JAKARTA EE

Jakarta Servlet Specification

Jakarta Servlet Team, https://projects.eclipse.org/projects/ee4j.servlet

5.0, July 20, 2020: Final

Table of Contents

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Jakarta Servlet Specification, Version 5.0

The Jakarta Servlet Team - July 20, 2020

Comments to: servlet-dev@eclipse.org [mailto:servlet-dev@eclipse.org]

Preface

This document is the Jakarta Servlet Specification, version 5.0. The standard for the Jakarta Servlet API is described herein.

Additional Sources

The specification is intended to be a complete and clear explanation of the Jakarta Servlet API, but if questions remain, the following sources may be consulted:

- A reference implementation (RI) has been made available which provides a behavioral benchmark for this specification. Where the specification leaves implementation of a particular feature open to interpretation, implementors may use the reference implementation as a model of how to carry out the intention of the specification.
- A compatibility test suite (CTS) has been provided for assessing whether implementations meet the compatibility requirements of the Jakarta Servlet API standard. The test results have normative value for resolving questions about whether an implementation is standard.
- If further clarification is required, the working group for the Jakarta Servlet API under the Jakarta EE Working Group should be consulted, and is the final arbiter of such issues.

Comments and feedback are welcome, and will be used to improve future versions.

Who Should Read This Specification

The intended audience for this specification includes the following groups:

- Web server and application server vendors that want to provide servlet engines that conform to this standard.
- Authoring tool developers that want to support web applications that conform to this specification.
- Experienced servlet authors who want to understand the underlying mechanisms of servlet technology.

We emphasize that this specification is not a user's guide for servlet developers and is not intended to be used as such.

API Reference

The full specifications of classes, interfaces, and method signatures that define the Jakarta Servlet API, as well as their accompanying Javadoc™ documentation, is available online at https://jakarta.ee/specifications/servlet.

Other Jakarta Platform Specifications

The following Jakarta API specifications are referenced throughout this specification:

- Jakarta EE Platform, version 9
- Jakarta Server Pages™ (JSP), version 3.0
- Java Naming and Directory Interface™ (JNDI).
- Jakarta Context and Dependency Injection for the Jakarta EE Platform
- Jakarta Managed Beans specification

These specifications may be found at the Jakarta EE Platform, web site: https://jakarta.ee/specifications/.

Other Important References

The following Internet specifications provide information relevant to the development and implementation of the Jakarta Servlet API and standard servlet engines:

- RFC 1630 Uniform Resource Identifiers (URI)
- RFC 1738 Uniform Resource Locators (URL)
- RFC 3986 Uniform Resource Identifiers (URI): Generic Syntax
- RFC 1945 Hypertext Transfer Protocol (HTTP/1.0)
- RFC 2045 MIME Part One: Format of Internet Message Bodies
- RFC 2046 MIME Part Two: Media Types
- RFC 2047 MIME Part Three: Message Header Extensions for non-ASCII text
- RFC 2048 MIME Part Four: Registration Procedures
- RFC 2049 MIME Part Five: Conformance Criteria and Examples
- RFC 6265 HTTP State Management Mechanism
- RFC 7258 Pervasive Monitoring Is an Attack
- RFC 7540 Hypertext Transfer Protocol Version 2 (HTTP/2)

- RFC 7541 HPACK: Header Compression for HTTP/2 (HPACK)
- RFC 7230 Hypertext Transfer Protocol (HTTP/1.1): Message Syntax and Routing
- RFC 7231 Hypertext Transfer Protocol (HTTP/1.1): Semantics and Content
- RFC 7232 Hypertext Transfer Protocol (HTTP/1.1): Conditional Requests
- RFC 7233 Hypertext Transfer Protocol (HTTP/1.1): Range Requests
- RFC 7234 Hypertext Transfer Protocol (HTTP/1.1): Caching
- RFC 7235 Hypertext Transfer Protocol (HTTP/1.1): Authentication
- RFC 7301 Transport Layer Security (TLS) Application-Layer Protocol Negotiation Extension (ALPN)
- RFC 7168 The Hyper Text Coffee Pot Control Protocol for Tea Ef (HTCPCP-TEA)[1]
- RFC 2617 HTTP Authentication: Basic and Digest Authentication
- RFC 2119 Key words for use in RFCs to Indicate Requirement Levels

Online versions of these RFCs are at http://www.ietf.org/rfc/.

The World Wide Web Consortium (http://www.w3.org/) is a definitive source of HTTP related information affecting this specification and its implementations.

The eXtensible Markup Language (XML) is used for the specification of the Deployment Descriptors described in Chapter 13 of this specification.

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC2119.

Providing Feedback

We welcome any and all feedback about this specification. Please e-mail your comments to servlet-dev@eclipse.org.

[1] This reference is mostly tongue-in-cheek although most of the concepts described in the HTCPCP -TEA RFC are relevant to all well-designed web servers.

Chapter 1. Overview

1.1. What is a Servlet?

A servlet is a Jakarta technology-based web component, managed by a container, that generates dynamic content. Like other Jakarta technology-based components, servlets are platform-independent Java classes that are compiled to platform-neutral byte code that can be loaded dynamically into and run by a Jakarta technology-enabled web server. Containers, sometimes called servlet engines, are web server extensions that provide servlet functionality. Servlets interact with web clients via a request/response paradigm implemented by the servlet container.

1.2. What is a Servlet Container?

The servlet container is a part of a web server or application server that provides the network services over which requests and responses are sent, decodes MIME-based requests, and formats MIME-based responses. A servlet container also contains and manages servlets through their lifecycle.

A servlet container can be built into a host web server, or installed as an add-on component to a web server via that server's native extension API. Servlet containers can also be built into or possibly installed into web-enabled application servers.

All servlet containers must support HTTP as a protocol for requests and responses, but additional request/response-based protocols such as HTTPS (HTTP over SSL) may be supported. The required versions of the HTTP specification that a container must implement are HTTP/1.1 and HTTP/2. When supporting HTTP/2, servlet containers must support the "h2" and "h2c" protocol identifiers (as specified in section 3.1 of the HTTP/2 RFC). This implies all servlet containers must support ALPN. Because the container may have a caching mechanism described in RFC 7234 (HTTP/1.1 Caching), it may modify requests from the clients before delivering them to the servlet, may modify responses produced by servlets before sending them to the clients, or may respond to requests without delivering them to the servlet under the compliance with RFC 7234.

A servlet container may place security restrictions on the environment in which a servlet executes. These restrictions may be placed using the permission architecture defined by the Java platform. For example some application servers may limit the creation of a `Thread` object to insure that other components of the container are not negatively impacted.

Java SE 8 is the minimum version of the underlying Java platform with which servlet containers must be built.

1.3. An Example

The following is a typical sequence of events:

1. A client (e.g., a web browser) accesses a web server and makes an HTTP request.

2. The request is received by the web server and handed off to the servlet container. The servlet container can be running in the same process as the host web server, in a different process on the same host, or on a different host from the web server for which it processes requests.
3. The servlet container determines which servlet to invoke based on the configuration of its servlets, and calls it with objects representing the request and response.
4. The servlet uses the request object to find out who the remote user is, what HTTP `POST` parameters may have been sent as part of this request, and other relevant data. The servlet performs whatever logic it was programmed with, and generates data to send back to the client. It sends this data back to the client via the response object.
5. Once the servlet has finished processing the request, the servlet container ensures that the response is properly flushed, and returns control back to the host web server.

1.4. Comparing Servlets with Other Technologies

In functionality, servlets provide a higher level abstraction than Common Gateway Interface (CGI) programs but a lower level of abstraction than that provided by web frameworks such as Jakarta Server Faces.

Servlets have the following advantages over other server extension mechanisms:

- They are generally much faster than CGI scripts because a different process model is used.
- They use a standard API that is supported by many web servers.
- They have all the advantages of the Java programming language, including ease of development and platform independence.
- They can access the large set of APIs available for the Java platform.

1.5. Relationship to Jakarta EE Platform

The Jakarta Servlet API v.5.0 is a required API of the Jakarta EE Platform, 9[2]. Servlet containers and servlets deployed into them must meet additional requirements, described in the Jakarta EE specification, for executing in a Jakarta EE environment.

[2] Please see the Jakarta EE Platform, specification available at https://jakarta.ee/specifications/platform/9/

Chapter 2. The Servlet Interface

The `Servlet` interface is the central abstraction of the Jakarta Servlet API. All servlets implement this interface either directly, or more commonly, by extending a class that implements the interface. The two classes in the Jakarta Servlet API that implement the `Servlet` interface are `GenericServlet` and `HttpServlet`. For most purposes, Developers will extend `HttpServlet` to implement their servlets.

2.1. Request Handling Methods

The basic `Servlet` interface defines a `service` method for handling client requests. This method is called for each request that the servlet container routes to an instance of a servlet.

The handling of concurrent requests to a web application generally requires that the web developer design servlets that can deal with multiple threads executing within the `service` method at a particular time.

Generally the web container handles concurrent requests to the same servlet by concurrent execution of the `service` method on different threads.

2.1.1. HTTP Specific Request Handling Methods

The `HttpServlet` abstract subclass adds additional methods beyond the basic `Servlet` interface that are automatically called by the `service` method in the `HttpServlet` class to aid in processing HTTP-based requests. These methods are:

- `doGet` for handling HTTP `GET` requests
- `doPost` for handling HTTP `POST` requests
- `doPut` for handling HTTP `PUT` requests
- `doDelete` for handling HTTP `DELETE` requests
- `doHead` for handling HTTP `HEAD` requests
- `doOptions` for handling HTTP `OPTIONS` requests
- `doTrace` for handling HTTP `TRACE` requests

Typically when developing HTTP-based servlets, an Application Developer is concerned with the `doGet` and `doPost` methods. The other methods are considered to be methods for use by programmers very familiar with HTTP programming.

2.1.2. Additional Methods

The `doPut` and `doDelete` methods allow Servlet Developers to support HTTP/1.1 clients that employ these features. The `doHead` method in `HttpServlet` is a specialized form of the `doGet` method that returns only the headers produced by the `doGet` method. The `doOptions` method responds with which HTTP methods

are supported by the servlet. The `doTrace` method generates a response containing all instances of the headers sent in the `TRACE` request.

The `CONNECT` method is not supported because it applies to proxies and the Jakarta Servlet API is targeted at endpoints.

2.1.3. Conditional GET Support

The `HttpServlet` class defines the `getLastModified` method to support conditional `GET` operations. A conditional `GET` operation requests a resource be sent only if it has been modified since a specified time. In appropriate situations, implementation of this method may aid efficient utilization of network resources.

2.2. Number of Instances

The servlet declaration which is either via the annotation as described in Chapter 8, *Annotations and Pluggability* or part of the deployment descriptor of the web application containing the servlet, as described in Chapter 14, *Deployment Descriptor*, controls how the servlet container provides instances of the servlet.

For a servlet not hosted in a distributed environment (the default), the servlet container must use only one instance per servlet declaration. However, for a servlet implementing the `SingleThreadModel` interface, the servlet container may instantiate multiple instances to handle a heavy request load and serialize requests to a particular instance.

In the case where a servlet was deployed as part of an application marked in the deployment descriptor as distributable, a container may have only one instance per servlet declaration per Java Virtual Machine (JVM™). However, if the servlet in a distributable application implements the `SingleThreadModel` interface, the container may instantiate multiple instances of that servlet in each JVM of the container.

2.2.1. Note About The Single Thread Model

The use of the `SingleThreadModel` interface guarantees that only one thread at a time will execute in a given servlet instance's `service` method. It is important to note that this guarantee only applies to each servlet instance, since the container may choose to pool such objects. Objects that are accessible to more than one servlet instance at a time, such as instances of `HttpSession`, may be available at any particular time to multiple servlets, including those that implement `SingleThreadModel`.

It is recommended that a developer take other means to resolve those issues instead of implementing this interface, such as avoiding the usage of an instance variable or synchronizing the block of the code accessing those resources. The `SingleThreadModel` Interface has been deprecated since version 2.4 of this specification.

2.3. Servlet Life Cycle

A servlet is managed through a well defined life cycle that defines how it is loaded and instantiated, is initialized, handles requests from clients, and is taken out of service. This life cycle is expressed in the API by the `init`, `service`, and `destroy` methods of the `jakarta.servlet.Servlet` interface that all servlets must implement directly or indirectly through the `GenericServlet` or `HttpServlet` abstract classes.

