Web on Servlet Stack

Version 6.0.0-M1

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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 Jakarta EE version ranges, see the Spring Framework Wiki.

1.1. DispatcherServlet

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):

Java

```
public class MyWebApplicationInitializer implements WebApplicationInitializer {

    @Override
    public void onStartup(ServletContext servletContext) {

        // Load Spring web application configuration
        AnnotationConfigWebApplicationContext context = new
AnnotationConfigWebApplicationContext();
        context.register(AppConfig.class);

        // Create and register the DispatcherServlet
        DispatcherServlet servlet = new DispatcherServlet(context);
        ServletRegistration.Dynamic registration = servletContext.addServlet("app",
servlet);
        registration.setLoadOnStartup(1);
        registration.addMapping("/app/*");
    }
}
```

Kotlin

```
class MyWebApplicationInitializer : WebApplicationInitializer {

    override fun onStartup(servletContext: ServletContext) {

        // Load Spring web application configuration
        val context = AnnotationConfigWebApplicationContext()
        context.register(AppConfig::class.java)

        // Create and register the DispatcherServlet
        val servlet = DispatcherServlet(context)
        val registration = servletContext.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>
```

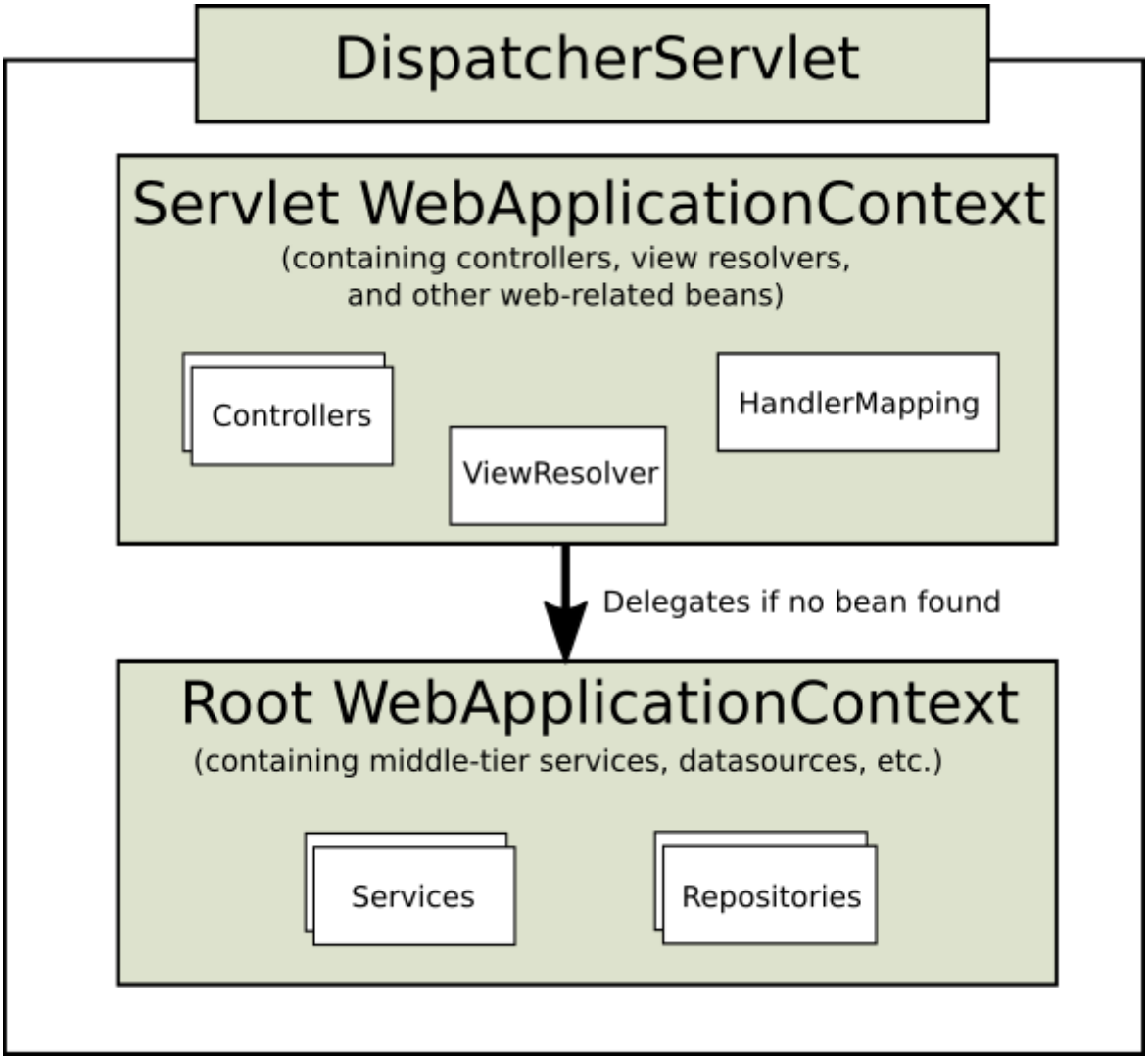
Spring Boot follows a different initialization sequence. Rather than hooking into the lifecycle of the Servlet container, Spring Boot uses Spring configuration to bootstrap itself and the embedded Servlet container. `Filter` and `Servlet` declarations are detected in Spring configuration and registered 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:

Java

```
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/*" };
    }
}
```

Kotlin

```
class MyWebAppInitializer : AbstractAnnotationConfigDispatcherServletInitializer() {

    override fun getRootConfigClasses(): Array<Class<*>> {
        return arrayOf(RootConfig::class.java)
    }

    override fun getServletConfigClasses(): Array<Class<*>> {
        return arrayOf(App1Config::class.java)
    }

    override fun getServletMappings(): Array<String> {
        return arrayOf("/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

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 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 `DispatcherServlet`:

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

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 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`:

Java

```
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("/");
    }
}
```

Kotlin

```
import org.springframework.web.WebApplicationInitializer

class MyWebApplicationInitializer : WebApplicationInitializer {

    override fun onStartup(container: ServletContext) {
        val appContext = XmlWebApplicationContext()
        appContext.setConfigLocation("/WEB-INF/spring/dispatcher-config.xml")

        val registration = container.addServlet("dispatcher",
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:

Java

```
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[] { "/" };
    }
}
```

Kotlin

```
class MyWebAppInitializer : AbstractAnnotationConfigDispatcherServletInitializer() {

    override fun getRootConfigClasses(): Array<Class<*>>? {
        return null
    }

    override fun getServletConfigClasses(): Array<Class<*>>? {
        return arrayOf(MyWebConfig::class.java)
    }

    override fun getServletMappings(): Array<String> {
        return arrayOf("/")
    }
}
```

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

Java

```
public class MyWebAppInitializer extends AbstractDispatcherServletInitializer {

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

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

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

Kotlin

```
class MyWebAppInitializer : AbstractDispatcherServletInitializer() {

    override fun createRootApplicationContext(): WebApplicationContext? {
        return null
    }

    override fun createServletApplicationContext(): WebApplicationContext {
        return XmlWebApplicationContext().apply {
            setConfigLocation("/WEB-INF/spring/dispatcher-config.xml")
        }
    }

    override fun getServletMappings(): Array<String> {
        return arrayOf("/")
    }
}
```

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

Java

```
public class MyWebAppInitializer extends AbstractDispatcherServletInitializer {

    // ...

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

Kotlin

```
class MyWebAppInitializer : AbstractDispatcherServletInitializer() {

    // ...

    override fun getServletFilters(): Array<Filter> {
        return arrayOf(HiddenHttpMethodFilter(), 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

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 multiparts. If multiparts 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 run to prepare a model for 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.

For HTTP caching support, handlers can use the `checkNotModified` methods of `WebRequest`, along with further options for annoated controllers as described in HTTP Caching for Controllers.

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
`contextClass`	Class that implements `ConfigurableWebApplicationContext`, to be instantiated and locally configured by this Servlet. By default, `XmlWebApplicationContext` is used.
`contextConfigLocation`	String that is passed to the context instance (specified by `contextClass`) 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.
`namespace`	Namespace of the `WebApplicationContext`. Defaults to `[servlet-name]-servlet`.

Parameter	Explanation
`throwExceptionIfNoHandlerFound`	Whether to throw a `NoHandlerFoundException` when no handler was found for a request. The exception can then be caught with a `HandlerExceptionResolver` (for example, by using an `@ExceptionHandler` controller method) and handled as any others. By default, this is set to `false`, in which case the `DispatcherServlet` sets the response status to 404 (NOT_FOUND) without raising an exception. Note that, if default servlet handling is also configured, unresolved requests are always forwarded to the default servlet and a 404 is never raised.

1.1.6. Path Matching

The Servlet API exposes the full request path as `requestURI` and further sub-divides it into `contextPath`, `servletPath`, and `pathInfo` whose values vary depending on how a Servlet is mapped. From these inputs, Spring MVC needs to determine the lookup path to use for handler mapping, which is the path within the mapping of the `DispatcherServlet` itself, excluding the `contextPath` and any `servletMapping` prefix, if present.

The `servletPath` and `pathInfo` are decoded and that makes them impossible to compare directly to the full `requestURI` in order to derive the lookupPath and that makes it necessary to decode the `requestURI`. However this introduces its own issues because the path may contain encoded reserved characters such as `"/"` or `";"` that can in turn alter the structure of the path after they are decoded which can also lead to security issues. In addition, Servlet containers may normalize the `servletPath` to varying degrees which makes it further impossible to perform `startsWith` comparisons against the `requestURI`.

This is why it is best to avoid reliance on the `servletPath` which comes with the prefix-based `servletPath` mapping type. If the `DispatcherServlet` is mapped as the default Servlet with `"/"` or otherwise without a prefix with `"/*"` and the Servlet container is 4.0+ then Spring MVC is able to detect the Servlet mapping type and avoid use of the `servletPath` and `pathInfo` altogether. On a 3.1 Servlet container, assuming the same Servlet mapping types, the equivalent can be achieved by providing a `UrlPathHelper` with `alwaysUseFullPath=true` via Path Matching in the MVC config.

Fortunately the default Servlet mapping `"/"` is a good choice. However, there is still an issue in that the `requestURI` needs to be decoded to make it possible to compare to controller mappings. This is again undesirable because of the potential to decode reserved characters that alter the path structure. If such characters are not expected, then you can reject them (like the Spring Security HTTP firewall), or you can configure `UrlPathHelper` with `urlDecode=false` but controller mappings will need to match to the encoded path which may not always work well. Furthermore, sometimes the `DispatcherServlet` needs to share the URL space with another Servlet and may need to be mapped by prefix.

The above issues can be addressed more comprehensively by switching from `PathMatcher` to the parsed `PathPattern` available in 5.3 or higher, see Pattern Comparison. Unlike `AntPathMatcher` which needs either the lookup path decoded or the controller mapping encoded, a parsed `PathPattern` matches to a parsed representation of the path called `RequestPath`, one path segment at a time. This allows decoding and sanitizing path segment values individually without the risk of altering the structure of the path. Parsed `PathPattern` also supports the use of `servletPath` prefix mapping as long as the prefix is kept simple and does not have any characters that need to be encoded.

1.1.7. 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 run
- `postHandle(..)`: After the handler is run
- `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`.

1.1.8. Exceptions

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

HandlerExceptionResolver	Description
SimpleMappingExceptionResolver	A mapping between exception class names and error view names. Useful for rendering error pages in a browser application.
DefaultHandlerExceptionResolver	Resolves exceptions raised by Spring MVC and maps them to HTTP status codes. See also alternative ResponseEntityExceptionHandler and REST API exceptions.
ResponseStatusExceptionResolver	Resolves exceptions with the @ResponseStatus annotation and maps them to HTTP status codes based on the value in the annotation.
ExceptionHandlerExceptionResolver	Resolves exceptions by invoking an @ExceptionHandler method in a @Controller or a @ControllerAdvice class. See @ExceptionHandler 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:

Java

```
@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("jakarta.servlet.error.status_code"));
        map.put("reason", request.getAttribute("jakarta.servlet.error.message"));
        return map;
    }
}
```

Kotlin

```
@RestController
class ErrorController {

    @RequestMapping(path = ["/error"])
    fun handle(request: HttpServletRequest): Map<String, Any> {
        val map = HashMap<String, Any>()
        map["status"] = request.getAttribute("jakarta.servlet.error.status_code")
        map["reason"] = request.getAttribute("jakarta.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`.

1.1.9. View Resolution

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
`AbstractCachingViewResolver`	Subclasses of `AbstractCachingViewResolver` cache view instances that they resolve. Caching improves performance of certain view technologies. You can turn off the cache by setting the `cache` property to `false`. Furthermore, if you must refresh a certain view at runtime (for example, when a FreeMarker template is modified), you can use the `removeFromCache(String viewName, Locale loc)` method.
`UrlBasedViewResolver`	Simple implementation of the `ViewResolver` interface that effects 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 `setViewClass(..)`. 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.
`BeanNameViewResolver`	Implementation of the `ViewResolver` interface that interprets a view name as a bean name in the current application context. This is a very flexible variant which allows for mixing and matching different view types based on distinct view names. Each such `View` can be defined as a bean e.g. in XML or in configuration classes.

Handling

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

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:https://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

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.

