
    return emitter;
}

// In some other thread
emitter.send("Hello once");

// and again later on
emitter.send("Hello again");

// and done at some point
emitter.complete();

```

While SSE is the main option for streaming into browsers, note that Internet Explorer does not support Server-Sent Events. Consider using Spring's [WebSocket messaging](#) with [SockJS](#) fallback transports (including SSE) that target a wide range of browsers.

See also [previous section](#) for notes on exception handling.

Raw Data

Sometimes, it is useful to bypass message conversion and stream directly to the response [OutputStream](#) (for example, for a file download). You can use the [StreamingResponseBody](#) return value type to do so, as the following example shows:

```

@GetMapping("/download")
public StreamingResponseBody handle() {
    return new StreamingResponseBody() {
        @Override
        public void writeTo(OutputStream outputStream) throws IOException {
            // write...
        }
    };
}

```

You can use [StreamingResponseBody](#) as the body in a [ResponseEntity](#) to customize the status and headers of the response.

1.5.5. Reactive Types

[Same as in Spring WebFlux](#)

Spring MVC supports use of reactive client libraries in a controller (also read [Reactive Libraries](#) in the WebFlux section). This includes the `WebClient` from `spring-webflux` and others, such as Spring Data reactive data repositories. In such scenarios, it is convenient to be able to return reactive types from the controller method.

Reactive return values are handled as follows:

- A single-value promise is adapted to, similar to using `DeferredResult`. Examples include `Mono` (Reactor) or `Single` (RxJava).
- A multi-value stream with a streaming media type (such as `application/stream+json` or `text/event-stream`) is adapted to, similar to using `ResponseBodyEmitter` or `SseEmitter`. Examples include `Flux` (Reactor) or `Observable` (RxJava). Applications can also return `Flux<ServerSentEvent>` or `Observable<ServerSentEvent>`.
- A multi-value stream with any other media type (such as `application/json`) is adapted to, similar to using `DeferredResult<List<?>>`.



Spring MVC supports Reactor and RxJava through the `ReactiveAdapterRegistry` from `spring-core`, which lets it adapt from multiple reactive libraries.

For streaming to the response, reactive back pressure is supported, but writes to the response are still blocking and are executed on a separate thread through the `configured TaskExecutor`, to avoid blocking the upstream source (such as a `Flux` returned from `WebClient`). By default, `SimpleAsyncTaskExecutor` is used for the blocking writes, but that is not suitable under load. If you plan to stream with a reactive type, you should use the [MVC configuration](#) to configure a task executor.

1.5.6. Disconnects

[Same as in Spring WebFlux](#)

The Servlet API does not provide any notification when a remote client goes away. Therefore, while streaming to the response, whether through `SseEmitter` or <<mvc-ann-async-reactive-types,reactive types>>, it is important to send data periodically, since the write fails if the client has disconnected. The send could take the form of an empty (comment-only) SSE event or any other data that the other side would have to interpret as a heartbeat and ignore.

Alternatively, consider using web messaging solutions (such as [STOMP over WebSocket](#) or [WebSocket with SockJS](#)) that have a built-in heartbeat mechanism.

1.5.7. Configuration

[Compared to WebFlux](#)

The asynchronous request processing feature must be enabled at the Servlet container level. The MVC configuration also exposes several options for asynchronous requests.

Servlet Container

Filter and Servlet declarations have an `asyncSupported` flag that needs to be set to `true` to enable asynchronous request processing. In addition, Filter mappings should be declared to handle the ASYNC `javax.servlet.DispatchType`.

In Java configuration, when you use `AbstractAnnotationConfigDispatcherServletInitializer` to initialize the Servlet container, this is done automatically.

In `web.xml` configuration, you can add `<async-supported>true</async-supported>` to the `DispatcherServlet` and to `Filter` declarations and add `<dispatcher>ASYNC</dispatcher>` to filter mappings.

Spring MVC

The MVC configuration exposes the following options related to asynchronous request processing:

- Java configuration: Use the `configureAsyncSupport` callback on `WebMvcConfigurer`.
- XML namespace: Use the `<async-support>` element under `<mvc:annotation-driven>`.

You can configure the following:

- Default timeout value for async requests, which if not set, depends on the underlying Servlet container (for example, 10 seconds on Tomcat).
- `AsyncTaskExecutor` to use for blocking writes when streaming with `Reactive Types` and for executing `Callable` instances returned from controller methods. We highly recommended configuring this property if you stream with reactive types or have controller methods that return `Callable`, since by default, it is a `SimpleAsyncTaskExecutor`.
- `DeferredResultProcessingInterceptor` implementations and `CallableProcessingInterceptor` implementations.

Note that you can also set the default timeout value on a `DeferredResult`, a `ResponseBodyEmitter`, and an `SseEmitter`. For a `Callable`, you can use `WebAsyncTask` to provide a timeout value.

1.6. CORS

[Same as in Spring WebFlux](#)

Spring MVC lets you handle CORS (Cross-Origin Resource Sharing). This section describes how to do so.

1.6.1. Introduction

[Same as in Spring WebFlux](#)

For security reasons, browsers prohibit AJAX calls to resources outside the current origin. For example, you could have your bank account in one tab and evil.com in another. Scripts from evil.com should not be able to make AJAX requests to your bank API with your credentials—for example withdrawing money from your account!

Cross-Origin Resource Sharing (CORS) is a [W3C specification](#) implemented by [most browsers](#) that lets you specify what kind of cross-domain requests are authorized, rather than using less secure and less powerful workarounds based on IFRAME or JSONP.

1.6.2. Processing

[Same as in Spring WebFlux](#)

The CORS specification distinguishes between preflight, simple, and actual requests. To learn how CORS works, you can read [this article](#), among many others, or see the specification for more details.

Spring MVC [HandlerMapping](#) implementations provide built-in support for CORS. After successfully mapping a request to a handler, [HandlerMapping](#) implementations check the CORS configuration for the given request and handler and take further actions. Preflight requests are handled directly, while simple and actual CORS requests are intercepted, validated, and have required CORS response headers set.

In order to enable cross-origin requests (that is, the `Origin` header is present and differs from the host of the request), you need to have some explicitly declared CORS configuration. If no matching CORS configuration is found, preflight requests are rejected. No CORS headers are added to the responses of simple and actual CORS requests and, consequently, browsers reject them.

Each [HandlerMapping](#) can be [configured](#) individually with URL pattern-based [CorsConfiguration](#) mappings. In most cases, applications use the MVC Java configuration or the XML namespace to declare such mappings, which results in a single global map being passed to all [HandlerMapping](#) instances.

You can combine global CORS configuration at the [HandlerMapping](#) level with more fine-grained, handler-level CORS configuration. For example, annotated controllers can use class- or method-level [@CrossOrigin](#) annotations (other handlers can implement [CorsConfigurationSource](#)).

The rules for combining global and local configuration are generally additive—for example, all global and all local origins. For those attributes where only a single value can be accepted (such as `allowCredentials` and `maxAge`), the local overrides the global value. See [CorsConfiguration#combine\(CorsConfiguration\)](#) for more details.

To learn more from the source or make advanced customizations, check the code behind:



- [CorsConfiguration](#)
- [CorsProcessor, DefaultCorsProcessor](#)
- [AbstractHandlerMapping](#)

1.6.3. `@CrossOrigin`

[Same as in Spring WebFlux](#)

The [@CrossOrigin](#) annotation enables cross-origin requests on annotated controller methods, as the following example shows:

```
@RestController
@RequestMapping("/account")
public class AccountController {

    @CrossOrigin
    @GetMapping("/{id}")
    public Account retrieve(@PathVariable Long id) {
        // ...
    }

    @DeleteMapping("/{id}")
    public void remove(@PathVariable Long id) {
        // ...
    }
}
```

By default, `@CrossOrigin` allows:

- All origins.
- All headers.
- All HTTP methods to which the controller method is mapped.

`allowedCredentials` is not enabled by default, since that establishes a trust level that exposes sensitive user-specific information (such as cookies and CSRF tokens) and should only be used where appropriate.

`maxAge` is set to 30 minutes.

`@CrossOrigin` is supported at the class level, too, and is inherited by all methods, as the following example shows:

```

@CrossOrigin(origins = "http://domain2.com", maxAge = 3600)
@RestController
@RequestMapping("/account")
public class AccountController {

    @GetMapping("/{id}")
    public Account retrieve(@PathVariable Long id) {
        // ...
    }

    @DeleteMapping("/{id}")
    public void remove(@PathVariable Long id) {
        // ...
    }
}

```

You can use `@CrossOrigin` at both the class level and the method level, as the following example shows:

```

@CrossOrigin(maxAge = 3600)
@RestController
@RequestMapping("/account")
public class AccountController {

    @CrossOrigin("http://domain2.com")
    @GetMapping("/{id}")
    public Account retrieve(@PathVariable Long id) {
        // ...
    }

    @DeleteMapping("/{id}")
    public void remove(@PathVariable Long id) {
        // ...
    }
}

```

1.6.4. Global Configuration

Same as in Spring WebFlux

In addition to fine-grained, controller method level configuration, you probably want to define some global CORS configuration, too. You can set URL-based `CorsConfiguration` mappings individually on any `HandlerMapping`. Most applications, however, use the MVC Java configuration or the MVC XNM namespace to do that.

By default, global configuration enables the following:

- All origins.
- All headers.
- **GET**, **HEAD**, and **POST** methods.

`allowedCredentials` is not enabled by default, since that establishes a trust level that exposes sensitive user-specific information (such as cookies and CSRF tokens) and should only be used where appropriate.

`maxAge` is set to 30 minutes.

Java Configuration

Same as in Spring WebFlux

To enable CORS in the MVC Java config, you can use the `CorsRegistry` callback, as the following example shows:

```
@Configuration
@EnableWebMvc
public class WebConfig implements WebMvcConfigurer {

    @Override
    public void addCorsMappings(CorsRegistry registry) {

        registry.addMapping("/api/**")
            .allowedOrigins("http://domain2.com")
            .allowedMethods("PUT", "DELETE")
            .allowedHeaders("header1", "header2", "header3")
            .exposedHeaders("header1", "header2")
            .allowCredentials(true).maxAge(3600);

        // Add more mappings...
    }
}
```

XML Configuration

To enable CORS in the XML namespace, you can use the `<mvc:cors>` element, as the following example shows:

```

<mvc:cors>

    <mvc:mapping path="/api/**"
        allowed-origins="http://domain1.com, http://domain2.com"
        allowed-methods="GET, PUT"
        allowed-headers="header1, header2, header3"
        exposed-headers="header1, header2" allow-credentials="true"
        max-age="123" />

    <mvc:mapping path="/resources/**"
        allowed-origins="http://domain1.com" />

</mvc:cors>

```

1.6.5. CORS Filter

[Same as in Spring WebFlux](#)

You can apply CORS support through the built-in `CorsFilter`.



If you try to use the `CorsFilter` with Spring Security, keep in mind that Spring Security has [built-in support](#) for CORS.

To configure the filter, pass a `CorsConfigurationSource` to its constructor, as the following example shows:

```

CorsConfiguration config = new CorsConfiguration();

// Possibly...
// config.applyPermitDefaultValues()

config.setAllowCredentials(true);
config.addAllowedOrigin("http://domain1.com");
config.addAllowedHeader("*");
config.addAllowedMethod("*");

UrlBasedCorsConfigurationSource source = new UrlBasedCorsConfigurationSource();
source.registerCorsConfiguration("/**", config);

CorsFilter filter = new CorsFilter(source);

```

1.7. Web Security

[Same as in Spring WebFlux](#)

The [Spring Security](#) project provides support for protecting web applications from malicious exploits. See the Spring Security reference documentation, including:

- [Spring MVC Security](#)
- [Spring MVC Test Support](#)
- [CSRF protection](#)
- [Security Response Headers](#)

[HDIV](#) is another web security framework that integrates with Spring MVC.

1.8. HTTP Caching

[Same as in Spring WebFlux](#)

HTTP caching can significantly improve the performance of a web application. HTTP caching revolves around the `Cache-Control` response header and, subsequently, conditional request headers (such as `Last-Modified` and `ETag`). `Cache-Control` advises private (for example, browser) and public (for example, proxy) caches on how to cache and re-use responses. An `ETag` header is used to make a conditional request that may result in a 304 (NOT_MODIFIED) without a body, if the content has not changed. `ETag` can be seen as a more sophisticated successor to the `Last-Modified` header.

This section describes the HTTP caching-related options that are available in Spring Web MVC.

1.8.1. CacheControl

[Same as in Spring WebFlux](#)

`CacheControl` provides support for configuring settings related to the `Cache-Control` header and is accepted as an argument in a number of places:

- [WebContentInterceptor](#)
- [WebContentGenerator](#)
- [Controllers](#)
- [Static Resources](#)

While [RFC 7234](#) describes all possible directives for the `Cache-Control` response header, the `CacheControl` type takes a use case-oriented approach that focuses on the common scenarios:

```

// Cache for an hour - "Cache-Control: max-age=3600"
CacheControl ccCacheOneHour = CacheControl.maxAge(1, TimeUnit.HOURS);

// Prevent caching - "Cache-Control: no-store"
CacheControl ccNoStore = CacheControl.noStore();

// Cache for ten days in public and private caches,
// public caches should not transform the response
// "Cache-Control: max-age=864000, public, no-transform"
CacheControl ccCustom = CacheControl.maxAge(10, TimeUnit.DAYS).noTransform()
.cachePublic();

```

`WebContentGenerator` also accept a simpler `cachePeriod` property (defined in seconds) that works as follows:

- A `-1` value does not generate a `Cache-Control` response header.
- A `0` value prevents caching by using the '`Cache-Control: no-store`' directive.
- An `n > 0` value caches the given response for `n` seconds by using the '`Cache-Control: max-age=n`' directive.

1.8.2. Controllers

Same as in Spring WebFlux

Controllers can add explicit support for HTTP caching. We recommended doing so, since the `lastModified` or `ETag` value for a resource needs to be calculated before it can be compared against conditional request headers. A controller can add an `ETag` header and `Cache-Control` settings to a `ResponseEntity`, as the following example shows:

```

@GetMapping("/book/{id}")
public ResponseEntity<Book> showBook(@PathVariable Long id) {

    Book book = findBook(id);
    String version = book.getVersion();

    return ResponseEntity
        .ok()
        .cacheControl(CacheControl.maxAge(30, TimeUnit.DAYS))
        .eTag(version) // lastModified is also available
        .body(book);
}

```

The preceding example sends an 304 (NOT_MODIFIED) response with an empty body if the comparison to the conditional request headers indicates that the content has not changed.

Otherwise, the `ETag` and `Cache-Control` headers are added to the response.

You can also make the check against conditional request headers in the controller, as the following example shows:

```
@RequestMapping  
public String myHandleMethod(WebRequest webRequest, Model model) {  
  
    long eTag = ... ①  
  
    if (request.checkNotModified(eTag)) {  
        return null; ②  
    }  
  
    model.addAttribute(...); ③  
    return "myViewName";  
}
```

① Application-specific calculation.

② The response has been set to 304 (NOT_MODIFIED)—no further processing.

③ Continue with the request processing.

There are three variants for checking conditional requests against `eTag` values, `lastModified` values, or both. For conditional `GET` and `HEAD` requests, you can set the response to 304 (NOT_MODIFIED). For conditional `POST`, `PUT`, and `DELETE`, you can instead set the response to 409 (PRECONDITION_FAILED), to prevent concurrent modification.

1.8.3. Static Resources

[Same as in Spring WebFlux](#)

You should serve static resources with a `Cache-Control` and conditional response headers for optimal performance. See the section on configuring [Static Resources](#).

1.8.4. ETag Filter

You can use the `ShallowEtagHeaderFilter` to add “shallow” `eTag` values that are computed from the response content and, thus, save bandwidth but not CPU time. See [Shallow ETag](#).

1.9. View Technologies

[Same as in Spring WebFlux](#)

The use of view technologies in Spring MVC is pluggable, whether you decide to use Thymeleaf, Groovy Markup Templates, JSPs, or other technologies, is primarily a matter of a configuration change. This chapter covers view technologies integrated with Spring MVC. We assume you are already familiar with [View Resolution](#).

1.9.1. Thymeleaf

[Same as in Spring WebFlux](#)

Thymeleaf is a modern server-side Java template engine that emphasizes natural HTML templates that can be previewed in a browser by double-clicking, which is very helpful for independent work on UI templates (for example, by a designer) without the need for a running server. If you want to replace JSPs, Thymeleaf offers one of the most extensive set of features to make such a transition easier. Thymeleaf is actively developed and maintained. For a more complete introduction, see the [Thymeleaf](#) project home page.

The Thymeleaf integration with Spring MVC is managed by the Thymeleaf project. The configuration involves a few bean declarations, such as `ServletContextTemplateResolver`, `SpringTemplateEngine`, and `ThymeleafViewResolver`. See [Thymeleaf+Spring](#) for more details.

1.9.2. FreeMarker

[Same as in Spring WebFlux](#)

Apache [FreeMarker](#) is a template engine for generating any kind of text output from HTML to email and others. The Spring Framework has a built-in integration for using Spring MVC with FreeMarker templates.

View Configuration

[Same as in Spring WebFlux](#)

The following example shows how to configure FreeMarker as a view technology:

```
@Configuration  
@EnableWebMvc  
public class WebConfig implements WebMvcConfigurer {  
  
    @Override  
    public void configureViewResolvers(ViewResolverRegistry registry) {  
        registry.freemarker();  
    }  
  
    // Configure FreeMarker...  
  
    @Bean  
    public FreeMarkerConfigurer freeMarkerConfigurer() {  
        FreeMarkerConfigurer configurer = new FreeMarkerConfigurer();  
        configurer.setTemplateLoaderPath("/WEB-INF/freemarker");  
        return configurer;  
    }  
}
```

The following example shows how to configure the same in XML:

```
<mvc:annotation-driven/>

<mvc:view-resolvers>
    <mvc:freemarker/>
</mvc:view-resolvers>

<!-- Configure FreeMarker... -->
<mvc:freemarker-configure>
    <mvc:template-loader-path location="/WEB-INF/freemarker"/>
</mvc:freemarker-configure>
```

Alternatively, you can also declare the `FreeMarkerConfigurer` bean for full control over all properties, as the following example shows:

```
<bean id="freemarkerConfig" class=
"org.springframework.web.servlet.view.freemarker.FreeMarkerConfigurer">
    <property name="templateLoaderPath" value="/WEB-INF/freemarker"/>
</bean>
```

Your templates need to be stored in the directory specified by the `FreeMarkerConfigurer` shown in the preceding example. Given the preceding configuration, if your controller returns a view name of `welcome`, the resolver looks for the `/WEB-INF/freemarker/welcome.ftl` template.

FreeMarker Configuration

Same as in Spring WebFlux

You can pass FreeMarker 'Settings' and 'SharedVariables' directly to the FreeMarker `Configuration` object (which is 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`. The following example shows how to do so:

```

<bean id="freemarkerConfig" class=
"org.springframework.web.servlet.view.freemarker.FreeMarkerConfigurer">
    <property name="templateLoaderPath" value="/WEB-INF/freemarker/" />
    <property name="freemarkerVariables">
        <map>
            <entry key="xml_escape" value-ref="fmXmlEscape"/>
        </map>
    </property>
</bean>

<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.

Form Handling

Spring provides a tag library for use in JSPs that contains, among others, a `<spring:bind/>` element. This element primarily lets forms display values from form-backing objects and show the results of failed validations from a `Validator` in the web or business tier. Spring also has support for the same functionality in FreeMarker, with additional convenience macros for generating form input elements themselves.

The Bind Macros

A standard set of macros are maintained within the `spring-webmvc.jar` file for both languages, so they are always available to a suitably configured application.

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 directly call from within your templates. If you wish to view the macro code directly, the file is called `spring.ftl` and is in the `org.springframework.web.servlet.view.freemarker` package.

Simple Binding

In your HTML forms (vm or ftl templates) that act as a form view for a Spring MVC controller, you can use code similar to the next example to bind to field values and display error messages for each input field in similar fashion to the JSP equivalent. The following example shows the `personForm` view that was configured earlier:

```

<!-- freemarker macros have to be imported into a namespace. We strongly
recommend sticking to 'spring' -->
<#import "/spring.ftl" as spring/>
<html>
  ...
  <form action="" method="POST">
    Name:
    <@spring.bind "myModelObject.name"/>
    <input type="text"
      name="${spring.status.expression}"
      value="${spring.status.value?html}" /><br>
    <#list spring.status.errorMessages as error> <b>$error</b> <br> </#list>
    <br>
    ...
    <input type="submit" value="submit"/>
  </form>
  ...
</html>

```

`<@spring.bind>` requires a 'path' argument, which consists of the name of your command object (it is 'command', unless you changed it in your `FormController` properties) followed by a period and the name of the field on the command object to which you wish to bind. You can also use nested fields, 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 `<@spring.bindEscaped>` takes a second argument and explicitly specifies whether HTML escaping should be used in the status error messages or values. You can set it to `true` or `false` as required. Additional form handling macros simplify the use of HTML escaping, and you should use these macros wherever possible. They are explained in the next section.

Input 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 you can mix and match them with simple HTML or direct calls to the spring bind macros that we highlighted previously.

The following table of available macros shows the FTL definitions and the parameter list that each takes:

Table 6. Table of macro definitions

macro	FTL definition
<code>message</code> (output a string from a resource bundle based on the code parameter)	<code><@spring.message code/></code>

macro	FTL definition
<code>messageText</code> (output a string from a resource bundle based on the code parameter, falling back to the value of the default parameter)	<code><@spring.messageText code, text/></code>
<code>url</code> (prefix a relative URL with the application's context root)	<code><@spring.url relativeUrl/></code>
<code>formInput</code> (standard input field for gathering user input)	<code><@spring.formInput path, attributes, fieldType/></code>
<code>formHiddenInput</code> (hidden input field for submitting non-user input)	<code><@spring.formHiddenInput path, attributes/></code>
<code>formPasswordInput</code> (standard input field for gathering passwords. Note that no value is ever populated in fields of this type.)	<code><@spring.formPasswordInput path, attributes/></code>
<code>formTextarea</code> (large text field for gathering long, freeform text input)	<code><@spring.formTextarea path, attributes/></code>
<code>formSingleSelect</code> (drop down box of options that let a single required value be selected)	<code><@spring.formSingleSelect path, options, attributes/></code>
<code>formMultiSelect</code> (a list box of options that let the user select 0 or more values)	<code><@spring.formMultiSelect path, options, attributes/></code>
<code>formRadioButtons</code> (a set of radio buttons that let a single selection be made from the available choices)	<code><@spring.formRadioButtons path, options separator, attributes/></code>
<code>formCheckboxes</code> (a set of checkboxes that let 0 or more values be selected)	<code><@spring.formCheckboxes path, options separator, attributes/></code>
<code>formCheckbox</code> (a single checkbox)	<code><@spring.formCheckbox path, attributes/></code>
<code>showErrors</code> (simplify display of validation errors for the bound field)	<code><@spring.showErrors separator, classOrStyle/></code>

- In FTL (FreeMarker), `formHiddenInput` and `formPasswordInput` are not actually required, as you can use the normal `formInput` macro, specifying `hidden` or `password` as the value for the `fieldType` parameter.