2.3.1. Loading and Instantiation

The servlet container is responsible for loading and instantiating servlets. The loading and instantiation can occur when the container is started, or delayed until the container determines the servlet is needed to service a request.

When the servlet engine is started, needed servlet classes must be located by the servlet container. The servlet container loads the servlet class using normal Java class loading facilities. The loading may be from a local file system, a remote file system, or other network services.

After loading the `Servlet` class, the container instantiates it for use.

2.3.2. Initialization

After the servlet object is instantiated, the container must initialize the servlet before it can handle requests from clients. Initialization is provided so that a servlet can read persistent configuration data, initialize costly resources (such as JDBC™ API-based connections), and perform other one-time activities. The container initializes the servlet instance by calling the `init` method of the `Servlet` interface with a unique (per servlet declaration) object implementing the `ServletConfig` interface. This configuration object allows the servlet to access name-value initialization parameters from the web application's configuration information. The configuration object also gives the servlet access to an object (implementing the `ServletContext` interface) that describes the servlet's runtime environment. See Chapter 4, *Servlet Context* for more information about the `ServletContext` interface.

2.3.2.1. Error Conditions on Initialization

During initialization, the servlet instance can throw an `UnavailableException` or a `ServletException`. In this case, the servlet must not be placed into active service and must be released by the servlet container. The `destroy` method is not called as it is considered unsuccessful initialization.

A new instance may be instantiated and initialized by the container after a failed initialization. The exception to this rule is when an `UnavailableException` indicates a minimum time of unavailability, and the container must wait for the period to pass before creating and initializing a new servlet instance.

2.3.2.2. Tool Considerations

The triggering of static initialization methods when a tool loads and introspects a web application is to be distinguished from the calling of the `init` method. Developers should not assume a servlet is in an active container runtime until the `init` method of the `Servlet` interface is called. For example, a servlet

should not try to establish connections to databases or Jakarta Enterprise Beans containers when only static (class) initialization methods have been invoked.

2.3.3. Request Handling

After a servlet is properly initialized, the servlet container may use it to handle client requests. Requests are represented by request objects of type `ServletRequest`. The servlet fills out responses to requests by calling methods of a provided object of type `ServletResponse`. These objects are passed as parameters to the `service` method of the `Servlet` interface.

In the case of an HTTP request, the objects provided by the container are of types `HttpServletRequest` and `HttpServletResponse`.

Note that a servlet instance placed into service by a servlet container may handle no requests during its lifetime.

2.3.3.1. Multithreading Issues

A servlet container may send concurrent requests through the `service` method of the servlet. To handle the requests, the Application Developer must make adequate provisions for concurrent processing with multiple threads in the `service` method.

An alternative for the Application Developer was to implement the `SingleThreadModel` interface but this is now deprecated. The `SingleThreadModel` interface requires the container to guarantee that there is only one request thread at a time in the `service` method. A servlet container may satisfy this requirement by serializing requests on a servlet, or by maintaining a pool of servlet instances. If the servlet is part of a web application that has been marked as distributable, the container may maintain a pool of servlet instances in each JVM that the application is distributed across.

For servlets not implementing the `SingleThreadModel` interface, if the `service` method (or methods such as `doGet` or `doPost` to which the `service` method of the `HttpServlet` abstract class is dispatched) has been defined with the `synchronized` keyword, the servlet container cannot use the instance pool approach, but must serialize requests through it. It is strongly recommended that Developers not synchronize the `service` method (or methods dispatched to it) in these circumstances because of detrimental effects on performance.

2.3.3.2. Exceptions During Request Handling

A servlet may throw either a `ServletException` or an `UnavailableException` during the service of a request. A `ServletException` signals that some error occurred during the processing of the request and that the container should take appropriate measures to clean up the request.

An `UnavailableException` signals that the servlet is unable to handle requests either temporarily or permanently.

If a permanent unavailability is indicated by the `UnavailableException`, the servlet container must remove the servlet from service, call its `destroy` method, and release the servlet instance. Any requests

refused by the container by that cause must be returned with a SC_NOT_FOUND (404) response.

If temporary unavailability is indicated by the UnavailableException, the container may choose to not route any requests through the servlet during the time period of the temporary unavailability. Any requests refused by the container during this period must be returned with a SC_SERVICE_UNAVAILABLE (503) response status along with a Retry-After header indicating when the unavailability will terminate.

The container may choose to ignore the distinction between a permanent and temporary unavailability and treat all UnavailableExceptions as permanent, thereby removing a servlet that throws any UnavailableException from service.

2.3.3.3. Asynchronous processing

Sometimes a filter and/or servlet is unable to complete the processing of a request without waiting for a resource or event before generating a response. For example, a servlet may need to wait for an available JDBC connection, for a response from a remote web service, for a JMS message, or for an application event, before proceeding to generate a response. Waiting within the servlet is an inefficient operation as it is a blocking operation that consumes a thread and other limited resources. Frequently a slow resource such as a database may have many threads blocked waiting for access and can cause thread starvation and poor quality of service for an entire web container.

The asynchronous processing of requests is introduced to allow the thread to return to the container and perform other tasks. When asynchronous processing begins on the request, another thread or callback may either generate the response and call complete or dispatch the request so that it may run in the context of the container using the AsyncContext.dispatch method. A typical sequence of events for asynchronous processing is:

1. The request is received and passed via normal filters for authentication etc. to the servlet.
2. The servlet processes the request parameters and/or content to determine the nature of the request.
3. The servlet issues requests for resources or data, for example, sends a remote web service request or joins a queue waiting for a JDBC connection.
4. The servlet returns without generating a response.
5. After some time, the requested resource becomes available, the thread handling that event continues processing either in the same thread or by dispatching to a resource in the container using the AsyncContext.

Jakarta EE features such as Section 15.2.2, “Web Application Environment” and Section 15.3.1, “Propagation of Security Identity in Jakarta Enterprise Bean Calls” are available only to threads executing the initial request or when the request is dispatched to the container via the AsyncContext.dispatch method. Jakarta EE features may be available to other threads operating directly on the response object via the AsyncContext.start(Runnable) method.

The @WebServlet and @WebFilter annotations described in Chapter 8 have an attribute asyncSupported

that is a `boolean` with a default value of `false`. When `asyncSupported` is set to true the application can start asynchronous processing in a separate thread by calling `startAsync` (see below), passing it a reference to the request and response objects, and then exit from the container on the original thread. This means that the response will traverse (in reverse order) the same filters (or filter chain) that were traversed on the way in. The response isn't committed till `complete` (see below) is called on the `AsyncContext`. The application is responsible for handling concurrent access to the request and response objects if the async task is executing before the container-initiated dispatch that called `startAsync` has returned to the container.

Dispatching from a servlet that has `asyncSupported=true` to one where `asyncSupported` is set to `false` is allowed. In this case, the response will be committed when the service method of the servlet that does not support async is exited, and it is the container's responsibility to call `complete` on the `AsyncContext` so that any interested `AsyncListener` instances will be notified. The `AsyncListener.onComplete` notification should also be used by filters as a mechanism to clear up resources that they have been holding on to for the async task to complete.

Dispatching from a synchronous servlet to an asynchronous servlet would be illegal. However the decision of throwing an `IllegalStateException` is deferred to the point when the application calls `startAsync`. This would allow a servlet to either function as a synchronous or an asynchronous servlet.

The async task that the application is waiting for could write directly to the response, on a different thread than the one that was used for the initial request. This thread knows nothing about any filters. If a filter wanted to manipulate the response in the new thread, it would have to wrap the response when it was processing the initial request "on the way in", and passed the wrapped response to the next filter in the chain, and eventually to the servlet. So if the response was wrapped (possibly multiple times, once per filter), and the application processes the request and writes directly to the response, it is really writing to the response wrapper(s), i.e., any output added to the response will still be processed by the response wrapper(s). When an application reads from a request in a separate thread, and adds output to the response, it really reads from the request wrapper(s), and writes to the response wrapper(s), so any input and/or output manipulation intended by the wrapper(s) will continue to occur.

Alternately if the application chooses to do so it can use the `AsyncContext` to `dispatch` the request from the new thread to a resource in the container. This would enable using content generation technologies like Jakarta Server Pages within the scope of the container.

In addition to the annotation attributes, the following methods / classes are provided:

ServletRequest

`public AsyncContext startAsync(ServletRequest req, ServletResponse res)`

This method puts the request into asynchronous mode and initializes its `AsyncContext` with the given request and response objects and the time out returned by `getAsyncTimeout`. The `ServletRequest` and `ServletResponse` parameters MUST be either the same objects as were passed to the calling servlet's `service`, or the filter's `doFilter` method, or be subclasses of `ServletRequestWrapper` or `ServletResponseWrapper` classes that wrap them. A call to this method ensures that the response isn't

committed when the application exits out of the `service` method. It is committed when `AsyncContext.complete` is called on the returned `AsyncContext` or the `AsyncContext` times out and there are no listeners associated to handle the time out. The timer for async time outs will not start until the request and its associated response have returned from the container. The `AsyncContext` could be used to write to the response from the async thread. It can also be used to just notify that the response is not closed and committed.

It is illegal to call `startAsync` if the request is within the scope of a servlet or filter that does not support asynchronous operations, or if the response has been committed and closed, or is called again during the same `dispatch`. The `AsyncContext` returned from a call to `startAsync` can then be used for further asynchronous processing. Calling the `AsyncContext.hasOriginalRequestResponse()` on the returned `AsyncContext` will return `false`, unless the passed `ServletRequest` and `ServletResponse` arguments are the original ones and do not carry application provided wrappers. Any filters invoked in the outbound direction after this request was put into asynchronous mode MAY use this as an indication that some of the request and / or response wrappers that they added during their inbound invocation MAY need to stay in place for the duration of the asynchronous operation, and their associated resources MAY not be released. A `ServletRequestWrapper` applied during the inbound invocation of a filter MAY be released by the outbound invocation of the filter only if the given `ServletRequest` which is used to initialize the `AsyncContext` and will be returned by a call to `AsyncContext.getRequest()`, does not contain the said `ServletRequestWrapper`. The same holds true for `ServletResponseWrapper` instances.

`public AsyncContext startAsync()`

This method is provided as a convenience that uses the original request and response objects for the async processing. Please note users of this method SHOULD flush the response if they are wrapped before calling this method if you wish, to ensure that any data written to the wrapped response isn't lost.

`public AsyncContext getAsyncContext()`

Returns the `AsyncContext` that was created or re initialized by the invocation of `startAsync`. It is illegal to call `getAsyncContext` if the request has not been put in asynchronous mode.

`public boolean isAsyncSupported()`

Returns `true` if the request supports async processing, and `false` otherwise. Async support will be disabled as soon as the request has passed a filter or servlet that does not support async processing (either via the designated annotation or declaratively).

`public boolean isAsyncStarted()`

Returns `true` if async processing has started on this request, and `false` otherwise. If this request has been dispatched using one of the `AsyncContext.dispatch` methods since it was put in asynchronous mode, or a call to `AsynContext.complete` is made, this method returns `false`.

`public DispatcherType getDispatcherType()`

Returns the dispatcher type of a request. The dispatcher type of a request is used by the container to select the filters that need to be applied to the request. Only filters with the matching dispatcher

type and url patterns will be applied. Allowing a filter that has been configured for multiple dispatcher types to query a request for its dispatcher type allows the filter to process the request differently depending on its dispatcher type. The initial dispatcher type of a request is defined as `DispatcherType.REQUEST`. The dispatcher type of a request dispatched via `RequestDispatcher.forward(ServletRequest, ServletResponse)` or `RequestDispatcher.include(ServletRequest, ServletResponse)` is given as `DispatcherType.FORWARD` or `DispatcherType.INCLUDE` respectively, while a dispatcher type of an asynchronous request dispatched via one of the `AsyncContext.dispatch` methods is given as `DispatcherType.ASYNC`. Finally the dispatcher type of a request dispatched to an error page by the container's error handling mechanism is given as `DispatcherType.ERROR`.