1.1.10. 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
`cookieName`	classname + LOCALE	The name of the cookie
`cookieMaxAge`	Servlet container default	The maximum time a cookie persists on the client. If `-1` is specified, the cookie will not be persisted. It is available only until the client shuts down the browser.
`cookiePath`	/	Limits the visibility of the cookie to a certain part of your site. When `cookiePath` 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 ends.

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, `https://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>
```

1.1.11. 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="<spring:theme code='styleSheet'/>"
type="text/css"/>
    </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
`FixedThemeResolver`	Selects a fixed theme, set by using the `defaultThemeName` property.
`SessionThemeResolver`	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.
`CookieThemeResolver`	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.

1.1.12. Multipart Resolver

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 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 a content type of `multipart/form-data` is received, the resolver parses the content wraps the current `HttpServletRequest` as a `MultipartHttpServletRequest` to provide access to resolved files in addition to exposing parts 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 the `commons-fileupload` jar as a dependency on your classpath.

This resolver variant delegates to a local library within the application, providing maximum portability across Servlet containers. As an alternative, consider standard Servlet multipart resolution through the container's own parser as discussed below.

> Commons FileUpload traditionally applies to POST requests only but accepts any `multipart/` content type. See the `CommonsMultipartResolver` javadoc for details and configuration options.

Servlet Multipart Parsing

Servlet 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:

Java

```
public class AppInitializer extends
AbstractAnnotationConfigDispatcherServletInitializer {

    // ...

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

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

}
```

Kotlin

```
class AppInitializer : AbstractAnnotationConfigDispatcherServletInitializer() {

    // ...

    override fun customizeRegistration(registration: ServletRegistration.Dynamic) {

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

}
```

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

> This resolver variant uses your Servlet container's multipart parser as-is, potentially exposing the application to container implementation differences. By default, it will try to parse any `multipart/` content type with any HTTP method but this may not be supported across all Servlet containers. See the `StandardServletMultipartResolver` javadoc for details and configuration options.

1.1.13. Logging

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

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:

Java

```
public class MyInitializer
        extends AbstractAnnotationConfigDispatcherServletInitializer {

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

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

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

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

}
```

Kotlin

```
class MyInitializer : AbstractAnnotationConfigDispatcherServletInitializer() {

    override fun getRootConfigClasses(): Array<Class<*>>? {
        return ...
    }

    override fun getServletConfigClasses(): Array<Class<*>>? {
        return ...
    }

    override fun getServletMappings(): Array<String> {
        return ...
    }

    override fun customizeRegistration(registration: ServletRegistration.Dynamic) {
        registration.setInitParameter("enableLoggingRequestDetails", "true")
    }
}
```

1.2. Filters

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

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 request in order to a) change the host, port, and scheme based on `Forwarded` headers, and b) to remove those headers to eliminate further impact. The filter relies on wrapping the request, and therefore it must be ordered ahead of other filters, such as `RequestContextFilter`, that should work with the modified and not the original request.

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.

In order to support asynchronous requests and error dispatches this filter should be mapped with `DispatcherType.ASYNC` and also `DispatcherType.ERROR`. If using Spring Framework's `AbstractAnnotationConfigDispatcherServletInitializer` (see Servlet Config) all filters are

automatically registered for all dispatch types. However if registering the filter via `web.xml` or in Spring Boot via a `FilterRegistrationBean` be sure to include `DispatcherType.ASYNC` and `DispatcherType.ERROR` in addition to `DispatcherType.REQUEST`.

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).

In order to support asynchronous requests this filter must be mapped with `DispatcherType.ASYNC` so that the filter can delay and successfully generate an ETag to the end of the last async dispatch. If using Spring Framework's `AbstractAnnotationConfigDispatcherServletInitializer` (see Servlet Config) all filters are automatically registered for all dispatch types. However if registering the filter via `web.xml` or in Spring Boot via a `FilterRegistrationBean` be sure to include `DispatcherType.ASYNC`.

1.2.4. CORS

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

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:

Java

```
@Controller
public class HelloController {

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

Kotlin

```
import org.springframework.ui.set

@Controller
class HelloController {

    @GetMapping("/hello")
    fun handle(model: Model): String {
        model["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

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:

Java

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

    // ...
}
```

Kotlin

```
@Configuration
@ComponentScan("org.example.web")
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
        https://www.springframework.org/schema/beans/spring-beans.xsd
        http://www.springframework.org/schema/context
        https://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

WebFlux

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 automatically the case with such annotations directly on the controller.

If the controller implements an interface, and needs AOP proxying, you may need to explicitly configure class-based proxying. For example, with `@EnableTransactionManagement` you can change to `@EnableTransactionManagement(proxyTargetClass = true)`, and with `<tx:annotation-driven/>` you can change to `<tx:annotation-driven proxy-target-class="true"/>`.

> Keep in mind that as of 6.0, with interface proxying, Spring MVC no longer detects controllers based solely on a type-level `@RequestMapping` annotation on the interface. Please, enable class based proxying, or otherwise the interface must also have an `@Controller` annotation.

1.3.2. Request Mapping

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. A `@RequestMapping` is still needed at the class level to express shared mappings.

The following example has type and method level mappings:

Java

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

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

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

Kotlin

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

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

    @PostMapping
    @ResponseStatus(HttpStatus.CREATED)
    fun add(@RequestBody person: Person) {
        // ...
    }
}
```

URI patterns

WebFlux

`@RequestMapping` methods can be mapped using URL patterns. There are two alternatives:

- `PathPattern` — a pre-parsed pattern matched against the URL path also pre-parsed as `PathContainer`. Designed for web use, this solution deals effectively with encoding and path parameters, and matches efficiently.
- `AntPathMatcher` — match String patterns against a String path. This is the original solution also used in Spring configuration to select resources on the classpath, on the filesystem, and other locations. It is less efficient and the String path input is a challenge for dealing effectively with encoding and other issues with URLs.

`PathPattern` is the recommended solution for web applications and it is the only choice in Spring WebFlux. Prior to version 5.3, `AntPathMatcher` was the only choice in Spring MVC and continues to be the default. However `PathPattern` can be enabled in the MVC config.

`PathPattern` supports the same pattern syntax as `AntPathMatcher`. In addition it also supports the capturing pattern, e.g. `{*spring}`, for matching 0 or more path segments at the end of a path. `PathPattern` also restricts the use of `**` for matching multiple path segments such that it's only allowed at the end of a pattern. This eliminates many cases of ambiguity when choosing the best matching pattern for a given request. For full pattern syntax please refer to PathPattern and AntPathMatcher.

Some example patterns:

- `"/resources/ima?e.png"` - match one character in a path segment
- `"/resources/*.png"` - match zero or more characters in a path segment
- `"/resources/**"` - match multiple path segments
- `"/projects/{project}/versions"` - match a path segment and capture it as a variable
- `"/projects/{project:[a-z]+}/versions"` - match and capture a variable with a regex

Captured URI variables can be accessed with `@PathVariable`. For example:

Java

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

Kotlin

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

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

Java

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

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

Kotlin

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

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

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:

Java

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

Kotlin

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

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.

Pattern Comparison

WebFlux

When multiple patterns match a URL, the best match must be selected. This is done with one of the following depending on whether use of parsed `PathPattern` is enabled for use or not:

- `PathPattern.SPECIFICITY_COMPARATOR`
- `AntPathMatcher.getPatternComparator(String path)`

Both help to sort patterns with more specific ones on top. A pattern is less specific if it has a lower count of URI variables (counted as 1), 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, follow the above links to the pattern Comparators.

Suffix Match

Starting in 5.3, by default Spring MVC no longer performs `.*` suffix pattern matching where a controller mapped to `/person` is also implicitly mapped to `/person.*`. As a consequence path extensions are no longer used to interpret the requested content type for the response — for example, `/person.pdf`, `/person.xml`, and so on.

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 becomes more difficult.

To completely disable the use of path extensions in versions prior to 5.3, set the following:

- `useSuffixPatternMatching(false)`, see PathMatchConfigurer
- `favorPathExtension(false)`, see ContentNegotiationConfigurer

Having a way to request content types other than through the `"Accept"` header can still be useful, e.g. when typing a URL in a browser. A safe alternative to path extensions is to use the query parameter strategy. 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 allowed as safe 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 allowed as safe 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

WebFlux

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

Java

```
@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.

Kotlin

```
@PostMapping("/pets", consumes = ["application/json"]) ①
fun 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

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:

Java

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

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

Kotlin

```
@GetMapping("/pets/{petId}", produces = ["application/json"]) ①
@ResponseBody
fun getPet(@PathVariable petId: String): Pet {
    // ...
}
```

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".

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_VALUE` and `APPLICATION_XML_VALUE`.

Parameters, headers

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:

Java

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

① Testing whether `myParam` equals `myValue`.

Kotlin

```
@GetMapping("/pets/{petId}", params = ["myParam=myValue"]) ①
fun findPet(@PathVariable petId: String) {
    // ...
}
```

① Testing whether `myParam` equals `myValue`.

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

Java

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

① Testing whether `myHeader` equals `myValue`.

Kotlin

```
@GetMapping("/pets", headers = ["myHeader=myValue"]) ①
fun findPet(@PathVariable petId: String) {
    // ...
}
```

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

HTTP HEAD, OPTIONS

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 `jakarta.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

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

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:

Java

```
@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.

Kotlin

```
@Configuration
class MyConfig {

    @Autowired
    fun setHandlerMapping(mapping: RequestMappingHandlerMapping, handler: UserHandler)
{ ①
        val info =
RequestMappingInfo.paths("/user/{id}").methods(RequestMethod.GET).build() ②
        val method = UserHandler::class.java.getMethod("getUser", Long::class.java) 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

WebFlux

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

Method Arguments

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
`WebRequest`, `NativeWebRequest`	Generic access to request parameters and request and session attributes, without direct use of the Servlet API.
`jakarta.servlet.ServletRequest`, `jakarta.servlet.ServletResponse`	Choose any specific request or response type — for example, `ServletRequest`, `HttpServletRequest`, or Spring's `MultipartRequest`, `MultipartHttpServletRequest`.
`jakarta.servlet.http.HttpSession`	Enforces the presence of a session. As a consequence, such an argument is never `null`. Note that session access is not thread-safe. Consider setting the `RequestMappingHandlerAdapter` instance's `synchronizeOnSession` flag to `true` if multiple requests are allowed to concurrently access a session.
`jakarta.servlet.http.PushBuilder`	Servlet 4.0 push builder API for programmatic HTTP/2 resource pushes. Note that, per the Servlet specification, the injected `PushBuilder` instance can be null if the client does not support that HTTP/2 feature.
`java.security.Principal`	Currently authenticated user — possibly a specific `Principal` implementation class if known. Note that this argument is not resolved eagerly, if it is annotated in order to allow a custom resolver to resolve it before falling back on default resolution via `HttpServletRequest#getUserPrincipal`. For example, the Spring Security `Authentication` implements `Principal` and would be injected as such via `HttpServletRequest#getUserPrincipal`, unless it is also annotated with `@AuthenticationPrincipal` in which case it is resolved by a custom Spring Security resolver through `Authentication#getPrincipal`.
`HttpMethod`	The HTTP method of the request.

Controller method argument	Description
`java.util.Locale`	The current request locale, determined by the most specific `LocaleResolver` available (in effect, the configured `LocaleResolver` or `LocaleContextResolver`).
`java.util.TimeZone` + `java.time.ZoneId`	The time zone associated with the current request, as determined by a `LocaleContextResolver`.
`java.io.InputStream`, `java.io.Reader`	For access to the raw request body as exposed by the Servlet API.
`java.io.OutputStream`, `java.io.Writer`	For access to the raw response body as exposed by the Servlet API.
`@PathVariable`	For access to URI template variables. See URI patterns.
`@MatrixVariable`	For access to name-value pairs in URI path segments. See Matrix Variables.
`@RequestParam`	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 `@RequestParam` is optional for simple parameter values. See “Any other argument”, at the end of this table.
`@RequestHeader`	For access to request headers. Header values are converted to the declared method argument type. See `@RequestHeader`.
`@CookieValue`	For access to cookies. Cookies values are converted to the declared method argument type. See `@CookieValue`.
`@RequestBody`	For access to the HTTP request body. Body content is converted to the declared method argument type by using `HttpMessageConverter` implementations. See `@RequestBody`.
`HttpEntity<B>`	For access to request headers and body. The body is converted with an `HttpMessageConverter`. See HttpEntity.
`@RequestPart`	For access to a part in a `multipart/form-data` request, converting the part’s body with an `HttpMessageConverter`. See Multipart.
`java.util.Map`, `org.springframework.ui.Model`, `org.springframework.ui.ModelMap`	For access to the model that is used in HTML controllers and exposed to templates as part of view rendering.
`RedirectAttributes`	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.

Controller method argument	Description
`@ModelAttribute`	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 `@ModelAttribute` is optional (for example, to set its attributes). See “Any other argument” at the end of this table.
`Errors`, `BindingResult`	For access to errors from validation and data binding for a command object (that is, a `@ModelAttribute` argument) or errors from the validation of a `@RequestBody` or `@RequestPart` arguments. You must declare an `Errors`, or `BindingResult` argument immediately after the validated method argument.
`SessionStatus` + class-level `@SessionAttributes`	For marking form processing complete, which triggers cleanup of session attributes declared through a class-level `@SessionAttributes` annotation. See `@SessionAttributes` for more details.
`UriComponentsBuilder`	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.
`@SessionAttribute`	For access to any session attribute, in contrast to model attributes stored in the session as a result of a class-level `@SessionAttributes` declaration. See `@SessionAttribute` for more details.
`@RequestAttribute`	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 BeanUtils#isSimpleProperty, it is resolved as a `@RequestParam`. Otherwise, it is resolved as a `@ModelAttribute`.