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 are 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. You can use any `Map` implementation, depending on required behavior. For strictly sorted maps, you can use a `SortedMap` (such as a `TreeMap`) with a

suitable `Comparator` 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 (such as `
`).
- **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 `textarea` field, you may supply attributes (such 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` element that wraps each error uses. If no information is supplied (or the value is empty), the errors are wrapped in `` tags.

The following sections outline examples of the macros (some in FTL and some in VTL). Where usage differences exist between the two languages, they are explained in the notes.

Input Fields

The `formInput` macro takes the `path` parameter (`command.name`) and an additional `attributes` parameter (which is empty in the upcoming example). 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 does not need to pass the path parameter again—it operates on the field for which a bind was last created.

The `showErrors` macro takes a separator parameter (the characters that are 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 can specify default values for the attributes parameter. The following example shows how to use the `formInput` and `showErrors` macros:

```
<@spring.formInput "command.name"/>
<@spring.showErrors "<br>"/>
```

The next example shows the output 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 resembles the following example:

```
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) is used to pass style information or `rows` and `cols` attributes for the `textarea`.

Selection Fields

You can use four selection field macros 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 that contains the value for the form field and the label that corresponds to that value. The value and the label can be the same.

The next example is for radio buttons in FTL. The form-backing object specifies a default value of 'London' for this field, 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'. The following listing shows the example:

```
....  
Town:  
<@spring.formRadioButtons "command.address.town", cityMap, ""/><br><br>
```

The preceding listing renders a line of radio buttons, one for each value in `cityMap`, and uses a separator of `" "`. 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. The map values are the labels that the user sees. In the preceding example, given a list of three well known cities and a default value in the form backing object, the HTML resembles the following:

```
Town:  
<input type="radio" name="address.town" value="London">London</input>  
<input type="radio" name="address.town" value="Paris"  
checked="checked">Paris</input>  
<input type="radio" name="address.town" value="New York">New York</input>
```

If your application expects to handle cities by internal codes (for example), you can create the map of codes with suitable keys, as the following example shows:

```

protected Map<String, String> referenceData(HttpServletRequest request) throws
Exception {
    Map<String, String> cityMap = new LinkedHashMap<>();
    cityMap.put("LDN", "London");
    cityMap.put("PRS", "Paris");
    cityMap.put("NYC", "New York");

    Map<String, String> model = new HashMap<>();
    model.put("cityMap", cityMap);
    return model;
}

```

The code now produces output where the radio values are the relevant codes, but the user still sees the more user-friendly city names, as follows:

```

Town:
<input type="radio" name="address.town" value="LDN">London</input>
<input type="radio" name="address.town" value="PRS"
checked="checked">Paris</input>
<input type="radio" name="address.town" value="NYC">New York</input>

```

HTML Escaping

Default usage of the form macros described earlier results in HTML elements that are HTML 4.01 compliant and that use the default value for HTML escaping defined in your `web.xml` file, as used by Spring's bind support. To make the elements be XHTML compliant or to override the default HTML escaping value, you can specify two variables in your template (or in your model, where they are 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 or context variable named `xhtmlCompliant`, as the following example shows:

```

<!-- for FreeMarker -->
<#assign xhtmlCompliant = true>

```

After processing this directive, any elements generated by the Spring macros are now XHTML compliant.

In similar fashion, you can specify HTML escaping per field, as the following example shows:

```

<-- until this point, default HTML escaping is used -->

<#assign htmlEscape = true>
<-- next field will use HTML escaping -->
<@spring.formInput "command.name"/>

<assign htmlEscape = false in spring>
<-- all future fields will be bound with HTML escaping off -->

```

1.9.3. Groovy Markup

The [Groovy Markup Template Engine](#) is primarily aimed at generating XML-like markup (XML, XHTML, HTML5, and others), but you can use it to generate any text-based content. The Spring Framework has a built-in integration for using Spring MVC with Groovy Markup.



The Groovy Markup Template engine requires Groovy 2.3.1+.

Configuration

The following example shows how to configure the Groovy Markup Template Engine:

```

@Configuration
@EnableWebMvc
public class WebConfig implements WebMvcConfigurer {

    @Override
    public void configureViewResolvers(ViewResolverRegistry registry) {
        registry.groovy();
    }

    // Configure the Groovy Markup Template Engine...

    @Bean
    public GroovyMarkupConfigurer groovyMarkupConfigurer() {
        GroovyMarkupConfigurer configurer = new GroovyMarkupConfigurer();
        configurer.setResourceLoaderPath("/WEB-INF/");
        return configurer;
    }
}

```

The following example shows how to configure the same in XML:

```

<mvc:annotation-driven/>

<mvc:view-resolvers>
    <mvc:groovy/>
</mvc:view-resolvers>

<!-- Configure the Groovy Markup Template Engine... -->
<mvc:groovy-configuration resource-loader-path="/WEB-INF/" />

```

Example

Unlike traditional template engines, Groovy Markup relies on a DSL that uses a builder syntax. The following example shows a sample template for an HTML page:

```

yieldUnescaped '<!DOCTYPE html>'
html(lang:'en') {
    head {
        meta('http-equiv':'Content-Type' content="text/html; charset=utf-8")
        title('My page')
    }
    body {
        p('This is an example of HTML contents')
    }
}

```

1.9.4. Script Views

[Same as in Spring WebFlux](#)

The Spring Framework has a built-in integration for using Spring MVC with any templating library that can run on top of the [JSR-223](#) Java scripting engine. We have tested the following templating libraries on different script engines:

Scripting Library	Scripting Engine
Handlebars	Nashorn
Mustache	Nashorn
React	Nashorn
EJS	Nashorn
ERB	JRuby
String templates	Jython
Kotlin Script templating	Kotlin



The basic rule for integrating any other script engine is that it must implement the `ScriptEngine` and `Invocable` interfaces.

Requirements

Same as in Spring WebFlux

You need to have the script engine on your classpath, the details of which vary by script engine:

- The `Nashorn` JavaScript engine is provided with Java 8+. Using the latest update release available is highly recommended.
- `JRuby` should be added as a dependency for Ruby support.
- `Jython` should be added as a dependency for Python support.
- `org.jetbrains.kotlin:kotlin-script-util` dependency and a `META-INF/services/javax.script.ScriptEngineFactory` file containing a `org.jetbrains.kotlin.script.jsr223.KotlinJs223JvmLocalScriptEngineFactory` line should be added for Kotlin script support. See [this example](#) for more details.

You need to have the script templating library. One way to do that for Javascript is through [WebJars](#).

Script Templates

Same as in Spring WebFlux

You can declare a `ScriptTemplateConfigurer` bean to specify the script engine to use, the script files to load, what function to call to render templates, and so on. The following example uses Mustache templates and the Nashorn JavaScript engine:

```

@Configuration
@EnableWebMvc
public class WebConfig implements WebMvcConfigurer {

    @Override
    public void configureViewResolvers(ViewResolverRegistry registry) {
        registry.scriptTemplate();
    }

    @Bean
    public ScriptTemplateConfigurer configurer() {
        ScriptTemplateConfigurer configurer = new ScriptTemplateConfigurer();
        configurer.setEngineName("nashorn");
        configurer.setScripts("mustache.js");
        configurer.setRenderObject("Mustache");
        configurer.setRenderFunction("render");
        return configurer;
    }
}

```

The following example shows the same arrangement in XML:

```

<mvc:annotation-driven/>

<mvc:view-resolvers>
    <mvc:script-template/>
</mvc:view-resolvers>

<mvc:script-template-configure engine-name="nashorn" render-object="Mustache"
render-function="render">
    <mvc:script location="mustache.js"/>
</mvc:script-template-configure>

```

The controller would look no different for the Java and XML configurations, as the following example shows:

```
@Controller
public class SampleController {

    @GetMapping("/sample")
    public String test(Model model) {
        model addObject("title", "Sample title");
        model addObject("body", "Sample body");
        return "template";
    }
}
```

The following example shows the Mustache template:

```
<html>
  <head>
    <title>{{title}}</title>
  </head>
  <body>
    <p>{{body}}</p>
  </body>
</html>
```

The render function is called with the following parameters:

- `String template`: The template content
- `Map model`: The view model
- `RenderingContext renderingContext`: The `RenderingContext` that gives access to the application context, the locale, the template loader, and the URL (since 5.0)

`Mustache.render()` is natively compatible with this signature, so you can call it directly.

If your templating technology requires some customization, you can provide a script that implements a custom render function. For example, `Handlebars` needs to compile templates before using them and requires a `polyfill` to emulate some browser facilities that are not available in the server-side script engine.

The following example shows how to do so:

```

@Configuration
@EnableWebMvc
public class WebConfig implements WebMvcConfigurer {

    @Override
    public void configureViewResolvers(ViewResolverRegistry registry) {
        registry.scriptTemplate();
    }

    @Bean
    public ScriptTemplateConfigurer configurer() {
        ScriptTemplateConfigurer configurer = new ScriptTemplateConfigurer();
        configurer.setEngineName("nashorn");
        configurer.setScripts("polyfill.js", "handlebars.js", "render.js");
        configurer.setRenderFunction("render");
        configurer.setSharedEngine(false);
        return configurer;
    }
}

```



Setting the `sharedEngine` property to `false` is required when you use non-thread-safe script engines with templating libraries not designed for concurrency, such as Handlebars or React running on Nashorn. In that case, Java 8u60 or greater is required, due to [this bug](#).

`polyfill.js` defines only the `window` object needed by Handlebars to run properly, as follows:

```
var window = {};
```

This basic `render.js` implementation compiles the template before using it. A production-ready implementation should also store any reused cached templates or pre-compiled templates. You can do so on the script side (and handle any customization you need—managing template engine configuration, for example). The following example shows how to do so:

```

function render(template, model) {
    var compiledTemplate = Handlebars.compile(template);
    return compiledTemplate(model);
}

```

Check out the Spring Framework unit tests, [Java](#), and [resources](#), for more configuration examples.

1.9.5. JSP and JSTL

The Spring Framework has a built-in integration for using Spring MVC with JSP and JSTL.

View Resolvers

When developing with JSPs, you can declare a `InternalResourceViewResolver` or a `ResourceBundleViewResolver` bean.

`ResourceBundleViewResolver` relies on a properties file to define the view names mapped to a class and a URL. With a `ResourceBundleViewResolver`, you can mix different types of views by using only one resolver, as the following example shows:

```
<!-- the ResourceBundleViewResolver -->
<bean id="viewResolver" class=
"org.springframework.web.servlet.view.ResourceBundleViewResolver">
    <property name="basename" value="views"/>
</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
```

`InternalResourceBundleViewResolver` can also be used for JSPs. As a best practice, we strongly encourage placing your JSP files in a directory under the '`WEB-INF`' directory so there can be no direct access by clients.

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

JSPs versus JSTL

When using the 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 can work.

Spring's JSP Tag Library

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 `spring.tld` tag library descriptor (TLD) is included in the `spring-webmvc.jar`. For a comprehensive reference on individual tags, browse the [API reference](#) or see the tag library description.

Spring's form tag library

As of version 2.0, Spring provides a comprehensive set of data binding-aware tags for handling form elements when using JSP and Spring Web MVC. Each tag provides support for the set of attributes of its corresponding HTML tag counterpart, making the tags familiar and intuitive to use. The tag-generated HTML is HTML 4.01/XHTML 1.0 compliant.

Unlike other form/input tag libraries, Spring's form tag library is integrated with Spring Web MVC, giving the tags access to the command object and reference data your controller deals with. As we show in the following examples, the form tags make JSPs easier to develop, read, and maintain.

We go through the form tags and look at an example of how each tag is used. We have included generated HTML snippets where certain tags require further commentary.

Configuration

The form tag library comes bundled in `spring-webmvc.jar`. The library descriptor is called `spring-form.tld`.

To use the tags from this library, add the following directive to the top of your JSP page:

```
<%@ taglib prefix="form" uri="http://www.springframework.org/tags/form" %>
```

where `form` is the tag name prefix you want to use for the tags from this library.

The Form Tag

This tag renders an HTML 'form' element and exposes a binding path to inner tags for binding. It puts the command object in the `PageContext` so that the command object can be accessed by inner tags. All the other tags in this library are nested tags of the `form` tag.

Assume that we have a domain object called `User`. It is a JavaBean with properties such as `firstName` and `lastName`. We can use it as the form-backing object of our form controller, which returns `form.jsp`. The following example shows what `form.jsp` could look like:

```

<form:form>
  <table>
    <tr>
      <td>First Name:</td>
      <td><form:input path="firstName"/></td>
    </tr>
    <tr>
      <td>Last Name:</td>
      <td><form:input path="lastName"/></td>
    </tr>
    <tr>
      <td colspan="2">
        <input type="submit" value="Save Changes"/>
      </td>
    </tr>
  </table>
</form:form>

```

The `firstName` and `lastName` values are retrieved from the command object placed in the `PageContext` by the page controller. Keep reading to see more complex examples of how inner tags are used with the `form` tag.

The following listing shows the generated HTML, which looks like a standard form:

```

<form method="POST">
  <table>
    <tr>
      <td>First Name:</td>
      <td><input name="firstName" type="text" value="Harry"/></td>
    </tr>
    <tr>
      <td>Last Name:</td>
      <td><input name="lastName" type="text" value="Potter"/></td>
    </tr>
    <tr>
      <td colspan="2">
        <input type="submit" value="Save Changes"/>
      </td>
    </tr>
  </table>
</form>

```

The preceding JSP assumes that the variable name of the form-backing object is `command`. If you have put the form-backing object into the model under another name (definitely a best practice), you can bind the form to the named variable, as the following example shows:

```
<form:form modelAttribute="user">
    <table>
        <tr>
            <td>First Name:</td>
            <td><form:input path="firstName"/></td>
        </tr>
        <tr>
            <td>Last Name:</td>
            <td><form:input path="lastName"/></td>
        </tr>
        <tr>
            <td colspan="2">
                <input type="submit" value="Save Changes"/>
            </td>
        </tr>
    </table>
</form:form>
```

The `input` Tag

This tag renders an HTML `input` element with the bound value and `type='text'` by default. For an example of this tag, see [The Form Tag](#). You can also use HTML5-specific types, such as `email`, `tel`, `date`, and others.

The `checkbox` Tag

This tag renders an HTML `input` tag with the `type` set to `checkbox`.

Assume that our `User` has preferences such as newsletter subscription and a list of hobbies. The following example shows the `Preferences` class:

```
public class Preferences {

    private boolean receiveNewsletter;
    private String[] interests;
    private String favouriteWord;

    public boolean isReceiveNewsletter() {
        return receiveNewsletter;
    }

    public void setReceiveNewsletter(boolean receiveNewsletter) {
        this.receiveNewsletter = receiveNewsletter;
    }

    public String[] getInterests() {
        return interests;
    }

    public void setInterests(String[] interests) {
        this.interests = interests;
    }

    public String getFavouriteWord() {
        return favouriteWord;
    }

    public void setFavouriteWord(String favouriteWord) {
        this.favouriteWord = favouriteWord;
    }
}
```

The corresponding `form.jsp` could then resemble the following:

```

<form:form>
  <table>
    <tr>
      <td>Subscribe to newsletter?:</td>
      <%-- Approach 1: Property is of type java.lang.Boolean --%>
      <td><form:checkbox path="preferences.receiveNewsletter"/></td>
    </tr>

    <tr>
      <td>Interests:</td>
      <%-- Approach 2: Property is of an array or of type
java.util.Collection --%>
      <td>
        Quidditch: <form:checkbox path="preferences.interests" value=
"Quidditch"/>
        Herbology: <form:checkbox path="preferences.interests" value=
"Herbology"/>
        Defence Against the Dark Arts: <form:checkbox path=
"preferences.interests" value="Defence Against the Dark Arts"/>
      </td>
    </tr>

    <tr>
      <td>Favourite Word:</td>
      <%-- Approach 3: Property is of type java.lang.Object --%>
      <td>
        Magic: <form:checkbox path="preferences.favouriteWord" value=
"Magic"/>
      </td>
    </tr>
  </table>
</form:form>

```

There are three approaches to the `checkbox` tag, which should meet all your checkbox needs.

- Approach One: When the bound value is of type `java.lang.Boolean`, the `input(checkbox)` is marked as `checked` if the bound value is `true`. The `value` attribute corresponds to the resolved value of the `setValue(Object)` value property.
- Approach Two: When the bound value is of type `array` or `java.util.Collection`, the `input(checkbox)` is marked as `checked` if the configured `setValue(Object)` value is present in the bound `Collection`.
- Approach Three: For any other bound value type, the `input(checkbox)` is marked as `checked` if the configured `setValue(Object)` is equal to the bound value.

Note that, regardless of the approach, the same HTML structure is generated. The following HTML snippet defines some checkboxes:

```

<tr>
    <td>Interests:</td>
    <td>
        Quidditch: <input name="preferences.interests" type="checkbox" value="Quidditch"/>
        <input type="hidden" value="1" name="_preferences.interests"/>
        Herbology: <input name="preferences.interests" type="checkbox" value="Herbology"/>
        <input type="hidden" value="1" name="_preferences.interests"/>
        Defence Against the Dark Arts: <input name="preferences.interests" type="checkbox" value="checkbox" value="Defence Against the Dark Arts"/>
        <input type="hidden" value="1" name="_preferences.interests"/>
    </td>
</tr>

```

You might not expect to see the additional hidden field after each checkbox. When a checkbox in an HTML page is not checked, its value is not sent to the server as part of the HTTP request parameters once the form is submitted, so we need a workaround for this quirk in HTML for Spring form data binding to work. The `checkbox` tag follows the existing Spring convention of including a hidden parameter prefixed by an underscore (`_`) for each checkbox. By doing this, you are effectively telling Spring that “the checkbox was visible in the form, and I want my object to which the form data binds to reflect the state of the checkbox, no matter what.”

The `checkboxes` Tag

This tag renders multiple HTML `input` tags with the `type` set to `checkbox`.

This section build on the example from the previous `checkbox` tag section. Sometimes, you prefer not to have to list all the possible hobbies in your JSP page. You would rather provide a list at runtime of the available options and pass that in to the tag. That is the purpose of the `checkboxes` tag. You can pass in an `Array`, a `List`, or a `Map` that contains the available options in the `items` property. Typically, the `bound` property is a collection so that it can hold multiple values selected by the user. The following example shows a JSP that uses this tag:

```

<form:form>
  <table>
    <tr>
      <td>Interests:</td>
      <td>
        <%-- Property is of an array or of type java.util.Collection --%>
        <form:checkboxes path="preferences.interests" items=
"${interestList}" />
      </td>
    </tr>
  </table>
</form:form>

```

This example assumes that the `interestList` is a `List` available as a model attribute that contains strings of the values to be selected from. If you use a `Map`, the map entry key is used as the value, and the map entry's value is used as the label to be displayed. You can also use a custom object where you can provide the property names for the value by using `itemValue` and the label by using `itemLabel`.

The `radiobutton` Tag

This tag renders an HTML `input` element with the `type` set to `radio`.

A typical usage pattern involves multiple tag instances bound to the same property but with different values, as the following example shows:

```

<tr>
  <td>Sex:</td>
  <td>
    Male: <form:radio button path="sex" value="M"/> <br/>
    Female: <form:radio button path="sex" value="F"/>
  </td>
</tr>

```

The `radioButtons` Tag

This tag renders multiple HTML `input` elements with the `type` set to `radio`.

As with the `checkboxes tag`, you might want to pass in the available options as a runtime variable. For this usage, you can use the `radioButtons` tag. You pass in an `Array`, a `List`, or a `Map` that contains the available options in the `items` property. If you use a `Map`, the map entry key is used as the value and the map entry's value are used as the label to be displayed. You can also use a custom object where you can provide the property names for the value by using `itemValue` and the label by using `itemLabel`, as the following example shows:

```

<tr>
    <td>Sex:</td>
    <td><form:radioButtons path="sex" items="${sexOptions}" /></td>
</tr>

```

The `password` Tag

This tag renders an HTML `input` tag with the type set to `password` with the bound value.