AsyncContext

This class represents the execution context for the asynchronous operation that was started on the `ServletRequest`. An `AsyncContext` is created and initialized by a call to `ServletRequest.startAsync` as described above. The following methods are in the `AsyncContext`:

`public ServletRequest getRequest()`

Returns the request that was used to initialize the `AsyncContext` by calling one of the `startAsync` methods. Calling `getRequest` when complete or any of the dispatch methods has been previously called in the asynchronous cycle will result in an `IllegalStateException`.

`public ServletResponse getResponse()`

Returns the response that was used to initialize the `AsyncContext` by calling one of the `startAsync` methods. Calling `getResponse` when complete or any of the dispatch methods has been previously called in the asynchronous cycle will result in an `IllegalStateException`.

`public void setTimeout(long timeoutMilliseconds)`

Sets the time out for the asynchronous processing in milliseconds. A call to this method overrides the time out set by the container. If the time out is not specified via the call to `setTimeout`, 30000 is used as the default. A value of 0 or less indicates that the asynchronous operation will never time out. The time out applies to the `AsyncContext` once the container-initiated dispatch, during which one of the `ServletRequest.startAsync` methods was called, has returned to the container. It is illegal to call this method after the container-initiated dispatch on which the asynchronous cycle was started has returned to the container and will result in an `IllegalStateException`.

`public long getTimeout()`

Gets the time out, in milliseconds, associated with the `AsyncContext`. This method returns the container's default time out, or the time out value set via the most recent invocation of `setTimeout` method.

`public void addListener(AsyncListener listener, ServletRequest req, ServletResponse res)`

Registers the given listener for notifications of `onTimeout`, `onError`, `onComplete` or `onStartAsync`. The first three are associated with the most recent asynchronous cycle started by calling one of the `ServletRequest.startAsync` methods. The `onStartAsync` is associated to a new asynchronous cycle via one of the `ServletRequest.startAsync` methods. Async listeners will be notified in the order in which

they were added to the request. The request and response objects passed in to the method are the exact same ones that are available from the `AsyncEvent.getSuppliedRequest()` and `AsyncEvent.getSuppliedResponse()` when the `AsyncListener` is notified. These objects should not be read from or written to, because additional wrapping may have occurred since the given `AsyncListener` was registered, but may be used in order to release any resources associated with them. It is illegal to call this method after the container-initiated dispatch on which the asynchronous cycle was started has returned to the container and before a new asynchronous cycle was started and will result in an `IllegalStateException`.

`public <T extends AsyncListener> createListener(Class<T> clazz)`

Instantiates the given `AsyncListener` class. The returned `AsyncListener` instance may be further customized before it is registered with the `AsyncContext` via a call to one of the `addListener` methods specified below. The given `AsyncListener` class MUST define a zero argument constructor, which is used to instantiate it. This method supports any annotations applicable to the `AsyncListener`.

`public void addListener(AsyncListener)`

Registers the given listener for notifications of `onTimeout`, `onError`, `onComplete` or `onStartAsync`. The first three are associated with the most recent asynchronous cycle started by calling one of the `ServletRequest.startAsync` methods. The `onStartAsync` is associated to a new asynchronous cycle via one of the `ServletRequest.startAsync` methods. If `startAsync(req, res)` or `startAsync()` is called on the request, the exact same request and response objects are available from the `AsyncEvent` when the `AsyncListener` is notified. The request and response may or may not be wrapped. Async listeners will be notified in the order in which they were added to the request. It is illegal to call this method after the container-initiated dispatch on which the asynchronous cycle was started has returned to the container and before a new asynchronous cycle was started and will result in an `IllegalStateException`.

`public void dispatch(String path)`

Dispatches the request and response that were used to initialize the `AsyncContext` to the resource with the given path. The given path is interpreted as relative to the `ServletContext` that initialized the `AsyncContext`. All path related query methods of the request MUST reflect the dispatch target, while the original request URI, context path, path info and query string may be obtained from the request attributes as defined in Section 9.7.2, “Dispatched Request Parameters”. These attributes MUST always reflect the original path elements, even after multiple dispatches.

`public void dispatch()`

Provided as a convenience to dispatch the request and response used to initialize the `AsyncContext` as follows. If the `AsyncContext` was initialized via the `startAsync(ServletRequest, ServletResponse)` and the request passed is an instance of `HttpServletRequest`, then the dispatch is to the URI returned by `HttpServletRequest.getRequestURI()`. Otherwise the dispatch is to the URI of the request when it was last dispatched by the container. The examples CODE EXAMPLE 2-1, CODE EXAMPLE 2-2 and CODE EXAMPLE 2-3 shown below demonstrate what the target URI of dispatch would be in the different cases.

CODE EXAMPLE 2-1

```
// REQUEST to /url/A
AsyncContext ac = request.startAsync();
...
ac.dispatch(); // ASYNC dispatch to /url/A
```

CODE EXAMPLE 2-2

```
// REQUEST to /url/A

// FORWARD to /url/B

request.getRequestDispatcher("/url/B").forward(request, response);

// Start async operation from within the target of the FORWARD

AsyncContext ac = request.startAsync();

ac.dispatch(); // ASYNC dispatch to /url/A
```

CODE EXAMPLE 2-3

```
// REQUEST to /url/A

// FORWARD to /url/B

request.getRequestDispatcher("/url/B").forward(request, response);

// Start async operation from within the target of the FORWARD

AsyncContext ac = request.startAsync(request, response);

ac.dispatch(); // ASYNC dispatch to /url/B
```

`public void dispatch(ServletContext context, String path)`

Dispatches the request and response used to initialize the `AsyncContext` to the resource with the given path in the given `ServletContext`.

For all the 3 variations of the `dispatch` methods defined above, calls to the methods returns immediately after passing the request and response objects to a container managed thread, on which the dispatch operation will be performed. The dispatcher type of the request is set to `ASYNC`. Unlike `RequestDispatcher.forward(ServletRequest, ServletResponse)` dispatches, the response buffer and headers will not be reset, and it is legal to dispatch even if the response has already been committed. Control over the request and response is delegated to the dispatch target, and the

response will be closed when the dispatch target has completed execution, unless `ServletRequest.startAsync()` or `ServletRequest.startAsync(ServletRequest, ServletResponse)` is called. If any of the dispatch methods are called before the container-initiated dispatch that called `startAsync` has returned to the container, the following conditions must hold during that time between the invocation of `dispatch` and the return of control to the container:

i. any `dispatch` invocations invoked during that time will not take effect until after the container-initiated dispatch has returned to the container.

ii. any `AsyncListener.onComplete(AsyncEvent)`, `AsyncListener.onTimeout(AsyncEvent)` and `AsyncListener.onError(AsyncEvent)` invocations will also be delayed until after the container-initiated dispatch has returned to the container.

iii. any calls to `request.isAsyncStarted()` must return `true` until after the container-initiated dispatch has returned to the container.

There can be at most one asynchronous dispatch operation per asynchronous cycle, which is started by a call to one of the `ServletRequest.startAsync` methods. Any attempt to perform additional asynchronous dispatch operations within the same asynchronous cycle is illegal and will result in an `IllegalStateException`. If `startAsync` is subsequently called on the dispatched request, then any of the `dispatch` methods may be called with the same restriction as above.

Any errors or exceptions that may occur during the execution of the `dispatch` methods MUST be caught and handled by the container as follows:

i. invoke the `AsyncListener.onError(AsyncEvent)` method for all instances of the `AsyncListener` registered with the `ServletRequest` for which the `AsyncContext` was created and make the `Throwable` available via the `AsyncEvent.getThrowable()`.

ii. If none of the listeners called `AsyncContext.complete` or any of the `AsyncContext.dispatch` methods, then perform an error dispatch with a status code equal to `HttpServletResponse.SC_INTERNAL_SERVER_ERROR` and make the `Throwable` available as the value of the `RequestDispatcher.ERROR_EXCEPTION` request attribute.

iii. If no matching error page is found, or the error page does not call `AsyncContext.complete()` or any of the `AsyncContext.dispatch` methods, then the container MUST call `AsyncContext.complete`.

`public boolean hasOriginalRequestAndResponse()`

This method checks if the `AsyncContext` was initialized with the original request and response objects by calling `ServletRequest.startAsync()` or if it was initialized by calling `ServletRequest.startAsync(ServletRequest, ServletResponse)` and neither the `ServletRequest` nor the `ServletResponse` argument carried any application provided wrappers, in which case it returns `true`. If the `AsyncContext` was initialized with wrapped request and/or response objects using `ServletRequest.startAsync(ServletRequest, ServletResponse)`, it returns `false`. This information may be used by filters invoked in the outbound direction, after a request was put into asynchronous mode, to determine whether any request and/or response wrappers that they added during their inbound invocation need to be preserved for the duration of the asynchronous operation or may be released.

`public void start(Runnable r)`

This method causes the container to dispatch a thread, possibly from a managed thread pool, to run the specified `Runnable`. The container may propagate appropriate contextual information to the `Runnable`.

`public void complete()`

If `request.startAsync` is called then this method MUST be called to complete the async processing and commit and close the response. The `complete` method can be invoked by the container if the request is dispatched to a servlet that does not support async processing, or the target servlet called by `AsyncContext.dispatch` does not do a subsequent call to `startAsync`. In this case, it is the container's responsibility to call `complete()` as soon as that servlet's `service` method is exited. An `IllegalStateException` MUST be thrown if `startAsync` was not called. It is legal to call this method anytime after a call to `ServletRequest.startAsync()` or `ServletRequest.startAsync(ServletRequest, ServletResponse)` and before a call to one of the dispatch methods. If this method is called before the container-initiated dispatch that called `startAsync` has returned to the container, the following conditions must hold during that time between the invocation of `complete` and the return of control to the container:

i. the behavior specified for `complete` will not take effect until after the container-initiated dispatch has returned to the container.

ii. any `AsyncListener.onComplete(AsyncEvent)` invocations will also be delayed until after the container-initiated dispatch has returned to the container.

iii. any calls to `request.isAsyncStarted()` must return `true` until after the container-initiated dispatch has returned to the container.

ServletRequestWrapper

`public boolean isWrapperFor(ServletRequest req)`

Checks recursively if this wrapper wraps the given `ServletRequest` and returns `true` if it does, else it returns `false`.

ServletResponseWrapper

`public boolean isWrapperFor(ServletResponse res)`

Checks recursively if this wrapper wraps the given `ServletResponse` and returns `true` if it does, else it returns `false`.

AsyncListener

`public void onComplete(AsyncEvent event)`

Is used to notify the listener of completion of the asynchronous operation started on the `ServletRequest`.

`public void onTimeout(AsyncEvent event)`

Is used to notify the listener of a time out of the asynchronous operation started on the `ServletRequest`.

`public void onError(AsyncEvent event)`

Is used to notify the listener that the asynchronous operation has failed to complete.