Return Values

WebFlux

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

Controller method return value	Description
`@ResponseBody`	The return value is converted through `HttpMessageConverter` implementations and written to the response. See `@ResponseBody`.
`HttpEntity<B>`, `ResponseEntity<B>`	The return value that specifies the full response (including HTTP headers and body) is to be converted through `HttpMessageConverter` implementations and written to the response. See ResponseEntity.

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

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

Type Conversion

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.

A practical issue in type conversion is the treatment of an empty String source value. Such a value is treated as missing if it becomes `null` as a result of type conversion. This can be the case for `Long`, `UUID`, and other target types. If you want to allow `null` to be injected, either use the `required` flag on the argument annotation, or declare the argument as `@Nullable`.

As of 5.3, non-null arguments will be enforced even after type conversion. If your handler method intends to accept a null value as well, either declare your argument as `@Nullable` or mark it as `required=false` in the corresponding `@RequestParam`, etc. annotation. This is a best practice and the recommended solution for regressions encountered in a 5.3 upgrade.

Alternatively, you may specifically handle e.g. the resulting `MissingPathVariableException` in the case of a required `@PathVariable`. A null value after conversion will be treated like an empty original value, so the corresponding `Missing…Exception` variants will be thrown.

Matrix Variables

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:

Java

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

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

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

Kotlin

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

@GetMapping("/pets/{petId}")
fun findPet(@PathVariable petId: String, @MatrixVariable q: Int) {

    // 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:

Java

```
// 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
}
```

Kotlin

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

@GetMapping("/owners/{ownerId}/pets/{petId}")
fun findPet(
        @MatrixVariable(name = "q", pathVar = "ownerId") q1: Int,
        @MatrixVariable(name = "q", pathVar = "petId") q2: Int) {

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

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

Java

```
// GET /pets/42

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

    // q == 1
}
```

Kotlin

```
// GET /pets/42

@GetMapping("/pets/{petId}")
fun findPet(@MatrixVariable(required = false, defaultValue = "1") q: Int) {

    // q == 1
}
```

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

Java

```
// 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]
}
```

Kotlin

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

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

    // 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`

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:

Java

```
@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`.

Kotlin

```
import org.springframework.ui.set

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

    // ...

    @GetMapping
    fun setupForm(@RequestParam("petId") petId: Int, model: Model): String { ①
        val pet = this.clinic.loadPet(petId);
        model["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`

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:

Java

```
@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.

Kotlin

```
@GetMapping("/demo")
fun handle(
        @RequestHeader("Accept-Encoding") encoding: String, ①
        @RequestHeader("Keep-Alive") keepAlive: Long) { 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`

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:

Java

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

① Get the value of the `JSESSIONID` cookie.

Kotlin

```
@GetMapping("/demo")
fun handle(@CookieValue("JSESSIONID") cookie: String) { 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`

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:

Java

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

Kotlin

```
@PostMapping("/owners/{ownerId}/pets/{petId}/edit")
fun processSubmit(@ModelAttribute pet: Pet): String {
    // method logic...
}
```

The `Pet` instance above is sourced in one of the following ways:

- Retrieved from the model where it may have been added by a @ModelAttribute method.
- Retrieved from the HTTP session if the model attribute was listed in the class-level `@SessionAttributes` annotation.
- Obtained through a `Converter` where the model attribute name matches the name of a request value such as a path variable or a request parameter (see next example).
- Instantiated using its default constructor.
- Instantiated through 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.

One alternative to using a @ModelAttribute method to supply it or relying on the framework to create the model attribute, is to have a `Converter<String, T>` to provide the instance. This is applied when the model attribute name matches to the name of a request value such as a path variable or a request parameter, and there is a `Converter` from `String` to the model attribute type. In the following example, the model attribute name is `account` which matches the URI path variable `account`, and there is a registered `Converter<String, Account>` which could load the `Account` from a data store:

Java

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

Kotlin

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

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:

Java

```
@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`.

Kotlin

```
@PostMapping("/owners/{ownerId}/pets/{petId}/edit")
fun processSubmit(@ModelAttribute("pet") pet: Pet, result: BindingResult): String { 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:

Java

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

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

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

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

Kotlin

```
@ModelAttribute
fun setUpForm(): AccountForm {
    return AccountForm()
}

@ModelAttribute
fun findAccount(@PathVariable accountId: String): Account {
    return accountRepository.findOne(accountId)
}

@PostMapping("update")
fun update(@Valid form: AccountForm, result: BindingResult,
           @ModelAttribute(binding = false) account: Account): String { ①
    // ...
}
```

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

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

Java

```
@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.

Kotlin

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

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`

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:

Java

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

① Using the `@SessionAttributes` annotation.

Kotlin

```
@Controller
@SessionAttributes("pet") ①
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:

Java

```
@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.

Kotlin

```
@Controller
@SessionAttributes("pet") ①
class EditPetForm {

    // ...

    @PostMapping("/pets/{id}")
    fun handle(pet: Pet, errors: BindingResult, status: SessionStatus): String {
        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`

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:

Java

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

① Using a `@SessionAttribute` annotation.

Kotlin

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

For use cases that require adding or removing session attributes, consider injecting `org.springframework.web.context.request.WebRequest` or `jakarta.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`

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`):

Java

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

① Using the `@RequestAttribute` annotation.

Kotlin

```
@GetMapping("/")
fun handle(@RequestAttribute client: Client): String { 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 don't need to explicitly add them through `Model` or `RedirectAttributes`. The following example shows how to define a redirect:

Java

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

Kotlin

```
@PostMapping("/files/{path}")
fun upload(...): String {
    // ...
    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

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:

Java

```
@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";
    }
}
```

Kotlin

```
@Controller
class FileUploadController {

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

        if (!file.isEmpty) {
            val bytes = file.bytes
            // 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 multipart parsing, you may also declare `jakarta.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:

Java

```
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";
    }
}
```

Kotlin

```
class MyForm(val name: String, val file: MultipartFile, ...)

@Controller
class FileUploadController {

    @PostMapping("/form")
    fun handleFormUpload(form: MyForm, errors: BindingResult): String {
        if (!form.file.isEmpty) {
            val bytes = form.file.bytes
            // 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:

Java

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

Kotlin

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

You can use `@RequestPart` in combination with `jakarta.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:

Java

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

Kotlin

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

`@RequestBody`

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:

Java

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

Kotlin

```
@PostMapping("/accounts")
fun 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 `jakarta.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:

Java

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

Kotlin

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

HttpEntity

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:

Java

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

Kotlin

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

`@ResponseBody`

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:

Java

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

Kotlin

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

`@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.

ResponseEntity

WebFlux

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

Java

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

Kotlin

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

Spring MVC supports using a single value reactive type to produce the `ResponseEntity` asynchronously, and/or single and multi-value reactive types for the body. This allows the following types of async responses:

- `ResponseEntity<Mono<T>>` or `ResponseEntity<Flux<T>>` make the response status and headers

known immediately while the body is provided asynchronously at a later point. Use `Mono` if the body consists of 0..1 values or `Flux` if it can produce multiple values.

- `Mono<ResponseEntity<T>>` provides all three — response status, headers, and body, asynchronously at a later point. This allows the response status and headers to vary depending on the outcome of asynchronous request handling.

Jackson JSON

Spring offers support for the Jackson JSON library.

JSON Views

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 `ResponseEntity` controller methods, you can use Jackson's `@JsonView` annotation to activate a serialization view class, as the following example shows:

Java

```
@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;
    }
}
```

Kotlin

```
@RestController
class UserController {

    @GetMapping("/user")
    @JsonView(User.WithoutPasswordView::class)
    fun getUser() = User("eric", "7!jd#h23")
}

class User(
        @JsonView(WithoutPasswordView::class) val username: String,
        @JsonView(WithPasswordView::class) val password: String) {

    interface WithoutPasswordView
    interface WithPasswordView : WithoutPasswordView
}
```

`@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.

If you want to do the above programmatically, instead of declaring an `@JsonView` annotation, wrap the return value with `MappingJacksonValue` and use it to supply the serialization view:

Java

```
@RestController
public class UserController {

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

Kotlin

```
@RestController
class UserController {

    @GetMapping("/user")
    fun getUser(): MappingJacksonValue {
        val value = MappingJacksonValue(User("eric", "7!jd#h23"))
        value.serializationView = User.WithoutPasswordView::class.java
        return value
    }
}
```

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

Java

```
@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";
    }
}
```

Kotlin

```
import org.springframework.ui.set

@Controller
class UserController : AbstractController() {

    @GetMapping("/user")
    fun getUser(model: Model): String {
        model["user"] = User("eric", "7!jd#h23")
        model[JsonView::class.qualifiedName] = User.WithoutPasswordView::class.java
        return "userView"
    }
}
```

1.3.4. Model

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:

Java

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

Kotlin

```
@ModelAttribute
fun populateModel(@RequestParam number: String, model: Model) {
    model.addAttribute(accountRepository.findAccount(number))
    // add more ...
}
```

The following example adds only one attribute:

Java

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

Kotlin

```
@ModelAttribute
fun addAccount(@RequestParam number: String): Account {
    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:

Java

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

Kotlin

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

1.3.5. `DataBinder`

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.beans.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:

Java

```
@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.

Kotlin

```
@Controller
class FormController {

    @InitBinder ①
    fun initBinder(binder: WebDataBinder) {
        val dateFormat = SimpleDateFormat("yyyy-MM-dd")
        dateFormat.isLenient = false
        binder.registerCustomEditor(Date::class.java, 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:

Java

```
@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.

Kotlin

```
@Controller
class FormController {

    @InitBinder ①
    protected fun initBinder(binder: WebDataBinder) {
        binder.addCustomFormatter(DateFormatter("yyyy-MM-dd"))
    }

    // ...
}
```

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

1.3.6. Exceptions

WebFlux

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

Java

```
@Controller
public class SimpleController {

    // ...

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

Kotlin

```
@Controller
class SimpleController {

    // ...

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

The exception may match against a top-level exception being propagated (e.g. a direct `IOException` being thrown) or against a nested cause within a wrapper exception (e.g. an `IOException` wrapped inside an `IllegalStateException`). As of 5.3, this can match at arbitrary cause levels, whereas previously only an immediate cause was considered.

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:

Java

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

Kotlin

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

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

Java

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

Kotlin

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

> 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.
`HandlerMethod`	For access to the controller method that raised the exception.
`WebRequest`, `NativeWebRequest`	Generic access to request parameters and request and session attributes without direct use of the Servlet API.
`jakarta.servlet.ServletRequest`, `jakarta.servlet.ServletResponse`	Choose any specific request or response type (for example, `ServletRequest` or `HttpServletRequest` or Spring's `MultipartRequest` or `MultipartHttpServletRequest`).
`jakarta.servlet.http.HttpSession`	Enforces the presence of a session. As a consequence, such an argument is never `null`. Note that session access is not thread-safe. Consider setting the `RequestMappingHandlerAdapter` instance's `synchronizeOnSession` flag to `true` if multiple requests are allowed to access a session concurrently.
`java.security.Principal`	Currently authenticated user — possibly a specific `Principal` implementation class if known.
`HttpMethod`	The HTTP method of the request.
`java.util.Locale`	The current request locale, determined by the most specific `LocaleResolver` available — in effect, the configured `LocaleResolver` or `LocaleContextResolver`.
`java.util.TimeZone`, `java.time.ZoneId`	The time zone associated with the current request, as determined by a `LocaleContextResolver`.
`java.io.OutputStream`, `java.io.Writer`	For access to the raw response body, as exposed by the Servlet API.
`java.util.Map`, `org.springframework.ui.Model`, `org.springframework.ui.ModelMap`	For access to the model for an error response. Always empty.
`RedirectAttributes`	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.
`@SessionAttribute`	For access to any session attribute, in contrast to model attributes stored in the session as a result of a class-level `@SessionAttributes` declaration. See `@SessionAttribute` for more details.
`@RequestAttribute`	For access to request attributes. See `@RequestAttribute` for more details.

Return Values

`@ExceptionHandler` methods support the following return values:

Return value	Description
`@ResponseBody`	The return value is converted through `HttpMessageConverter` instances and written to the response. See `@ResponseBody`.
`HttpEntity<B>`, `ResponseEntity<B>`	The return value specifies that the full response (including the HTTP headers and the body) be converted through `HttpMessageConverter` instances and written to the response. See ResponseEntity.
`String`	A view name to be resolved with `ViewResolver` implementations and used together with the implicit model — determined through command objects and `@ModelAttribute` methods. The handler method can also programmatically enrich the model by declaring a `Model` argument (described earlier).
`View`	A `View` instance to use for rendering together with the implicit model — determined through command objects and `@ModelAttribute` methods. The handler method may also programmatically enrich the model by declaring a `Model` argument (descried earlier).
`java.util.Map`, `org.springframework.ui.Model`	Attributes to be added to the implicit model with the view name implicitly determined through a `RequestToViewNameTranslator`.
`@ModelAttribute`	An attribute to be added to the model with the view name implicitly determined through a `RequestToViewNameTranslator`. Note that `@ModelAttribute` is optional. See “Any other return value” at the end of this table.
`ModelAndView` object	The view and model attributes to use and, optionally, a response status.
`void`	A method with a `void` return type (or `null` return value) is considered to have fully handled the response if it also has a `ServletResponse` an `OutputStream` argument, or a `@ResponseStatus` annotation. The same is also true if the controller has made a positive `ETag` or `lastModified` timestamp check (see Controllers for details). If none of the above is true, a `void` return type can also indicate “no response body” for REST controllers or default view name selection for HTML controllers.
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 BeanUtils#isSimpleProperty), 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

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

WebFlux

`@ExceptionHandler`, `@InitBinder`, and `@ModelAttribute` methods apply only to the `@Controller` class, or class hierarchy, in which they are declared. If, instead, they are declared in an `@ControllerAdvice` or `@RestControllerAdvice` class, then they apply to any controller. Moreover, as of 5.3, `@ExceptionHandler` methods in `@ControllerAdvice` can be used to handle exceptions from any `@Controller` or any other handler.

`@ControllerAdvice` is meta-annotated with `@Component` and therefore can be registered as a Spring bean through component scanning. `@RestControllerAdvice` is meta-annotated with `@ControllerAdvice` and `@ResponseBody`, and that means `@ExceptionHandler` methods will have their return value rendered via response body message conversion, rather than via HTML views.

On startup, `RequestMappingHandlerMapping` and `ExceptionHandlerExceptionResolver` detect controller advice beans and apply them at runtime. Global `@ExceptionHandler` methods, from an `@ControllerAdvice`, are applied *after* local ones, from the `@Controller`. By contrast, global `@ModelAttribute` and `@InitBinder` methods are applied *before* local ones.

The `@ControllerAdvice` annotation has attributes that let you narrow the set of controllers and handlers that they apply to. For example:

Java