```

<tr>
    <td>Password:</td>
    <td>
        <form:password path="password" />
    </td>
</tr>

```

Note that, by default, the password value is not shown. If you do want the password value to be shown, you can set the value of the `showPassword` attribute to `true`, as the following example shows:

```

<tr>
    <td>Password:</td>
    <td>
        <form:password path="password" value="^76525bvH6q" showPassword="true" />
    </td>
</tr>

```

The `select` Tag

This tag renders an HTML 'select' element. It supports data binding to the selected option as well as the use of nested `option` and `options` tags.

Assume that a `User` has a list of skills. The corresponding HTML could be as follows:

```

<tr>
    <td>Skills:</td>
    <td><form:select path="skills" items="${skills}" /></td>
</tr>

```

If the `User's` skill are in Herbology, the HTML source of the 'Skills' row could be as follows:

```

<tr>
  <td>Skills:</td>
  <td>
    <select name="skills" multiple="true">
      <option value="Potions">Potions</option>
      <option value="Herbology" selected="selected">Herbology</option>
      <option value="Quidditch">Quidditch</option>
    </select>
  </td>
</tr>

```

The `option` Tag

This tag renders an HTML `option` element. It sets `selected`, based on the bound value. The following HTML shows typical output for it:

```

<tr>
  <td>House:</td>
  <td>
    <form:select path="house">
      <form:option value="Gryffindor"/>
      <form:option value="Hufflepuff"/>
      <form:option value="Ravenclaw"/>
      <form:option value="Slytherin"/>
    </form:select>
  </td>
</tr>

```

If the User's house was in Gryffindor, the HTML source of the 'House' row would be as follows:

```

<tr>
  <td>House:</td>
  <td>
    <select name="house">
      <option value="Gryffindor" selected="selected">Gryffindor</option> ①
      <option value="Hufflepuff">Hufflepuff</option>
      <option value="Ravenclaw">Ravenclaw</option>
      <option value="Slytherin">Slytherin</option>
    </select>
  </td>
</tr>

```

① Note the addition of a `selected` attribute.

The `options` Tag

This tag renders a list of HTML `option` elements. It sets the `selected` attribute, based on the bound value. The following HTML shows typical output for it:

```
<tr>
    <td>Country:</td>
    <td>
        <form:select path="country">
            <form:option value="-" label="--Please Select"/>
            <form:options items="${countryList}" itemValue="code" itemLabel="name"
        "/>
        </form:select>
    </td>
</tr>
```

If the `User` lived in the UK, the HTML source of the 'Country' row would be as follows:

```
<tr>
    <td>Country:</td>
    <td>
        <select name="country">
            <option value="-">--Please Select</option>
            <option value="AT">Austria</option>
            <option value="UK" selected="selected">United Kingdom</option> ①
            <option value="US">United States</option>
        </select>
    </td>
</tr>
```

① Note the addition of a `selected` attribute.

As the preceding example shows, the combined usage of an `option` tag with the `options` tag generates the same standard HTML but lets you explicitly specify a value in the JSP that is for display only (where it belongs), such as the default string in the example: "-- Please Select".

The `items` attribute is typically populated with a collection or array of item objects. `itemValue` and `itemLabel` refer to bean properties of those item objects, if specified. Otherwise, the item objects themselves are turned into strings. Alternatively, you can specify a `Map` of items, in which case the map keys are interpreted as option values and the map values correspond to option labels. If `itemValue` or `itemLabel` (or both) happen to be specified as well, the item value property applies to the map key, and the item label property applies to the map value.

The `textarea` Tag

This tag renders an HTML `textarea` element. The following HTML shows typical output for it:

```
<tr>
    <td>Notes:</td>
    <td><form:textarea path="notes" rows="3" cols="20"/></td>
    <td><form:errors path="notes"/></td>
</tr>
```

The `hidden` Tag

This tag renders an HTML `input` tag with the `type` set to `hidden` with the bound value. To submit an unbound hidden value, use the HTML `input` tag with the `type` set to `hidden`. The following HTML shows typical output for it:

```
<form:hidden path="house"/>
```

If we choose to submit the `house` value as a hidden one, the HTML would be as follows:

```
<input name="house" type="hidden" value="Gryffindor"/>
```

The `errors` Tag

This tag renders field errors in an HTML `span` element. It provides access to the errors created in your controller or those that were created by any validators associated with your controller.

Assume that we want to display all error messages for the `firstName` and `lastName` fields once we submit the form. We have a validator for instances of the `User` class called `UserValidator`, as the following example shows:

```

public class UserValidator implements Validator {

    public boolean supports(Class candidate) {
        return User.class.isAssignableFrom(candidate);
    }

    public void validate(Object obj, Errors errors) {
        ValidationUtils.rejectIfEmptyOrWhitespace(errors, "firstName", "required",
        "Field is required.");
        ValidationUtils.rejectIfEmptyOrWhitespace(errors, "lastName", "required",
        "Field is required.");
    }
}

```

The `form.jsp` could be as follows:

```

<form:form>
    <table>
        <tr>
            <td>First Name:</td>
            <td><form:input path="firstName"/></td>
            <%-- Show errors for firstName field --%>
            <td><form:errors path="firstName"/></td>
        </tr>

        <tr>
            <td>Last Name:</td>
            <td><form:input path="lastName"/></td>
            <%-- Show errors for lastName field --%>
            <td><form:errors path="lastName"/></td>
        </tr>
        <tr>
            <td colspan="3">
                <input type="submit" value="Save Changes"/>
            </td>
        </tr>
    </table>
</form:form>

```

If we submit a form with empty values in the `firstName` and `lastName` fields, the HTML would be as follows:

```

<form method="POST">
  <table>
    <tr>
      <td>First Name:</td>
      <td><input name="firstName" type="text" value="" /></td>
      <%-- Associated errors to firstName field displayed --%>
      <td><span name="firstName.errors">Field is required.</span></td>
    </tr>

    <tr>
      <td>Last Name:</td>
      <td><input name="lastName" type="text" value="" /></td>
      <%-- Associated errors to lastName field displayed --%>
      <td><span name="lastName.errors">Field is required.</span></td>
    </tr>
    <tr>
      <td colspan="3">
        <input type="submit" value="Save Changes"/>
      </td>
    </tr>
  </table>
</form>

```

What if we want to display the entire list of errors for a given page? The next example shows that the `errors` tag also supports some basic wildcarding functionality.

- `path="*"`: Displays all errors.
- `path="lastName"`: Displays all errors associated with the `lastName` field.
- If `path` is omitted, only object errors are displayed.

The following example displays a list of errors at the top of the page, followed by field-specific errors next to the fields:

```

<form:form>
    <form:errors path="*" cssClass="errorBox"/>
    <table>
        <tr>
            <td>First Name:</td>
            <td><form:input path="firstName"/></td>
            <td><form:errors path="firstName"/></td>
        </tr>
        <tr>
            <td>Last Name:</td>
            <td><form:input path="lastName"/></td>
            <td><form:errors path="lastName"/></td>
        </tr>
        <tr>
            <td colspan="3">
                <input type="submit" value="Save Changes"/>
            </td>
        </tr>
    </table>
</form:form>

```

The HTML would be as follows:

```

<form method="POST">
    <span name="*.errors" class="errorBox">Field is required.<br/>Field is
required.</span>
    <table>
        <tr>
            <td>First Name:</td>
            <td><input name="firstName" type="text" value="" /></td>
            <td><span name="firstName.errors">Field is required.</span></td>
        </tr>
        <tr>
            <td>Last Name:</td>
            <td><input name="lastName" type="text" value="" /></td>
            <td><span name="lastName.errors">Field is required.</span></td>
        </tr>
        <tr>
            <td colspan="3">
                <input type="submit" value="Save Changes"/>
            </td>
        </tr>
    </table>
</form>

```

The `spring-form.tld` tag library descriptor (TLD) is included in the `spring-webmvc.jar`. For a comprehensive reference on individual tags, browse the [API reference](#) or see the tag library description.

HTTP Method Conversion

A key principle of REST is the use of the “Uniform Interface”. This means that all resources (URLs) can be manipulated by using the same four HTTP methods: GET, PUT, POST, and DELETE. For each method, the HTTP specification defines the exact semantics. For instance, a GET should always be a safe operation, meaning that it has no side effects, and a PUT or DELETE should be idempotent, meaning that you can repeat these operations over and over again, but the end result should be the same. While HTTP defines these four methods, HTML only supports two: GET and POST. Fortunately, there are two possible workarounds: you can either use JavaScript to do your PUT or DELETE, or you can do a POST with the “real” method as an additional parameter (modeled as a hidden input field in an HTML form). Spring’s `HiddenHttpMethodFilter` uses this latter trick. This filter is a plain Servlet filter and, therefore, it can be used in combination with any web framework (not just Spring MVC). Add this filter to your `web.xml`, and a POST with a hidden `method` parameter is converted into the corresponding HTTP method request.

To support HTTP method conversion, the Spring MVC form tag was updated to support setting the HTTP method. For example, the following snippet comes from the Pet Clinic sample:

```
<form:form method="delete">
    <p class="submit"><input type="submit" value="Delete Pet"/></p>
</form:form>
```

The preceding example performs an HTTP POST, with the “real” DELETE method hidden behind a request parameter. It is picked up by the `HiddenHttpMethodFilter`, which is defined in `web.xml`, as the following example shows:

```
<filter>
    <filter-name>httpMethodFilter</filter-name>
    <filter-class>org.springframework.web.filter.HiddenHttpMethodFilter</filter-
class>
</filter>

<filter-mapping>
    <filter-name>httpMethodFilter</filter-name>
    <servlet-name>petclinic</servlet-name>
</filter-mapping>
```

The following example shows the corresponding `@Controller` method:

```
@RequestMapping(method = RequestMethod.DELETE)
public String deletePet(@PathVariable int ownerId, @PathVariable int petId) {
    this.clinic.deletePet(petId);
    return "redirect:/owners/" + ownerId;
}
```

HTML5 Tags

The Spring form tag library allows entering dynamic attributes, which means you can enter any HTML5 specific attributes.

The form `input` tag supports entering a type attribute other than `text`. This is intended to allow rendering new HTML5 specific input types, such as `email`, `date`, `range`, and others. Note that entering `type='text'` is not required, since `text` is the default type.

1.9.6. Tiles

You can integrate Tiles - just as any other view technology - in web applications that use Spring. This section describes, in a broad way, how to do so.



This section focuses on Spring's support for Tiles version 3 in the `org.springframework.web.servlet.view.tiles3` package.

Dependencies

To be able to use Tiles, you have to add a dependency on Tiles version 3.0.1 or higher and its transitive dependencies to your project.

Configuration

To be able to use Tiles, you have to configure it by using files that contain definitions (for basic information on definitions and other Tiles concepts, see <http://tiles.apache.org>). In Spring, this is done by using the `TilesConfigurer`. The following example `ApplicationContext` configuration shows how to do so:

```

<bean id="tilesConfigurer" class=
"org.springframework.web.servlet.view.tiles3.TilesConfigurer">
    <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>

```

The preceding example defines five files that contain definitions. The files are all located in the `WEB-INF/defs` directory. At initialization of the `WebApplicationContext`, the files are loaded, and the definitions factory are initialized. After that has been done, the Tiles included 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` as with any other view technology used with Spring. You can can use either of two implementations, the `UrlBasedViewResolver` and the `ResourceBundleViewResolver`.

You can specify locale-specific Tiles definitions by adding an underscore and then the locale, as the following example shows:

```

<bean id="tilesConfigurer" class=
"org.springframework.web.servlet.view.tiles3.TilesConfigurer">
    <property name="definitions">
        <list>
            <value>/WEB-INF/defs/tiles.xml</value>
            <value>/WEB-INF/defs/tiles_fr_FR.xml</value>
        </list>
    </property>
</bean>

```

With the preceding configuration, `tiles_fr_FR.xml` is used for requests with the `fr_FR` locale, and `tiles.xml` is used by default.



Since underscores are used to indicate locales, we recommended not using them otherwise in the file names for Tiles definitions.

`UrlBasedViewResolver`

The `UrlBasedViewResolver` instantiates the given `viewClass` for each view it has to resolve. The following bean defines a `UrlBasedViewResolver`:

```
<bean id="viewResolver" class="org.springframework.web.servlet.view.UrlBasedViewResolver">
    <property name="viewClass" value="org.springframework.web.servlet.view.tiles3.TilesView"/>
</bean>
```

ResourceBundleViewResolver

The `ResourceBundleViewResolver` has to be provided with a property file that contains view names and view classes that the resolver can use. The following example shows a bean definition for a `ResourceBundleViewResolver` and the corresponding view names and view classes (taken from the Pet Clinic sample):

```
<bean id="viewResolver" class="org.springframework.web.servlet.view.ResourceBundleViewResolver">
    <property name="basename" value="views"/>
</bean>
```

```
...
welcomeView.(class)=org.springframework.web.servlet.view.tiles3.TilesView
welcomeView.url=welcome (this is the name of a Tiles definition)
```

```
vetsView.(class)=org.springframework.web.servlet.view.tiles3.TilesView
vetsView.url=vetsView (again, this is the name of a Tiles definition)
```

```
findOwnersForm.(class)=org.springframework.web.servlet.view.JstlView
findOwnersForm.url=/WEB-INF/jsp/findOwners.jsp
...
```

When you use the `ResourceBundleViewResolver`, you can easily mix different view technologies.

Note that the `TilesView` class supports JSTL (the JSP Standard Tag Library).

SimpleSpringPreparerFactory and SpringBeanPreparerFactory

As an advanced feature, Spring also supports two special Tiles `PreparerFactory` implementations. See the Tiles documentation for details on how to use `ViewPreparer` references in your Tiles definition files.

You can specify `SimpleSpringPreparerFactory` to autowire `ViewPreparer` instances based on specified preparer classes, applying Spring's container callbacks as well as applying configured Spring BeanPostProcessors. If Spring's context-wide annotation configuration has been activated, annotations in `ViewPreparer` classes are automatically detected and applied. Note that this expects preparer classes in the Tiles definition files, as the default `PreparerFactory` does.

You can specify `SpringBeanPreparerFactory` to operate on specified preparer names (instead of classes), obtaining the corresponding Spring bean from the DispatcherServlet's application context. The full bean creation process is in the control of the Spring application context in this case, allowing for the use of explicit dependency injection configuration, scoped beans, and so on. Note that you need to define one Spring bean definition for each preparer name (as used in your Tiles definitions). The following example shows how to define a set a `SpringBeanPreparerFactory` property on a `TilesConfigurer` bean:

```
<bean id="tilesConfigurer" class=
"org.springframework.web.servlet.view.tiles3.TilesConfigurer">
    <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>

    <!-- resolving preparer names as Spring bean definition names -->
    <property name="preparerFactoryClass"
        value=
"org.springframework.web.servlet.view.tiles3.SpringBeanPreparerFactory"/>

</bean>
```

1.9.7. RSS and Atom

Both `AbstractAtomFeedView` and `AbstractRssFeedView` inherit from the `AbstractFeedView` base class and are used to provide Atom and RSS Feed views, respectively. They are based on java.net's `ROME` project and are located in the package `org.springframework.web.servlet.view.feed`.

`AbstractAtomFeedView` requires you to implement the `buildFeedEntries()` method and optionally override the `buildFeedMetadata()` method (the default implementation is empty). The following example shows how to do so:

```

public class SampleContentAtomView extends AbstractAtomFeedView {

    @Override
    protected void buildFeedMetadata(Map<String, Object> model,
        Feed feed, HttpServletRequest request) {
        // implementation omitted
    }

    @Override
    protected List<Entry> buildFeedEntries(Map<String, Object> model,
        HttpServletRequest request, HttpServletResponse response) throws
    Exception {
        // implementation omitted
    }

}

```

Similar requirements apply for implementing `AbstractRssFeedView`, as the following example shows:

```

public class SampleContentAtomView extends AbstractRssFeedView {

    @Override
    protected void buildFeedMetadata(Map<String, Object> model,
        Channel feed, HttpServletRequest request) {
        // implementation omitted
    }

    @Override
    protected List<Item> buildFeedItems(Map<String, Object> model,
        HttpServletRequest request, HttpServletResponse response) throws
    Exception {
        // implementation omitted
    }

}

```

The `buildFeedItems()` and `buildFeedEntries()` methods pass in the HTTP request, in case you need to access the Locale. The HTTP response is passed in only for the setting of cookies or other HTTP headers. The feed is automatically written to the response object after the method returns.

For an example of creating an Atom view, see Alef Arendsen's Spring Team Blog [entry](#).

1.9.8. PDF and Excel

Spring offers ways to return output other than HTML, including PDF and Excel spreadsheets. This section describes how to use those features.

Introduction to Document Views

An HTML page is not 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 is 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 Apache POI library to your classpath, For PDF generation, you need to add (preferably) the OpenPDF library.



You should use the latest versions of the underlying document-generation libraries, if possible. In particular, we strongly recommend OpenPDF (for example, OpenPDF 1.0.5) instead of the outdated original iText 2.1.7, since OpenPDF is actively maintained and fixes an important vulnerability for untrusted PDF content.

PDF Views

A simple PDF view for a word list could extend the `org.springframework.web.servlet.view.document.AbstractPdfView` and implement the `buildPdfDocument()` method, as the following example shows:

```
public class PdfWordList extends AbstractPdfView {

    protected void buildPdfDocument(Map<String, Object> model, Document doc,
        PdfWriter writer,
        HttpServletRequest request, HttpServletResponse response) throws
        Exception {

        List<String> words = (List<String>) model.get("wordList");
        for (String word : words) {
            doc.add(new Paragraph(word));
        }
    }
}
```

A controller can return such a view either from an external view definition (referencing it by name) or as a `View` instance from the handler method.

Excel Views

Since Spring Framework 4.2, `org.springframework.web.servlet.view.document.AbstractXlsView` is provided as a base class for Excel views. It is based on Apache POI, with specialized subclasses (`AbstractXlsxView` and `AbstractXlsxStreamingView`) that supersede the outdated `AbstractExcelView` class.

The programming model is similar to `AbstractPdfView`, with `buildExcelDocument()` as the central

template method and controllers being able to return such a view from an external definition (by name) or as a `View` instance from the handler method.

1.9.9. Jackson

[Same as in Spring WebFlux](#)

Spring offers support for the Jackson JSON library.

Jackson-based JSON Views

[Same as in Spring WebFlux](#)

The `MappingJackson2JsonView` uses the Jackson library's `ObjectMapper` to render the response content as JSON. By default, the entire contents of the model map (with the exception of framework-specific classes) are encoded as JSON. For cases where the contents of the map need to be filtered, you can specify a specific set of model attributes to encode by using the `modelKeys` property. You can also use the `extractValueFromSingleKeyModel` property to have the value in single-key models extracted and serialized directly rather than as a map of model attributes.

You can customize JSON mapping as needed by using Jackson's provided annotations. When you need further control, you can inject a custom `ObjectMapper` through the `ObjectMapper` property, for cases where you need to provide custom JSON serializers and deserializers for specific types.

Jackson-based XML Views

[Same as in Spring WebFlux](#)

`MappingJackson2XmlView` uses the Jackson XML extension's `XmlMapper` to render the response content as XML. If the model contains multiples entries, you should explicitly set the object to be serialized by using the `modelKey` bean property. If the model contains a single entry, it is serialized automatically.

You can customized XML mapping as needed by using JAXB or Jackson's provided annotations. When you need further control, you can inject a custom `XmlMapper` through the `ObjectMapper` property, for cases where custom XML you need to provide serializers and deserializers for specific types.

1.9.10. XML Marshalling

The `MarshallingView` uses an XML `Marshaller` (defined in the `org.springframework.oxm` package) to render the response content as XML. You can explicitly set the object to be marshalled by using a `MarshallingView` instance's `modelKey` bean property. Alternatively, the view iterates over all model properties and marshals the first type that is supported by the `Marshaller`. For more information on the functionality in the `org.springframework.oxm` package, see [Marshalling XML using O/X Mappers](#).

1.9.11. XSLT Views

XSLT is a transformation language for XML and is popular as a view technology within web applications. XSLT can be a good choice as a view technology if your application naturally deals

with XML or if your model can easily be converted to XML. The following section shows how to produce an XML document as model data and have it transformed with XSLT in a Spring Web MVC application.

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 [Annotated Controllers](#) for details of Spring Web MVC's [Controller](#) interface. The XSLT controller turns the list of words into a simple XML document ready for transformation.

Beans

Configuration is standard for a simple Spring web application: The MVC configuration has to define an [XsltViewResolver](#) bean and regular MVC annotation configuration. The following example shows how to do so:

```
@EnableWebMvc
@ComponentScan
@Configuration
public class WebConfig implements WebMvcConfigurer {

    @Bean
    public XsltViewResolver xsltViewResolver() {
        XsltViewResolver viewResolver = new XsltViewResolver();
        viewResolver.setPrefix("/WEB-INF/xsl/");
        viewResolver.setSuffix(".xslt");
        return viewResolver;
    }
}
```

Controller

We also need a Controller that encapsulates our word-generation logic.

The controller logic is encapsulated in a [@Controller](#) class, with the handler method being defined as follows:

```

@Controller
public class XsltController {

    @RequestMapping("/")
    public String home(Model model) throws Exception {
        Document document = DocumentBuilderFactory.newInstance()
            .newDocumentBuilder().newDocument();
        Element root = document.createElement("wordList");

        List<String> words = Arrays.asList("Hello", "Spring", "Framework");
        for (String word : words) {
            Element wordNode = document.createElement("word");
            Text textNode = document.createTextNode(word);
            wordNode.appendChild(textNode);
            root.appendChild(wordNode);
        }

        model.addAttribute("wordList", root);
        return "home";
    }
}

```

So far, we have only created a DOM document and added it to the Model map. Note that you can also load an XML file as a **Resource** and use it instead of a custom DOM document.

There are software packages available that 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.

Transformation

Finally, the **XsltViewResolver** resolves the “home” XSLT template file and merges the DOM document into it to generate our view. As shown in the **XsltViewResolver** configuration, XSLT templates live in the **war** file in the **WEB-INF/xsl** directory and end with an **xslt** file extension.

The following example shows an XSLT transform:

```

<?xml version="1.0" encoding="utf-8"?>
<xsl:stylesheet version="1.0" xmlns:xsl="http://www.w3.org/1999/XSL/Transform">

    <xsl:output method="html" omit-xml-declaration="yes"/>

    <xsl:template match="/">
        <html>
            <head><title>Hello!</title></head>
            <body>
                <h1>My First Words</h1>
                <ul>
                    <xsl:apply-templates/>
                </ul>
            </body>
        </html>
    </xsl:template>

    <xsl:template match="word">
        <li><xsl:value-of select=". . ."/></li>
    </xsl:template>

</xsl:stylesheet>

```

The preceding transform is rendered as the following HTML:

```

<html>
    <head>
        <META http-equiv="Content-Type" content="text/html; charset=UTF-8">
        <title>Hello!</title>
    </head>
    <body>
        <h1>My First Words</h1>
        <ul>
            <li>Hello</li>
            <li>Spring</li>
            <li>Framework</li>
        </ul>
    </body>
</html>

```

1.10. MVC Config

Same as in Spring WebFlux

The MVC Java configuration and the MVC XML namespace provide default configuration suitable

for most applications and a configuration API to customize it.

For more advanced customizations, which are not available in the configuration API, see [Advanced Java Config](#) and [Advanced XML Config](#).

You do not need to understand the underlying beans created by the MVC Java configuration and the MVC namespace. If you want to learn more, see [Special Bean Types](#) and [Web MVC Config](#).

1.10.1. Enable MVC Configuration

Same as in Spring WebFlux

In Java configuration, you can use the `@EnableWebMvc` annotation to enable MVC configuration, as the following example shows:

```
@Configuration  
@EnableWebMvc  
public class WebConfig {  
}
```

In XML configuration, you can use the `<mvc:annotation-driven>` element to enable MVC configuration, as the following example shows:

```
<?xml version="1.0" encoding="UTF-8"?>  
<beans xmlns="http://www.springframework.org/schema/beans"  
       xmlns:mvc="http://www.springframework.org/schema/mvc"  
       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.xsd  
           http://www.springframework.org/schema/mvc  
           http://www.springframework.org/schema/mvc/spring-mvc.xsd">  
  
    <mvc:annotation-driven/>  
  
  </beans>
```

The preceding example registers a number of Spring MVC [infrastructure beans](#) and adapts to dependencies available on the classpath (for example, payload converters for JSON, XML, and others).

1.10.2. MVC Config API

Same as in Spring WebFlux

In Java configuration, you can implement the `WebMvcConfigurer` interface, as the following example shows:

```
@Configuration  
@EnableWebMvc  
public class WebConfig implements WebMvcConfigurer {  
  
    // Implement configuration methods...  
}
```

In XML, you can check attributes and sub-elements of `<mvc:annotation-driven/>`. You can view the [Spring MVC XML schema](#) or use the code completion feature of your IDE to discover what attributes and sub-elements are available.

1.10.3. Type Conversion

[Same as in Spring WebFlux](#)

By default formatters, for `Number` and `Date` types are installed, including support for the `@NumberFormat` and `@DateTimeFormat` annotations. Full support for the Joda-Time formatting library is also installed if Joda-Time is present on the classpath.

In Java configuration, you can register custom formatters and converters, as the following example shows:

```
@Configuration  
@EnableWebMvc  
public class WebConfig implements WebMvcConfigurer {  
  
    @Override  
    public void addFormatters(FormatterRegistry registry) {  
        // ...  
    }  
}
```

The following example shows how to achieve the same configuration in XML:

```

<?xml version="1.0" encoding="UTF-8"?>
<beans xmlns="http://www.springframework.org/schema/beans"
    xmlns:mvc="http://www.springframework.org/schema/mvc"
    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.xsd
        http://www.springframework.org/schema/mvc
        http://www.springframework.org/schema/mvc/spring-mvc.xsd">

    <mvc:annotation-driven conversion-service="conversionService"/>

    <bean id="conversionService"
        class=
"org.springframework.format.support.FormattingConversionServiceFactoryBean">
        <property name="converters">
            <set>
                <bean class="org.example.MyConverter"/>
            </set>
        </property>
        <property name="formatters">
            <set>
                <bean class="org.example.MyFormatter"/>
                <bean class="org.example.MyAnnotationFormatterFactory"/>
            </set>
        </property>
        <property name="formatterRegistrars">
            <set>
                <bean class="org.example.MyFormatterRegistrar"/>
            </set>
        </property>
    </bean>

</beans>

```



See the [FormatterRegistrar SPI](#) and the [FormattingConversionServiceFactoryBean](#) for more information on when to use FormatterRegistrar implementations.

1.10.4. Validation

[Same as in Spring WebFlux](#)

By default, if [Bean Validation](#) is present on the classpath (for example, Hibernate Validator), the [LocalValidatorFactoryBean](#) is registered as a global [Validator](#) for use with [@Valid](#) and [Validated](#) on controller method arguments.

In Java configuration, you can customize the global [Validator](#) instance, as the following example

shows:

```
@Configuration  
@EnableWebMvc  
public class WebConfig implements WebMvcConfigurer {  
  
    @Override  
    public Validator getValidator() {  
        // ...  
    }  
}
```

The following example shows how to achieve the same configuration in XML:

```
<?xml version="1.0" encoding="UTF-8"?>  
<beans xmlns="http://www.springframework.org/schema/beans"  
       xmlns:mvc="http://www.springframework.org/schema/mvc"  
       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.xsd  
           http://www.springframework.org/schema/mvc  
           http://www.springframework.org/schema/mvc/spring-mvc.xsd">  
  
    <mvc:annotation-driven validator="globalValidator"/>  
  
  </beans>
```

Note that you can also register **Validator** implementations locally, as the following example shows:

```
@Controller  
public class MyController {  
  
    @InitBinder  
    protected void initBinder(WebDataBinder binder) {  
        binder.addValidators(new FooValidator());  
    }  
}
```



If you need to have a `LocalValidatorFactoryBean` injected somewhere, create a bean and mark it with `@Primary` in order to avoid conflict with the one declared in the MVC configuration.

1.10.5. Interceptors

In Java configuration, you can register interceptors to apply to incoming requests, as the following example shows:

```
@Configuration  
@EnableWebMvc  
public class WebConfig implements WebMvcConfigurer {  
  
    @Override  
    public void addInterceptors(InterceptorRegistry registry) {  
        registry.addInterceptor(new LocaleChangeInterceptor());  
        registry.addInterceptor(new ThemeChangeInterceptor()).addPathPatterns(  
"/**").excludePathPatterns("/admin/**");  
        registry.addInterceptor(new SecurityInterceptor()).addPathPatterns(  
"/secure/**");  
    }  
}
```

The following example shows how to achieve the same configuration in XML:

```
<mvc:interceptors>  
    <bean class="org.springframework.web.servlet.i18n.LocaleChangeInterceptor"/>  
    <mvc:interceptor>  
        <mvc:mapping path="/**"/>  
        <mvc:exclude-mapping path="/admin/**"/>  
        <bean class="org.springframework.web.servlet.theme.ThemeChangeInterceptor"  
    "/>  
    </mvc:interceptor>  
    <mvc:interceptor>  
        <mvc:mapping path="/secure/*"/>  
        <bean class="org.example.SecurityInterceptor"/>  
    </mvc:interceptor>  
</mvc:interceptors>
```

1.10.6. Content Types

Same as in Spring WebFlux

You can configure how Spring MVC determines the requested media types from the request (for

example, `Accept` header, URL path extension, query parameter, and others).

By default, the URL path extension is checked first—with `json`, `xml`, `rss`, and `atom` registered as known extensions (depending on classpath dependencies). The `Accept` header is checked second.

Consider changing those defaults to `Accept` header only, and, if you must use URL-based content type resolution, consider using the query parameter strategy over path extensions. See [Suffix Match](#) and [Suffix Match and RFD](#) for more details.

In Java configuration, you can customize requested content type resolution, as the following example shows:

```
@Configuration
@EnableWebMvc
public class WebConfig implements WebMvcConfigurer {

    @Override
    public void configureContentNegotiation(ContentNegotiationConfigurer
configurer) {
        configurer.mediaType("json", MediaType.APPLICATION_JSON);
        configurer.mediaType("xml", MediaType.APPLICATION_XML);
    }
}
```

The following example shows how to achieve the same configuration in XML:

```
<mvc:annotation-driven content-negotiation-manager="contentNegotiationManager"/>

<bean id="contentNegotiationManager" class=
"org.springframework.web.accept.ContentNegotiationManagerFactoryBean">
    <property name="mediaTypes">
        <value>
            json=application/json
            xml=application/xml
        </value>
    </property>
</bean>
```

1.10.7. Message Converters

[Same as in Spring WebFlux](#)

You can customize `HttpMessageConverter` in Java configuration by overriding `configureMessageConverters()` (to replace the default converters created by Spring MVC) or by overriding `extendMessageConverters()` (to customize the default converters or add additional

converters to the default ones).

The following example adds XML and Jackson JSON converters with a customized `ObjectMapper` instead of the default ones:

```
@Configuration
@EnableWebMvc
public class WebConfiguration implements WebMvcConfigurer {

    @Override
    public void configureMessageConverters(List<HttpMessageConverter<?>>
converters) {
        Jackson2ObjectMapperBuilder builder = new Jackson2ObjectMapperBuilder()
            .indentOutput(true)
            .dateFormat(new SimpleDateFormat("yyyy-MM-dd"))
            .modulesToInstall(new ParameterNamesModule());
        converters.add(new MappingJackson2HttpMessageConverter(builder.build()));
        converters.add(new MappingJackson2XmlHttpMessageConverter(builder
.createXmlMapper(true).build()));
    }
}
```

In the preceding example, `Jackson2ObjectMapperBuilder` is used to create a common configuration for both `MappingJackson2HttpMessageConverter` and `MappingJackson2XmlHttpMessageConverter` with indentation enabled, a customized date format, and the registration of `jackson-module-parameter-names`, Which adds support for accessing parameter names (a feature added in Java 8).

This builder customizes Jackson's default properties as follows:

- `DeserializationFeature.FAIL_ON_UNKNOWN_PROPERTIES` is disabled.
- `MapperFeature.DEFAULT_VIEW_INCLUSION` is disabled.

It also automatically registers the following well-known modules if they are detected on the classpath:

- `jackson-datatype-jdk7`: Support for Java 7 types, such as `java.nio.file.Path`.
- `jackson-datatype-joda`: Support for Joda-Time types.
- `jackson-datatype-jsr310`: Support for Java 8 Date and Time API types.
- `jackson-datatype-jdk8`: Support for other Java 8 types, such as `Optional`.



Enabling indentation with Jackson XML support requires `woodstox-core-asl` dependency in addition to `jackson-dataformat-xml` one.

Other interesting Jackson modules are available:

- `jackson-datatype-money`: Support for `javax.money` types (unofficial module).

- **jackson-datatype-hibernate**: Support for Hibernate-specific types and properties (including lazy-loading aspects).

The following example shows how to achieve the same configuration in XML:

```

<mvc:annotation-driven>
    <mvc:message-converters>
        <bean class=
"org.springframework.http.converter.json.MappingJackson2HttpMessageConverter">
            <property name="objectMapper" ref="objectMapper"/>
        </bean>
        <bean class=
"org.springframework.http.converter.xml.MappingJackson2XmlHttpMessageConverter">
            <property name="objectMapper" ref="xmlMapper"/>
        </bean>
    </mvc:message-converters>
</mvc:annotation-driven>

<bean id="objectMapper" class=
"org.springframework.http.converter.json.Jackson2ObjectMapperFactoryBean">
    p:indentOutput="true"
    p:simpleDateFormat="yyyy-MM-dd"
    p:modulesToInstall=
"com.fasterxml.jackson.module.paramnames.ParameterNamesModule"/>

<bean id="xmlMapper" parent="objectMapper" p:createXmlMapper="true"/>
```

1.10.8. View Controllers

This is a shortcut for defining a `ParameterizableViewController` that immediately forwards to a view when invoked. You can use it in static cases when there is no Java controller logic to execute before the view generates the response.

The following example of Java configuration forwards a request for `/` to a view called `home`:

```

@Configuration
@EnableWebMvc
public class WebConfig implements WebMvcConfigurer {

    @Override
    public void addViewControllers(ViewControllerRegistry registry) {
        registry.addViewController("/").setViewName("home");
    }
}
```

The following example achieves the same thing as the preceding example, but with XML, by using the `<mvc:view-controller>` element:

```
<mvc:view-controller path="/" view-name="home"/>
```

1.10.9. View Resolvers

Same as in Spring WebFlux

The MVC configuration simplifies the registration of view resolvers.

The following Java configuration example configures content negotiation view resolution by using JSP and Jackson as a default `View` for JSON rendering:

```
@Configuration
@EnableWebMvc
public class WebConfig implements WebMvcConfigurer {

    @Override
    public void configureViewResolvers(ViewResolverRegistry registry) {
        registry.enableContentNegotiation(new MappingJackson2JsonView());
        registry.jsp();
    }
}
```

The following example shows how to achieve the same configuration in XML:

```
<mvc:view-resolvers>
    <mvc:content-negotiation>
        <mvc:default-views>
            <bean class=
"org.springframework.web.servlet.view.json.MappingJackson2JsonView"/>
        </mvc:default-views>
    </mvc:content-negotiation>
    <mvc:jsp/>
</mvc:view-resolvers>
```

Note, however, that FreeMarker, Tiles, Groovy Markup, and script templates also require configuration of the underlying view technology.

The MVC namespace provides dedicated elements. The following example works with FreeMarker:

```

<mvc:view-resolvers>
    <mvc:content-negotiation>
        <mvc:default-views>
            <bean class=
"org.springframework.web.servlet.view.json.MappingJackson2JsonView"/>
        </mvc:default-views>
    </mvc:content-negotiation>
    <mvc:freemarker cache="false"/>
</mvc:view-resolvers>

<mvc:freemarker-configure>
    <mvc:template-loader-path location="/freemarker"/>
</mvc:freemarker-configure>

```

In Java configuration, you can add the respective **Configurer** bean, as the following example shows:

```

@Configuration
@EnableWebMvc
public class WebConfig implements WebMvcConfigurer {

    @Override
    public void configureViewResolvers(ViewResolverRegistry registry) {
        registry.enableContentNegotiation(new MappingJackson2JsonView());
        registry.freeMarker().cache(false);
    }

    @Bean
    public FreeMarkerConfigurer freeMarkerConfigurer() {
        FreeMarkerConfigurer configurer = new FreeMarkerConfigurer();
        configurer.setTemplateLoaderPath("/freemarker");
        return configurer;
    }
}

```

1.10.10. Static Resources

[Same as in Spring WebFlux](#)

This option provides a convenient way to serve static resources from a list of **Resource**-based locations.

In the next example, given a request that starts with `/resources`, the relative path is used to find and serve static resources relative to `/public` under the web application root or on the classpath under `/static`. The resources are served with a one-year future expiration to ensure maximum use of the browser cache and a reduction in HTTP requests made by the browser. The **Last-Modified** header is

also evaluated and, if present, a [304](#) status code is returned.

The following listing shows how to do so with Java configuration:

```
@Configuration  
@EnableWebMvc  
public class WebConfig implements WebMvcConfigurer {  
  
    @Override  
    public void addResourceHandlers(ResourceHandlerRegistry registry) {  
        registry.addResourceHandler("/resources/**")  
            .addResourceLocations("/public", "classpath:/static/")  
            .setCachePeriod(31556926);  
    }  
}
```

The following example shows how to achieve the same configuration in XML:

```
<mvc:resources mapping="/resources/**"  
    location="/public, classpath:/static/"  
    cache-period="31556926" />
```

See also [HTTP caching support for static resources](#).

The resource handler also supports a chain of [ResourceResolver](#) implementations and [ResourceTransformer](#) implementations, which you can use to create a toolchain for working with optimized resources.

You can use the [VersionResourceResolver](#) for versioned resource URLs based on an MD5 hash computed from the content, a fixed application version, or other. A [ContentVersionStrategy](#) (MD5 hash) is a good choice—with some notable exceptions, such as JavaScript resources used with a module loader.

The following example shows how to use [VersionResourceResolver](#) in Java configuration:

```

@Configuration
@EnableWebMvc
public class WebConfig implements WebMvcConfigurer {

    @Override
    public void addResourceHandlers(ResourceHandlerRegistry registry) {
        registry.addResourceHandler("/resources/**")
            .addResourceLocations("/public/")
            .resourceChain(true)
            .addResolver(new VersionResourceResolver())
        .addContentVersionStrategy("/**"));
    }
}

```

The following example shows how to achieve the same configuration in XML:

```

<mvc:resources mapping="/resources/**" location="/public/">
    <mvc:resource-chain>
        <mvc:resource-cache/>
        <mvc:resolvers>
            <mvc:version-resolver>
                <mvc:content-version-strategy patterns="/**"/>
            </mvc:version-resolver>
        </mvc:resolvers>
    </mvc:resource-chain>
</mvc:resources>

```

You can then use `ResourceUrlProvider` to rewrite URLs and apply the full chain of resolvers and transformers—for example, to insert versions. The MVC configuration provides a `ResourceUrlProvider` bean so that it can be injected into others. You can also make the rewrite transparent with the `ResourceUrlEncodingFilter` for Thymeleaf, JSPs, FreeMarker, and others with URL tags that rely on `HttpServletResponse#encodeURL`.

Note that, when using both `EncodedResourceResolver` (for example, for serving gzipped or brotli-encoded resources) and `VersionedResourceResolver`, you must register them in this order. That ensures content-based versions are always computed reliably, based on the unencoded file.

`WebJars` is also supported through `WebJarsResourceResolver` and is automatically registered when `org.webjars:webjars-locator` is present on the classpath. The resolver can re-write URLs to include the version of the jar and can also match to incoming URLs without versions—for example, `/jquery/jquery.min.js` to `/jquery/1.2.0/jquery.min.js`.

1.10.11. Default Servlet

Spring MVC allows for mapping the `DispatcherServlet` to `/` (thus overriding the mapping of the container's default Servlet), while still allowing static resource requests to be handled by the container's default Servlet. It configures a `DefaultServletHttpRequestHandler` with a URL mapping of `/**` and the lowest priority relative to other URL mappings.

This handler forwards all requests to the default Servlet. Therefore, it must remain last in the order of all other URL `HandlerMappings`. That is the case if you use `<mvc:annotation-driven>`. Alternatively, if you set up your own customized `HandlerMapping` instance, be sure to set its `order` property to a value lower than that of the `DefaultServletHttpRequestHandler`, which is `Integer.MAX_VALUE`.

The following example shows how to enable the feature by using the default setup:

```
@Configuration  
@EnableWebMvc  
public class WebConfig implements WebMvcConfigurer {  
  
    @Override  
    public void configureDefaultServletHandling(DefaultServletHandlerConfigurer  
configurer) {  
        configurer.enable();  
    }  
}
```

The following example shows how to achieve the same configuration in XML:

```
<mvc:default-servlet-handler/>
```

The caveat to overriding the `/` Servlet mapping is that the `RequestDispatcher` for the default Servlet must be retrieved by name rather than by path. The `DefaultServletHttpRequestHandler` tries to auto-detect the default Servlet for the container at startup time, using a list of known names for most of the major Servlet containers (including Tomcat, Jetty, GlassFish, JBoss, Resin, WebLogic, and WebSphere). If the default Servlet has been custom-configured with a different name, or if a different Servlet container is being used where the default Servlet name is unknown, then you must explicitly provide the default Servlet's name, as the following example shows:

```
@Configuration  
@EnableWebMvc  
public class WebConfig implements WebMvcConfigurer {  
  
    @Override  
    public void configureDefaultServletHandling(DefaultServletHandlerConfigurer configurer) {  
        configurer.enable("myCustomDefaultServlet");  
    }  
  
}
```

The following example shows how to achieve the same configuration in XML:

```
<mvc:default-servlet-handler default-servlet-name="myCustomDefaultServlet"/>
```

1.10.12. Path Matching

Same as in Spring WebFlux

You can customize options related to path matching and treatment of the URL. For details on the individual options, see the [PathMatchConfigurer](#) javadoc.

The following example shows how to customize path matching in Java configuration:

```

@Configuration
@EnableWebMvc
public class WebConfig implements WebMvcConfigurer {

    @Override
    public void configurePathMatch(PathMatchConfigurer configurer) {
        configurer
            .setUseSuffixPatternMatch(true)
            .setUseTrailingSlashMatch(false)
            .setUseRegisteredSuffixPatternMatch(true)
            .setPathMatcher(antPathMatcher())
            .setUrlPathHelper(urlPathHelper())
            .addPathPrefix("/api",
                HandlerTypePredicate.forAnnotation(RestController.class));
    }

    @Bean
    public UrlPathHelper urlPathHelper() {
        //...
    }

    @Bean
    public PathMatcher antPathMatcher() {
        //...
    }

}

```

The following example shows how to achieve the same configuration in XML:

```

<mvc:annotation-driven>
    <mvc:path-matching
        suffix-pattern="true"
        trailing-slash="false"
        registered-suffixes-only="true"
        path-helper="pathHelper"
        path-matcher="pathMatcher"/>
</mvc:annotation-driven>

<bean id="pathHelper" class="org.example.app.MyPathHelper"/>
<bean id="pathMatcher" class="org.example.app.MyPathMatcher"/>

```

1.10.13. Advanced Java Config

Same as in Spring WebFlux

`@EnableWebMvc` imports `DelegatingWebMvcConfiguration`, which:

- Provides default Spring configuration for Spring MVC applications
- Detects and delegates to `WebMvcConfigurer` implementations to customize that configuration.

For advanced mode, you can remove `@EnableWebMvc` and extend directly from `DelegatingWebMvcConfiguration` instead of implementing `WebMvcConfigurer`, as the following example shows:

```
@Configuration  
public class WebConfig extends DelegatingWebMvcConfiguration {  
  
    // ...  
  
}
```

You can keep existing methods in `WebConfig`, but you can now also override bean declarations from the base class, and you can still have any number of other `WebMvcConfigurer` implementations on the classpath.

1.10.14. Advanced XML Config

The MVC namespace does not have an advanced mode. If you need to customize a property on a bean that you cannot change otherwise, you can use the `BeanPostProcessor` lifecycle hook of the Spring `ApplicationContext`, as the following example shows:

```
@Component  
public class MyPostProcessor implements BeanPostProcessor {  
  
    public Object postProcessBeforeInitialization(Object bean, String name) throws BeansException {  
        // ...  
    }  
}
```

Note that you need to declare `MyPostProcessor` as a bean, either explicitly in XML or by letting it be detected through a `<component-scan/>` declaration.

1.11. HTTP/2

Same as in Spring WebFlux

Servlet 4 containers are required to support HTTP/2, and Spring Framework 5 is compatible with Servlet API 4. From a programming model perspective, there is nothing specific that applications

need to do. However, there are considerations related to server configuration. For more details, see the [HTTP/2 wiki page](#).

The Servlet API does expose one construct related to HTTP/2. You can use the `javax.servlet.http.PushBuilder` proactively push resources to clients, and it is supported as a method argument to `@RequestMapping` methods.

Chapter 2. REST Clients

This section describes options for client-side access to REST endpoints.

2.1. RestTemplate

`RestTemplate` is a synchronous client to perform HTTP requests. It is the original Spring REST client and exposes a simple, template-method API over underlying HTTP client libraries.



As of 5.0, the non-blocking, reactive `WebClient` offers a modern alternative to the `RestTemplate`, with efficient support for both synchronous and asynchronous, as well as streaming scenarios. The `RestTemplate` will be deprecated in a future version and will not have major new features added going forward.

See [REST Endpoints](#) for details.

2.2. WebClient

`WebClient` is a non-blocking, reactive client to perform HTTP requests. It was introduced in 5.0 and offers a modern alternative to the `RestTemplate`, with efficient support for both synchronous and asynchronous, as well as streaming scenarios.

In contrast to `RestTemplate`, `WebClient` supports the following:

- Non-blocking I/O.
- Reactive Streams back pressure.
- High concurrency with fewer hardware resources.
- Functional-style, fluent API that takes advantage of Java 8 lambdas.
- Synchronous and asynchronous interactions.
- Streaming up to or streaming down from a server.

See [WebClient](#) for more details.

Chapter 3. Testing

[Same in Spring WebFlux](#)

This section summarizes the options available in `spring-test` for Spring MVC applications.

- Servlet API Mocks: Mock implementations of Servlet API contracts for unit testing controllers, filters, and other web components. See [Servlet API](#) mock objects for more details.
- TestContext Framework: Support for loading Spring configuration in JUnit and TestNG tests, including efficient caching of the loaded configuration across test methods and support for loading a `WebApplicationContext` with a `MockServletContext`. See [TestContext Framework](#) for more details.
- Spring MVC Test: A framework, also known as `MockMvc`, for testing annotated controllers through the `DispatcherServlet` (that is, supporting annotations), complete with the Spring MVC infrastructure but without an HTTP server. See [Spring MVC Test](#) for more details.
- Client-side REST: `spring-test` provides a `MockRestServiceServer` that you can use as a mock server for testing client-side code that internally uses the `RestTemplate`. See [Client REST Tests](#) for more details.
- `WebTestClient`: Built for testing WebFlux applications, but it can also be used for end-to-end integration testing, to any server, over an HTTP connection. It is a non-blocking, reactive client and is well suited for testing asynchronous and streaming scenarios.

Chapter 4. WebSockets

Same as in Spring WebFlux

This part of the reference documentation covers support for Servlet stack, WebSocket messaging that includes raw WebSocket interactions, WebSocket emulation through SockJS, and publish-subscribe messaging through STOMP as a sub-protocol over WebSocket.

4.1. Introduction to WebSocket

The WebSocket protocol, [RFC 6455](#), provides a standardized way to establish a full-duplex, two-way communication channel between client and server over a single TCP connection. It is a different TCP protocol from HTTP but is designed to work over HTTP, using ports 80 and 443 and allowing reuse of existing firewall rules.

A WebSocket interaction begins with an HTTP request that uses the HTTP `Upgrade` header to upgrade or, in this case, to switch to the WebSocket protocol. The following example shows such an interaction:

```
GET /spring-websocket-portfolio/portfolio HTTP/1.1
Host: localhost:8080
Upgrade: websocket ①
Connection: Upgrade ②
Sec-WebSocket-Key: Uc9l9TMkWGbhFD2qnFHltg==
Sec-WebSocket-Protocol: v10.stomp, v11.stomp
Sec-WebSocket-Version: 13
Origin: http://localhost:8080
```

① The `Upgrade` header.

② Using the `Upgrade` connection.

Instead of the usual 200 status code, a server with WebSocket support returns output similar to the following:

```
HTTP/1.1 101 Switching Protocols ①
Upgrade: websocket
Connection: Upgrade
Sec-WebSocket-Accept: 1qVdfYHU9hP014JYYNxF623Gzn0=
Sec-WebSocket-Protocol: v10.stomp
```

① Protocol switch

After a successful handshake, the TCP socket underlying the HTTP upgrade request remains open for both the client and the server to continue to send and receive messages.

A complete introduction of how WebSockets work is beyond the scope of this document. See RFC 6455, the WebSocket chapter of HTML5, or any of the many introductions and tutorials on the Web.

Note that, if a WebSocket server is running behind a web server (e.g. nginx), you likely need to configure it to pass WebSocket upgrade requests on to the WebSocket server. Likewise, if the application runs in a cloud environment, check the instructions of the cloud provider related to WebSocket support.

4.1.1. HTTP Versus WebSocket

Even though WebSocket is designed to be HTTP-compatible and starts with an HTTP request, it is important to understand that the two protocols lead to very different architectures and application programming models.

In HTTP and REST, an application is modeled as many URLs. To interact with the application, clients access those URLs, request-response style. Servers route requests to the appropriate handler based on the HTTP URL, method, and headers.

By contrast, in WebSockets, there is usually only one URL for the initial connect. Subsequently, all application messages flow on that same TCP connection. This points to an entirely different asynchronous, event-driven, messaging architecture.

WebSocket is also a low-level transport protocol, which, unlike HTTP, does not prescribe any semantics to the content of messages. That means that there is no way to route or process a message unless the client and the server agree on message semantics.

WebSocket clients and servers can negotiate the use of a higher-level, messaging protocol (for example, STOMP), through the [Sec-WebSocket-Protocol](#) header on the HTTP handshake request. In the absence of that, they need to come up with their own conventions.

4.1.2. When to Use WebSockets

WebSockets can make a web page be dynamic and interactive. However, in many cases, a combination of Ajax and HTTP streaming or long polling can provide a simple and effective solution.

For example, news, mail, and social feeds need to update dynamically, but it may be perfectly okay to do so every few minutes. Collaboration, games, and financial apps, on the other hand, need to be much closer to real-time.

Latency alone is not a deciding factor. If the volume of messages is relatively low (for example, monitoring network failures) HTTP streaming or polling can provide an effective solution. It is the combination of low latency, high frequency, and high volume that make the best case for the use of WebSocket.

Keep in mind also that over the Internet, restrictive proxies that are outside of your control may preclude WebSocket interactions, either because they are not configured to pass on the [Upgrade](#) header or because they close long-lived connections that appear idle. This means that the use of WebSocket for internal applications within the firewall is a more straightforward decision than it is for public facing applications.

4.2. WebSocket API

Same as in Spring WebFlux

The Spring Framework provides a WebSocket API that you can use to write client- and server-side applications that handle WebSocket messages.

4.2.1. `WebSocketHandler`

Same as in Spring WebFlux

Creating a WebSocket server is as simple as implementing `WebSocketHandler` or, more likely, extending either `TextWebSocketHandler` or `BinaryWebSocketHandler`. The following example uses `TextWebSocketHandler`:

```
import org.springframework.web.socket.WebSocketHandler;
import org.springframework.web.socket.WebSocketSession;
import org.springframework.web.socket.TextMessage;

public class MyHandler extends TextWebSocketHandler {

    @Override
    public void handleTextMessage(WebSocketSession session, TextMessage message) {
        // ...
    }
}
```

There is dedicated WebSocket Java configuration and XML namespace support for mapping the preceding WebSocket handler to a specific URL, as the following example shows:

```

import org.springframework.web.socket.config.annotation.EnableWebSocket;
import org.springframework.web.socket.config.annotation.WebSocketConfigurer;
import org.springframework.web.socket.config.annotation.WebSocketHandlerRegistry;

@Configuration
@EnableWebSocket
public class WebSocketConfig implements WebSocketConfigurer {

    @Override
    public void registerWebSocketHandlers(WebSocketHandlerRegistry registry) {
        registry.addHandler(myHandler(), "/myHandler");
    }

    @Bean
    public WebSocketHandler myHandler() {
        return new MyHandler();
    }

}

```

The following example shows the XML configuration equivalent of the preceding example:

```

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

    <websocket:handlers>
        <websocket:mapping path="/myHandler" handler="myHandler"/>
    </websocket:handlers>

    <bean id="myHandler" class="org.springframework.samples.MyHandler"/>

</beans>

```

The preceding example is for use in Spring MVC applications and should be included in the configuration of a `DispatcherServlet`. However, Spring's WebSocket support does not depend on Spring MVC. It is relatively simple to integrate a `WebSocketHandler` into other HTTP-serving environments with the help of `WebSocketHttpRequestHandler`.

When using the `WebSocketHandler` API directly vs indirectly, e.g. through the `STOMP` messaging, the

application must synchronize the sending of messages since the underlying standard WebSocket session (JSR-356) does not allow concurrent sending. One option is to wrap the `WebSocketSession` with `ConcurrentWebSocketSessionDecorator`.

4.2.2. WebSocket Handshake

Same as in Spring WebFlux

The easiest way to customize the initial HTTP WebSocket handshake request is through a `HandshakeInterceptor`, which exposes methods for “before” and “after” the handshake. You can use such an interceptor to preclude the handshake or to make any attributes available to the `WebSocketSession`. The following example uses a built-in interceptor to pass HTTP session attributes to the WebSocket session:

```
@Configuration
@EnableWebSocket
public class WebSocketConfig implements WebSocketConfigurer {

    @Override
    public void registerWebSocketHandlers(WebSocketHandlerRegistry registry) {
        registry.addHandler(new MyHandler(), "/myHandler")
            .addInterceptors(new HttpSessionHandshakeInterceptor());
    }

}
```

The following example shows the XML configuration equivalent of the preceding example:

```

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

    <websocket:handlers>
        <websocket:mapping path="/myHandler" handler="myHandler"/>
        <websocket:handshake-interceptors>
            <bean class=
"org.springframework.web.socket.server.support.HttpSessionHandshakeInterceptor"/>
            </websocket:handshake-interceptors>
        </websocket:handlers>

        <bean id="myHandler" class="org.springframework.samples.MyHandler"/>
    </beans>

```

A more advanced option is to extend the `DefaultHandshakeHandler` that performs the steps of the WebSocket handshake, including validating the client origin, negotiating a sub-protocol, and other details. An application may also need to use this option if it needs to configure a custom `RequestUpgradeStrategy` in order to adapt to a WebSocket server engine and version that is not yet supported (see `Deployment` for more on this subject). Both the Java configuration and XML namespace make it possible to configure a custom `HandshakeHandler`.



Spring provides a `WebSocketHandlerDecorator` base class that you can use to decorate a `WebSocketHandler` with additional behavior. Logging and exception handling implementations are provided and added by default when using the WebSocket Java configuration or XML namespace. The `ExceptionWebSocketHandlerDecorator` catches all uncaught exceptions that arise from any `WebSocketHandler` method and closes the WebSocket session with status `1011`, which indicates a server error.

4.2.3. Deployment

The Spring WebSocket API is easy to integrate into a Spring MVC application where the `DispatcherServlet` serves both HTTP WebSocket handshake and other HTTP requests. It is also easy to integrate into other HTTP processing scenarios by invoking `WebSocketHttpRequestHandler`. This is convenient and easy to understand. However, special considerations apply with regards to JSR-356 runtimes.

The Java WebSocket API (JSR-356) provides two deployment mechanisms. The first involves a Servlet container classpath scan (a Servlet 3 feature) at startup. The other is a registration API to

use at Servlet container initialization. Neither of these mechanism makes it possible to use a single “front controller” for all HTTP processing—including WebSocket handshake and all other HTTP requests—such as Spring MVC’s `DispatcherServlet`.

This is a significant limitation of JSR-356 that Spring’s WebSocket support addresses with server-specific `RequestUpgradeStrategy` implementations even when running in a JSR-356 runtime. Such strategies currently exist for Tomcat, Jetty, GlassFish, WebLogic, WebSphere, and Undertow (and WildFly).



A request to overcome the preceding limitation in the Java WebSocket API has been created and can be followed at eclipse-ee4j/websocket-api#211. Tomcat, Undertow, and WebSphere provide their own API alternatives that make it possible to do this, and it is also possible with Jetty. We are hopeful that more servers will do the same.

A secondary consideration is that Servlet containers with JSR-356 support are expected to perform a `ServletContainerInitializer` (SCI) scan that can slow down application startup—in some cases, dramatically. If a significant impact is observed after an upgrade to a Servlet container version with JSR-356 support, it should be possible to selectively enable or disable web fragments (and SCI scanning) through the use of the `<absolute-ordering />` element in `web.xml`, as the following example shows:

```
<web-app xmlns="http://java.sun.com/xml/ns/javaee"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:schemaLocation="
    http://java.sun.com/xml/ns/javaee
    http://java.sun.com/xml/ns/javaee/web-app_3_0.xsd"
  version="3.0">

  <absolute-ordering/>

</web-app>
```

You can then selectively enable web fragments by name, such as Spring’s own `SpringServletContainerInitializer` that provides support for the Servlet 3 Java initialization API. The following example shows how to do so:

```

<web-app xmlns="http://java.sun.com/xml/ns/javaee"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="
        http://java.sun.com/xml/ns/javaee
        http://java.sun.com/xml/ns/javaee/web-app_3_0.xsd"
    version="3.0">

    <absolute-ordering>
        <name>spring_web</name>
    </absolute-ordering>

</web-app>

```

4.2.4. Server Configuration

Same as in Spring WebFlux

Each underlying WebSocket engine exposes configuration properties that control runtime characteristics, such as the size of message buffer sizes, idle timeout, and others.

For Tomcat, WildFly, and GlassFish, you can add a `ServletServerContainerFactoryBean` to your WebSocket Java config, as the following example shows:

```

@Configuration
@EnableWebSocket
public class WebSocketConfig implements WebSocketConfigurer {

    @Bean
    public ServletServerContainerFactoryBean createWebSocketContainer() {
        ServletServerContainerFactoryBean container = new
        ServletServerContainerFactoryBean();
        container.setMaxTextMessageBufferSize(8192);
        container.setMaxBinaryMessageBufferSize(8192);
        return container;
    }

}

```

The following example shows the XML configuration equivalent of the preceding example:

```

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

    <bean class="org.springframework...ServletServerContainerFactoryBean">
        <property name="maxTextMessageBufferSize" value="8192"/>
        <property name="maxBinaryMessageBufferSize" value="8192"/>
    </bean>

</beans>

```



For client-side WebSocket configuration, you should use `WebSocketContainerFactoryBean` (XML) or `ContainerProvider.getWebSocketContainer()` (Java configuration).

For Jetty, you need to supply a pre-configured Jetty `WebSocketServerFactory` and plug that into Spring's `DefaultHandshakeHandler` through your WebSocket Java config. The following example shows how to do so:

```
@Configuration
@EnableWebSocket
public class WebSocketConfig implements WebSocketConfigurer {

    @Override
    public void registerWebSocketHandlers(WebSocketHandlerRegistry registry) {
        registry.addHandler(echoWebSocketHandler(),
            "/echo").setHandshakeHandler(handshakeHandler());
    }

    @Bean
    public DefaultHandshakeHandler handshakeHandler() {

        WebSocketPolicy policy = new WebSocketPolicy(WebSocketBehavior.SERVER);
        policy.setInputBufferSize(8192);
        policy.setIdleTimeout(600000);

        return new DefaultHandshakeHandler(
            new JettyRequestUpgradeStrategy(new WebSocketServerFactory(policy
        )));
    }

}
```

The following example shows the XML configuration equivalent of the preceding example:

```

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

    <websocket:handlers>
        <websocket:mapping path="/echo" handler="echoHandler"/>
        <websocket:handshake-handler ref="handshakeHandler"/>
    </websocket:handlers>

    <bean id="handshakeHandler" class=
"org.springframework...DefaultHandshakeHandler">
        <constructor-arg ref="upgradeStrategy"/>
    </bean>

    <bean id="upgradeStrategy" class=
"org.springframework...JettyRequestUpgradeStrategy">
        <constructor-arg ref="serverFactory"/>
    </bean>

    <bean id="serverFactory" class="org.eclipse.jetty...WebSocketServerFactory">
        <constructor-arg>
            <bean class="org.eclipse.jetty...WebSocketPolicy">
                <constructor-arg value="SERVER"/>
                <property name="inputBufferSize" value="8092"/>
                <property name="idleTimeout" value="600000"/>
            </bean>
        </constructor-arg>
    </bean>

</beans>

```

4.2.5. Allowed Origins

Same as in Spring WebFlux

As of Spring Framework 4.1.5, the default behavior for WebSocket and SockJS is to accept only same-origin requests. It is also possible to allow all or a specified list of origins. This check is mostly designed for browser clients. Nothing prevents other types of clients from modifying the [Origin](#) header value (see [RFC 6454: The Web Origin Concept](#) for more details).

The three possible behaviors are:

- Allow only same-origin requests (default): In this mode, when SockJS is enabled, the Iframe

HTTP response header `X-Frame-Options` is set to `SAMEORIGIN`, and JSONP transport is disabled, since it does not allow checking the origin of a request. As a consequence, IE6 and IE7 are not supported when this mode is enabled.

- Allow a specified list of origins: Each allowed origin must start with `http://` or `https://`. In this mode, when SockJS is enabled, IFrame transport is disabled. As a consequence, IE6 through IE9 are not supported when this mode is enabled.
- Allow all origins: To enable this mode, you should provide `*` as the allowed origin value. In this mode, all transports are available.

You can configure WebSocket and SockJS allowed origins, as the following example shows:

```
import org.springframework.web.socket.config.annotation.EnableWebSocket;
import org.springframework.web.socket.config.annotation.WebSocketConfigurer;
import org.springframework.web.socket.config.annotation.WebSocketHandlerRegistry;

@Configuration
@EnableWebSocket
public class WebSocketConfig implements WebSocketConfigurer {

    @Override
    public void registerWebSocketHandlers(WebSocketHandlerRegistry registry) {
        registry.addHandler(myHandler(), "/myHandler").setAllowedOrigins(
            "http://mydomain.com");
    }

    @Bean
    public WebSocketHandler myHandler() {
        return new MyHandler();
    }

}
```

The following example shows the XML configuration equivalent of the preceding example:

```

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

    <websocket:handlers allowed-origins="http://mydomain.com">
        <websocket:mapping path="/myHandler" handler="myHandler" />
    </websocket:handlers>

    <bean id="myHandler" class="org.springframework.samples.MyHandler"/>

</beans>

```

4.3. SockJS Fallback

Over the public Internet, restrictive proxies outside your control may preclude WebSocket interactions, either because they are not configured to pass on the [Upgrade](#) header or because they close long-lived connections that appear to be idle.

The solution to this problem is WebSocket emulation—that is, attempting to use WebSocket first and then falling back on HTTP-based techniques that emulate a WebSocket interaction and expose the same application-level API.

On the Servlet stack, the Spring Framework provides both server (and also client) support for the SockJS protocol.

4.3.1. Overview

The goal of SockJS is to let applications use a WebSocket API but fall back to non-WebSocket alternatives when necessary at runtime, without the need to change application code.

SockJS consists of:

- The [SockJS protocol](#) defined in the form of executable [narrated tests](#).
- The [SockJS JavaScript client](#) — a client library for use in browsers.
- SockJS server implementations, including one in the Spring Framework [spring-websocket](#) module.
- A SockJS Java client in the [spring-websocket](#) module (since version 4.1).

SockJS is designed for use in browsers. It uses a variety of techniques to support a wide range of browser versions. For the full list of SockJS transport types and browsers, see the [SockJS client](#) page. Transports fall in three general categories: WebSocket, HTTP Streaming, and HTTP Long Polling. For

an overview of these categories, see [this blog post](#).

The SockJS client begins by sending `GET /info` to obtain basic information from the server. After that, it must decide what transport to use. If possible, WebSocket is used. If not, in most browsers, there is at least one HTTP streaming option. If not, then HTTP (long) polling is used.

All transport requests have the following URL structure:

```
http://host:port/myApp/myEndpoint/{server-id}/{session-id}/{transport}
```

where:

- `{server-id}` is useful for routing requests in a cluster but is not used otherwise.
- `{session-id}` correlates HTTP requests belonging to a SockJS session.
- `{transport}` indicates the transport type (for example, `websocket`, `xhr-streaming`, and others).

The WebSocket transport needs only a single HTTP request to do the WebSocket handshake. All messages thereafter are exchanged on that socket.

HTTP transports require more requests. Ajax/XHR streaming, for example, relies on one long-running request for server-to-client messages and additional HTTP POST requests for client-to-server messages. Long polling is similar, except that it ends the current request after each server-to-client send.

SockJS adds minimal message framing. For example, the server sends the letter `o` (“open” frame) initially, messages are sent as `a["message1", "message2"]` (JSON-encoded array), the letter `h` (“heartbeat” frame) if no messages flow for 25 seconds (by default), and the letter `c` (“close” frame) to close the session.

To learn more, run an example in a browser and watch the HTTP requests. The SockJS client allows fixing the list of transports, so it is possible to see each transport one at a time. The SockJS client also provides a debug flag, which enables helpful messages in the browser console. On the server side, you can enable `TRACE` logging for `org.springframework.web.socket`. For even more detail, see the SockJS protocol [narrated test](#).

4.3.2. Enabling SockJS

You can enable SockJS through Java configuration, as the following example shows:

```

@Configuration
@EnableWebSocket
public class WebSocketConfig implements WebSocketConfigurer {

    @Override
    public void registerWebSocketHandlers(WebSocketHandlerRegistry registry) {
        registry.addHandler(myHandler(), "/myHandler").withSockJS();
    }

    @Bean
    public WebSocketHandler myHandler() {
        return new MyHandler();
    }

}

```

The following example shows the XML configuration equivalent of the preceding example:

```

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

    <websocket:handlers>
        <websocket:mapping path="/myHandler" handler="myHandler"/>
        <websocket:sockjs/>
    </websocket:handlers>

    <bean id="myHandler" class="org.springframework.samples.MyHandler"/>

</beans>

```

The preceding example is for use in Spring MVC applications and should be included in the configuration of a `DispatcherServlet`. However, Spring's WebSocket and SockJS support does not depend on Spring MVC. It is relatively simple to integrate into other HTTP serving environments with the help of `SockJsHttpRequestHandler`.

On the browser side, applications can use the `sockjs-client` (version 1.0.x). It emulates the W3C WebSocket API and communicates with the server to select the best transport option, depending on the browser in which it runs. See the `sockjs-client` page and the list of transport types supported by browser. The client also provides several configuration options—for example, to specify which

transports to include.

4.3.3. IE 8 and 9

Internet Explorer 8 and 9 remain in use. They are a key reason for having SockJS. This section covers important considerations about running in those browsers.

The SockJS client supports Ajax/XHR streaming in IE 8 and 9 by using Microsoft's `XDomainRequest`. That works across domains but does not support sending cookies. Cookies are often essential for Java applications. However, since the SockJS client can be used with many server types (not just Java ones), it needs to know whether cookies matter. If so, the SockJS client prefers Ajax/XHR for streaming. Otherwise, it relies on an iframe-based technique.

The first `/info` request from the SockJS client is a request for information that can influence the client's choice of transports. One of those details is whether the server application relies on cookies (for example, for authentication purposes or clustering with sticky sessions). Spring's SockJS support includes a property called `sessionCookieNeeded`. It is enabled by default, since most Java applications rely on the `JSESSIONID` cookie. If your application does not need it, you can turn off this option, and SockJS client should then choose `xdr-streaming` in IE 8 and 9.

If you do use an iframe-based transport, keep in mind that browsers can be instructed to block the use of IFrames on a given page by setting the HTTP response header `X-Frame-Options` to `DENY`, `SAMEORIGIN`, or `ALLOW-FROM <origin>`. This is used to prevent [clickjacking](#).



Spring Security 3.2+ provides support for setting `X-Frame-Options` on every response. By default, the Spring Security Java configuration sets it to `DENY`. In 3.2, the Spring Security XML namespace does not set that header by default but can be configured to do so. In the future, it may set it by default.

See [Default Security Headers](#) of the Spring Security documentation for details on how to configure the setting of the `X-Frame-Options` header. You can also see [SEC-2501](#) for additional background.

If your application adds the `X-Frame-Options` response header (as it should!) and relies on an iframe-based transport, you need to set the header value to `SAMEORIGIN` or `ALLOW-FROM <origin>`. The Spring SockJS support also needs to know the location of the SockJS client, because it is loaded from the iframe. By default, the iframe is set to download the SockJS client from a CDN location. It is a good idea to configure this option to use a URL from the same origin as the application.

The following example shows how to do so in Java configuration:

```

@Configuration
@EnableWebSocket
public class WebSocketConfig implements WebSocketConfigurer {

    @Override
    public void registerStompEndpoints(StompEndpointRegistry registry) {
        registry.addEndpoint("/portfolio").withSockJS()
            .setClientLibraryUrl("http://localhost:8080/myapp/js/sockjs-
client.js");
    }