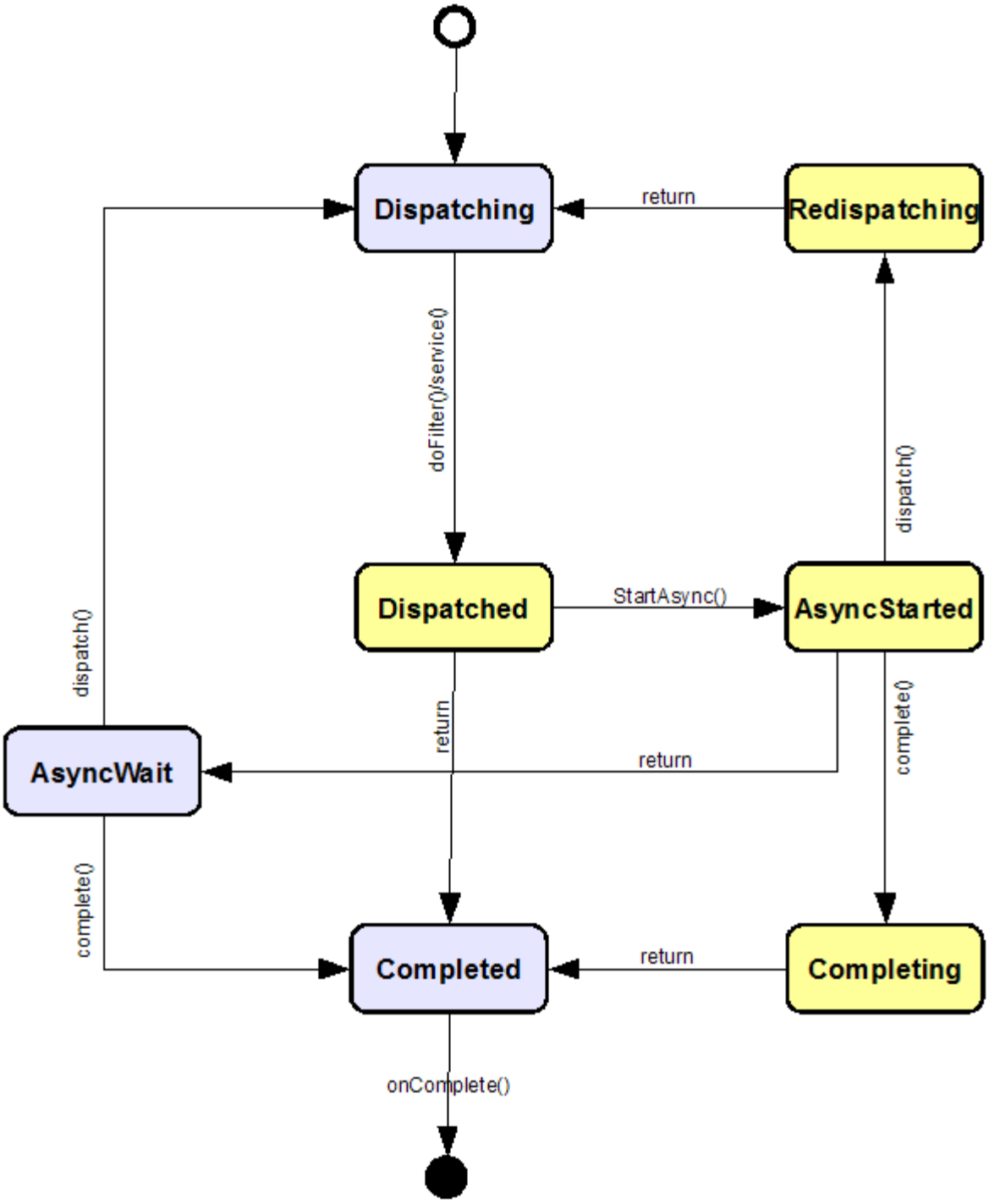
`public void onStartAsync(AsyncEvent event)`

Is used to notify the listener that a new asynchronous cycle is being initiated via a call to one of the `ServletRequest.startAsync` methods. The `AsyncContext` corresponding to the asynchronous operation that is being reinitialized may be obtained by calling `AsyncEvent.getAsyncContext` on the given event.

In the event that an asynchronous operation times out, the container must run through the following steps:

- Invoke the `AsyncListener.onTimeout` method on all the `AsyncListener` instances registered with the `ServletRequest` on which the asynchronous operation was initiated.
- If none of the listeners called `AsyncContext.complete()` or any of the `AsyncContext.dispatch` methods, perform an error dispatch with a status code equal to `HttpServletResponse.SC_INTERNAL_SERVER_ERROR`.
- If no matching error page was found, or the error page did not call `AsyncContext.complete()` or any of the `AsyncContext.dispatch` methods, the container MUST call `AsyncContext.complete()`.
- If an exception is thrown while invoking methods in an `AsyncListener`, it is logged and will not affect the invocation of any other `AsyncListeners`.
- Async processing in JSP would not be supported by default as it is used for content generation and async processing would have to be done before the content generation. It is up to the container how to handle this case. Once all the async activities are done, a dispatch to the JSP page using the `AsyncContext.dispatch` can be used for generating content.
- Figure 2-1 shown below is a diagram depicting the state transitions for various asynchronous operations.

Figure 2-1 *State transition diagram for asynchronous operations*



2.3.3.4. Thread Safety

Other than the `startAsync` and `complete` methods, implementations of the request and response objects are not guaranteed to be thread safe. This means that they should either only be used within the scope of the request handling thread or the application must ensure that access to the request and response objects are thread safe.

If a thread created by the application uses the container-managed objects, such as the request or

response object, those objects must be accessed only within the object's life cycle as defined in sections Section 3.13, "Lifetime of the Request Object" and Section 5.8, "Lifetime of the Response Object" respectively. Be aware that other than the `startAsync`, and `complete` methods, the request and response objects are not thread safe. If those objects were accessed in the multiple threads, the access should be synchronized or be done through a wrapper to add the thread safety, for instance, synchronizing the call of the methods to access the request attribute, or using a local output stream for the response object within a thread.

2.3.3.5. Upgrade Processing

In HTTP/1.1, the Upgrade header allows the client to specify the additional communication protocols that it supports and would like to use. If the server finds it appropriate to switch protocols, then new protocols will be used in subsequent communication.

The servlet container provides an HTTP upgrade mechanism. However the servlet container itself does not have knowledge about the upgraded protocol. The protocol processing is encapsulated in the `HttpUpgradeHandler`. Data reading or writing between the servlet container and the `HttpUpgradeHandler` is in byte streams.

When an upgrade request is received, the servlet can invoke the `HttpServletRequest.upgrade` method, which starts the upgrade process. This method instantiates the given `HttpUpgradeHandler` class. The returned `HttpUpgradeHandler` instance may be further customized. The application prepares and sends an appropriate response to the client. After exiting the `service` method of the servlet, the servlet container completes the processing of all filters and marks the connection to be handled by the `HttpUpgradeHandler`. It then calls the `HttpUpgradeHandler`'s `init` method, passing a `WebConnection` to allow the protocol handler access to the data streams.

The servlet filters only process the initial HTTP request and response. They are not involved in subsequent communications. In other words, they are not invoked once the request has been upgraded.

The `HttpUpgradeHandler` may use non-blocking IO to consume and produce messages.

The Application Developer has the responsibility for thread safe access to the `ServletInputStream` and `ServletOutputStream` while processing HTTP upgrade.

When the upgrade processing is done, `HttpUpgradeHandler.destroy` will be invoked.

2.3.4. End of Service

The servlet container is not required to keep a servlet loaded for any particular period of time. A servlet instance may be kept active in a servlet container for a period of milliseconds, for the lifetime of the servlet container (which could be a number of days, months, or years), or any amount of time in between.

When the servlet container determines that a servlet should be removed from service, it calls the `destroy` method of the `Servlet` interface to allow the servlet to release any resources it is using and save

any persistent state. For example, the container may do this when it wants to conserve memory resources, or when it is being shut down.

Before the servlet container calls the `destroy` method, it must allow any threads that are currently running in the `service` method of the servlet to complete execution, or exceed a server-defined time limit.

Once the `destroy` method is called on a servlet instance, the container may not route other requests to that instance of the servlet. If the container needs to enable the servlet again, it must do so with a new instance of the servlet's class.

After the `destroy` method completes, the servlet container must release the servlet instance so that it is eligible for garbage collection.

Chapter 3. The Request

The request object encapsulates all information from the client request. In the HTTP protocol, this information is transmitted from the client to the server in the HTTP headers and the message body of the request.

3.1. HTTP Protocol Parameters

Request parameters for the servlet are the strings sent by the client to a servlet container as part of its request. When the request is an `HttpServletRequest` object, and the conditions set out in Section 3.1.1, "When Parameters Are Available" are met, the container populates the parameters from the URI query string and POST-ed data.

The parameters are stored as a set of name-value pairs. Multiple parameter values can exist for any given parameter name. The following methods of the `ServletRequest` interface are available to access parameters:

- `getParameter`
- `getParameterNames`
- `getParameterValues`
- `getParameterMap`

The `getParameterValues` method returns an array of `String` objects containing all the parameter values associated with a parameter name. The value returned from the `getParameter` method must be the first value in the array of `String` objects returned by `getParameterValues`. The `getParameterMap` method returns a `java.util.Map` of the parameter of the request, which contains names as keys and parameter values as map values.

Data from the query string and the post body are aggregated into the request parameter set. Query string data is presented before post body data. For example, if a request is made with a query string of `a=hello` and a post body of `a=goodbye&a=world`, the resulting parameter set would be ordered `a=(hello, goodbye, world)`.

Path parameters that are part of a GET request (as defined by HTTP/1.1) are not exposed by these APIs. They must be parsed from the `String` values returned by the `getRequestURI` method or the `getPathInfo` method.

3.1.1. When Parameters Are Available

The following are the conditions that must be met before form data will be populated to the parameter set:

1. The request is an HTTP or HTTPS request.
2. The HTTP method is POST.

3. The content type is `application/x-www-form-urlencoded`.
4. The servlet has made an initial call of any of the `getParameter` family of methods on the request object.

If the conditions are not met and the form data is not included in the parameter set, the form data must still be available to the servlet via the request object's input stream. If the conditions are met, form data will no longer be available for reading directly from the request object's input stream.

3.2. File Upload

Servlet container allows files to be uploaded when data is sent as `multipart/form-data`.

The servlet container provides `multipart/form-data` processing if any one of the following conditions is met.

- The servlet handling the request is annotated with the `@MultipartConfig` as defined in Section 8.1.5, "@MultipartConfig".
- Deployment descriptors contain a `multipart-config` element for the servlet handling the request.

How data in a request of type `multipart/form-data` is made available depends on whether the servlet container provides `multipart/form-data` processing:

- If the servlet container provides `multipart/form-data` processing, the data is made available through the following methods in `HttpServletRequest`:
  - `public Collection<Part> getParts()`
  - `public Part getPart(String name)`

  Each part provides access to the headers, content type related with it and the content via the `Part.getInputStream` method.

  For parts with `form-data` as the `Content-Disposition`, but without a filename, the string value of the part will also be available through the `getParameter` and `getParameterValues` methods on `HttpServletRequest`, using the name of the part.

- If the servlet container does not provide the `multi-part/form-data` processing, the data will be available through `HttpServletReuqest.getInputStream`.

3.3. Attributes

Attributes are objects associated with a request. Attributes may be set by the container to express information that otherwise could not be expressed via the API, or may be set by a servlet to communicate information to another servlet (via the `RequestDispatcher`). Attributes are accessed with the following methods of the `ServletRequest` interface:

- `getAttribute`
- `getAttributeNames`
- `setAttribute`

Only one attribute value may be associated with an attribute name.

Attribute names beginning with the prefix of `jakarta.` are reserved for definition by this specification. It is suggested that all attributes placed in the attribute set be named in accordance with the reverse domain name convention suggested by the Java Programming Language Specification [3] for package naming.

3.4. Headers

A servlet can access the headers of an HTTP request through the following methods of the `HttpServletRequest` interface:

- `getHeader`
- `getHeaders`
- `getHeaderNames`

The `getHeader` method returns a header value given the name of the header. There can be multiple headers with the same name, e.g. `Cache-Control` headers, in an HTTP request. If there are multiple headers with the same name, the `getHeader` method returns the value of first header in the request. The `getHeaders` method allows access to all the header values associated with a particular header name, returning an `Enumeration` of `String` objects.

Headers may contain `String` representations of `int` or `Date` data. The following convenience methods of the `HttpServletRequest` interface provide access to header data in a one of these formats:

- `getIntHeader`
- `getDateHeader`

If the `getIntHeader` method cannot translate the header value to an `int`, a `NumberFormatException` is thrown. If the `getDateHeader` method cannot translate the header to a `Date` object, an `IllegalArgumentException` is thrown.

3.5. Request Path Elements

The request path that leads to a servlet servicing a request is composed of many important sections. The following elements are obtained from the request URI path and exposed via the request object:

- **Context Path:** The path prefix associated with the `ServletContext` that this servlet is a part of. If this context is the “default” context rooted at the base of the web server’s URL name space, this path will be an empty string. Otherwise, if the context is not rooted at the root of the server’s name

space, the path starts with a "/" character but does not end with a "/" character.

- **Servlet Path:** The path section that directly corresponds to the mapping which activated this request. This path starts with a "/" character except in the case where the request is matched with the "/*" or "" pattern, in which case it is an empty string.
- **PathInfo:** The part of the request path that is not part of the Context Path or the Servlet Path. It is either null if there is no extra path, or is a string with a leading "/".