```
// 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 {}
```

Kotlin

```
// Target all Controllers annotated with @RestController
@ControllerAdvice(annotations = [RestController::class])
class ExampleAdvice1

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

// Target all Controllers assignable to specific classes
@ControllerAdvice(assignableTypes = [ControllerInterface::class,
AbstractController::class])
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. Functional Endpoints

WebFlux

Spring Web MVC includes WebMvc.fn, a lightweight functional programming model in which functions are used to route and handle requests and contracts are designed for immutability. It is an alternative to the annotation-based programming model but otherwise runs on the same DispatcherServlet.

1.4.1. Overview

WebFlux

In WebMvc.fn, an HTTP request is handled with a `HandlerFunction`: a function that takes `ServerRequest` and returns a `ServerResponse`. Both the request and the response object have immutable contracts that offer JDK 8-friendly access to the HTTP request and response.

`HandlerFunction` is the equivalent of the body of a `@RequestMapping` method in the annotation-based programming model.

Incoming requests are routed to a handler function with a `RouterFunction`: a function that takes `ServerRequest` and returns an optional `HandlerFunction` (i.e. `Optional<HandlerFunction>`). When the router function matches, a handler function is returned; otherwise an empty Optional. `RouterFunction` is the equivalent of a `@RequestMapping` annotation, but with the major difference that router functions provide not just data, but also behavior.

`RouterFunctions.route()` provides a router builder that facilitates the creation of routers, as the following example shows:

Java

```
import static org.springframework.http.MediaType.APPLICATION_JSON;
import static org.springframework.web.servlet.function.RequestPredicates.*;
import static org.springframework.web.servlet.function.RouterFunctions.route;

PersonRepository repository = ...
PersonHandler handler = new PersonHandler(repository);

RouterFunction<ServerResponse> route = route()
    .GET("/person/{id}", accept(APPLICATION_JSON), handler::getPerson)
    .GET("/person", accept(APPLICATION_JSON), handler::listPeople)
    .POST("/person", handler::createPerson)
    .build();


public class PersonHandler {

    // ...

    public ServerResponse listPeople(ServerRequest request) {
        // ...
    }

    public ServerResponse createPerson(ServerRequest request) {
        // ...
    }

    public ServerResponse getPerson(ServerRequest request) {
        // ...
    }
}
```

Kotlin

```
import org.springframework.web.servlet.function.router

val repository: PersonRepository = ...
val handler = PersonHandler(repository)

val route = router { ①
    accept(APPLICATION_JSON).nest {
        GET("/person/{id}", handler::getPerson)
        GET("/person", handler::listPeople)
    }
    POST("/person", handler::createPerson)
}


class PersonHandler(private val repository: PersonRepository) {

    // ...

    fun listPeople(request: ServerRequest): ServerResponse {
        // ...
    }

    fun createPerson(request: ServerRequest): ServerResponse {
        // ...
    }

    fun getPerson(request: ServerRequest): ServerResponse {
        // ...
    }
}
```

① Create router using the router DSL.

If you register the `RouterFunction` as a bean, for instance by exposing it in a `@Configuration` class, it will be auto-detected by the servlet, as explained in Running a Server.

1.4.2. HandlerFunction

WebFlux

`ServerRequest` and `ServerResponse` are immutable interfaces that offer JDK 8-friendly access to the HTTP request and response, including headers, body, method, and status code.

ServerRequest

`ServerRequest` provides access to the HTTP method, URI, headers, and query parameters, while access to the body is provided through the `body` methods.

The following example extracts the request body to a `String`:

Java

```
String string = request.body(String.class);
```

Kotlin

```
val string = request.body<String>()
```

The following example extracts the body to a `List<Person>`, where `Person` objects are decoded from a serialized form, such as JSON or XML:

Java

```
List<Person> people = request.body(new ParameterizedTypeReference<List<Person>>() {});
```

Kotlin

```
val people = request.body<Person>()
```

The following example shows how to access parameters:

Java

```
MultiValueMap<String, String> params = request.params();
```

Kotlin

```
val map = request.params()
```

ServerResponse

`ServerResponse` provides access to the HTTP response and, since it is immutable, you can use a `build` method to create it. You can use the builder to set the response status, to add response headers, or to provide a body. The following example creates a 200 (OK) response with JSON content:

Java

```
Person person = ...
ServerResponse.ok().contentType(MediaType.APPLICATION_JSON).body(person);
```

Kotlin

```
val person: Person = ...
ServerResponse.ok().contentType(MediaType.APPLICATION_JSON).body(person)
```

The following example shows how to build a 201 (CREATED) response with a `Location` header and

no body:

Java

```
URI location = ...
ServerResponse.created(location).build();
```

Kotlin

```
val location: URI = ...
ServerResponse.created(location).build()
```

You can also use an asynchronous result as the body, in the form of a `CompletableFuture`, `Publisher`, or any other type supported by the `ReactiveAdapterRegistry`. For instance:

Java

```
Mono<Person> person = webClient.get().retrieve().bodyToMono(Person.class);
ServerResponse.ok().contentType(MediaType.APPLICATION_JSON).body(person);
```

Kotlin

```
val person = webClient.get().retrieve().awaitBody<Person>()
ServerResponse.ok().contentType(MediaType.APPLICATION_JSON).body(person)
```

If not just the body, but also the status or headers are based on an asynchronous type, you can use the static `async` method on `ServerResponse`, which accepts `CompletableFuture<ServerResponse>`, `Publisher<ServerResponse>`, or any other asynchronous type supported by the `ReactiveAdapterRegistry`. For instance:

Java

```
Mono<ServerResponse> asyncResponse =
webClient.get().retrieve().bodyToMono(Person.class)
  .map(p -> ServerResponse.ok().header("Name", p.name()).body(p));
ServerResponse.async(asyncResponse);
```

Server-Sent Events can be provided via the static `sse` method on `ServerResponse`. The builder provided by that method allows you to send Strings, or other objects as JSON. For example:

Java

```
public RouterFunction<ServerResponse> sse() {
    return route(GET("/sse"), request -> ServerResponse.sse(sseBuilder -> {
                // Save the sseBuilder object somewhere..
            }));
}

// In some other thread, sending a String
sseBuilder.send("Hello world");

// Or an object, which will be transformed into JSON
Person person = ...
sseBuilder.send(person);

// Customize the event by using the other methods
sseBuilder.id("42")
        .event("sse event")
        .data(person);

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

Kotlin

```
fun sse(): RouterFunction<ServerResponse> = router {
    GET("/sse") { request -> ServerResponse.sse { sseBuilder ->
        // Save the sseBuilder object somewhere..
    }
}

// In some other thread, sending a String
sseBuilder.send("Hello world")

// Or an object, which will be transformed into JSON
val person = ...
sseBuilder.send(person)

// Customize the event by using the other methods
sseBuilder.id("42")
        .event("sse event")
        .data(person)

// and done at some point
sseBuilder.complete()
```

Handler Classes

We can write a handler function as a lambda, as the following example shows:

Java

```
HandlerFunction<ServerResponse> helloWorld =
  request -> ServerResponse.ok().body("Hello World");
```

Kotlin

```
val helloWorld: (ServerRequest) -> ServerResponse =
  { ServerResponse.ok().body("Hello World") }
```

That is convenient, but in an application we need multiple functions, and multiple inline lambda's can get messy. Therefore, it is useful to group related handler functions together into a handler class, which has a similar role as `@Controller` in an annotation-based application. For example, the following class exposes a reactive `Person` repository:

Java

```
import static org.springframework.http.MediaType.APPLICATION_JSON;
import static org.springframework.web.reactive.function.server.ServerResponse.ok;

public class PersonHandler {

    private final PersonRepository repository;

    public PersonHandler(PersonRepository repository) {
        this.repository = repository;
    }

    public ServerResponse listPeople(ServerRequest request) { ①
        List<Person> people = repository.allPeople();
        return ok().contentType(APPLICATION_JSON).body(people);
    }

    public ServerResponse createPerson(ServerRequest request) throws Exception { ②
        Person person = request.body(Person.class);
        repository.savePerson(person);
        return ok().build();
    }

    public ServerResponse getPerson(ServerRequest request) { ③
        int personId = Integer.parseInt(request.pathVariable("id"));
        Person person = repository.getPerson(personId);
        if (person != null) {
            return ok().contentType(APPLICATION_JSON).body(person);
        }
        else {
            return ServerResponse.notFound().build();
        }
    }

}
```

① `listPeople` is a handler function that returns all `Person` objects found in the repository as JSON.

② `createPerson` is a handler function that stores a new `Person` contained in the request body.

③ `getPerson` is a handler function that returns a single person, identified by the `id` path variable. We retrieve that `Person` from the repository and create a JSON response, if it is found. If it is not found, we return a 404 Not Found response.

Kotlin

```
class PersonHandler(private val repository: PersonRepository) {

    fun listPeople(request: ServerRequest): ServerResponse { ①
        val people: List<Person> = repository.allPeople()
        return ok().contentType(APPLICATION_JSON).body(people);
    }

    fun createPerson(request: ServerRequest): ServerResponse { ②
        val person = request.body<Person>()
        repository.savePerson(person)
        return ok().build()
    }

    fun getPerson(request: ServerRequest): ServerResponse { ③
        val personId = request.pathVariable("id").toInt()
        return repository.getPerson(personId)?.let {
ok().contentType(APPLICATION_JSON).body(it) }
                ?: ServerResponse.notFound().build()

    }
}
```

① `listPeople` is a handler function that returns all `Person` objects found in the repository as JSON.

② `createPerson` is a handler function that stores a new `Person` contained in the request body.

③ `getPerson` is a handler function that returns a single person, identified by the `id` path variable. We retrieve that `Person` from the repository and create a JSON response, if it is found. If it is not found, we return a 404 Not Found response.

Validation

A functional endpoint can use Spring's validation facilities to apply validation to the request body. For example, given a custom Spring Validator implementation for a `Person`:

Java

```
public class PersonHandler {

    private final Validator validator = new PersonValidator(); ①

    // ...

    public ServerResponse createPerson(ServerRequest request) {
        Person person = request.body(Person.class);
        validate(person); ②
        repository.savePerson(person);
        return ok().build();
    }

    private void validate(Person person) {
        Errors errors = new BeanPropertyBindingResult(person, "person");
        validator.validate(person, errors);
        if (errors.hasErrors()) {
            throw new ServerWebInputException(errors.toString()); ③
        }
    }
}
```

① Create `Validator` instance.

② Apply validation.

③ Raise exception for a 400 response.

Kotlin

```
class PersonHandler(private val repository: PersonRepository) {

    private val validator = PersonValidator() ①

    // ...