    // ...
}

```

The XML namespace provides a similar option through the `<websocket:sockjs>` element.



During initial development, do enable the SockJS client `devel` mode that prevents the browser from caching SockJS requests (like the iframe) that would otherwise be cached. For details on how to enable it see the [SockJS client](#) page.

4.3.4. Heartbeats

The SockJS protocol requires servers to send heartbeat messages to preclude proxies from concluding that a connection is hung. The Spring SockJS configuration has a property called `heartbeatTime` that you can use to customize the frequency. By default, a heartbeat is sent after 25 seconds, assuming no other messages were sent on that connection. This 25-second value is in line with the following [IETF recommendation](#) for public Internet applications.



When using STOMP over WebSocket and SockJS, if the STOMP client and server negotiate heartbeats to be exchanged, the SockJS heartbeats are disabled.

The Spring SockJS support also lets you configure the `TaskScheduler` to schedule heartbeats tasks. The task scheduler is backed by a thread pool, with default settings based on the number of available processors. You should consider customizing the settings according to your specific needs.

4.3.5. Client Disconnects

HTTP streaming and HTTP long polling SockJS transports require a connection to remain open longer than usual. For an overview of these techniques, see [this blog post](#).

In Servlet containers, this is done through Servlet 3 asynchronous support that allows exiting the Servlet container thread, processing a request, and continuing to write to the response from another thread.

A specific issue is that the Servlet API does not provide notifications for a client that has gone away. See [eclipse-ee4j/servlet-api#44](#). However, Servlet containers raise an exception on subsequent attempts to write to the response. Since Spring's SockJS Service supports server-sent heartbeats (every 25 seconds by default), that means a client disconnect is usually detected within that time period (or earlier, if messages are sent more frequently).



As a result, network I/O failures can occur because a client has disconnected, which can fill the log with unnecessary stack traces. Spring makes a best effort to identify such network failures that represent client disconnects (specific to each server) and log a minimal message by using the dedicated log category, `DISCONNECTED_CLIENT_LOG_CATEGORY` (defined in `AbstractSockJsSession`). If you need to see the stack traces, you can set that log category to TRACE.

4.3.6. SockJS and CORS

If you allow cross-origin requests (see [Allowed Origins](#)), the SockJS protocol uses CORS for cross-domain support in the XHR streaming and polling transports. Therefore, CORS headers are added automatically, unless the presence of CORS headers in the response is detected. So, if an application is already configured to provide CORS support (for example, through a Servlet Filter), Spring's `SockJsService` skips this part.

It is also possible to disable the addition of these CORS headers by setting the `suppressCors` property in Spring's `SockJsService`.

SockJS expects the following headers and values:

- `Access-Control-Allow-Origin`: Initialized from the value of the `Origin` request header.
- `Access-Control-Allow-Credentials`: Always set to `true`.
- `Access-Control-Request-Headers`: Initialized from values from the equivalent request header.
- `Access-Control-Allow-Methods`: The HTTP methods a transport supports (see `TransportType` enum).
- `Access-Control-Max-Age`: Set to 31536000 (1 year).

For the exact implementation, see `addCorsHeaders` in `AbstractSockJsService` and the `TransportType` enum in the source code.

Alternatively, if the CORS configuration allows it, consider excluding URLs with the SockJS endpoint prefix, thus letting Spring's `SockJsService` handle it.

4.3.7. SockJsClient

Spring provides a SockJS Java client to connect to remote SockJS endpoints without using a browser. This can be especially useful when there is a need for bidirectional communication between two servers over a public network (that is, where network proxies can preclude the use of the WebSocket protocol). A SockJS Java client is also very useful for testing purposes (for example, to simulate a large number of concurrent users).

The SockJS Java client supports the `websocket`, `xhr-streaming`, and `xhr-polling` transports. The

remaining ones only make sense for use in a browser.

You can configure the `WebSocketTransport` with:

- `StandardWebSocketClient` in a JSR-356 runtime.
- `JettyWebSocketClient` by using the Jetty 9+ native WebSocket API.
- Any implementation of Spring's `WebSocketClient`.

An `XhrTransport`, by definition, supports both `xhr-streaming` and `xhr-polling`, since, from a client perspective, there is no difference other than in the URL used to connect to the server. At present there are two implementations:

- `RestTemplateXhrTransport` uses Spring's `RestTemplate` for HTTP requests.
- `JettyXhrTransport` uses Jetty's `HttpClient` for HTTP requests.

The following example shows how to create a SockJS client and connect to a SockJS endpoint:

```
List<Transport> transports = new ArrayList<>(2);
transports.add(new WebSocketTransport(new StandardWebSocketClient()));
transports.add(new RestTemplateXhrTransport());

SockJsClient sockJsClient = new SockJsClient(transports);
sockJsClient.doHandshake(new MyWebSocketHandler(), "ws://example.com:8080/sockjs"
);
```



SockJS uses JSON formatted arrays for messages. By default, Jackson 2 is used and needs to be on the classpath. Alternatively, you can configure a custom implementation of `SockJsMessageCodec` and configure it on the `SockJsClient`.

To use `SockJsClient` to simulate a large number of concurrent users, you need to configure the underlying HTTP client (for XHR transports) to allow a sufficient number of connections and threads. The following example shows how to do so with Jetty:

```
HttpClient jettyHttpClient = new HttpClient();
jettyHttpClient.setMaxConnectionsPerDestination(1000);
jettyHttpClient.setExecutor(new QueuedThreadPool(1000));
```

The following example shows the server-side SockJS-related properties (see javadoc for details) that you should also consider customizing:

```

@Configuration
public class WebSocketConfig extends WebSocketMessageBrokerConfigurationSupport {

    @Override
    public void registerStompEndpoints(StompEndpointRegistry registry) {
        registry.addEndpoint("/sockjs").withSockJS()
            .setStreamBytesLimit(512 * 1024) ①
            .setHttpMessageCacheSize(1000) ②
            .setDisconnectDelay(30 * 1000); ③
    }

    // ...
}

```

① Set the `streamBytesLimit` property to 512KB (the default is 128KB — `128 * 1024`).

② Set the `httpMessageCacheSize` property to 1,000 (the default is `100`).

③ Set the `disconnectDelay` property to 30 property seconds (the default is five seconds — `5 * 1000`).

4.4. STOMP

The WebSocket protocol defines two types of messages (text and binary), but their content is undefined. The protocol defines a mechanism for client and server to negotiate a sub-protocol (that is, a higher-level messaging protocol) to use on top of WebSocket to define what kind of messages each can send, what the format is, the content of each message, and so on. The use of a sub-protocol is optional but, either way, the client and the server need to agree on some protocol that defines message content.

4.4.1. Overview

STOMP (Simple Text Oriented Messaging Protocol) was originally created for scripting languages (such as Ruby, Python, and Perl) to connect to enterprise message brokers. It is designed to address a minimal subset of commonly used messaging patterns. STOMP can be used over any reliable two-way streaming network protocol, such as TCP and WebSocket. Although STOMP is a text-oriented protocol, message payloads can be either text or binary.

STOMP is a frame-based protocol whose frames are modeled on HTTP. The following listing shows the structure of a STOMP frame:

```
COMMAND  
header1:value1  
header2:value2
```

```
Body^@
```

Clients can use the **SEND** or **SUBSCRIBE** commands to send or subscribe for messages, along with a **destination** header that describes what the message is about and who should receive it. This enables a simple publish-subscribe mechanism that you can use to send messages through the broker to other connected clients or to send messages to the server to request that some work be performed.

When you use Spring's STOMP support, the Spring WebSocket application acts as the STOMP broker to clients. Messages are routed to **@Controller** message-handling methods or to a simple in-memory broker that keeps track of subscriptions and broadcasts messages to subscribed users. You can also configure Spring to work with a dedicated STOMP broker (such as RabbitMQ, ActiveMQ, and others) for the actual broadcasting of messages. In that case, Spring maintains TCP connections to the broker, relays messages to it, and passes messages from it down to connected WebSocket clients. Thus, Spring web applications can rely on unified HTTP-based security, common validation, and a familiar programming model for message handling.

The following example shows a client subscribing to receive stock quotes, which the server may emit periodically (for example, via a scheduled task that sends messages through a **SimpMessagingTemplate** to the broker):

```
SUBSCRIBE  
id:sub-1  
destination:/topic/price.stock.*
```

```
^@
```

The following example shows a client that sends a trade request, which the server can handle through an **@MessageMapping** method:

```
SEND  
destination:/queue/trade  
content-type:application/json  
content-length:44
```

```
{"action": "BUY", "ticker": "MMM", "shares", 44}^@
```

After the execution, the server can broadcast a trade confirmation message and details down to the

client.

The meaning of a destination is intentionally left opaque in the STOMP spec. It can be any string, and it is entirely up to STOMP servers to define the semantics and the syntax of the destinations that they support. It is very common, however, for destinations to be path-like strings where `/topic/..` implies publish-subscribe (one-to-many) and `/queue/` implies point-to-point (one-to-one) message exchanges.

STOMP servers can use the `MESSAGE` command to broadcast messages to all subscribers. The following example shows a server sending a stock quote to a subscribed client:

```
MESSAGE
message-id:nxahk1f6-1
subscription:sub-1
destination:/topic/price.stock.MMM

{"ticker":"MMM","price":129.45}^@
```

A server cannot send unsolicited messages. All messages from a server must be in response to a specific client subscription, and the `subscription-id` header of the server message must match the `id` header of the client subscription.

The preceding overview is intended to provide the most basic understanding of the STOMP protocol. We recommended reviewing the protocol [specification](#) in full.

4.4.2. Benefits

Using STOMP as a sub-protocol lets the Spring Framework and Spring Security provide a richer programming model versus using raw WebSockets. The same point can be made about HTTP versus raw TCP and how it lets Spring MVC and other web frameworks provide rich functionality. The following is a list of benefits:

- No need to invent a custom messaging protocol and message format.
- STOMP clients, including a [Java client](#) in the Spring Framework, are available.
- You can (optionally) use message brokers (such as RabbitMQ, ActiveMQ, and others) to manage subscriptions and broadcast messages.
- Application logic can be organized in any number of `@Controller` instances and messages can be routed to them based on the STOMP destination header versus handling raw WebSocket messages with a single `WebSocketHandler` for a given connection.
- You can use Spring Security to secure messages based on STOMP destinations and message types.

4.4.3. Enable STOMP

STOMP over WebSocket support is available in the `spring-messaging` and `spring-websocket` modules.

Once you have those dependencies, you can expose a STOMP endpoints, over WebSocket with [SockJS Fallback](#), as the following example shows:

```
import org.springframework.web.socket.config.annotation.EnableWebSocketMessageBroker;
import org.springframework.web.socket.config.annotation.StompEndpointRegistry;

@Configuration
@EnableWebSocketMessageBroker
public class WebSocketConfig implements WebSocketMessageBrokerConfigurer {

    @Override
    public void registerStompEndpoints(StompEndpointRegistry registry) {
        registry.addEndpoint("/portfolio").withSockJS(); ①
    }

    @Override
    public void configureMessageBroker(MessageBrokerRegistry config) {
        config.setApplicationDestinationPrefixes("/app"); ②
        config.enableSimpleBroker("/topic", "/queue"); ③
    }
}
```

① `/portfolio` is the HTTP URL for the endpoint to which a WebSocket (or SockJS) client needs to connect for the WebSocket handshake.

② STOMP messages whose destination header begins with `/app` are routed to `@MessageMapping` methods in `@Controller` classes.

③ Use the built-in message broker for subscriptions and broadcasting and route messages whose destination header begins with `/topic` or `'/queue'` to the broker.

The following example shows the XML configuration equivalent of the preceding example:

```

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

    <websocket:message-broker application-destination-prefix="/app">
        <websocket:stomp-endpoint path="/portfolio">
            <websocket:sockjs/>
        </websocket:stomp-endpoint>
        <websocket:simple-broker prefix="/topic, /queue"/>
    </websocket:message-broker>

</beans>

```



For the built-in simple broker, the `/topic` and `/queue` prefixes do not have any special meaning. They are merely a convention to differentiate between pub-sub versus point-to-point messaging (that is, many subscribers versus one consumer). When you use an external broker, check the STOMP page of the broker to understand what kind of STOMP destinations and prefixes it supports.

To connect from a browser, for SockJS, you can use the `sockjs-client`. For STOMP, many applications have used the `jmesnil/stomp-websocket` library (also known as `stomp.js`), which is feature-complete and has been used in production for years but is no longer maintained. At present the `JSteunou/webstomp-client` is the most actively maintained and evolving successor of that library. The following example code is based on it:

```

var socket = new SockJS("/spring-websocket-portfolio/portfolio");
var stompClient = webstomp.over(socket);

stompClient.connect({}, function(frame) {
}

```

Alternatively, if you connect through WebSocket (without SockJS), you can use the following code:

```

var socket = new WebSocket("/spring-websocket-portfolio/portfolio");
var stompClient = Stomp.over(socket);

stompClient.connect({}, function(frame) {
}

```

Note that `stompClient` in the preceding example does not need to specify `login` and `passcode` headers. Even if it did, they would be ignored (or, rather, overridden) on the server side. See [Connecting to a Broker](#) and [Authentication](#) for more information on authentication.

For more example code see:

- [Using WebSocket to build an interactive web application](#) — a getting started guide.
- [Stock Portfolio](#) — a sample application.

4.4.4. WebSocket Server

To configure the underlying WebSocket server, the information in [Server Configuration](#) applies. For Jetty, however you need to set the `HandshakeHandler` and `WebSocketPolicy` through the `StompEndpointRegistry`:

```

@Configuration
@EnableWebSocketMessageBroker
public class WebSocketConfig implements WebSocketMessageBrokerConfigurer {

    @Override
    public void registerStompEndpoints(StompEndpointRegistry registry) {
        registry.addEndpoint("/portfolio").setHandshakeHandler(handshakeHandler())
    }

    @Bean
    public DefaultHandshakeHandler handshakeHandler() {

        WebSocketPolicy policy = new WebSocketPolicy(WebSocketBehavior.SERVER);
        policy.setInputBufferSize(8192);
        policy.setIdleTimeout(60000);

        return new DefaultHandshakeHandler(
            new JettyRequestUpgradeStrategy(new WebSocketServerFactory(policy
        )));
    }
}

```

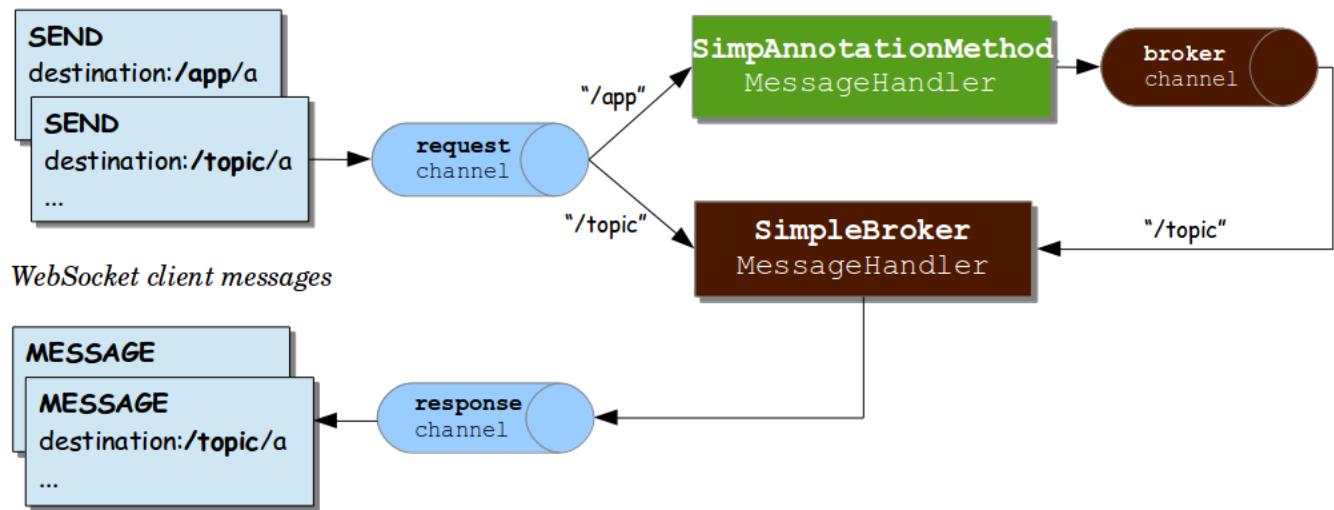
4.4.5. Flow of Messages

Once a STOMP endpoint is exposed, the Spring application becomes a STOMP broker for connected clients. This section describes the flow of messages on the server side.

The `spring-messaging` module contains foundational support for messaging applications that originated in [Spring Integration](#) and was later extracted and incorporated into the Spring Framework for broader use across many [Spring projects](#) and application scenarios. The following list briefly describes a few of the available messaging abstractions:

- **Message**: Simple representation for a message, including headers and payload.
- **MessageHandler**: Contract for handling a message.
- **MessageChannel**: Contract for sending a message that enables loose coupling between producers and consumers.
- **SubscribableChannel**: **MessageChannel** with **MessageHandler** subscribers.
- **ExecutorSubscribableChannel**: **SubscribableChannel** that uses an **Executor** for delivering messages.

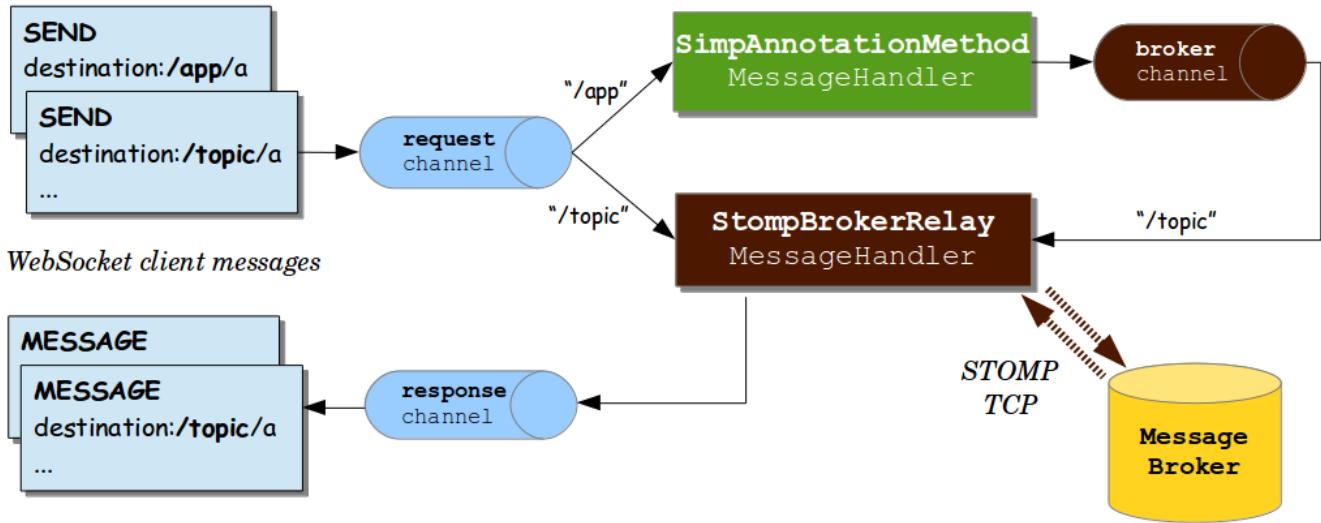
Both the Java configuration (that is, `@EnableWebSocketMessageBroker`) and the XML namespace configuration (that is, `<websocket:message-broker>`) use the preceding components to assemble a message workflow. The following diagram shows the components used when the simple built-in message broker is enabled:



The preceding diagram shows three message channels:

- **clientInboundChannel**: For passing messages received from WebSocket clients.
- **clientOutboundChannel**: For sending server messages to WebSocket clients.
- **brokerChannel**: For sending messages to the message broker from within server-side application code.

The next diagram shows the components used when an external broker (such as RabbitMQ) is configured for managing subscriptions and broadcasting messages:



The main difference between the two preceding diagrams is the use of the “broker relay” for passing messages up to the external STOMP broker over TCP and for passing messages down from the broker to subscribed clients.

When messages are received from a WebSocket connection, they are decoded to STOMP frames, turned into a Spring `Message` representation, and sent to the `clientInboundChannel` for further processing. For example, STOMP messages whose destination headers start with `/app` may be routed to `@MessageMapping` methods in annotated controllers, while `/topic` and `/queue` messages may be routed directly to the message broker.

An annotated `@Controller` that handles a STOMP message from a client may send a message to the message broker through the `brokerChannel`, and the broker broadcasts the message to matching subscribers through the `clientOutboundChannel`. The same controller can also do the same in response to HTTP requests, so a client can perform an HTTP POST, and then a `@PostMapping` method can send a message to the message broker to broadcast to subscribed clients.

We can trace the flow through a simple example. Consider the following example, which sets up a server:

```

@Configuration
@EnableWebSocketMessageBroker
public class WebSocketConfig implements WebSocketMessageBrokerConfigurer {

    @Override
    public void registerStompEndpoints(StompEndpointRegistry registry) {
        registry.addEndpoint("/portfolio");
    }

    @Override
    public void configureMessageBroker(MessageBrokerRegistry registry) {
        registry.setApplicationDestinationPrefixes("/app");
        registry.enableSimpleBroker("/topic");
    }

}

@Controller
public class GreetingController {

    @MessageMapping("/greeting")
    public String handle(String greeting) {
        return "[" + getTimestamp() + " : " + greeting;
    }