The following methods exist in the HttpServletRequest interface to access this information:

- getContextPath
- getServletPath
- getPathInfo

It is important to note that, except for URL encoding differences between the request URI and the path parts, the following equation is always true:

```
requestURI = contextPath + servletPath + pathInfo
```

To give a few examples to clarify the above points, consider the following:

Table 3-1 Example Context Configuration

Context Path	/catalog
Servlet Mapping	Pattern: /lawn/* Servlet: LawnServlet
Servlet Mapping	Pattern: /garden/* Servlet: GardenServlet
Servlet Mapping	Pattern: *.jsp Servlet: JSPServlet

The following behavior is observed:

Table 3-2 Observed Path Element Behavior

Request Path	**Path Elements**
/catalog/lawn/index.html	ContextPath: /catalog ServletPath: /lawn PathInfo: /index.html
/catalog/garden/implements/	ContextPath: /catalog ServletPath: /garden PathInfo: /implements/

Request Path	Path Elements
`/catalog/help/feedback.jsp`	ContextPath: `/catalog` ServletPath: `/help/feedback.jsp` PathInfo: `null`

3.6. Path Translation Methods

There are two convenience methods in the API which allow the Application Developer to obtain the file system path equivalent to a particular path. These methods are:

- `ServletContext.getRealPath`
- `HttpServletRequest.getPathTranslated`

The `getRealPath` method takes a `String` argument and returns a `String` representation of a file on the local file system to which a path corresponds. The `getPathTranslated` method computes the real path of the `pathInfo` of the request.

In situations where the servlet container cannot determine a valid file path for these methods, such as when the web application is executed from an archive, on a remote file system not accessible locally, or in a database, these methods must return null. Resources inside the `META-INF/resources` directory of JAR file must be considered only if the container has unpacked them from their containing JAR file when a call to `getRealPath()` is made, and in this case MUST return the unpacked location.

3.7. Non-Blocking IO

Non-blocking request processing in the web container helps improve the ever increasing demand for improved web container scalability, increase the number of connections that can simultaneously be handled by the web container. Non-blocking IO in the servlet container allows developers to read data as it becomes available or write data when possible to do so. Non-blocking IO only works with async request processing in servlets and filters (as defined in Section 2.3.3.3, “Asynchronous processing”), and upgrade processing (as defined in Section 2.3.3.5, “Upgrade Processing”). Otherwise, an `IllegalStateException` must be thrown when `ServletInputStream.setReadListener` or `ServletOutputStream.setWriteListener` is invoked.

The `ReadListener` provides the following callback methods for non-blocking IO:

ReadListener

`onDataAvailable()`

The `onDataAvailable` method is invoked on the `ReadListener` when data is available to read from the incoming request stream. The container will invoke the method the first time when data is available to read. The container will subsequently invoke the `onDataAvailable` method if and only if the `isReady` method on `ServletInputStream`, described below, has been called and returned a value of `false` and data has subsequently become available to read.

`onAllDataRead()`

The `onAllDataRead` method is invoked when all the data for the `ServletRequest` for which the listener was registered has been read.

`onError(Throwable t)`

The `onError` method is invoked if there is any error or exception that occurs while processing the request.

The servlet container must access methods in `ReadListener` in a thread safe manner.

In addition to the `ReadListener` defined above, the following methods have been added to `ServletInputStream` class:

ServletInputStream

`boolean isFinished()`

The `isFinished` method returns `true` when all the data for the request associated with the `ServletInputStream` has been read. Otherwise it returns `false`.

`boolean isReady()`

The `isReady` method returns `true` if data can be read without blocking. If no data can be read without blocking it returns `false`. If `isReady` returns `false` it is illegal to call the read method and an `IllegalStateException` MUST be thrown.

`void setReadListener(ReadListener listener)`

Sets the `ReadListener` defined above to be invoked to read data in a non-blocking fashion. Once a listener is associated with the `ServletInputStream`, the container invokes the methods on the `ReadListener` when data is available to read, all the data has been read or if there was an error processing the request. Registering a `ReadListener` will start non-blocking IO. It is illegal to switch to the traditional blocking IO at that point and an `IllegalStateException` MUST be thrown. A subsequent call to `setReadListener` in the scope of the current request is illegal and an `IllegalStateException` MUST be thrown.

3.8. HTTP/2 Server Push

Server push is the most visible of the improvements in HTTP/2 to appear in the servlet API. All of the new features in HTTP/2, including server push, are aimed at improving the perceived performance of the web browsing experience. Server push derives its contribution to improved perceived browser performance from the simple fact that servers are in a much better position than clients to know what additional assets (such as images, stylesheets and scripts) go along with initial requests. For example, it is possible for servers to know that whenever a browser requests `index.html`, it will shortly thereafter request `header.gif`, `footer.gif` and `style.css`. Since servers know this, they can preemptively start sending the bytes of these assets along side the bytes of the `index.html`.

To use server push, obtain a reference to a `PushBuilder` from an `HttpServletRequest`, mutate the builder as desired, then call `push()`. Please see the javadoc for method

`jakarta.servlet.http.HttpServletRequest.newPushBuilder()` and class `jakarta.servlet.http.PushBuilder` for the normative specification. The remainder of this section calls out implementation requirements with respect to the section titled “Server Push” in the HTTP/2 specification version referenced in Other Important References.

Unless explicitly excluded, Servlet 5.0 containers must support server push as specified in the HTTP/2 specification section “Server Push”. Containers must enable server push if the client is capable of speaking HTTP/2, unless the client has explicitly disabled server push by sending a `SETTINGS_ENABLE_PUSH` setting value of 0 (zero) for the current connection. In that case, for that connection only, server push must not be enabled.

In addition to allowing clients to disable server push with the `SETTINGS_ENABLE_PUSH` setting, servlet containers must honor a client’s request to not receive a pushed response on a finer grained basis by heeding the `CANCEL` or `REFUSED_STREAM` code that references the pushed stream’s stream identifier. One common use of this interaction is when a browser already has the resource in its cache.

3.9. Cookies

The `HttpServletRequest` interface provides the `getCookies` method to obtain an array of cookies that are present in the request. These cookies are data sent from the client to the server on every request that the client makes. Typically, the only information that the client sends back as part of a cookie is the cookie name and the cookie value. Other cookie attributes that can be set when the cookie is sent to the browser, such as comments, are not typically returned. The specification also allows for the cookies to be `HttpOnly` cookies. `HttpOnly` cookies indicate to the client that they should not be exposed to client-side scripting code (it’s not filtered out unless the client knows to look for this attribute). The use of `HttpOnly` cookies helps mitigate certain kinds of cross-site scripting attacks.

3.10. SSL Attributes

If a request has been transmitted over a secure protocol, such as HTTPS, this information must be exposed via the `isSecure` method of the `ServletRequest` interface. The web container must expose the following attributes to the servlet programmer:

Table 3-3 Protocol Attributes

Attribute	Attribute Name	Java Type
cipher suite	`jakarta.servlet.request.cipher_suite`	`String`
bit size of the algorithm	`jakarta.servlet.request.key_size`	`Integer`
SSL session id	`jakarta.servlet.request.ssl_session_id`	`String`

If there is an SSL certificate associated with the request, it must be exposed by the servlet container to the servlet programmer as an array of objects of type `java.security.cert.X509Certificate` and accessible via a `ServletRequest` attribute of `jakarta.servlet.request.X509Certificate`.

The order of this array is defined as being in ascending order of trust. The first certificate in the chain is the one set by the client, the next is the one used to authenticate the first, and so on.

3.11. Internationalization

Clients may optionally indicate to a web server what language they would prefer the response be given in. This information can be communicated from the client using the `Accept-Language` header along with other mechanisms described in the HTTP/1.1 specification. The following methods are provided in the `ServletRequest` interface to determine the preferred locale of the sender:

- `getLocale`
- `getLocales`

The `getLocale` method will return the preferred locale for which the client wants to accept content. See section 14.4 of RFC 7231 (HTTP/1.1) for more information about how the `Accept-Language` header must be interpreted to determine the preferred language of the client.

The `getLocales` method will return an `Enumeration` of `Locale` objects indicating, in decreasing order starting with the preferred locale, the locales that are acceptable to the client.

If no preferred locale is specified by the client, the locale returned by the `getLocale` method must be the default locale for the servlet container and the `getLocales` method must contain an enumeration of a single `Locale` element of the default locale.

3.12. Request Data Encoding

Currently, many browsers do not send a char encoding qualifier with the Content-Type header, leaving open the determination of the character encoding for reading HTTP requests. In the absence of a char encoding qualifier, if the `Content-Type` is `application/x-www-form-urlencoded`, the default encoding the container uses to create the request reader and parse POST data must be `US-ASCII`. Any `%nn` encoded values must be decoded to ISO-8859-1. For any other `Content-Type`, if none has been specified by the client request, web application or container vendor specific configuration (for all web applications in the container), the default encoding of a request the container uses to create the request reader and parse POST data must be ISO-8859-1. However, in order to indicate to the developer the absence of a char encoding qualifier, the container must return `null` from the `getCharacterEncoding()` method.

If the client hasn't set character encoding and the request data is encoded with a different encoding than the default as described above, breakage can occur. To remedy this situation, `setRequestCharacterEncoding(String enc)` is available on `ServletContext`, the `<request-character-encoding>` element is available in the `web.xml` and `setCharacterEncoding(String enc)` is available on the `ServletRequest` interface. Developers can override the character encoding supplied by the container by calling this method. It must be called prior to parsing any post data or reading any input from the request. Calling this method once data has been read will not affect the encoding.

3.13. Lifetime of the Request Object

Each request object is valid only within the scope of a servlet's `service` method, or within the scope of a filter's `doFilter` method, unless the asynchronous processing is enabled for the component and the startAsync method is invoked on the request object. In the case where asynchronous processing occurs, the request object remains valid until `complete` is invoked on the `AsyncContext`. Containers commonly recycle request objects in order to avoid the performance overhead of request object creation. The developer must be aware that maintaining references to request objects for which `startAsync` has not been called outside the scope described above is not recommended as it may have indeterminate results.

In case of upgrade, the above is still true.

[3] The Java Programming Language Specification is available at `http://docs.oracle.com/javase/specs/`

Chapter 4. Servlet Context

4.1. Introduction to the ServletContext Interface

The `ServletContext` interface defines a servlet's view of the web application within which the servlet is running. The Container Provider is responsible for providing an implementation of the `ServletContext` interface in the servlet container. Using the `ServletContext` object, a servlet can log events, obtain URL references to resources, and set and store attributes that other servlets in the context can access.

A `ServletContext` is rooted at a known path within a web server. For example, a servlet context could be located at `http://example.com/catalog`. All requests that begin with the `/catalog` request path, known as the context path, are routed to the web application associated with the `ServletContext`.

4.2. Scope of a ServletContext Interface

There is one instance object of the `ServletContext` interface associated with each web application deployed into a container. In cases where the container is distributed over many virtual machines, a web application will have an instance of the `ServletContext` for each JVM.

4.3. Initialization Parameters

The following methods of the `ServletContext` interface allow the servlet access to context initialization parameters associated with a web application as specified by the Application Developer in the deployment descriptor:

- `getInitParameter`
- `getInitParameterNames`

Initialization parameters are used by an Application Developer to convey setup information. Typical examples are a webmaster's e-mail address, or the name of a system that holds critical data.

4.4. Configuration Methods

The following methods are provided on the `ServletContext` interface to enable programmatic definition of servlets, filters and the url pattern(s) that they map to. These methods can only be called during the initialization of the application either from the `contexInitialized` method of a `ServletContextListener` implementation or from the `onStartup` method of a `ServletContainerInitializer` implementation. In addition to adding servlets and filters, one can also look up an instance of a `Registration` object corresponding to a servlet or filter or a map of all the Registration objects for the servlets or filters. If a `ServletContext` is passed to the ServletContextListener's `contextInitialized` method where the `ServletContextListener` was neither declared in `web.xml` or `web-fragment.xml` nor annotated with `@WebListener` then an `UnsupportedOperationException` MUST be thrown for all the methods defined in `ServletContext` for programmatic configuration of servlets, filters and listeners.

4.4.1. Programmatically Adding and Configuring Servlets

The ability to programmatically add a servlet to a context is useful for framework developers. For example a framework could declare a controller servlet using this method. The return value of this method is a `ServletRegistration` or a `ServletRegistration.Dynamic` object which further allows the setup of the other parameters of the servlet like `init-param`, `url-mappings` etc. There are three overloaded versions of the method as described below.