    fun createPerson(request: ServerRequest): ServerResponse {
        val person = request.body<Person>()
        validate(person) ②
        repository.savePerson(person)
        return ok().build()
    }

    private fun validate(person: Person) {
        val errors: Errors = BeanPropertyBindingResult(person, "person")
        validator.validate(person, errors)
        if (errors.hasErrors()) {
            throw ServerWebInputException(errors.toString()) ③
        }
    }
}
```

① Create `Validator` instance.

② Apply validation.

③ Raise exception for a 400 response.

Handlers can also use the standard bean validation API (JSR-303) by creating and injecting a global `Validator` instance based on `LocalValidatorFactoryBean`. See Spring Validation.

1.4.3. `RouterFunction`

WebFlux

Router functions are used to route the requests to the corresponding `HandlerFunction`. Typically, you do not write router functions yourself, but rather use a method on the `RouterFunctions` utility class to create one. `RouterFunctions.route()` (no parameters) provides you with a fluent builder for creating a router function, whereas `RouterFunctions.route(RequestPredicate, HandlerFunction)` offers a direct way to create a router.

Generally, it is recommended to use the `route()` builder, as it provides convenient short-cuts for typical mapping scenarios without requiring hard-to-discover static imports. For instance, the router function builder offers the method `GET(String, HandlerFunction)` to create a mapping for GET requests; and `POST(String, HandlerFunction)` for POSTs.

Besides HTTP method-based mapping, the route builder offers a way to introduce additional predicates when mapping to requests. For each HTTP method there is an overloaded variant that takes a `RequestPredicate` as a parameter, through which additional constraints can be expressed.

Predicates

You can write your own `RequestPredicate`, but the `RequestPredicates` utility class offers commonly used implementations, based on the request path, HTTP method, content-type, and so on. The following example uses a request predicate to create a constraint based on the `Accept` header:

Java

```
RouterFunction<ServerResponse> route = RouterFunctions.route()
    .GET("/hello-world", accept(MediaType.TEXT_PLAIN),
        request -> ServerResponse.ok().body("Hello World")).build();
```

Kotlin

```
import org.springframework.web.servlet.function.router

val route = router {
    GET("/hello-world", accept(TEXT_PLAIN)) {
        ServerResponse.ok().body("Hello World")
    }
}
```

You can compose multiple request predicates together by using:

- `RequestPredicate.and(RequestPredicate)` — both must match.
- `RequestPredicate.or(RequestPredicate)` — either can match.

Many of the predicates from `RequestPredicates` are composed. For example, `RequestPredicates.GET(String)` is composed from `RequestPredicates.method(HttpMethod)` and `RequestPredicates.path(String)`. The example shown above also uses two request predicates, as the builder uses `RequestPredicates.GET` internally, and composes that with the `accept` predicate.

Routes

Router functions are evaluated in order: if the first route does not match, the second is evaluated, and so on. Therefore, it makes sense to declare more specific routes before general ones. This is also important when registering router functions as Spring beans, as will be described later. Note that this behavior is different from the annotation-based programming model, where the "most specific" controller method is picked automatically.

When using the router function builder, all defined routes are composed into one `RouterFunction` that is returned from `build()`. There are also other ways to compose multiple router functions together:

- `add(RouterFunction)` on the `RouterFunctions.route()` builder
- `RouterFunction.and(RouterFunction)`
- `RouterFunction.andRoute(RequestPredicate, HandlerFunction)` — shortcut for `RouterFunction.and()` with nested `RouterFunctions.route()`.

The following example shows the composition of four routes:

Java

```
import static org.springframework.http.MediaType.APPLICATION_JSON;
import static org.springframework.web.servlet.function.RequestPredicates.*;

PersonRepository repository = ...
PersonHandler handler = new PersonHandler(repository);

RouterFunction<ServerResponse> otherRoute = ...

RouterFunction<ServerResponse> route = route()
    .GET("/person/{id}", accept(APPLICATION_JSON), handler::getPerson) ①
    .GET("/person", accept(APPLICATION_JSON), handler::listPeople) ②
    .POST("/person", handler::createPerson) ③
    .add(otherRoute) ④
    .build();
```

① `GET /person/{id}` with an `Accept` header that matches JSON is routed to `PersonHandler.getPerson`

② `GET /person` with an `Accept` header that matches JSON is routed to `PersonHandler.listPeople`

③ `POST /person` with no additional predicates is mapped to `PersonHandler.createPerson`, and

④ `otherRoute` is a router function that is created elsewhere, and added to the route built.

Kotlin

```
import org.springframework.http.MediaType.APPLICATION_JSON
import org.springframework.web.servlet.function.router

val repository: PersonRepository = ...
val handler = PersonHandler(repository);

val otherRoute = router {  }

val route = router {
    GET("/person/{id}", accept(APPLICATION_JSON), handler::getPerson) ①
    GET("/person", accept(APPLICATION_JSON), handler::listPeople) ②
    POST("/person", handler::createPerson) ③
}.and(otherRoute) ④
```

① `GET /person/{id}` with an `Accept` header that matches JSON is routed to `PersonHandler.getPerson`

② `GET /person` with an `Accept` header that matches JSON is routed to `PersonHandler.listPeople`

③ `POST /person` with no additional predicates is mapped to `PersonHandler.createPerson`, and

④ `otherRoute` is a router function that is created elsewhere, and added to the route built.

Nested Routes

It is common for a group of router functions to have a shared predicate, for instance a shared path.

In the example above, the shared predicate would be a path predicate that matches `/person`, used by three of the routes. When using annotations, you would remove this duplication by using a type-level `@RequestMapping` annotation that maps to `/person`. In WebMvc.fn, path predicates can be shared through the `path` method on the router function builder. For instance, the last few lines of the example above can be improved in the following way by using nested routes:

Java

```
RouterFunction<ServerResponse> route = route()
    .path("/person", builder -> builder ①
        .GET("/{id}", accept(APPLICATION_JSON), handler::getPerson)
        .GET(accept(APPLICATION_JSON), handler::listPeople)
        .POST("/person", handler::createPerson))
    .build();
```

① Note that second parameter of `path` is a consumer that takes the router builder.

Kotlin

```
import org.springframework.web.servlet.function.router

val route = router {
    "/person".nest {
        GET("/{id}", accept(APPLICATION_JSON), handler::getPerson)
        GET(accept(APPLICATION_JSON), handler::listPeople)
        POST("/person", handler::createPerson)
    }
}
```

Though path-based nesting is the most common, you can nest on any kind of predicate by using the `nest` method on the builder. The above still contains some duplication in the form of the shared `Accept`-header predicate. We can further improve by using the `nest` method together with `accept`:

Java

```
RouterFunction<ServerResponse> route = route()
    .path("/person", b1 -> b1
        .nest(accept(APPLICATION_JSON), b2 -> b2
            .GET("/{id}", handler::getPerson)
            .GET(handler::listPeople))
        .POST("/person", handler::createPerson))
    .build();
```

Kotlin

```
import org.springframework.web.servlet.function.router

val route = router {
    "/person".nest {
        accept(APPLICATION_JSON).nest {
            GET("/{id}", handler::getPerson)
            GET("", handler::listPeople)
            POST("/person", handler::createPerson)
        }
    }
}
```

1.4.4. Running a Server

WebFlux

You typically run router functions in a `DispatcherHandler`-based setup through the MVC Config, which uses Spring configuration to declare the components required to process requests. The MVC Java configuration declares the following infrastructure components to support functional endpoints:

- `RouterFunctionMapping`: Detects one or more `RouterFunction<?>` beans in the Spring configuration, orders them, combines them through `RouterFunction.andOther`, and routes requests to the resulting composed `RouterFunction`.
- `HandlerFunctionAdapter`: Simple adapter that lets `DispatcherHandler` invoke a `HandlerFunction` that was mapped to a request.

The preceding components let functional endpoints fit within the `DispatcherServlet` request processing lifecycle and also (potentially) run side by side with annotated controllers, if any are declared. It is also how functional endpoints are enabled by the Spring Boot Web starter.

The following example shows a WebFlux Java configuration:

Java

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

    @Bean
    public RouterFunction<?> routerFunctionA() {
        // ...
    }

    @Bean
    public RouterFunction<?> routerFunctionB() {
        // ...
    }

    // ...

    @Override
    public void configureMessageConverters(List<HttpMessageConverter<?>> converters) {
        // configure message conversion...
    }

    @Override
    public void addCorsMappings(CorsRegistry registry) {
        // configure CORS...
    }

    @Override
    public void configureViewResolvers(ViewResolverRegistry registry) {
        // configure view resolution for HTML rendering...
    }
}
```

Kotlin

```
@Configuration
@EnableMvc
class WebConfig : WebMvcConfigurer {

    @Bean
    fun routerFunctionA(): RouterFunction<*> {
        // ...
    }

    @Bean
    fun routerFunctionB(): RouterFunction<*> {
        // ...
    }

    // ...

    override fun configureMessageConverters(converters: List<HttpMessageConverter<*>>)
{
        // configure message conversion...
    }

    override fun addCorsMappings(registry: CorsRegistry) {
        // configure CORS...
    }

    override fun configureViewResolvers(registry: ViewResolverRegistry) {
        // configure view resolution for HTML rendering...
    }
}
```

1.4.5. Filtering Handler Functions

WebFlux

You can filter handler functions by using the `before`, `after`, or `filter` methods on the routing function builder. With annotations, you can achieve similar functionality by using `@ControllerAdvice`, a `ServletFilter`, or both. The filter will apply to all routes that are built by the builder. This means that filters defined in nested routes do not apply to "top-level" routes. For instance, consider the following example:

Java

```
RouterFunction<ServerResponse> route = route()
    .path("/person", b1 -> b1
        .nest(accept(APPLICATION_JSON), b2 -> b2
            .GET("/{id}", handler::getPerson)
            .GET(handler::listPeople)
            .before(request -> ServerRequest.from(request) ①
                .header("X-RequestHeader", "Value")
                .build()))
        .POST("/person", handler::createPerson))
    .after((request, response) -> logResponse(response)) ②
    .build();
```

① The `before` filter that adds a custom request header is only applied to the two GET routes.

② The `after` filter that logs the response is applied to all routes, including the nested ones.

Kotlin

```
import org.springframework.web.servlet.function.router

val route = router {
    "/person".nest {
        GET("/{id}", handler::getPerson)
        GET(handler::listPeople)
        before { ①
            ServerRequest.from(it)
                    .header("X-RequestHeader", "Value").build()
        }
    }
    POST("/person", handler::createPerson)
    after { _, response -> ②
        logResponse(response)
    }
}
```

① The `before` filter that adds a custom request header is only applied to the two GET routes.

② The `after` filter that logs the response is applied to all routes, including the nested ones.

The `filter` method on the router builder takes a `HandlerFilterFunction`: a function that takes a `ServerRequest` and `HandlerFunction` and returns a `ServerResponse`. The handler function parameter represents the next element in the chain. This is typically the handler that is routed to, but it can also be another filter if multiple are applied.

Now we can add a simple security filter to our route, assuming that we have a `SecurityManager` that can determine whether a particular path is allowed. The following example shows how to do so:

Java

```
SecurityManager securityManager = ...

RouterFunction<ServerResponse> route = route()
    .path("/person", b1 -> b1
        .nest(accept(APPLICATION_JSON), b2 -> b2
            .GET("/{id}", handler::getPerson)
            .GET(handler::listPeople))
        .POST("/person", handler::createPerson))
    .filter((request, next) -> {
        if (securityManager.allowAccessTo(request.path())) {
            return next.handle(request);
        }
        else {
            return ServerResponse.status(UNAUTHORIZED).build();
        }
    })
    .build();
```

Kotlin

```
import org.springframework.web.servlet.function.router

val securityManager: SecurityManager = ...

val route = router {
    ("/person" and accept(APPLICATION_JSON)).nest {
        GET("/{id}", handler::getPerson)
        GET("", handler::listPeople)
        POST("/person", handler::createPerson)
        filter { request, next ->
            if (securityManager.allowAccessTo(request.path())) {
                next(request)
            }
            else {
                status(UNAUTHORIZED).build();
            }
        }
    }
}
```

The preceding example demonstrates that invoking the `next.handle(ServerRequest)` is optional. We only let the handler function be run when access is allowed.

Besides using the `filter` method on the router function builder, it is possible to apply a filter to an existing router function via `RouterFunction.filter(HandlerFilterFunction)`.

CORS support for functional endpoints is provided through a dedicated `CorsFilter`.

1.5. URI Links

WebFlux

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

1.5.1. UriComponents

Spring MVC and Spring WebFlux

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

Java

```
UriComponents uriComponents = UriComponentsBuilder
        .fromUriString("https://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`.

Kotlin

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

val 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:

Java

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

Kotlin

```
val uri = UriComponentsBuilder
        .fromUriString("https://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:

Java

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

Kotlin

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

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

Java

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

Kotlin

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

1.5.2. 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`:

Java

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

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

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

Kotlin

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

val baseUrl = "https://example.org"
val factory = DefaultUriBuilderFactory(baseUrl)
factory.encodingMode = EncodingMode.TEMPLATE_AND_VALUES

val restTemplate = RestTemplate()
restTemplate.uriTemplateHandler = factory
```

The following example configures a `WebClient`:

Java

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

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

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

Kotlin

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

val baseUrl = "https://example.org"
val factory = DefaultUriBuilderFactory(baseUrl)
factory.encodingMode = EncodingMode.TEMPLATE_AND_VALUES

val 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:

Java

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

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

Kotlin

```
val baseUrl = "https://example.com"
val uriBuilderFactory = DefaultUriBuilderFactory(baseUrl)

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

1.5.3. 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 the second option is useful if URI variables do intentionally contain reserved characters. The second option is also useful when not expanding URI variables at all since that will also encode anything that incidentally looks like a URI variable.