}

```

The preceding example supports the following flow:

1. The client connects to `http://localhost:8080/portfolio` and, once a WebSocket connection is established, STOMP frames begin to flow on it.
2. The client sends a SUBSCRIBE frame with a destination header of `/topic/greeting`. Once received and decoded, the message is sent to the `clientInboundChannel` and is then routed to the message broker, which stores the client subscription.
3. The client sends a SEND frame to `/app/greeting`. The `/app` prefix helps to route it to annotated controllers. After the `/app` prefix is stripped, the remaining `/greeting` part of the destination is mapped to the `@MessageMapping` method in `GreetingController`.
4. The value returned from `GreetingController` is turned into a Spring `Message` with a payload based on the return value and a default destination header of `/topic/greeting` (derived from the input destination with `/app` replaced by `/topic`). The resulting message is sent to the `brokerChannel` and handled by the message broker.
5. The message broker finds all matching subscribers and sends a MESSAGE frame to each one through the `clientOutboundChannel`, from where messages are encoded as STOMP frames and sent on the WebSocket connection.

The next section provides more details on annotated methods, including the kinds of arguments

and return values that are supported.

4.4.6. Annotated Controllers

Applications can use annotated `@Controller` classes to handle messages from clients. Such classes can declare `@MessageMapping`, `@SubscribeMapping`, and `@ExceptionHandler` methods, as described in the following topics:

- `@MessageMapping`
- `@SubscribeMapping`
- `@MessageExceptionHandler`

`@MessageMapping`

You can use `@MessageMapping` to annotate methods that route messages based on their destination. It is supported at the method level as well as at the type level. At the type level, `@MessageMapping` is used to express shared mappings across all methods in a controller.

By default, the mapping values are Ant-style path patterns (for example `/thing*`, `/thing/**`), including support for template variables (for example, `/thing/{id}`). The values can be referenced through `@DestinationVariable` method arguments. Applications can also switch to a dot-separated destination convention for mappings, as explained in [Dots as Separators](#).

Supported Method Arguments

The following table describes the method arguments:

Method argument	Description
<code>Message</code>	For access to the complete message.
<code>MessageHeaders</code>	For access to the headers within the <code>Message</code> .
<code>MessageHeaderAccessor</code> , <code>SimpMessageHeaderAccessor</code> , and <code>StompHeaderAccessor</code>	For access to the headers through typed accessor methods.
<code>@Payload</code>	<p>For access to the payload of the message, converted (for example, from JSON) by a configured <code>MessageConverter</code>.</p> <p>The presence of this annotation is not required since it is, by default, assumed if no other argument is matched.</p> <p>You can annotate payload arguments with <code>@javax.validation.Valid</code> or Spring's <code>@Validated</code>, to have the payload arguments be automatically validated.</p>
<code>@Header</code>	For access to a specific header value — along with type conversion using an <code>org.springframework.core.convert.converter.Converter</code> , if necessary.
<code>@Headers</code>	For access to all headers in the message. This argument must be assignable to <code>java.util.Map</code> .

Method argument	Description
<code>@DestinationVariable</code>	For access to template variables extracted from the message destination. Values are converted to the declared method argument type as necessary.
<code>java.security.Principal</code>	Reflects the user logged in at the time of the WebSocket HTTP handshake.

Return Values

By default, the return value from a `@MessageMapping` method is serialized to a payload through a matching `MessageConverter` and sent as a `Message` to the `brokerChannel`, from where it is broadcast to subscribers. The destination of the outbound message is the same as that of the inbound message but prefixed with `/topic`.

You can use the `@SendTo` and `@SendToUser` annotations to customize the destination of the output message. `@SendTo` is used to customize the target destination or to specify multiple destinations. `@SendToUser` is used to direct the output message to only the user associated with the input message. See [User Destinations](#).

You can use both `@SendTo` and `@SendToUser` at the same time on the same method, and both are supported at the class level, in which case they act as a default for methods in the class. However, keep in mind that any method-level `@SendTo` or `@SendToUser` annotations override any such annotations at the class level.

Messages can be handled asynchronously and a `@MessageMapping` method can return `ListenableFuture`, `CompletableFuture`, or `CompletionStage`.

Note that `@SendTo` and `@SendToUser` are merely a convenience that amounts to using the `SimpMessagingTemplate` to send messages. If necessary, for more advanced scenarios, `@MessageMapping` methods can fall back on using the `SimpMessagingTemplate` directly. This can be done instead of, or possibly in addition to, returning a value. See [Sending Messages](#).

`@SubscribeMapping`

`@SubscribeMapping` is similar to `@MessageMapping` but narrows the mapping to subscription messages only. It supports the same `method arguments` as `@MessageMapping`. However for the return value, by default, a message is sent directly to the client (through `clientOutboundChannel`, in response to the subscription) and not to the broker (through `brokerChannel`, as a broadcast to matching subscriptions). Adding `@SendTo` or `@SendToUser` overrides this behavior and sends to the broker instead.

When is this useful? Assume that the broker is mapped to `/topic` and `/queue`, while application controllers are mapped to `/app`. In this setup, the broker stores all subscriptions to `/topic` and `/queue` that are intended for repeated broadcasts, and there is no need for the application to get involved. A client could also subscribe to some `/app` destination, and a controller could return a value in response to that subscription without involving the broker without storing or using the subscription again (effectively a one-time request-reply exchange). One use case for this is populating a UI with initial data on startup.

When is this not useful? Do not try to map broker and controllers to the same destination prefix unless you want both to independently process messages, including subscriptions, for some reason. Inbound messages are handled in parallel. There are no guarantees whether a broker or a controller processes a given message first. If the goal is to be notified when a subscription is stored and ready for broadcasts, a client should ask for a receipt if the server supports it (simple broker does not). For example, with the Java [STOMP client](#), you could do the following to add a receipt:

```
@Autowired  
private TaskScheduler messageBrokerTaskScheduler;  
  
// During initialization..  
stompClient.setTaskScheduler(this.messageBrokerTaskScheduler);  
  
// When subscribing..  
StompHeaders headers = new StompHeaders();  
headers.setDestination("/topic/...");  
headers.setReceipt("r1");  
FrameHandler handler = ...;  
stompSession.subscribe(headers, handler).addReceiptTask(() -> {  
    // Subscription ready...  
});
```

A server side option is [to register](#) an [ExecutorChannelInterceptor](#) on the [brokerChannel](#) and implement the [afterMessageHandled](#) method that is invoked after messages, including subscriptions, have been handled.

[@MessageExceptionHandler](#)

An application can use [@MessageExceptionHandler](#) methods to handle exceptions from [@MessageMapping](#) methods. You can declare exceptions in the annotation itself or through a method argument if you want to get access to the exception instance. The following example declares an exception through a method argument:

```
@Controller  
public class MyController {  
  
    // ...  
  
    @MessageExceptionHandler  
    public ApplicationError handleException(MyException exception) {  
        // ...  
        return appError;  
    }  
}
```

`@MessageExceptionHandler` methods support flexible method signatures and support the same method argument types and return values as `@MessageMapping` methods.

Typically, `@MessageExceptionHandler` methods apply within the `@Controller` class (or class hierarchy) in which they are declared. If you want such methods to apply more globally (across controllers), you can declare them in a class marked with `@ControllerAdvice`. This is comparable to [the similar support](#) that is available in Spring MVC.

4.4.7. Sending Messages

What if you want to send messages to connected clients from any part of the application? Any application component can send messages to the `brokerChannel`. The easiest way to do so is to inject a `SimpMessagingTemplate` and use it to send messages. Typically, you would inject it by type, as the following example shows:

```
@Controller
public class GreetingController {

    private SimpMessagingTemplate template;

    @Autowired
    public GreetingController(SimpMessagingTemplate template) {
        this.template = template;
    }

    @RequestMapping(path="/greetings", method=POST)
    public void greet(String greeting) {
        String text = "[" + getTimestamp() + "]: " + greeting;
        this.template.convertAndSend("/topic/greetings", text);
    }
}
```

However, you can also qualify it by its name (`brokerMessagingTemplate`), if another bean of the same type exists.

4.4.8. Simple Broker

The built-in simple message broker handles subscription requests from clients, stores them in memory, and broadcasts messages to connected clients that have matching destinations. The broker supports path-like destinations, including subscriptions to Ant-style destination patterns.



Applications can also use dot-separated (rather than slash-separated) destinations. See [Dots as Separators](#).

If configured with a task scheduler, the simple broker supports [STOMP heartbeats](#). For that, you can declare your own scheduler or use the one that is automatically declared and used internally. The

following example shows how to declare your own scheduler:

```
@Configuration
@EnableWebSocketMessageBroker
public class WebSocketConfig implements WebSocketMessageBrokerConfigurer {

    private TaskScheduler messageBrokerTaskScheduler;

    @Autowired
    public void setMessageBrokerTaskScheduler(TaskScheduler taskScheduler) {
        this.messageBrokerTaskScheduler = taskScheduler;
    }

    @Override
    public void configureMessageBroker(MessageBrokerRegistry registry) {

        registry.enableSimpleBroker("/queue/", "/topic/")
            .setHeartbeatValue(new long[] {10000, 20000})
            .setTaskScheduler(this.messageBrokerTaskScheduler);

        // ...
    }
}
```

4.4.9. External Broker

The simple broker is great for getting started but supports only a subset of STOMP commands (it does not support acks, receipts, and some other features), relies on a simple message-sending loop, and is not suitable for clustering. As an alternative, you can upgrade your applications to use a full-featured message broker.

See the STOMP documentation for your message broker of choice (such as [RabbitMQ](#), [ActiveMQ](#), and others), install the broker, and run it with STOMP support enabled. Then you can enable the STOMP broker relay (instead of the simple broker) in the Spring configuration.

The following example configuration enables a full-featured broker:

```

@Configuration
@EnableWebSocketMessageBroker
public class WebSocketConfig implements WebSocketMessageBrokerConfigurer {

    @Override
    public void registerStompEndpoints(StompEndpointRegistry registry) {
        registry.addEndpoint("/portfolio").withSockJS();
    }

    @Override
    public void configureMessageBroker(MessageBrokerRegistry registry) {
        registry.enableStompBrokerRelay("/topic", "/queue");
        registry.setApplicationDestinationPrefixes("/app");
    }

}

```

The following example shows the XML configuration equivalent of the preceding example:

```

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

    <websocket:message-broker application-destination-prefix="/app">
        <websocket:stomp-endpoint path="/portfolio" />
            <websocket:sockjs/>
        </websocket:stomp-endpoint>
        <websocket:stomp-broker-relay prefix="/topic,/queue" />
    </websocket:message-broker>

</beans>

```

The STOMP broker relay in the preceding configuration is a Spring `MessageHandler` that handles messages by forwarding them to an external message broker. To do so, it establishes TCP connections to the broker, forwards all messages to it, and then forwards all messages received from the broker to clients through their WebSocket sessions. Essentially, it acts as a “relay” that forwards messages in both directions.



Add `io.projectreactor.netty:reactor-netty` and `io.netty:netty-all` dependencies to your project for TCP connection management.

Furthermore, application components (such as HTTP request handling methods, business services, and others) can also send messages to the broker relay, as described in [Sending Messages](#), to broadcast messages to subscribed WebSocket clients.

In effect, the broker relay enables robust and scalable message broadcasting.

4.4.10. Connecting to a Broker

A STOMP broker relay maintains a single “system” TCP connection to the broker. This connection is used for messages originating from the server-side application only, not for receiving messages. You can configure the STOMP credentials (that is, the STOMP frame `login` and `passcode` headers) for this connection. This is exposed in both the XML namespace and Java configuration as the `systemLogin` and `systemPasscode` properties with default values of `guest` and `guest`.

The STOMP broker relay also creates a separate TCP connection for every connected WebSocket client. You can configure the STOMP credentials that are used for all TCP connections created on behalf of clients. This is exposed in both the XML namespace and Java configuration as the `clientLogin` and `'clientPasscode` properties with default values of `guest`and `guest`.



The STOMP broker relay always sets the `login` and `passcode` headers on every `CONNECT` frame that it forwards to the broker on behalf of clients. Therefore, WebSocket clients need not set those headers. They are ignored. As the [Authentication](#) section explains, WebSocket clients should instead rely on HTTP authentication to protect the WebSocket endpoint and establish the client identity.

The STOMP broker relay also sends and receives heartbeats to and from the message broker over the “system” TCP connection. You can configure the intervals for sending and receiving heartbeats (10 seconds each by default). If connectivity to the broker is lost, the broker relay continues to try to reconnect, every 5 seconds, until it succeeds.

Any Spring bean can implement `ApplicationListener<BrokerAvailabilityEvent>` to receive notifications when the “system” connection to the broker is lost and re-established. For example, a Stock Quote service that broadcasts stock quotes can stop trying to send messages when there is no active “system” connection.

By default, the STOMP broker relay always connects, and reconnects as needed if connectivity is lost, to the same host and port. If you wish to supply multiple addresses, on each attempt to connect, you can configure a supplier of addresses, instead of a fixed host and port. The following example shows how to do that:

```

@Configuration
@EnableWebSocketMessageBroker
public class WebSocketConfig extends AbstractWebSocketMessageBrokerConfigurer {

    // ...

    @Override
    public void configureMessageBroker(MessageBrokerRegistry registry) {
        registry.enableStompBrokerRelay("/queue/", "/topic/").setTcpClient(
            createTcpClient());
        registry.setApplicationDestinationPrefixes("/app");
    }

    private ReactorNettyTcpClient<byte[]> createTcpClient() {
        return new ReactorNettyTcpClient<>(
            client -> client.addressSupplier(() -> ... ),
            new StompReactorNettyCodec());
    }
}

```

You can also configure the STOMP broker relay with a `virtualHost` property. The value of this property is set as the `host` header of every `CONNECT` frame and can be useful (for example, in a cloud environment where the actual host to which the TCP connection is established differs from the host that provides the cloud-based STOMP service).

4.4.11. Dots as Separators

When messages are routed to `@MessageMapping` methods, they are matched with `AntPathMatcher`. By default, patterns are expected to use slash (`/`) as the separator. This is a good convention in web applications and similar to HTTP URLs. However, if you are more used to messaging conventions, you can switch to using dot (`.`) as the separator.

The following example shows how to do so in Java configuration:

```

@Configuration
@EnableWebSocketMessageBroker
public class WebSocketConfig implements WebSocketMessageBrokerConfigurer {

    // ...

    @Override
    public void configureMessageBroker(MessageBrokerRegistry registry) {
        registry.setPathMatcher(<strong>new AntPathMatcher(".")</strong>);
        registry.enableStompBrokerRelay("/queue", "/topic");
        registry.setApplicationDestinationPrefixes("/app");
    }
}

```

The following example shows the XML configuration equivalent of the preceding example:

```

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

    <websocket:message-broker application-destination-prefix="/app" path-matcher=
    "<strong>pathMatcher</strong>">
        <websocket:stomp-endpoint path="/stomp"/>
        <websocket:stomp-broker-relay prefix="/topic,/queue" />
    </websocket:message-broker>

    <strong>
        <bean id="pathMatcher" class="org.springframework.util.AntPathMatcher">
            <constructor-arg index="0" value="."/>
        </bean>
    </strong>

</beans>

```

After that, a controller can use a dot (.) as the separator in `@MessageMapping` methods, as the following example shows:

```

@Controller
@MessageMapping("red")
public class RedController {

    @MessageMapping("blue.{green}")
    public void handleGreen(@DestinationVariable String green) {
        // ...
    }
}

```

The client can now send a message to [/app/red.blue.green123](#).

In the preceding example, we did not change the prefixes on the “broker relay”, because those depend entirely on the external message broker. See the STOMP documentation pages for the broker you use to see what conventions it supports for the destination header.

The “simple broker”, on the other hand, does rely on the configured `PathMatcher`, so, if you switch the separator, that change also applies to the broker and the way the broker matches destinations from a message to patterns in subscriptions.

4.4.12. Authentication

Every STOMP over WebSocket messaging session begins with an HTTP request. That can be a request to upgrade to WebSockets (that is, a WebSocket handshake) or, in the case of SockJS fallbacks, a series of SockJS HTTP transport requests.

Many web applications already have authentication and authorization in place to secure HTTP requests. Typically, a user is authenticated through Spring Security by using some mechanism such as a login page, HTTP basic authentication, or another way. The security context for the authenticated user is saved in the HTTP session and is associated with subsequent requests in the same cookie-based session.

Therefore, for a WebSocket handshake or for SockJS HTTP transport requests, typically, there is already an authenticated user accessible through `HttpServletRequest#getUserPrincipal()`. Spring automatically associates that user with a WebSocket or SockJS session created for them and, subsequently, with all STOMP messages transported over that session through a user header.

In short, a typical web application needs to do nothing beyond what it already does for security. The user is authenticated at the HTTP request level with a security context that is maintained through a cookie-based HTTP session (which is then associated with WebSocket or SockJS sessions created for that user) and results in a user header being stamped on every `Message` flowing through the application.

Note that the STOMP protocol does have `login` and `passcode` headers on the `CONNECT` frame. Those were originally designed for and are still needed, for example, for STOMP over TCP. However, for STOMP over WebSocket, by default, Spring ignores authorization headers at the STOMP protocol level, assumes that the user is already authenticated at the HTTP transport level, and expects that

the WebSocket or SockJS session contain the authenticated user.



Spring Security provides [WebSocket sub-protocol authorization](#) that uses a [ChannelInterceptor](#) to authorize messages based on the user header in them. Also, Spring Session provides a [WebSocket integration](#) that ensures the user HTTP session does not expire when the WebSocket session is still active.

4.4.13. Token Authentication

[Spring Security OAuth](#) provides support for token based security, including JSON Web Token (JWT). You can use this as the authentication mechanism in Web applications, including STOMP over WebSocket interactions, as described in the previous section (that is, to maintain identity through a cookie-based session).

At the same time, cookie-based sessions are not always the best fit (for example, in applications that do not maintain a server-side session or in mobile applications where it is common to use headers for authentication).

The [WebSocket protocol, RFC 6455](#) “doesn’t prescribe any particular way that servers can authenticate clients during the WebSocket handshake.” In practice, however, browser clients can use only standard authentication headers (that is, basic HTTP authentication) or cookies and cannot (for example) provide custom headers. Likewise, the SockJS JavaScript client does not provide a way to send HTTP headers with SockJS transport requests. See [sockjs-client issue 196](#). Instead, it does allow sending query parameters that you can use to send a token, but that has its own drawbacks (for example, the token may be inadvertently logged with the URL in server logs).



The preceding limitations are for browser-based clients and do not apply to the Spring Java-based STOMP client, which does support sending headers with both WebSocket and SockJS requests.

Therefore, applications that wish to avoid the use of cookies may not have any good alternatives for authentication at the HTTP protocol level. Instead of using cookies, they may prefer to authenticate with headers at the STOMP messaging protocol level. Doing so requires two simple steps:

1. Use the STOMP client to pass authentication headers at connect time.
2. Process the authentication headers with a [ChannelInterceptor](#).

The next example uses server-side configuration to register a custom authentication interceptor. Note that an interceptor needs only to authenticate and set the user header on the [CONNECT Message](#). Spring notes and saves the authenticated user and associate it with subsequent STOMP messages on the same session. The following example shows how register a custom authentication interceptor:

```

@Configuration
@EnableWebSocketMessageBroker
public class MyConfig implements WebSocketMessageBrokerConfigurer {

    @Override
    public void configureClientInboundChannel(ChannelRegistration registration) {
        registration.interceptors(new ChannelInterceptor() {
            @Override
            public Message<?> preSend(Message<?> message, MessageChannel channel)
            {
                StompHeaderAccessor accessor =
                    MessageHeaderAccessor.getAccessor(message,
                    StompHeaderAccessor.class);
                if (StompCommand.CONNECT.equals(accessor.getCommand())) {
                    Authentication user = ... ; // access authentication header(s)
                    accessor.setUser(user);
                }
                return message;
            }
        });
    }
}

```

Also, note that, when you use Spring Security's authorization for messages, at present, you need to ensure that the authentication `ChannelInterceptor` config is ordered ahead of Spring Security's. This is best done by declaring the custom interceptor in its own implementation of `WebSocketMessageBrokerConfigurer` that is marked with `@Order(Ordered.HIGHEST_PRECEDENCE + 99)`.

4.4.14. User Destinations

An application can send messages that target a specific user, and Spring's STOMP support recognizes destinations prefixed with `/user/` for this purpose. For example, a client might subscribe to the `/user/queue/position-updates` destination. This destination is handled by the `UserDestinationMessageHandler` and transformed into a destination unique to the user session (such as `/queue/position-updates-user123`). This provides the convenience of subscribing to a generically named destination while, at the same time, ensuring no collisions with other users who subscribe to the same destination so that each user can receive unique stock position updates.

On the sending side, messages can be sent to a destination such as `/user/{username}/queue/position-updates`, which in turn is translated by the `UserDestinationMessageHandler` into one or more destinations, one for each session associated with the user. This lets any component within the application send messages that target a specific user without necessarily knowing anything more than their name and the generic destination. This is also supported through an annotation and a messaging template.

A message-handling method can send messages to the user associated with the message being handled through the `@SendToUser` annotation (also supported on the class-level to share a common

destination), as the following example shows:

```
@Controller
public class PortfolioController {

    @MessageMapping("/trade")
    @SendToUser("/queue/position-updates")
    public TradeResult executeTrade(Trade trade, Principal principal) {
        // ...
        return tradeResult;
    }
}
```

If the user has more than one session, by default, all of the sessions subscribed to the given destination are targeted. However, sometimes, it may be necessary to target only the session that sent the message being handled. You can do so by setting the `broadcast` attribute to false, as the following example shows:

```
@Controller
public class MyController {

    @MessageMapping("/action")
    public void handleAction() throws Exception{
        // raise MyBusinessException here
    }

    @MessageExceptionHandler
    @SendToUser(destinations="/queue/errors", broadcast=false)
    public ApplicationError handleException(MyBusinessException exception) {
        // ...
        return appError;
    }
}
```



While user destinations generally imply an authenticated user, it is not strictly required. A WebSocket session that is not associated with an authenticated user can subscribe to a user destination. In such cases, the `@SendToUser` annotation behaves exactly the same as with `broadcast=false` (that is, targeting only the session that sent the message being handled).

You can send a message to user destinations from any application component by, for example, injecting the `SimpMessagingTemplate` created by the Java configuration or the XML namespace. (The bean name is `"brokerMessagingTemplate"` if required for qualification with `@Qualifier`.) The following example shows how to do so:

```

@Service
public class TradeServiceImpl implements TradeService {

    private final SimpMessagingTemplate messagingTemplate;

    @Autowired
    public TradeServiceImpl(SimpMessagingTemplate messagingTemplate) {
        this.messagingTemplate = messagingTemplate;
    }

    // ...

    public void afterTradeExecuted(Trade trade) {
        this.messagingTemplate.convertAndSendToUser(
            trade.getUserName(), "/queue/position-updates", trade.getResult()
        );
    }
}

```



When you use user destinations with an external message broker, you should check the broker documentation on how to manage inactive queues, so that, when the user session is over, all unique user queues are removed. For example, RabbitMQ creates auto-delete queues when you use destinations such as `/exchange/amq.direct/position-updates`. So, in that case, the client could subscribe to `/user/exchange/amq.direct/position-updates`. Similarly, ActiveMQ has [configuration options](#) for purging inactive destinations.

In a multi-application server scenario, a user destination may remain unresolved because the user is connected to a different server. In such cases, you can configure a destination to broadcast unresolved messages so that other servers have a chance to try. This can be done through the `userDestinationBroadcast` property of the `MessageBrokerRegistry` in Java configuration and the `user-destination-broadcast` attribute of the `message-broker` element in XML.

4.4.15. Order of Messages

Messages from the broker are published to the `clientOutboundChannel`, from where they are written to WebSocket sessions. As the channel is backed by a `ThreadPoolExecutor`, messages are processed in different threads, and the resulting sequence received by the client may not match the exact order of publication.

If this is an issue, enable the `setPreservePublishOrder` flag, as the following example shows:

```

@Configuration
@EnableWebSocketMessageBroker
public class MyConfig implements WebSocketMessageBrokerConfigurer {

    @Override
    protected void configureMessageBroker(MessageBrokerRegistry registry) {
        // ...
        registry.setPreservePublishOrder(true);
    }

}

```

The following example shows the XML configuration equivalent of the preceding example:

```

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

    <websocket:message-broker preserve-publish-order="true">
        <!-- ... -->
    </websocket:message-broker>