4.4.1.1. addServlet(String servletName, String className)

This method allows the application to declare a servlet programmatically. It adds a servlet with the given name, and class name to the servlet context.

4.4.1.2. addServlet(String servletName, Servlet servlet)

This method allows the application to declare a servlet programmatically. It adds a servlet with the given name, and servlet instance to the servlet context.

4.4.1.3. addServlet(String servletName, Class <? extends Servlet> servletClass)

This method allows the application to declare a servlet programmatically. It adds a servlet with the given name, and an instance of the servlet class to the servlet context.

4.4.1.4. addJspFile(String servletName, String jspfile)

This method allows the application to declare a jsp programmatically. It adds the jsp with the given name, and an instance of the servlet class corresponding to the jsp file to the servlet context.

4.4.1.5. <T extends Servlet> T createServlet(Class<T> clazz)

This method instantiates the given `Servlet` class. The method must support all the annotations applicable to servlets except `@WebServlet`. The returned `Servlet` instance may be further customized before it is registered with the `ServletContext` via a call to `addServlet(String, Servlet)` as defined above. The given `Servlet` class must define a zero argument constructor, which is used to instantiate it.

4.4.1.6. ServletRegistration getServletRegistration(String servletName)

This method returns the `ServletRegistration` corresponding to the servlet with the given `name`, or `null` if no `ServletRegistration` exists under that `name`. An `UnsupportedOperationException` is thrown if the `ServletContext` was passed to the `contextInitialized` method of a `ServletContextListener` that was neither declared in the `web.xml` or `web-fragment.xml`, nor annotated with `jakarta.servlet.annotation.WebListener`.

4.4.1.7. Map<String, ? extends ServletRegistration> getServletRegistrations()

This method returns a map of `ServletRegistration` objects, keyed by name corresponding to all servlets registered with the `ServletContext`. If there are no servlets registered with the `ServletContext` an empty

map is returned. The returned `Map` includes the `ServletRegistration` objects corresponding to all declared and annotated servlets, as well as the `ServletRegistration` objects corresponding to all servlets that have been added via one of the `addServlet` and `addJspFile` methods. Any changes to the returned `Map` MUST not affect the `ServletContext`. An `UnsupportedOperationException` is thrown if the `ServletContext` was passed to the `contextInitialized` method of a `ServletContextListener` that was neither declared in the `web.xml` or `web-fragment.xml`, nor annotated with `jakarta.servlet.annotation.WebListener`.

4.4.2. Programmatically Adding and Configuring Filters

4.4.2.1. addFilter(String filterName, String className)

This method allows the application to declare a filter programmatically. It adds a filter with the given name, and class name to the web application.

4.4.2.2. addFilter(String filterName, Filter filter)

This method allows the application to declare a filter programmatically. It adds a filter with the given name, and filter instance to the web application.

4.4.2.3. addFilter(String filterName, Class <? extends Filter> filterClass)

This method allows the application to declare a filter programmatically. It adds a filter with the given name, and an instance of the filter class to the web application.

4.4.2.4. <T extends Filter> T createFilter(Class<T> clazz)

This method instantiates the given `Filter` class. The method must support all the annotations applicable to filters. The returned `Filter` instance may be further customized before it is registered with the `ServletContext` via a call to `addFilter(String, Filter)` as defined above. The given `Filter` class must define a zero argument constructor, which is used to instantiate it.

4.4.2.5. FilterRegistration getFilterRegistration(String filterName)

This method returns the `FilterRegistration` corresponding to the filter with the given `name`, or `null` if no `FilterRegistration` exists under that `name`. An `UnsupportedOperationException` is thrown if the `ServletContext` was passed to the `contextInitialized` method of a `ServletContextListener` that was neither declared in the `web.xml` or `web-fragment.xml`, nor annotated with `jakarta.servlet.annotation.WebListener`.

4.4.2.6. Map<String, ? extends FilterRegistration> getFilterRegistrations()

This method returns a map of `FilterRegistration` objects, keyed by name corresponding to all filters registered with the `ServletContext`. If there are no filters registered with the `ServletContext` an empty `Map` is returned. The returned `Map` includes the `FilterRegistration` objects corresponding to all declared and annotated filters, as well as the `FilterRegistration` objects corresponding to all filters that have been added via one of the `addFilter` methods. Any changes to the returned `Map` MUST not affect the

ServletContext. An UnsupportedOperationException is thrown if the ServletContext was passed to the contextInitialized method of a ServletContextListener that was neither declared in the web.xml or web-fragment.xml, nor annotated with jakarta.servlet.annotation.WebListener.

4.4.3. Programmatically Adding and Configuring Listeners

4.4.3.1. void addListener(String className)

Add the listener with the given class name to the ServletContext. The class with the given name will be loaded using the classloader associated with the application represented by the ServletContext, and MUST implement one or more of the following interfaces:

- jakarta.servlet.ServletContextAttributeListener
- jakarta.servlet.ServletRequestListener
- jakarta.servlet.ServletRequestAttributeListener
- jakarta.servlet.http.HttpSessionListener
- jakarta.servlet.http.HttpSessionAttributeListener
- jakarta.servlet.http.HttpSessionIdListener

If the ServletContext was passed to the ServletContainerInitializer's onStartup method, then the class with the given name MAY also implement jakarta.servlet.ServletContextListener in addition to the interfaces listed above. As part of this method call, the container MUST load the class with the specified class name to ensure that it implements one of the required interfaces. If the class with the given name implements a listener interface whose invocation order corresponds to the declaration order, that is, if it implements jakarta.servlet.ServletRequestListener, jakarta.servlet.ServletContextListener or jakarta.servlet.http.HttpSessionListener then the new listener will be added to the end of the ordered list of listeners of that interface.

4.4.3.2. <T extends EventListener> void addListener(T t)

Add the given listener to the ServletContext. The given listener MUST be an instance of one or more of the following interfaces:

- jakarta.servlet.ServletContextAttributeListener
- jakarta.servlet.ServletRequestListener
- jakarta.servlet.ServletRequestAttributeListener
- jakarta.servlet.http.HttpSessionListener
- jakarta.servlet.http.HttpSessionAttributeListener
- jakarta.servlet.http.HttpSessionIdListener

If the ServletContext was passed to the ServletContainerInitializer's onStartup method, then the given listener MAY also be an instance of jakarta.servlet.ServletContextListener in addition to the

interfaces listed above. If the given listener is an instance of a listener interface whose invocation order corresponds to the declaration order, that is, if it implements `jakarta.servlet.ServletRequestListener`, `jakarta.servlet.ServletContextListener` or `jakarta.servlet.http.HttpSessionListener`, then the new listener will be added to the end of the ordered list of listeners of that interface.

4.4.3.3. void addListener(Class <? extends EventListener> listenerClass)

Add the listener of the given class type to the `ServletContext`. The given listener class MUST implement one or more of the following interfaces:

- `jakarta.servlet.ServletContextAttributeListener`
- `jakarta.servlet.ServletRequestListener`
- `jakarta.servlet.ServletRequestAttributeListener`
- `jakarta.servlet.http.HttpSessionListener`
- `jakarta.servlet.http.HttpSessionAttributeListener`
- `jakarta.servlet.http.HttpSessionIdListener`

If the `ServletContext` was passed to the `ServletContainerInitializer`'s `onStartup` method, then the given listener class MAY also implement `jakarta.servlet.ServletContextListener` in addition to the interfaces listed above. If the given listener class implements a listener interface whose invocation order corresponds to the declaration order, that is, if it implements `jakarta.servlet.ServletRequestListener`, `jakarta.servlet.ServletContextListener` or `jakarta.servlet.http.HttpSessionListener,` then the new listener will be added to the end of the ordered list of listeners of that interface.

4.4.3.4. <T extends EventListener> void createListener(Class<T> clazz)

This method instantiates the given EventListener class. The specified EventListener class MUST implement at least one of the following interfaces:

- `jakarta.servlet.ServletContextAttributeListener`
- `jakarta.servlet.ServletRequestListener`
- `jakarta.servlet.ServletRequestAttributeListener`
- `jakarta.servlet.http.HttpSessionListener`
- `jakarta.servlet.http.HttpSessionAttributeListener`
- `jakarta.servlet.http.HttpSessionIdListener`

This method MUST support all annotations applicable to the above listener interfaces as defined by this specification. The returned EventListener instance may be further customized before it is registered with the ServletContext via a call to addListener(T t). The given EventListener class MUST define a zero argument constructor, which is used to instantiate it.

4.4.3.5. Annotation processing requirements for programmatically added Servlets, Filters and Listeners

When using the programmatic API to add a servlet or create a servlet, apart from the addServlet that takes an instance, the following annotations must be introspected in the class in question and the metadata defined in it MUST be used unless it is overridden by calls to the API in the `ServletRegistration.Dynamic` / `ServletRegistration`.

`@ServletSecurity`, `@RunAs`, `@DeclareRoles`, `@MultipartConfig`.

For filters and listeners no annotations need to be introspected.

Resource injection on all components (servlets, filters and listeners) added programmatically or created programmatically, other than the ones added via the methods that takes an instance, will only be supported when the component is a CDI Managed Bean. For details please refer to Section 15.5.16, "Contexts and Dependency Injection for Jakarta EE Platform Requirements".

4.4.4. Programmatically Configuring Session Time Out

The following methods of the `ServletContext` interface allow the web application to access and configure the default session timeout interval for all sessions created in the given web application. The specified timeout in `setSessionTimeout` is in minutes. If the timeout is 0 or less the container ensures the default behavior of sessions is never to time out.

- `getSessionTimeout()`
- `setSessionTimeout(int timeout)`

4.4.5. Programmatically Configuring Character Encoding

The following methods of the `ServletContext` interface allow the web application to access and configure request and response character encoding.

- `getRequestCharacterEncoding()`
- `setRequestCharacterEncoding(String encoding)`
- `getResponseCharacterEncoding()`
- `setResponseCharacterEncoding(String encoding)`

If no request character encoding is specified in deployment descriptor or container specific configuration (for all web applications in the container), `getRequestCharacterEncoding()` returns null. If no response character encoding is specified in deployment descriptor or container specific configuration (for all web applications in the container), `getResponseCharacterEncoding()` returns null.

4.5. Context Attributes

A servlet can bind an object attribute into the context by name. Any attribute bound into a context is available to any other servlet that is part of the same web application. The following methods of `ServletContext` interface allow access to this functionality:

- `setAttribute`
- `getAttribute`
- `getAttributeNames`
- `removeAttribute`

4.5.1. Context Attributes in a Distributed Container

Context attributes are local to the JVM in which they were created. This prevents `ServletContext` attributes from being a shared memory store in a distributed container. When information needs to be shared between servlets running in a distributed environment, the information should be placed into a session (See Chapter 7, *Sessions*), stored in a database, or set in an Jakarta Enterprise Beans component.

4.6. Resources

The `ServletContext` interface provides direct access only to the hierarchy of static content documents that are part of the web application, including HTML, GIF, and JPEG files, via the following methods of the `ServletContext` interface:

- `getResource`
- `getResourceAsStream`

The `getResource` and `getResourceAsStream` methods take a `String` with a leading `"/"` as an argument that gives the path of the resource relative to the root of the context or relative to the `META-INF/resources` directory of a JAR file inside the web application's `WEB-INF/lib` directory. If there is a `WEB-INF` entry inside the `META-INF/resources` entry of a JAR file in `WEB-INF/lib`, then it and all child entries are available only as static resources. No classes or jars will be placed on the context classpath from such a `WEB-INF` entry, and no servlet specific descriptors will be processed. These methods will first search the root of the web application context for the requested resource before looking at any of the JAR files in the `WEB-INF/lib` directory. The order in which the JAR files in the `WEB-INF/lib` directory are scanned is undefined. This hierarchy of documents may exist in the server's file system, in a web application archive file, on a remote server, or at some other location.

These methods are not used to obtain dynamic content. For example, in a container supporting the Jakarta Server Pages specification [4], a method call of the form `getResource("/index.jsp")` would return the JSP source code and not the processed output. See Chapter 9, *Dispatching Requests* for more information about accessing dynamic content.