The following example uses the first option:

Java

```
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"
```

Kotlin

```
val 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:

Java

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

Kotlin

```
val 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:

Java

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

Kotlin

```
val uri = UriComponentsBuilder.fromUriString("/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:

Java

```
String baseUrl = "https://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();
```

Kotlin

```
val baseUrl = "https://example.com"
val factory = DefaultUriBuilderFactory(baseUrl).apply {
    encodingMode = EncodingMode.TEMPLATE_AND_VALUES
}

// Customize the RestTemplate..
val restTemplate = RestTemplate().apply {
    uriTemplateHandler = factory
}

// Customize the WebClient..
val 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_COMPONENT`: 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_COMPONENT` for historic reasons and for backwards compatibility. The `WebClient` relies on the default value in `DefaultUriBuilderFactory`, which was changed from `EncodingMode.URI_COMPONENT` in 5.0.x to `EncodingMode.TEMPLATE_AND_VALUES` in 5.1.

1.5.4. Relative Servlet Requests

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

Java

```
HttpServletRequest request = ...

// Re-uses host, scheme, port, path and query string...

ServletUriComponentsBuilder ucb = ServletUriComponentsBuilder.fromRequest(request)
        .replaceQueryParam("accountId", "{id}").build()
        .expand("123")
        .encode();
```

Kotlin

```
val request: HttpServletRequest = ...

// Re-uses host, scheme, port, path and query string...

val 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:

Java

```
// Re-uses host, port and context path...

ServletUriComponentsBuilder ucb = ServletUriComponentsBuilder.fromContextPath(request)
        .path("/accounts").build()
```

Kotlin

```
// Re-uses host, port and context path...

val ucb = ServletUriComponentsBuilder.fromContextPath(request)
        .path("/accounts").build()
```

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

Java

```
// Re-uses host, port, context path, and Servlet prefix...

ServletUriComponentsBuilder ucb =
ServletUriComponentsBuilder.fromServletMapping(request)
        .path("/accounts").build()
```

Kotlin

```
// Re-uses host, port, context path, and Servlet prefix...

val 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.

1.5.5. Links to Controllers

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

Java

```
@Controller
@RequestMapping("/hotels/{hotel}")
public class BookingController {

    @GetMapping("/bookings/{booking}")
    public ModelAndView getBooking(@PathVariable Long booking) {
        // ...
    }
}
```

Kotlin

```
@Controller
@RequestMapping("/hotels/{hotel}")
class BookingController {

    @GetMapping("/bookings/{booking}")
    fun getBooking(@PathVariable booking: Long): ModelAndView {
        // ...
    }
}
```

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

Java

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

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

Kotlin

```
val uriComponents = MvcUriComponentsBuilder
    .fromMethodName(BookingController::class.java, "getBooking",
21).buildAndExpand(42)

val 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`):

Java

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

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

Kotlin

```
val uriComponents = MvcUriComponentsBuilder

.fromMethodCall(on(BookingController::class.java).getBooking(21)).buildAndExpand(42)

val 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`:

Java

```
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();
```

Kotlin

```
val base = ServletUriComponentsBuilder.fromCurrentContextPath().path("/en")
val builder = MvcUriComponentsBuilder.relativeTo(base)
builder.withMethodCall(on(BookingController::class.java).getBooking(21)).buildAndExpan
d(42)

val 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.

1.5.6. 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:

Java

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

    @RequestMapping("/{country}")
    public HttpEntity<PersonAddress> getAddress(@PathVariable String country) { ... }
}
```

Kotlin

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

    @RequestMapping("/{country}")
    fun getAddress(@PathVariable country: String): HttpEntity<PersonAddress> { ... }
}
```

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`.

1.6. Asynchronous Requests

Compared to WebFlux

Spring MVC has an extensive integration with Servlet asynchronous request processing:

- `DeferredResult` and `Callable` return values in controller methods 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.

1.6.1. `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:

Java

```
@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(result);
```

Kotlin

```
@GetMapping("/quotes")
@ResponseBody
fun quotes(): DeferredResult<String> {
    val deferredResult = DeferredResult<String>()
    // Save the deferredResult somewhere..
    return deferredResult
}

// From some other thread...
deferredResult.setResult(result)
```

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.

1.6.2. `Callable`

Compared to WebFlux

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

Java

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

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

Kotlin

```
@PostMapping
fun processUpload(file: MultipartFile) = Callable<String> {
    // ...
    "someView"
}
```

The return value can then be obtained by running the given task through the configured `TaskExecutor`.

1.6.3. 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 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.

1.6.4. HTTP Streaming

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:

Java

```
@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();
```

Kotlin

```
@GetMapping("/events")
fun handle() = ResponseBodyEmitter().apply {
    // Save the emitter somewhere..
}

// 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:

Java

```
@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();
```

Kotlin

```
@GetMapping("/events", produces = [MediaType.TEXT_EVENT_STREAM_VALUE])
fun handle() = SseEmitter().apply {
    // Save the emitter somewhere..
}

// 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:

Java

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

Kotlin

```
@GetMapping("/download")
fun handle() = StreamingResponseBody {
    // write...
}
```

You can use `StreamingResponseBody` as the body in a `ResponseEntity` to customize the status and headers of the response.

1.6.5. Reactive Types

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/x-ndjson` 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 run 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.

1.6.6. Disconnects

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 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.

1.6.7. 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` `jakarta.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.
- `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.

1.7. CORS

WebFlux

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

1.7.1. Introduction

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.

1.7.2. Processing

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, e.g. `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`

1.7.3. `@CrossOrigin`

WebFlux

The `@CrossOrigin` annotation enables cross-origin requests on annotated controller methods, as the following example shows:

Java

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

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

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

Kotlin

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

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

    @DeleteMapping("/{id}")
    fun remove(@PathVariable id: Long) {
        // ...
    }
}
```

By default, `@CrossOrigin` allows:

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

`allowCredentials` 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. When it is enabled either `allowOrigins` must be set to one or more specific domain (but not the special value `"*"`) or alternatively the `allowOriginPatterns` property may be used to match to a dynamic set of origins.

`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:

Java

```
@CrossOrigin(origins = "https://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) {
        // ...
    }
}
```

Kotlin

```
@CrossOrigin(origins = ["https://domain2.com"], maxAge = 3600)
@RestController
@RequestMapping("/account")
class AccountController {

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

    @DeleteMapping("/{id}")
    fun remove(@PathVariable id: Long) {
        // ...
    }
```

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

Java

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

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

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

Kotlin

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

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

    @DeleteMapping("/{id}")
    fun remove(@PathVariable id: Long) {
        // ...
    }
}
```

1.7.4. Global Configuration

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 XML namespace to do that.

By default, global configuration enables the following:

- All origins.

- All headers.
- `GET`, `HEAD`, and `POST` methods.

`allowCredentials` 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. When it is enabled either `allowOrigins` must be set to one or more specific domain (but not the special value `"*"`) or alternatively the `allowOriginPatterns` property may be used to match to a dynamic set of origins.

`maxAge` is set to 30 minutes.

Java Configuration

WebFlux

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

Java

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

    @Override
    public void addCorsMappings(CorsRegistry registry) {

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

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

Kotlin

```
@Configuration
@EnableWebMvc
class WebConfig : WebMvcConfigurer {

    override fun addCorsMappings(registry: CorsRegistry) {

        registry.addMapping("/api/**")
                .allowedOrigins("https://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="https://domain1.com, https://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="https://domain1.com" />

</mvc:cors>
```

1.7.5. CORS Filter

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:

Java

```
CorsConfiguration config = new CorsConfiguration();

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

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

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

CorsFilter filter = new CorsFilter(source);
```

Kotlin

```
val config = CorsConfiguration()

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

config.allowCredentials = true
config.addAllowedOrigin("https://domain1.com")
config.addAllowedHeader("*")
config.addAllowedMethod("*")

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

val filter = CorsFilter(source)
```

1.8. Web Security

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.

1.9. HTTP Caching

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.

1.9.1. `CacheControl`

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:

Java

```
// 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();
```

Kotlin

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

// Prevent caching - "Cache-Control: no-store"
val 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"
val ccCustom = CacheControl.maxAge(10, TimeUnit.DAYS).noTransform().cachePublic()
```

`WebContentGenerator` also accepts 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.

1.9.2. Controllers

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:

Java

```
@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);
}
```

Kotlin

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

    val book = findBook(id);
    val version = book.getVersion()

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

The preceding example sends a 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:

Java

```
@RequestMapping
public String myHandleMethod(WebRequest request, 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.

Kotlin

```
@RequestMapping
fun myHandleMethod(request: WebRequest, model: Model): String? {

    val eTag: Long = ... ①

    if (request.checkNotModified(eTag)) {
        return null ②
    }

    model[...] = ... 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 412 (PRECONDITION_FAILED), to prevent concurrent modification.

1.9.3. Static Resources

WebFlux

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

1.9.4. `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.

1.10. View Technologies

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.

The views of a Spring MVC application live within the internal trust boundaries of that application. Views have access to all the beans of your application context. As such, it is not recommended to use Spring MVC's template support in applications where the templates are editable by external sources, since this can have security implications.

1.10.1. Thymeleaf

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 sets 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.

1.10.2. FreeMarker

WebFlux

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

View Configuration

WebFlux

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

Java

```
@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;
    }
}
```

Kotlin

```
@Configuration
@EnableWebMvc
class WebConfig : WebMvcConfigurer {

    override fun configureViewResolvers(registry: ViewResolverRegistry) {
        registry.freeMarker()
    }

    // Configure FreeMarker...

    @Bean
    fun freeMarkerConfigurer() = FreeMarkerConfigurer().apply {
        setTemplateLoaderPath("/WEB-INF/freemarker")
    }
}
```

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-configurer>
    <mvc:template-loader-path location="/WEB-INF/freemarker"/>
</mvc:freemarker-configurer>
```

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

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 use a `FreeMarkerConfigurer`:

```
<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

WebFlux

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

Some of the macros defined in the Spring templating 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 based on FreeMarker 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 a `personForm` view:

```
<!-- 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 "personForm.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 controller configuration) 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`.

An alternative form of the macro called `<@spring.bindEscaped>` takes a second argument that 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 FreeMarker 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 FreeMarker Template (FTL) definitions and the parameter list that each takes:

Table 6. Table of macro definitions

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

macro	FTL definition
formRadioButtons (a set of radio buttons that let a single selection be made from the available choices)	<@spring.formRadioButtons path, options separator, attributes/>
formCheckboxes (a set of checkboxes that let 0 or more values be selected)	<@spring.formCheckboxes path, options, separator, attributes/>
formCheckbox (a single checkbox)	<@spring.formCheckbox path, attributes/>
showErrors (simplify display of validation errors for the bound field)	<@spring.showErrors separator, classOrStyle/>

In FreeMarker templates, 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 <br>).
- attributes: An additional string of arbitrary tags or text to be included within the HTML tag itself. This string is echoed literally by the macro. For example, in a 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.

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 binding 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 `POST` 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:

Java

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

Kotlin

```
protected fun referenceData(request: HttpServletRequest): Map<String, *> {
    val cityMap = linkedMapOf(
            "LDN" to "London",
            "PRS" to "Paris",
            "NYC" to "New York"
    )
    return hashMapOf("cityMap" to cityMap)
}
```

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 -->
```

1.10.3. 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:

Java

```
@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;
    }
}
```

Kotlin

```
@Configuration
@EnableWebMvc
class WebConfig : WebMvcConfigurer {

    override fun configureViewResolvers(registry: ViewResolverRegistry) {
        registry.groovy()
    }

    // Configure the Groovy Markup Template Engine...

    @Bean
    fun groovyMarkupConfigurer() = GroovyMarkupConfigurer().apply {
        resourceLoaderPath = "/WEB-INF/"
    }
}
```

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-configurer 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')
    }
}
```

1.10.4. Script Views

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

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.KotlinJsr223JvmLocalScriptEngineFactory` 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

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:

Java

```
@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;
    }
}
```

Kotlin

```
@Configuration
@EnableWebMvc
class WebConfig : WebMvcConfigurer {

    override fun configureViewResolvers(registry: ViewResolverRegistry) {
        registry.scriptTemplate()
    }

    @Bean
    fun configurer() = ScriptTemplateConfigurer().apply {
        engineName = "nashorn"
        setScripts("mustache.js")
        renderObject = "Mustache"
        renderFunction = "render"
    }
}
```

The following example shows the same arrangement in XML:

```
<mvc:annotation-driven/>

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

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

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

Java

```
@Controller
public class SampleController {

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

Kotlin

```
@Controller
class SampleController {

    @GetMapping("/sample")
    fun test(model: Model): String {
        model["title"] = "Sample title"
        model["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, Handlerbars 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:

Java

```
@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;
    }
}
```

Kotlin

```
@Configuration
@EnableWebMvc
class WebConfig : WebMvcConfigurer {

    override fun configureViewResolvers(registry: ViewResolverRegistry) {
        registry.scriptTemplate()
    }

    @Bean
    fun configurer() = ScriptTemplateConfigurer().apply {
        engineName = "nashorn"
        setScripts("polyfill.js", "handlebars.js", "render.js")
        renderFunction = "render"
        isSharedEngine = false
    }
}
```

Setting the `sharedEngine` property to `false` is required when using non-thread-safe script engines with templating libraries not designed for concurrency, such as Handlebars or React running on Nashorn. In that case, Java SE 8 update 60 is required, due to this bug, but it is generally recommended to use a recent Java SE patch release in any case.