</beans>

```

When the flag is set, messages within the same client session are published to the `clientOutboundChannel` one at a time, so that the order of publication is guaranteed. Note that this incurs a small performance overhead, so you should enable it only if it is required.

4.4.16. Events

Several `ApplicationContext` events are published and can be received by implementing Spring's `ApplicationListener` interface:

- **BrokerAvailabilityEvent**: Indicates when the broker becomes available or unavailable. While the “simple” broker becomes available immediately on startup and remains so while the application is running, the STOMP “broker relay” can lose its connection to the full featured broker (for example, if the broker is restarted). The broker relay has reconnect logic and re-establishes the “system” connection to the broker when it comes back. As a result, this event is published whenever the state changes from connected to disconnected and vice-versa.

Components that use the `SimpMessagingTemplate` should subscribe to this event and avoid sending messages at times when the broker is not available. In any case, they should be prepared to handle `MessageDeliveryException` when sending a message.

- `SessionConnectEvent`: Published when a new STOMP CONNECT is received to indicate the start of a new client session. The event contains the message that represents the connect, including the session ID, user information (if any), and any custom headers the client sent. This is useful for tracking client sessions. Components subscribed to this event can wrap the contained message with `SimpMessageHeaderAccessor` or `StompMessageHeaderAccessor`.
- `SessionConnectedEvent`: Published shortly after a `SessionConnectEvent` when the broker has sent a STOMP CONNECTED frame in response to the CONNECT. At this point, the STOMP session can be considered fully established.
- `SessionSubscribeEvent`: Published when a new STOMP SUBSCRIBE is received.
- `SessionUnsubscribeEvent`: Published when a new STOMP UNSUBSCRIBE is received.
- `SessionDisconnectEvent`: Published when a STOMP session ends. The DISCONNECT may have been sent from the client or it may be automatically generated when the WebSocket session is closed. In some cases, this event is published more than once per session. Components should be idempotent with regard to multiple disconnect events.



When you use a full-featured broker, the STOMP “broker relay” automatically reconnects the “system” connection if broker becomes temporarily unavailable. Client connections, however, are not automatically reconnected. Assuming heartbeats are enabled, the client typically notices the broker is not responding within 10 seconds. Clients need to implement their own reconnecting logic.

4.4.17. Interception

Events provide notifications for the lifecycle of a STOMP connection but not for every client message. Applications can also register a `ChannelInterceptor` to intercept any message and in any part of the processing chain. The following example shows how to intercept inbound messages from clients:

```
@Configuration  
@EnableWebSocketMessageBroker  
public class WebSocketConfig implements WebSocketMessageBrokerConfigurer {  
  
    @Override  
    public void configureClientInboundChannel(ChannelRegistration registration) {  
        registration.interceptors(new MyChannelInterceptor());  
    }  
}
```

A custom `ChannelInterceptor` can use `StompHeaderAccessor` or `SimpMessageHeaderAccessor` to access information about the message, as the following example shows:

```

public class MyChannelInterceptor implements ChannelInterceptor {

    @Override
    public Message<?> preSend(Message<?> message, MessageChannel channel) {
        StompHeaderAccessor accessor = StompHeaderAccessor.wrap(message);
        StompCommand command = accessor.getStompCommand();
        // ...
        return message;
    }
}

```

Applications can also implement `ExecutorChannelInterceptor`, which is a sub-interface of `ChannelInterceptor` with callbacks in the thread in which the messages are handled. While a `ChannelInterceptor` is invoked once for each message sent to a channel, the `ExecutorChannelInterceptor` provides hooks in the thread of each `MessageHandler` subscribed to messages from the channel.

Note that, as with the `SesionDisconnectEvent` described earlier, a DISCONNECT message can be from the client or it can also be automatically generated when the WebSocket session is closed. In some cases, an interceptor may intercept this message more than once for each session. Components should be idempotent with regard to multiple disconnect events.

4.4.18. STOMP Client

Spring provides a STOMP over WebSocket client and a STOMP over TCP client.

To begin, you can create and configure `WebSocketStompClient`, as the following example shows:

```

WebSocketClient webSocketClient = new StandardWebSocketClient();
WebSocketStompClient stompClient = new WebSocketStompClient(webSocketClient);
stompClient.setMessageConverter(new StringMessageConverter());
stompClient.setTaskScheduler(taskScheduler); // for heartbeats

```

In the preceding example, you could replace `StandardWebSocketClient` with `SockJsClient`, since that is also an implementation of `WebSocketClient`. The `SockJsClient` can use WebSocket or HTTP-based transport as a fallback. For more details, see `SockJsClient`.

Next, you can establish a connection and provide a handler for the STOMP session, as the following example shows:

```
String url = "ws://127.0.0.1:8080/endpoint";
StompSessionHandler sessionHandler = new MyStompSessionHandler();
stompClient.connect(url, sessionHandler);
```

When the session is ready for use, the handler is notified, as the following example shows:

```
public class MyStompSessionHandler extends StompSessionHandlerAdapter {

    @Override
    public void afterConnected(StompSession session, StompHeaders
connectedHeaders) {
        // ...
    }
}
```

Once the session is established, any payload can be sent and is serialized with the configured [MessageConverter](#), as the following example shows:

```
session.send("/topic/something", "payload");
```

You can also subscribe to destinations. The [subscribe](#) methods require a handler for messages on the subscription and returns a [Subscription](#) handle that you can use to unsubscribe. For each received message, the handler can specify the target [Object](#) type to which the payload should be deserialized, as the following example shows:

```
session.subscribe("/topic/something", new StompFrameHandler() {

    @Override
    public Type getPayloadType(StompHeaders headers) {
        return String.class;
    }

    @Override
    public void handleFrame(StompHeaders headers, Object payload) {
        // ...
    }

});
```

To enable STOMP heartbeat, you can configure `WebSocketStompClient` with a `TaskScheduler` and optionally customize the heartbeat intervals (10 seconds for write inactivity, which causes a heartbeat to be sent, and 10 seconds for read inactivity, which closes the connection).



When you use `WebSocketStompClient` for performance tests to simulate thousands of clients from the same machine, consider turning off heartbeats, since each connection schedules its own heartbeat tasks and that is not optimized for a large number of clients running on the same machine.

The STOMP protocol also supports receipts, where the client must add a `receipt` header to which the server responds with a RECEIPT frame after the send or subscribe are processed. To support this, the `StompSession` offers `setAutoReceipt(boolean)` that causes a `receipt` header to be added on every subsequent send or subscribe event. Alternatively, you can also manually add a receipt header to the `StompHeaders`. Both send and subscribe return an instance of `Receiptable` that you can use to register for receipt success and failure callbacks. For this feature, you must configure the client with a `TaskScheduler` and the amount of time before a receipt expires (15 seconds by default).

Note that `StompSessionHandler` itself is a `StompFrameHandler`, which lets it handle ERROR frames in addition to the `handleException` callback for exceptions from the handling of messages and `handleTransportError` for transport-level errors including `ConnectionLostException`.

4.4.19. WebSocket Scope

Each WebSocket session has a map of attributes. The map is attached as a header to inbound client messages and may be accessed from a controller method, as the following example shows:

```
@Controller
public class MyController {

    @MessageMapping("/action")
    public void handle(SimpMessageHeaderAccessor headerAccessor) {
        Map<String, Object> attrs = headerAccessor.getSessionAttributes();
        // ...
    }
}
```

You can declare a Spring-managed bean in the `websocket` scope. You can inject WebSocket-scoped beans into controllers and any channel interceptors registered on the `clientInboundChannel`. Those are typically singletons and live longer than any individual WebSocket session. Therefore, you need to use a scope proxy mode for WebSocket-scoped beans, as the following example shows:

```

@Component
@Scope(scopeName = "websocket", proxyMode = ScopedProxyMode.TARGET_CLASS)
public class MyBean {

    @PostConstruct
    public void init() {
        // Invoked after dependencies injected
    }

    // ...

    @PreDestroy
    public void destroy() {
        // Invoked when the WebSocket session ends
    }
}

@Controller
public class MyController {

    private final MyBean myBean;

    @Autowired
    public MyController(MyBean myBean) {
        this.myBean = myBean;
    }

    @MessageMapping("/action")
    public void handle() {
        // this.myBean from the current WebSocket session
    }
}

```

As with any custom scope, Spring initializes a new `MyBean` instance the first time it is accessed from the controller and stores the instance in the WebSocket session attributes. The same instance is subsequently returned until the session ends. WebSocket-scoped beans have all Spring lifecycle methods invoked, as shown in the preceding examples.

4.4.20. Performance

There is no silver bullet when it comes to performance. Many factors affect it, including the size and volume of messages, whether application methods perform work that requires blocking, and external factors (such as network speed and other issues). The goal of this section is to provide an overview of the available configuration options along with some thoughts on how to reason about scaling.

In a messaging application, messages are passed through channels for asynchronous executions

that are backed by thread pools. Configuring such an application requires good knowledge of the channels and the flow of messages. Therefore, it is recommended to review [Flow of Messages](#).

The obvious place to start is to configure the thread pools that back the `clientInboundChannel` and the `clientOutboundChannel`. By default, both are configured at twice the number of available processors.

If the handling of messages in annotated methods is mainly CPU-bound, the number of threads for the `clientInboundChannel` should remain close to the number of processors. If the work they do is more IO-bound and requires blocking or waiting on a database or other external system, the thread pool size probably needs to be increased.

`ThreadPoolExecutor` has three important properties: the core thread pool size, the max thread pool size, and the capacity for the queue to store tasks for which there are no available threads.



A common point of confusion is that configuring the core pool size (for example, 10) and max pool size (for example, 20) results in a thread pool with 10 to 20 threads. In fact, if the capacity is left at its default value of `Integer.MAX_VALUE`, the thread pool never increases beyond the core pool size, since all additional tasks are queued.

See the javadoc of `ThreadPoolExecutor` to learn how these properties work and understand the various queuing strategies.

On the `clientOutboundChannel` side, it is all about sending messages to WebSocket clients. If clients are on a fast network, the number of threads should remain close to the number of available processors. If they are slow or on low bandwidth, they take longer to consume messages and put a burden on the thread pool. Therefore, increasing the thread pool size becomes necessary.

While the workload for the `clientInboundChannel` is possible to predict—after all, it is based on what the application does—how to configure the "clientOutboundChannel" is harder, as it is based on factors beyond the control of the application. For this reason, two additional properties relate to the sending of messages: `sendTimeLimit` and `sendBufferSizeLimit`. You can use those methods to configure how long a send is allowed to take and how much data can be buffered when sending messages to a client.

The general idea is that, at any given time, only a single thread can be used to send to a client. All additional messages, meanwhile, get buffered, and you can use these properties to decide how long sending a message is allowed to take and how much data can be buffered in the meantime. See the javadoc and documentation of the XML schema for important additional details.

The following example shows a possible configuration:

```

@Configuration
@EnableWebSocketMessageBroker
public class WebSocketConfig implements WebSocketMessageBrokerConfigurer {

    @Override
    public void configureWebSocketTransport(WebSocketTransportRegistration
registration) {
        registration.setSendTimeLimit(15 * 1000).setSendBufferSizeLimit(512 *
1024);
    }

    // ...

}

```

The following example shows the XML configuration equivalent of the preceding example:

```

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

    <websocket:message-broker>
        <websocket:transport send-timeout="15000" send-buffer-size="524288" />
        <!-- ... -->
    </websocket:message-broker>

</beans>

```

You can also use the WebSocket transport configuration shown earlier to configure the maximum allowed size for incoming STOMP messages. In theory, a WebSocket message can be almost unlimited in size. In practice, WebSocket servers impose limits—for example, 8K on Tomcat and 64K on Jetty. For this reason, STOMP clients (such as the JavaScript [webstomp-client](#) and others) split larger STOMP messages at 16K boundaries and send them as multiple WebSocket messages, which requires the server to buffer and re-assemble.

Spring's STOMP-over-WebSocket support does this, so applications can configure the maximum size for STOMP messages irrespective of WebSocket server-specific message sizes. Keep in mind that the WebSocket message size is automatically adjusted, if necessary, to ensure they can carry 16K WebSocket messages at a minimum.

The following example shows one possible configuration:

```
@Configuration
@EnableWebSocketMessageBroker
public class WebSocketConfig implements WebSocketMessageBrokerConfigurer {

    @Override
    public void configureWebSocketTransport(WebSocketTransportRegistration
registration) {
        registration.setMessageSizeLimit(128 * 1024);
    }

    // ...

}
```

The following example shows the XML configuration equivalent of the preceding example:

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

    <websocket:message-broker>
        <websocket:transport message-size="131072" />
        <!-- ... -->
    </websocket:message-broker>

</beans>
```

An important point about scaling involves using multiple application instances. Currently, you cannot do that with the simple broker. However, when you use a full-featured broker (such as RabbitMQ), each application instance connects to the broker, and messages broadcast from one application instance can be broadcast through the broker to WebSocket clients connected through any other application instances.

4.4.21. Monitoring

When you use `@EnableWebSocketMessageBroker` or `<websocket:message-broker>`, key infrastructure components automatically gather statisticss and counters that provide important insight into the internal state of the application. The configuration also declares a bean of type

[WebSocketMessageBrokerStats](#) that gathers all available information in one place and by default logs it at the `INFO` level once every 30 minutes. This bean can be exported to JMX through Spring's [MBeanExporter](#) for viewing at runtime (for example, through JDK's `jconsole`). The following list summarizes the available information:

Client WebSocket Sessions

Current

Indicates how many client sessions there are currently, with the count further broken down by WebSocket versus HTTP streaming and polling SockJS sessions.

Total

Indicates how many total sessions have been established.

Abnormally Closed

Connect Failures

Sessions that got established but were closed after not having received any messages within 60 seconds. This is usually an indication of proxy or network issues.

Send Limit Exceeded

Sessions closed after exceeding the configured send timeout or the send buffer limits, which can occur with slow clients (see previous section).

Transport Errors

Sessions closed after a transport error, such as failure to read or write to a WebSocket connection or HTTP request or response.

STOMP Frames

The total number of CONNECT, CONNECTED, and DISCONNECT frames processed, indicating how many clients connected on the STOMP level. Note that the DISCONNECT count may be lower when sessions get closed abnormally or when clients close without sending a DISCONNECT frame.

STOMP Broker Relay

TCP Connections

Indicates how many TCP connections on behalf of client WebSocket sessions are established to the broker. This should be equal to the number of client WebSocket sessions + 1 additional shared "system" connection for sending messages from within the application.

STOMP Frames

The total number of CONNECT, CONNECTED, and DISCONNECT frames forwarded to or received from the broker on behalf of clients. Note that a DISCONNECT frame is sent to the broker regardless of how the client WebSocket session was closed. Therefore, a lower DISCONNECT frame count is an indication that the broker is pro-actively closing connections (maybe because of a heartbeat that did not arrive in time, an invalid input frame, or other issue).

Client Inbound Channel

Statistics from the thread pool that backs the `clientInboundChannel` that provide insight into the health of incoming message processing. Tasks queueing up here is an indication that the application may be too slow to handle messages. If there I/O bound tasks (for example, slow database queries, HTTP requests to third party REST API, and so on), consider increasing the thread pool size.

Client Outbound Channel

Statistics from the thread pool that backs the `clientOutboundChannel` that provides insight into the health of broadcasting messages to clients. Tasks queueing up here is an indication clients are too slow to consume messages. One way to address this is to increase the thread pool size to accommodate the expected number of concurrent slow clients. Another option is to reduce the send timeout and send buffer size limits (see the previous section).

SockJS Task Scheduler

Statistics from the thread pool of the SockJS task scheduler that is used to send heartbeats. Note that, when heartbeats are negotiated on the STOMP level, the SockJS heartbeats are disabled.

4.4.22. Testing

There are two main approaches to testing applications when you use Spring's STOMP-over-WebSocket support. The first is to write server-side tests to verify the functionality of controllers and their annotated message-handling methods. The second is to write full end-to-end tests that involve running a client and a server.

The two approaches are not mutually exclusive. On the contrary, each has a place in an overall test strategy. Server-side tests are more focused and easier to write and maintain. End-to-end integration tests, on the other hand, are more complete and test much more, but they are also more involved to write and maintain.

The simplest form of server-side tests is to write controller unit tests. However, this is not useful enough, since much of what a controller does depends on its annotations. Pure unit tests simply cannot test that.

Ideally, controllers under test should be invoked as they are at runtime, much like the approach to testing controllers that handle HTTP requests by using the Spring MVC Test framework—that is, without running a Servlet container but relying on the Spring Framework to invoke the annotated controllers. As with Spring MVC Test, you have two possible alternatives here, either use a “context-based” or use a “standalone” setup:

- Load the actual Spring configuration with the help of the Spring TestContext framework, inject `clientInboundChannel` as a test field, and use it to send messages to be handled by controller methods.
- Manually set up the minimum Spring framework infrastructure required to invoke controllers (namely the `SimpAnnotationMethodMessageHandler`) and pass messages for controllers directly to it.

Both of these setup scenarios are demonstrated in the `tests for the stock portfolio` sample application.

The second approach is to create end-to-end integration tests. For that, you need to run a WebSocket server in embedded mode and connect to it as a WebSocket client that sends WebSocket messages containing STOMP frames. The [tests for the stock portfolio](#) sample application also demonstrate this approach by using Tomcat as the embedded WebSocket server and a simple STOMP client for test purposes.

Chapter 5. Other Web Frameworks

This chapter details Spring's integration with third party web frameworks.

One of the core value propositions of the Spring Framework is that of enabling *choice*. In a general sense, Spring does not force you to use or buy into any particular architecture, technology, or methodology (although it certainly recommends some over others). This freedom to pick and choose the architecture, technology, or methodology that is most relevant to a developer and their development team is arguably most evident in the web area, where Spring provides its own web framework ([Spring MVC](#)) while, at the same time, providing integration with a number of popular third party web frameworks.

5.1. Common Configuration

Before diving into the integration specifics of each supported web framework, let us first take a look at the Spring configuration that is not specific to any one web framework. (This section is equally applicable to Spring's own web framework, Spring MVC.)

One of the concepts (for want of a better word) espoused by Spring's lightweight application model is that of a layered architecture. Remember that in a “classic” layered architecture, the web layer is but one of many layers. It serves as one of the entry points into a server-side application, and it delegates to service objects (facades) that are defined in a service layer to satisfy business-specific (and presentation-technology agnostic) use cases. In Spring, these service objects, any other business-specific objects, data-access objects, and others exist in a distinct “business context”, which contains no web or presentation layer objects (presentation objects, such as Spring MVC controllers, are typically configured in a distinct “presentation context”). This section details how you can configure a Spring container (a [WebApplicationContext](#)) that contains all of the ‘business beans’ in your application.

Moving on to specifics, all you one need to do is declare a [ContextLoaderListener](#) in the standard Java EE servlet `web.xml` file of your web application and add a `contextConfigLocation<context-param>` section (in the same file) that defines which set of Spring XML configuration files to load.

Consider the following `<listener>` configuration:

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

Further consider the following `<context-param>` configuration:

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

If you do not specify the `contextConfigLocation` context parameter, the `ContextLoaderListener` looks for a file called `/WEB-INF/applicationContext.xml` to load. Once the context files are loaded, Spring creates a `WebApplicationContext` object based on the bean definitions and stores it in the `ServletContext` of the web application.

All Java web frameworks are built on top of the Servlet API, so you can use the following code snippet to get access to this “business context” `ApplicationContext` created by the `ContextLoaderListener`.

The following example shows how to get the `WebApplicationContext`:

```
WebApplicationContext ctx = WebApplicationContextUtils.getWebApplicationContext
(servlletContext);
```

The `WebApplicationContextUtils` class is for convenience, so you need not remember the name of the `ServletContext` attribute. Its `getWebApplicationContext()` method returns `null` if an object does not exist under the `WebApplicationContext.ROOT_WEB_APPLICATION_CONTEXT_ATTRIBUTE` key. Rather than risk getting `NullPointerExceptions` in your application, it is better to use the `getRequiredWebApplicationContext()` method. This method throws an exception when the `ApplicationContext` is missing.

Once you have a reference to the `WebApplicationContext`, you can retrieve beans by their name or type. Most developers retrieve beans by name and then cast them to one of their implemented interfaces.

Fortunately, most of the frameworks in this section have simpler ways of looking up beans. Not only do they make it easy to get beans from a Spring container, but they also let you use dependency injection on their controllers. Each web framework section has more detail on its specific integration strategies.

5.2. JSF

JavaServer Faces (JSF) is the JCP’s standard component-based, event-driven web user interface framework. As of Java EE 5, it is an official part of the Java EE umbrella.

For a popular JSF runtime as well as for popular JSF component libraries, check out the [Apache MyFaces project](#). The MyFaces project also provides common JSF extensions, such as [MyFaces Orchestra](#) (a Spring-based JSF extension that provides rich conversation scope support).



Spring Web Flow 2.0 provides rich JSF support through its newly established Spring Faces module, both for JSF-centric usage (as described in this section) and for Spring-centric usage (using JSF views within a Spring MVC dispatcher). See the [Spring Web Flow website](#) for details.

The key element in Spring's JSF integration is the JSF `ELResolver` mechanism.

5.2.1. Spring Bean Resolver

`SpringBeanFacesELResolver` is a JSF 1.2+ compliant `ELResolver` implementation, integrating with the standard Unified EL as used by JSF 1.2 and JSP 2.1. As `SpringBeanVariableResolver`, it delegates to Spring's "business context" `WebApplicationContext` first and then to the default resolver of the underlying JSF implementation.

Configuration-wise, you can define `SpringBeanFacesELResolver` in your JSF `faces-context.xml` file, as the following example shows:

```
<faces-config>
  <application>
    <el-resolver>org.springframework.web.jsf.el.SpringBeanFacesELResolver</el-
resolver>
    ...
  </application>
</faces-config>
```

5.2.2. Using FacesContextUtils

A custom `VariableResolver` works well when mapping your properties to beans in `faces-config.xml`, but, at times, you may need to explicitly grab a bean. The `FacesContextUtils` class makes this easy. It is similar to `WebApplicationContextUtils`, except that it takes a `FacesContext` parameter rather than a `ServletContext` parameter.

The following example shows how to use `FacesContextUtils`:

```
ApplicationContext ctx = FacesContextUtils.getWebApplicationContext(FacesContext
  .getCurrentInstance());
```

5.3. Apache Struts 2.x

Invented by Craig McClanahan, `Struts` is an open-source project hosted by the Apache Software Foundation. At the time, it greatly simplified the JSP/Servlet programming paradigm and won over many developers who were using proprietary frameworks. It simplified the programming model, it was open source (and thus free, as in beer), and it had a large community, which let the project

grow and become popular among Java web developers.

Check out the Struts [Spring Plugin](#) for the built-in Spring integration shipped with Struts.

5.4. Tapestry 5.x

[Tapestry](#) is a ""Component oriented framework for creating dynamic, robust, highly scalable web applications in Java.""

While Spring has its own [powerful web layer](#), there are a number of unique advantages to building an enterprise Java application by using a combination of Tapestry for the web user interface and the Spring container for the lower layers.

For more information, see Tapestry's dedicated [integration module for Spring](#).

5.5. Further Resources

The following links go to further resources about the various web frameworks described in this chapter.

- The [JSF](#) homepage
- The [Struts](#) homepage
- The [Tapestry](#) homepage