The full listing of the resources in the web application can be accessed using the `getResourcePaths(String path)` method. The full details on the semantics of this method may be found in the API documentation in this specification.

4.7. Multiple Hosts and Servlet Contexts

Web servers may support multiple logical hosts sharing one IP address on a server. This capability is sometimes referred to as "virtual hosting". In this case, each logical host must have its own servlet context or set of servlet contexts. Servlet contexts can not be shared across virtual hosts.

The `getVirtualServerName` method of `ServletContext` interface allows access to the configuration name of the logical host on which the `ServletContext` is deployed. Servlet containers may support multiple logical hosts. This method must return the same name for all the servlet contexts deployed on a logical host, and the name returned by this method must be distinct, stable per logical host, and suitable for use in associating server configuration information with the logical host.

4.8. Reloading Considerations

Although a Container Provider implementation of a class reloading scheme for ease of development is not required, any such implementation must ensure that all servlets, and classes that they may use [5], are loaded in the scope of a single class loader. This requirement is needed to guarantee that the application will behave as expected by the Application Developer. As a development aid, the full semantics of notification to session binding listeners should be supported by containers for use in the monitoring of session termination upon class reloading.

Previous generations of containers created new class loaders to load a servlet, distinct from class loaders used to load other servlets or classes used in the servlet context. This could cause object references within a servlet context to point at unexpected classes or objects, and cause unexpected behavior. The requirement is needed to prevent problems caused by demand generation of new class loaders.

4.8.1. Temporary Working Directories

A temporary storage directory is required for each servlet context. Servlet containers must provide a private temporary directory for each servlet context, and make it available via the `jakarta.servlet.context.tempdir` context attribute. The objects associated with the attribute must be of type `java.io.File`.

The requirement recognizes a common convenience provided in many servlet engine implementations. The container is not required to maintain the contents of the temporary directory when the servlet container restarts, but is required to ensure that the contents of the temporary directory of one servlet context is not visible to the servlet contexts of other web applications running on the servlet container.

[4] The Jakarta Server Pages specification can be found at `https://jakarta.ee/specifications/pages`

[5] An exception is system classes that the servlet may use in a different class loader.

Chapter 5. The Response

The response object encapsulates all information to be returned from the server to the client. In the HTTP protocol, this information is transmitted from the server to the client either by HTTP headers or the message body of the response.

5.1. Buffering

A servlet container is allowed, but not required, to buffer output going to the client for efficiency purposes. Typically servers that do buffering make it the default, but allow servlets to specify buffering parameters.

The following methods in the `ServletResponse` interface allow a servlet to access and set buffering information:

- `getBufferSize`
- `setBufferSize`
- `isCommitted`
- `reset`
- `resetBuffer`
- `flushBuffer`

These methods are provided on the `ServletResponse` interface to allow buffering operations to be performed whether the servlet is using a `ServletOutputStream` or a `Writer`.

The `getBufferSize` method returns the size of the underlying buffer being used. If no buffering is being used, this method must return the `int` value of `0` (zero).

The servlet can request a preferred buffer size by using the `setBufferSize` method. The buffer assigned is not required to be the size requested by the servlet, but must be at least as large as the size requested. This allows the container to reuse a set of fixed size buffers, providing a larger buffer than requested if appropriate. The method must be called before any content is written using a `ServletOutputStream` or `Writer`. If any content has been written or the response object has been committed, this method must throw an `IllegalStateException`.

The `isCommitted` method returns a boolean value indicating whether any response bytes have been returned to the client. The `flushBuffer` method forces content in the buffer to be written to the client.

The `reset` method clears data in the buffer when the response is not committed. Headers, status codes and the state of calling getWriter or getOutputStream set by the servlet prior to the reset call must be cleared as well. The `resetBuffer` method clears content in the buffer if the response is not committed without clearing the headers and status code.

If the response is committed and the `reset` or `resetBuffer` method is called, an `IllegalStateException`

must be thrown. The response and its associated buffer will be unchanged.

When using a buffer, the container must immediately flush the contents of a filled buffer to the client. If this is the first data that is sent to the client, the response is considered to be committed.

5.2. Headers

A servlet can set headers of an HTTP response via the following methods of the `HttpServletResponse` interface:

- `setHeader`
- `addHeader`

The `setHeader` method sets a header with a given name and value. A previous header is replaced by the new header. Where a set of header values exist for the name, the values are cleared and replaced with the new value.

The `addHeader` method adds a header value to the set with a given name. If there are no headers already associated with the name, a new set is created.

Headers may contain data that represents an `int` or a `Date` object. The following convenience methods of the `HttpServletResponse` interface allow a servlet to set a header using the correct formatting for the appropriate data type:

- `setIntHeader`
- `setDateHeader`
- `addIntHeader`
- `addDateHeader`

To be successfully transmitted back to the client, headers (other than those in a trailer) must be set before the response is committed. Headers (other than those in a trailer) set after the response is committed will be ignored by the servlet container. If an HTTP trailer, as specified in RFC 7230, is to be sent in the response, the fields must be provided using the `setTrailerFields()` method on `HttpServletResponse`. This method must have been called before the last chunk in the chunked response has been written.

Servlet programmers are responsible for ensuring that the `Content-Type` header is appropriately set in the response object for the content the servlet is generating. The HTTP/1.1 specification does not require that this header be set in an HTTP response. Servlet containers must not set a default content type when the servlet programmer does not set the type.

It is recommended that containers use the `X-Powered-By` HTTP header to publish its implementation information. The field value should consist of one or more implementation types, such as `Servlet/5.0`. Optionally, the supplementary information of the container and the underlying Java platform can be added after the implementation type within parentheses. The container should be configurable to

suppress this header.

Here's the examples of this header.

```
X-Powered-By: Servlet/5.0
```

```
X-Powered-By: Servlet/5.0 JSP/3.0 (GlassFish Server 6.0 Java/Oracle Corporation/1.8)
```

5.3. HTTP Trailer

An HTTP trailer is a collection of HTTP headers that comes after the response body. It is specified in RFC 7230. It is useful in the context of chunked transfer encoding and also in the implementation of additional communication protocols. Servlet containers provide support for trailers.

If trailer headers are ready for reading, `isTrailerFieldsReady()` will return true. Then a servlet can read trailer headers of the HTTP request via the `getTrailerFields()` method of the `HttpServletRequest` interface.

A servlet can write trailer headers to the response by providing a `Supplier` to the `setTrailerFields` method of the `HttpServletResponse` interface. The `Supplier` of the trailer headers can be obtained by accessing the `getTrailerFields()` method of the `HttpServletResponse` interface.

Please see the javadoc for these two methods for the normative specification.

5.4. Non-Blocking IO

Non-blocking IO only works with async request processing in servlets and filters (as defined in Section 2.3.3.3, "Asynchronous processing"), and upgrade processing (as defined in Section 2.3.3.5, "Upgrade Processing"). Otherwise, an `IllegalStateException` must be thrown when `ServletInputStream.setReadListener` or `ServletOutputStream.setWriteListener` is invoked. To support non-blocking writes in the web container, in addition to the changes made in the `ServletRequest` as described in Section 3.7, "Non-Blocking IO", the following changes have been made to handle response related classes / interfaces.

The `WriteListener` provides the following callback methods which the container invokes appropriately.

WriteListener

`void onWritePossible()`

When a `WriteListener` is registered with the `ServletOutputStream`, this method will be invoked by the container the first time when it is possible to write data. The container will subsequently invoke the `onWritePossible` method if and only if the `isReady` method on `ServletOutputStream`, described below, returns a value of `false` and a write operation has subsequently become possible.

`void onError(Throwable t)`

Invoked when an error occurs processing the response.

Along with the `WriteListener`, the following methods have been added to `ServletOutputStream` class to allow the developer to check with the runtime whether or not it is possible to write the data to be sent to the client.

ServletOutputStream

`boolean isReady()`

This method returns `true` if a write to the `ServletOutputStream` will succeed, otherwise it will return `false`. If this method returns `true`, a write operation can be performed on the `ServletOutputStream`. If no further data can be written to the `ServletOutputStream`. then this method will return `false` till the underlying data is flushed at which point the container will invoke the `onWritePossible` method of the `WriteListener.` A subsequent call to this method will return `true`.

`void setWriteListener(WriteListener listener)`

Associates the `WriteListener` with this `ServletOutputStream` for the container to invoke the callback methods on the `WriteListener` when it is possible to write data. Registering a `WriteListener` will start non-blocking IO. It is illegal to switch to the traditional blocking IO at that point. The use of IO related method calls after this illegal switch to traditional blocking IO produces unspecified behavior.

The servlet container must access methods in `WriteListener` in a thread safe manner.

5.5. Convenience Methods

The following convenience methods exist in the `HttpServletResponse` interface:

- `sendRedirect`
- `sendError`

The `sendRedirect` method will set the appropriate headers and content body to redirect the client to a different URL. It is legal to call this method with a relative URL path, however the underlying container must translate the relative path to a fully qualified URL for transmission back to the client. If a partial URL is given and, for whatever reason, cannot be converted into a valid URL, then this method must throw an `IllegalArgumentException`.

The `sendError` method will set the appropriate headers and content body for an error message to return to the client. An optional `String` argument can be provided to the `sendError` method which can be used in the content body of the error.

These methods will have the side effect of committing the response, if it has not already been committed, and terminating it. No further output to the client should be made by the servlet after these methods are called. If data is written to the response after these methods are called, the data is ignored.

If data has been written to the response buffer, but not returned to the client (i.e. the response is not committed), the data in the response buffer must be cleared and replaced with the data set by these methods. If the response is committed, these methods must throw an `IllegalStateException`.

5.6. Internationalization

Servlets should set the locale and the character encoding of a response. The locale is set using the `ServletResponse.setLocale` method. The method can be called repeatedly; but calls made after the response is committed have no effect. If the servlet does not set the locale before the page is committed, the container's default locale is used to determine the response's locale, but no specification is made for the communication with a client, such as `Content-Language` header in the case of HTTP.

```
<locale-encoding-mapping-list>
  <locale-encoding-mapping>
    <locale>ja</locale>
    <encoding>Shift_JIS</encoding>
  </locale-encoding-mapping>
</locale-encoding-mapping-list>
```

The <response-character-encoding> element can be used to explicitly set the default encoding for all responses in a given web application.

```
<response-character-encoding>UTF-8</response-character-encoding>
```

If neither element exists or does not provide a mapping, `setLocale` uses a container dependent mapping. The `setCharacterEncoding`, `setContentType`, and `setLocale` methods can be called repeatedly to change the character encoding. Calls made after the servlet response's `getWriter` method has been called or after the response is committed have no effect on the character encoding. Calls to `setContentType` set the character encoding only if the given content type string provides a value for the `charset` attribute. Calls to `setLocale` set the character encoding only if neither `setCharacterEncoding` nor `setContentType` has set the character encoding before.

If the servlet does not specify a character encoding before the `getWriter` method of the `ServletResponse` interface is called or the response is committed, the default `ISO-8859-1` is used.

Containers must communicate the locale and the character encoding used for the servlet response's writer to the client if the protocol in use provides a way for doing so. In the case of HTTP, the locale is communicated via the `Content-Language` header, the character encoding as part of the `Content-Type` header for text media types. Note that the character encoding cannot be communicated via HTTP headers if the servlet does not specify a content type; however, it is still used to encode text written via the servlet response's writer.

5.7. Closure of Response Object

When a response is closed, the container must immediately flush all remaining content in the response buffer to the client. The following events indicate that the servlet has satisfied the request and that the response object is to be closed:

- The termination of the `service` method of the servlet.
- The amount of content specified in the `setContentLength` or `setContentLengthLong` method of the response has been greater than zero and has been written to the response.
- The `sendError` method is called.
- The `sendRedirect` method is called.
- The `complete` method on `AsyncContext` is called.

5.8. Lifetime of the Response Object

Each response object is valid only within the scope of a servlet's `service` method, or within the scope of a filter's `doFilter` method, unless the associated request object has asynchronous processing enabled for the component. If asynchronous processing on the associated request is started, then the response object remains valid until `complete` method on `AsyncContext` is called. Containers commonly recycle response objects in order to avoid the performance overhead of response object creation. The developer must be aware that maintaining references to response objects for which `startAsync` on the corresponding request has not been called, outside the scope described above may lead to non-deterministic behavior.