`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.

1.10.5. 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 typically declare an `InternalResourceViewResolver` bean.

`InternalResourceViewResolver` can be used for dispatching to any Servlet resource but in particular 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 JSP Standard Tag Library (JSTL) 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:

Java

```
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;
    }
}
```

Kotlin

```
class Preferences(
        var receiveNewsletter: Boolean,
        var interests: StringArray,
        var favouriteWord: String
)
```

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="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:radiobutton path="sex" value="M"/> <br/>
        Female: <form:radiobutton 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="^76525bvHGq" 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:

Java

```
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.");
    }
}
```

Kotlin

```
class UserValidator : Validator {

    override fun supports(candidate: Class<*>): Boolean {
        return User::class.java.isAssignableFrom(candidate)
    }

    override fun validate(obj: Any, 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:

Java

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

Kotlin

```
@RequestMapping(method = [RequestMethod.DELETE])
fun deletePet(@PathVariable ownerId: Int, @PathVariable petId: Int): String {
    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.

1.10.6. 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 https://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 in Spring: typically a convenient `TilesViewResolver`.

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>
```

`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 `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>
```

1.10.7. 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 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:

Java

```
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
    }
}
```

Kotlin

```
class SampleContentAtomView : AbstractAtomFeedView() {

    override fun buildFeedMetadata(model: Map<String, Any>,
            feed: Feed, request: HttpServletRequest) {
        // implementation omitted
    }

    override fun buildFeedEntries(model: Map<String, Any>,
            request: HttpServletRequest, response: HttpServletResponse): List<Entry> {
        // implementation omitted
    }
}
```

Similar requirements apply for implementing `AbstractRssFeedView`, as the following example shows:

Java

```
public class SampleContentRssView 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
    }
}
```

Kotlin

```
class SampleContentRssView : AbstractRssFeedView() {

    override fun buildFeedMetadata(model: Map<String, Any>,
                                   feed: Channel, request: HttpServletRequest) {
        // implementation omitted
    }

    override fun buildFeedItems(model: Map<String, Any>,
            request: HttpServletRequest, response: HttpServletResponse): List<Item> {
        // 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.

1.10.8. 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 1.2.12) 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 `org.springframework.web.servlet.view.document.AbstractPdfView` and implement the `buildPdfDocument()` method, as the following example shows:

Java

```
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));
        }
    }
}
```

Kotlin

```
class PdfWordList : AbstractPdfView() {

    override fun buildPdfDocument(model: Map<String, Any>, doc: Document, writer:
PdfWriter,
            request: HttpServletRequest, response: HttpServletResponse) {

        val words = model["wordList"] as List<String>
        for (word in words) {
            doc.add(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.

1.10.9. Jackson

WebFlux

Spring offers support for the Jackson JSON library.

Jackson-based JSON MVC Views

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

WebFlux

`MappingJackson2XmlView` uses the Jackson XML extension's `XmlMapper` to render the response content as XML. If the model contains multiple 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.

1.10.10. 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.

1.10.11. 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:

Java

```
@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;
    }
}
```

Kotlin

```
@EnableWebMvc
@ComponentScan
@Configuration
class WebConfig : WebMvcConfigurer {

    @Bean
    fun xsltViewResolver() = XsltViewResolver().apply {
        setPrefix("/WEB-INF/xsl/")
        setSuffix(".xslt")
    }
}
```

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:

Java

```
@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";
    }
}
```

Kotlin

```
import org.springframework.ui.set

@Controller
class XsltController {

    @RequestMapping("/")
    fun home(model: Model): String {
        val document =
DocumentBuilderFactory.newInstance().newDocumentBuilder().newDocument()
        val root = document.createElement("wordList")

        val words = listOf("Hello", "Spring", "Framework")
        for (word in words) {
            val wordNode = document.createElement("word")
            val textNode = document.createTextNode(word)
            wordNode.appendChild(textNode)
            root.appendChild(wordNode)
        }

        model["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>
```

1.11. MVC Config

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.

1.11.1. Enable MVC Configuration

WebFlux

In Java configuration, you can use the `@EnableWebMvc` annotation to enable MVC configuration, as the following example shows:

Java

```
@Configuration
@EnableWebMvc
public class WebConfig {
}
```

Kotlin

```
@Configuration
@EnableWebMvc
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
        https://www.springframework.org/schema/beans/spring-beans.xsd
        http://www.springframework.org/schema/mvc
        https://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).

1.11.2. MVC Config API

WebFlux

In Java configuration, you can implement the `WebMvcConfigurer` interface, as the following example shows:

Java

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

    // Implement configuration methods...
}
```

Kotlin

```
@Configuration
@EnableWebMvc
class WebConfig : 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.

1.11.3. Type Conversion

WebFlux

By default, formatters for various number and date types are installed, along with support for customization via `@NumberFormat` and `@DateTimeFormat` on fields.

To register custom formatters and converters in Java config, use the following:

Java

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

    @Override
    public void addFormatters(FormatterRegistry registry) {
        // ...
    }
}
```

Kotlin

```
@Configuration
@EnableWebMvc
class WebConfig : WebMvcConfigurer {

    override fun addFormatters(registry: FormatterRegistry) {
        // ...
    }
}
```

To do the same in XML config, use the following:

```
<?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
        https://www.springframework.org/schema/beans/spring-beans.xsd
        http://www.springframework.org/schema/mvc
        https://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>
```

By default Spring MVC considers the request Locale when parsing and formatting date values. This works for forms where dates are represented as Strings with "input" form fields. For "date" and "time" form fields, however, browsers use a fixed format defined in the HTML spec. For such cases date and time formatting can be customized as follows:

Java

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

    @Override
    public void addFormatters(FormatterRegistry registry) {
        DateTimeFormatterRegistrar registrar = new DateTimeFormatterRegistrar();
        registrar.setUseIsoFormat(true);
        registrar.registerFormatters(registry);
    }
}
```

Kotlin

```
@Configuration
@EnableWebMvc
class WebConfig : WebMvcConfigurer {

    override fun addFormatters(registry: FormatterRegistry) {
        val registrar = DateTimeFormatterRegistrar()
        registrar.setUseIsoFormat(true)
        registrar.registerFormatters(registry)
    }
}
```

See the `FormatterRegistrar` SPI and the `FormattingConversionServiceFactoryBean` for more information on when to use FormatterRegistrar implementations.

1.11.4. Validation

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:

Java

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

    @Override
    public Validator getValidator() {
        // ...
    }
}
```

Kotlin

```
@Configuration
@EnableWebMvc
class WebConfig : WebMvcConfigurer {

    override fun getValidator(): Validator {
        // ...
    }
}
```

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
        https://www.springframework.org/schema/beans/spring-beans.xsd
        http://www.springframework.org/schema/mvc
        https://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:

Java

```
@Controller
public class MyController {

    @InitBinder
    protected void initBinder(WebDataBinder binder) {
        binder.addValidators(new FooValidator());
    }
}
```

Kotlin

```
@Controller
class MyController {

    @InitBinder
    protected fun initBinder(binder: WebDataBinder) {
        binder.addValidators(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.

1.11.5. Interceptors

In Java configuration, you can register interceptors to apply to incoming requests, as the following example shows:

Java

```
@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/*");
    }
}
```

Kotlin

```
@Configuration
@EnableWebMvc
class WebConfig : WebMvcConfigurer {

    override fun addInterceptors(registry: InterceptorRegistry) {
        registry.addInterceptor(LocaleChangeInterceptor())

registry.addInterceptor(ThemeChangeInterceptor()).addPathPatterns("/**").excludePathPa
tterns("/admin/**")
        registry.addInterceptor(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>
```

1.11.6. Content Types

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, only the `Accept` header is checked.

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:

Java

```
@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);
    }
}
```

Kotlin

```
@Configuration
@EnableWebMvc
class WebConfig : WebMvcConfigurer {

    override fun configureContentNegotiation(configurer: ContentNegotiationConfigurer)
{
        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>
```

1.11.7. Message Converters

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:

Java

```
@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()));
    }
}
```

Kotlin

```
@Configuration
@EnableWebMvc
class WebConfiguration : WebMvcConfigurer {

    override fun configureMessageConverters(converters:
MutableList<HttpMessageConverter<*>>) {
        val builder = Jackson2ObjectMapperBuilder()
                .indentOutput(true)
                .dateFormat(SimpleDateFormat("yyyy-MM-dd"))
                .modulesToInstall(ParameterNamesModule())
        converters.add(MappingJackson2HttpMessageConverter(builder.build()))

converters.add(MappingJackson2XmlHttpMessageConverter(builder.createXmlMapper(true).bu
ild()))
```

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-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`.
- `jackson-module-kotlin`: Support for Kotlin classes and data classes.

> 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"/>
```

1.11.8. 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 run before the view generates the response.

The following example of Java configuration forwards a request for `/` to a view called `home`:

Java

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

    @Override
    public void addViewControllers(ViewControllerRegistry registry) {
        registry.addViewController("/").setViewName("home");
    }
}
```

Kotlin

```
@Configuration
@EnableWebMvc
class WebConfig : WebMvcConfigurer {

    override fun addViewControllers(registry: ViewControllerRegistry) {
        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"/>
```

If an `@RequestMapping` method is mapped to a URL for any HTTP method then a view controller cannot be used to handle the same URL. This is because a match by URL to an annotated controller is considered a strong enough indication of endpoint ownership so that a 405 (METHOD_NOT_ALLOWED), a 415 (UNSUPPORTED_MEDIA_TYPE), or similar response can be sent to the client to help with debugging. For this reason it is recommended to avoid splitting URL handling across an annotated controller and a view controller.

1.11.9. View Resolvers

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:

Java

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

    @Override
    public void configureViewResolvers(ViewResolverRegistry registry) {
        registry.enableContentNegotiation(new MappingJackson2JsonView());
        registry.jsp();
    }
}
```

Kotlin

```
@Configuration
@EnableWebMvc
class WebConfig : WebMvcConfigurer {

    override fun configureViewResolvers(registry: ViewResolverRegistry) {
        registry.enableContentNegotiation(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-configurer>
    <mvc:template-loader-path location="/freemarker"/>
</mvc:freemarker-configurer>
```

In Java configuration, you can add the respective `Configurer` bean, as the following example shows:

Java

```
@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;
    }
}
```

Kotlin

```
@Configuration
@EnableWebMvc
class WebConfig : WebMvcConfigurer {

    override fun configureViewResolvers(registry: ViewResolverRegistry) {
        registry.enableContentNegotiation(MappingJackson2JsonView())
        registry.freeMarker().cache(false)
    }

    @Bean
    fun freeMarkerConfigurer() = FreeMarkerConfigurer().apply {
        setTemplateLoaderPath("/freemarker")
    }
}
```

1.11.10. Static Resources

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` information is deduced from `Resource#lastModified` so that HTTP conditional requests are supported with `"Last-Modified"` headers.

The following listing shows how to do so with Java configuration:

Java

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

    @Override
    public void addResourceHandlers(ResourceHandlerRegistry registry) {
        registry.addResourceHandler("/resources/**")
                .addResourceLocations("/public", "classpath:/static/")
                .setCacheControl(CacheControl.maxAge(Duration.ofDays(365)));
    }
}
```

Kotlin

```
@Configuration
@EnableWebMvc
class WebConfig : WebMvcConfigurer {

    override fun addResourceHandlers(registry: ResourceHandlerRegistry) {
        registry.addResourceHandler("/resources/**")
                .addResourceLocations("/public", "classpath:/static/")
                .setCacheControl(CacheControl.maxAge(Duration.ofDays(365)))
    }
}
```

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:

Java

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

    @Override
    public void addResourceHandlers(ResourceHandlerRegistry registry) {
        registry.addResourceHandler("/resources/**")
                .addResourceLocations("/public/")
                .resourceChain(true)
                .addResolver(new
VersionResourceResolver().addContentVersionStrategy("/**"));
    }
}
```

Kotlin

```
@Configuration
@EnableWebMvc
class WebConfig : WebMvcConfigurer {

    override fun addResourceHandlers(registry: ResourceHandlerRegistry) {
        registry.addResourceHandler("/resources/**")
                .addResourceLocations("/public/")
                .resourceChain(true)

.addResolver(VersionResourceResolver().addContentVersionStrategy("/**"))
    }
}
```

The following example shows how to achieve the same configuration in XML:

```
<mvc:resources mapping="/resources/**" location="/public/">
    <mvc:resource-chain resource-cache="true">
        <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 `VersionResourceResolver`, you must register them in this order. That ensures content-based versions are always computed reliably, based on the unencoded file.

WebJars are also supported through the `WebJarsResourceResolver` which is automatically registered when the `org.webjars:webjars-locator-core` library is present on the classpath. The resolver can rewrite URLs to include the version of the jar and can also match against incoming URLs without versions — for example, from `/jquery/jquery.min.js` to `/jquery/1.2.0/jquery.min.js`.

The Java configuration based on `ResourceHandlerRegistry` provides further options for fine-grained control, e.g. last-modified behavior and optimized resource resolution.

1.11.11. 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:

Java

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

    @Override
    public void configureDefaultServletHandling(DefaultServletHandlerConfigurer
configurer) {
        configurer.enable();
    }
}
```

Kotlin

```
@Configuration
@EnableWebMvc
class WebConfig : WebMvcConfigurer {

    override fun configureDefaultServletHandling(configurer:
DefaultServletHandlerConfigurer) {
        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:

Java

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

    @Override
    public void configureDefaultServletHandling(DefaultServletHandlerConfigurer
configurer) {
        configurer.enable("myCustomDefaultServlet");
    }
}
```

Kotlin

```
@Configuration
@EnableWebMvc
class WebConfig : WebMvcConfigurer {

    override fun configureDefaultServletHandling(configurer:
DefaultServletHandlerConfigurer) {
        configurer.enable("myCustomDefaultServlet")
    }
}
```

The following example shows how to achieve the same configuration in XML:

```
<mvc:default-servlet-handler default-servlet-name="myCustomDefaultServlet"/>
```

1.11.12. Path Matching

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:

Java

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

    @Override
    public void configurePathMatch(PathMatchConfigurer configurer) {
        configurer
            .setPatternParser(new PathPatternParser())
            .addPathPrefix("/api",
HandlerTypePredicate.forAnnotation(RestController.class));
    }

    private PathPatternParser patternParser() {
        // ...
    }
}
```

Kotlin

```
@Configuration
@EnableWebMvc
class WebConfig : WebMvcConfigurer {

    override fun configurePathMatch(configurer: PathMatchConfigurer) {
        configurer
            .setPatternParser(patternParser)
            .addPathPrefix("/api",
HandlerTypePredicate.forAnnotation(RestController::class.java))
    }

    fun patternParser(): PathPatternParser {
        //...
    }
}
```

The following example shows how to achieve the same configuration in XML:

```
<mvc:annotation-driven>
    <mvc:path-matching
        trailing-slash="false"
        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"/>
```

1.11.13. Advanced Java Config

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:

Java

```
@Configuration
public class WebConfig extends DelegatingWebMvcConfiguration {

    // ...
}
```

Kotlin

```
@Configuration
class WebConfig : 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.

1.11.14. 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:

Java

```
@Component
public class MyPostProcessor implements BeanPostProcessor {

    public Object postProcessBeforeInitialization(Object bean, String name) throws
BeansException {
        // ...
    }
}
```

Kotlin

```
@Component
class MyPostProcessor : BeanPostProcessor {

    override fun postProcessBeforeInitialization(bean: Any, name: String): Any {
        // ...
    }
}
```

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.

1.12. HTTP/2

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 `jakarta.servlet.http.PushBuilder` to 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 `RestTemplate` is in maintenance mode, with only minor requests for changes and bugs to be accepted going forward. Please, consider using the WebClient which offers a more modern API and supports sync, async, and streaming scenarios.

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

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 re-use 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: 1qVdfYHU9hPOl4JYYNXF623Gzn0=
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

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`

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
        https://www.springframework.org/schema/beans/spring-beans.xsd
        http://www.springframework.org/schema/websocket
        https://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

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
        https://www.springframework.org/schema/beans/spring-beans.xsd
        http://www.springframework.org/schema/websocket
        https://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
        https://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
        https://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

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
        https://www.springframework.org/schema/beans/spring-beans.xsd
        http://www.springframework.org/schema/websocket
        https://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
        https://www.springframework.org/schema/beans/spring-beans.xsd
        http://www.springframework.org/schema/websocket
        https://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

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("https://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
        https://www.springframework.org/schema/beans/spring-beans.xsd
        http://www.springframework.org/schema/websocket
        https://www.springframework.org/schema/websocket/spring-websocket.xsd">

    <websocket:handlers allowed-origins="https://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:

```
https://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
        https://www.springframework.org/schema/beans/spring-beans.xsd
        http://www.springframework.org/schema/websocket
        https://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
@EnableWebSocketMessageBroker
public class WebSocketConfig implements WebSocketMessageBrokerConfigurer {

    @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. Your 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:nxahklf6-1
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
        https://www.springframework.org/schema/beans/spring-beans.xsd
        http://www.springframework.org/schema/websocket
        https://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(600000);

        return new DefaultHandshakeHandler(
                new JettyRequestUpgradeStrategy(new WebSocketServerFactory(policy)));
    }
}
```

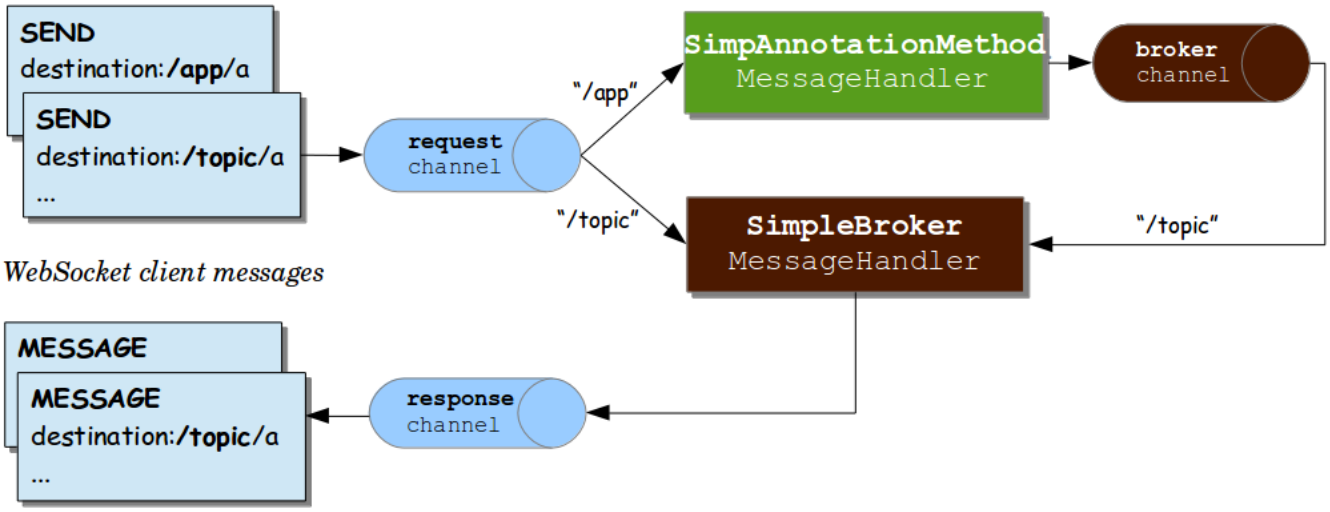
4.4.5. Flow of Messages

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.

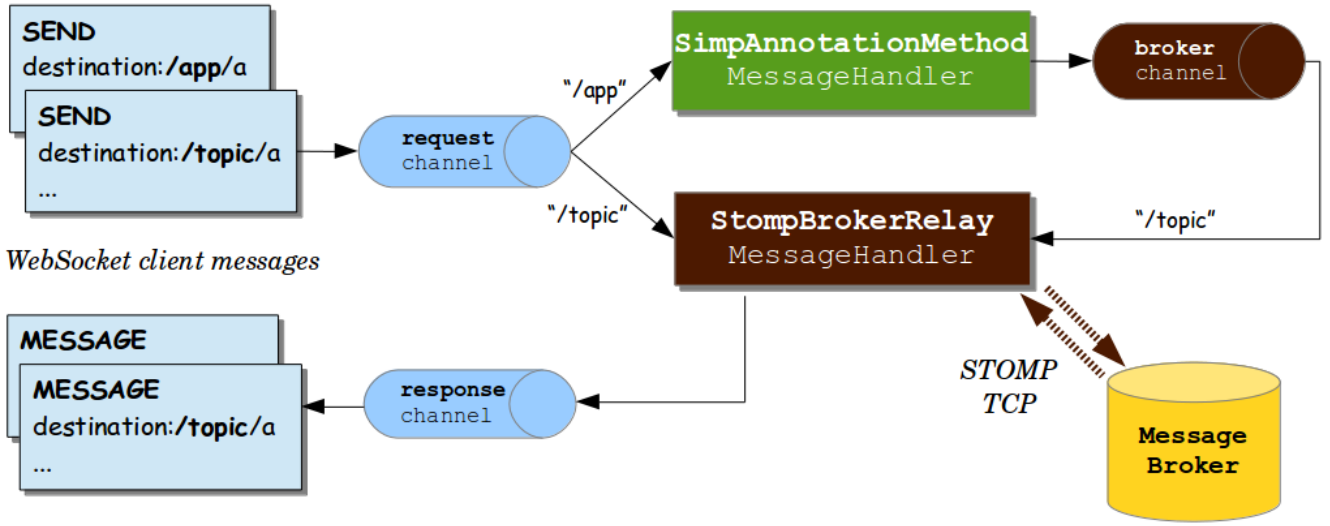
Both the Java configuration (that is, `@EnableWebSocketMessageBroker`) and the XML namespace configuration (that is, `<websocket:message-broker>`) use the preceding components to assemble a message workflow. The following diagram shows the components used when the simple built-in message broker is enabled:



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
`Message`	For access to the complete message.
`MessageHeaders`	For access to the headers within the `Message`.
`MessageHeaderAccessor`, `SimpMessageHeaderAccessor`, and `StompHeaderAccessor`	For access to the headers through typed accessor methods.
`@Payload`	For access to the payload of the message, converted (for example, from JSON) by a configured `MessageConverter`. The presence of this annotation is not required since it is, by default, assumed if no other argument is matched. You can annotate payload arguments with `@jakarta.validation.Valid` or Spring's `@Validated`, to have the payload arguments be automatically validated.

Method argument	Description
`@Header`	For access to a specific header value — along with type conversion using an `org.springframework.core.convert.converter.Converter`, if necessary.
`@Headers`	For access to all headers in the message. This argument must be assignable to `java.util.Map`.
`@DestinationVariable`	For access to template variables extracted from the message destination. Values are converted to the declared method argument type as necessary.
`java.security.Principal`	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 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. To configure a scheduler, you can declare your own `TaskScheduler` bean and set it through the `MessageBrokerRegistry`. Alternatively, you can use the one that is automatically declared in the built-in WebSocket configuration, however, you'll' need `@Lazy` to avoid a cycle between the built-in WebSocket configuration and your `WebSocketMessageBrokerConfigurer`. For example:

```
@Configuration
@EnableWebSocketMessageBroker
public class WebSocketConfig implements WebSocketMessageBrokerConfigurer {

    private TaskScheduler messageBrokerTaskScheduler;

    @Autowired
    public void setMessageBrokerTaskScheduler(@Lazy 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
        https://www.springframework.org/schema/beans/spring-beans.xsd
        http://www.springframework.org/schema/websocket
        https://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(new AntPathMatcher("."));
        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
                https://www.springframework.org/schema/beans/spring-beans.xsd
                http://www.springframework.org/schema/websocket
                https://www.springframework.org/schema/websocket/spring-
websocket.xsd">

    <websocket:message-broker application-destination-prefix="/app" path-
matcher="pathMatcher">
        <websocket:stomp-endpoint path="/stomp"/>
        <websocket:stomp-broker-relay prefix="/topic,/queue" />
    </websocket:message-broker>

    <bean id="pathMatcher" class="org.springframework.util.AntPathMatcher">
        <constructor-arg index="0" value="."/>
    </bean>

</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. `UserDestinationMessageHandler` handles this destination and transforms it 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.

> When working with user destinations, it is important to configure broker and application destination prefixes as shown in Enable STOMP, or otherwise the broker would handle "/user" prefixed messages that should only be handled by `UserDestinationMessageHandler`.

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
        https://www.springframework.org/schema/beans/spring-beans.xsd
        http://www.springframework.org/schema/websocket
        https://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 `SessionDisconnectEvent` 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).

`WebSocketStompClient` sends a heartbeat only in case of inactivity, i.e. when no other messages are sent. This can present a challenge when using an external broker since messages with a non-broker destination represent activity but aren't actually forwarded to the broker. In that case you can configure a `TaskScheduler` when initializing the External Broker which ensures a heartbeat is forwarded to the broker also when only messages with a non-broker destination are sent.

> 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
        https://www.springframework.org/schema/beans/spring-beans.xsd
        http://www.springframework.org/schema/websocket
        https://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
        https://www.springframework.org/schema/beans/spring-beans.xsd
        http://www.springframework.org/schema/websocket
        https://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 frameworks (Spring MVC and Spring WebFlux) while, at the same time, supporting 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 common Spring configuration that is not specific to any one web framework. (This section is equally applicable to Spring's own web framework variants.)

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 need to do is declare a `ContextLoaderListener` in the standard Jakarta 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(servletContext);
```

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. It is an official part of the Jakarta EE umbrella but also individually usable, e.g. through embedding Mojarra or MyFaces within Tomcat.

Please note that recent versions of JSF became closely tied to CDI infrastructure in application servers, with some new JSF functionality only working in such an environment. Spring's JSF support is not actively evolved anymore and primarily exists for migration purposes when modernizing older JSF-based applications.

The key element in Spring's JSF integration is the JSF `ELResolver` mechanism.

5.2.1. Spring Bean Resolver

`SpringBeanFacesELResolver` is a JSF compliant `ELResolver` implementation, integrating with the standard Unified EL as used by JSF and JSP. 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 `ELResolver` 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.

As a successor to the original Struts 1.x, check out Struts 2.x and the Struts-provided Spring Plugin for the built-in Spring integration.

5.4. Apache 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