Chapter 6. Filtering

Filters are Java components that allow on the fly transformations of payload and header information in both the request into a resource and the response from a resource.

The Jakarta Servlet API provides a lightweight framework for filtering active and static content. It describes how filters are configured in a web application, and conventions and semantics for their implementation.

API documentation for servlet filters is provided online. The configuration syntax for filters is given by the deployment descriptor schema described in Chapter 14, *Deployment Descriptor*. The reader should use these sources as references when reading this chapter.

6.1. What is a Filter?

A filter is a reusable piece of code that can transform the content of HTTP requests, responses, and header information. Filters do not generally create a response or respond to a request as servlets do, rather they modify or adapt the requests for a resource, and modify or adapt responses from a resource.

Filters can act on dynamic or static content. For the purposes of this chapter, dynamic and static content are referred to as web resources.

Among the types of functionality available to the developer needing to use filters are the following:

- The accessing of a resource before a request to it is invoked.
- The processing of the request for a resource before it is invoked.
- The modification of request headers and data by wrapping the request in customized versions of the request object.
- The modification of response headers and response data by providing customized versions of the response object.
- The interception of an invocation of a resource after its call.
- Actions on a servlet, on groups of servlets, or static content by zero, one, or more filters in a specifiable order.

6.1.1. Examples of Filtering Components

- Authentication filters
- Logging and auditing filters
- Image conversion filters
- Data compression filters

- Encryption filters
- Tokenizing filters
- Filters that trigger resource access events
- XSL/T filters that transform XML content
- MIME-type chain filters
- Caching filters

6.2. Main Concepts

The main concepts of this filtering model are described in this section.

The application developer creates a filter by implementing the `jakarta.servlet.Filter` interface and providing a public constructor taking no arguments. The class is packaged in the web archive along with the static content and servlets that make up the web application. A filter is declared using the `<filter>` element in the deployment descriptor. A filter or collection of filters can be configured for invocation by defining `<filter-mapping>` elements in the deployment descriptor. This is done by mapping filters to a particular servlet by the servlet's logical name, or mapping to a group of servlets and static content resources by mapping a filter to a URL pattern.

6.2.1. Filter Lifecycle

After deployment of the web application, and before a request causes the container to access a web resource, the container must locate the list of filters that must be applied to the web resource as described below. The container must ensure that it has instantiated a filter of the appropriate class for each filter in the list, and called its `init(FilterConfig config)` method. The filter may throw an exception to indicate that it cannot function properly. If the exception is of type `UnavailableException`, the container may examine the isPermanent attribute of the exception and may choose to retry the filter at some later time.

Only one instance per `<filter>` declaration in the deployment descriptor is instantiated per JVM of the container. The container provides the filter `config` as declared in the filter's deployment descriptor, the reference to the `ServletContext` for the web application, and the set of initialization parameters.

When the container receives an incoming request, it takes the first filter instance in the list and calls its `doFilter` method, passing in the `ServletRequest` and `ServletResponse` , and a reference to the `FilterChain` object it will use.

The `doFilter` method of a filter will typically be implemented following this or some subset of the following pattern:

1. The method examines the request's headers.
2. The method may wrap the request object with a customized implementation of `ServletRequest` or `HttpServletRequest` in order to modify request headers or data.

3. The method may wrap the response object passed in to its `doFilter` method with a customized implementation of `ServletResponse` or `HttpServletResponse` to modify response headers or data.
4. The filter may invoke the next entity in the filter chain. The next entity may be another filter, or if the filter making the invocation is the last filter configured in the deployment descriptor for this chain, the next entity is the target web resource. The invocation of the next entity is effected by calling the `doFilter` method on the `FilterChain` object, and passing in the request and response with which it was called or passing in wrapped versions it may have created.

   The filter chain's implementation of the `doFilter` method, provided by the container, must locate the next entity in the filter chain and invoke its `doFilter` method, passing in the appropriate request and response objects.

   Alternatively, the filter chain can block the request by not making the call to invoke the next entity, leaving the filter responsible for filling out the response object.

   The `service` method is required to run in the same thread as all filters that apply to the servlet.
5. After invocation of the next filter in the chain, the filter may examine response headers.
6. Alternatively, the filter may have thrown an exception to indicate an error in processing. If the filter throws an `UnavailableException` during its `doFilter` processing, the container must not attempt continued processing down the filter chain. It may choose to retry the whole chain at a later time if the exception is not marked permanent.
7. When the last filter in the chain has been invoked, the next entity accessed is the target servlet or resource at the end of the chain.
8. Before a filter instance can be removed from service by the container, the container must first call the `destroy` method on the filter to enable the filter to release any resources and perform other cleanup operations.

6.2.2. Wrapping Requests and Responses

Central to the notion of filtering is the concept of wrapping a request or response in order that it can override behavior to perform a filtering task. In this model, the developer not only has the ability to override existing methods on the request and response objects, but to provide new API suited to a particular filtering task to a filter or target web resource down the chain. For example, the developer may wish to extend the response object with higher level output objects than the output stream or the writer, such as API that allows DOM objects to be written back to the client.

In order to support this style of filter the container must support the following requirement. When a filter invokes the `doFilter` method on the container's filter chain implementation, the container must ensure that the request and response object that it passes to the next entity in the filter chain, or to the target web resource if the filter was the last in the chain, is the same object that was passed into the `doFilter` method by the calling filter.

The same requirement of wrapper object identity applies to the calls from a servlet or a filter to

`RequestDispatcher.forward` or `RequestDispatcher.include`, when the caller wraps the request or response objects. In this case, the request and response objects seen by the called servlet must be the same wrapper objects that were passed in by the calling servlet or filter.

6.2.3. Filter Environment

A set of initialization parameters can be associated with a filter using the `<init-param>` element in the deployment descriptor. The names and values of these parameters are available to the filter at runtime via the `getInitParameter` and `getInitParameterNames` methods on the filter's `FilterConfig` object. Additionally, the `FilterConfig` affords access to the `ServletContext` of the web application for the loading of resources, for logging functionality, and for storage of state in the `ServletContext`'s attribute list. A filter and the target servlet or resource at the end of the filter chain must execute in the same invocation thread.

6.2.4. Configuration of Filters in a Web Application

A filter is defined either via the `@WebFilter` annotation as defined in Section 8.1.2, "@WebFilter" of the specification or in the deployment descriptor using the `<filter>` element. In this element, the programmer declares the following:

- `filter-name`: used to map the filter to a servlet or URL
- `filter-class`: used by the container to identify the filter type
- `init-param`: initialization parameters for a filter

Optionally, the programmer can specify icons, a textual description, and a display name for tool manipulation. The container must instantiate exactly one instance of the Java class defining the filter per filter declaration in the deployment descriptor. Hence, two instances of the same filter class will be instantiated by the container if the developer makes two filter declarations for the same filter class.

Here is an example of a filter declaration:

```
<filter>
  <filter-name>Image Filter</filter-name>
  <filter-class>com.example.ImageServlet</filter-class>
</filter>
```

Once a filter has been declared in the deployment descriptor, the assembler uses the `<filter-mapping>` element to define servlets and static resources in the web application to which the filter is to be applied. Filters can be associated with a servlet using the `<servlet-name>` element. For example, the following code example maps the `Image Filter` filter to the `ImageServlet` servlet:

```
<filter-mapping>
  <filter-name>Image Filter</filter-name>
  <servlet-name>ImageServlet</servlet-name>
</filter-mapping>
```

Filters can be associated with groups of servlets and static content using the `<url-pattern>` style of filter mapping:

```
<filter-mapping>
  <filter-name>Logging Filter</filter-name>
  <url-pattern>/*</url-pattern>
</filter-mapping>
```

Here the `Logging Filter` is applied to all the servlets and static content pages in the web application, because every request URI matches the `/*` URL pattern.

When processing a `<filter-mapping>` element using the `<url-pattern>` style, the container must determine whether the `<url-pattern>` matches the request URI using the path mapping rules defined in Chapter 12, *Mapping Requests to Servlets*.

The order the container uses in building the chain of filters to be applied for a particular request URI is as follows:

1. First, the `<url-pattern>` matching filter mappings in the same order that these elements appear in the deployment descriptor.
2. Next, the `<servlet-name>` matching filter mappings in the same order that these elements appear in the deployment descriptor.

If a filter mapping contains both <servlet-name> and <url-pattern>, the container must expand the filter mapping into multiple filter mappings (one for each <servlet-name> and <url-pattern>), preserving the order of the <servlet-name> and <url-pattern> elements. For example, the following filter mapping:

```
<filter-mapping>
  <filter-name>Multiple Mappings Filter</filter-name>
  <url-pattern>/foo/*</url-pattern>
  <servlet-name>Servlet1</servlet-name>
  <servlet-name>Servlet2</servlet-name>
  <url-pattern>/bar/*</url-pattern>
</filter-mapping>
```

is equivalent to:

```
<filter-mapping>
  <filter-name>Multipe Mappings Filter</filter-name>
  <url-pattern>/foo/*</url-pattern>
</filter-mapping>

<filter-mapping>
  <filter-name>Multipe Mappings Filter</filter-name>
  <servlet-name>Servlet1</servlet-name>
</filter-mapping>

<filter-mapping>
  <filter-name>Multipe Mappings Filter</filter-name>
  <servlet-name>Servlet2</servlet-name>
</filter-mapping>

<filter-mapping>
  <filter-name>Multipe Mappings Filter</filter-name>
  <url-pattern>/bar/*</url-pattern>
</filter-mapping>
```

The requirement about the order of the filter chain means that the container, when receiving an incoming request, processes the request as follows:

- Identifies the target web resource according to the rules of Section 12.2, "Specification of Mappings".
- If there are filters matched by servlet name and the web resource has a `<servlet-name>`, the container builds the chain of filters matching in the order declared in the deployment descriptor. The last filter in this chain corresponds to the last `<servlet-name>` matching filter and is the filter that invokes the target web resource.
- If there are filters using `<url-pattern>` matching and the `<url-pattern>` matches the request URI according to the rules of Section 12.2, "Specification of Mappings", the container builds the chain of `<url-pattern>` matched filters in the same order as declared in the deployment descriptor. The last filter in this chain is the last `<url-pattern>` matching filter in the deployment descriptor for this request URI. The last filter in this chain is the filter that invokes the first filter in the `<servlet-name>` matching chain, or invokes the target web resource if there are none.

It is expected that high performance web containers will cache filter chains so that they do not need to compute them on a per-request basis.

6.2.5. Filters and the RequestDispatcher

The servlet specification provides the ability to configure filters to be invoked under request dispatcher `forward()` and `include()` calls.

By using the `<dispatcher>` element in the deployment descriptor, the developer can indicate for a filter-

mapping whether the filter should be applied to requests when:

1. The request comes directly from the client.

   This is indicated by a `<dispatcher>` element with value `REQUEST`, or by the absence of any `<dispatcher>` elements.

2. The request is being processed under a request dispatcher representing the web component matching the `<url-pattern>` or `<servlet-name>` using a `forward()` call.

   This is indicated by a `<dispatcher>` element with value `FORWARD`.

3. The request is being processed under a request dispatcher representing the web component matching the `<url-pattern>` or `<servlet-name>` using an `include()` call.

   This is indicated by a `<dispatcher>` element with value `INCLUDE`.

4. The request is being processed with the error page mechanism specified in Section 9.5, "Error Handling" to an error resource matching the `<url-pattern>`.

   This is indicated by a `<dispatcher>` element with the value `ERROR`.

5. The request is being processed with the async context dispatch mechanism specified in Section 2.3.3.3, "Asynchronous processing" to a web component using a `dispatch` call.

   This is indicated by a `<dispatcher>` element with the value `ASYNC.`

6. Or any combination of 1, 2, 3, 4 or 5 above.

For example:

```
<filter-mapping>
  <filter-name>Logging Filter</filter-name>
  <url-pattern>/products/*</url-pattern>
</filter-mapping>
```

would result in the `Logging Filter` being invoked by client requests starting `/products/⋯` but not underneath a request dispatcher call where the request dispatcher has path commencing `/products/⋯`. The following code:

```
<filter-mapping>
  <filter-name>Logging Filter</filter-name>
  <servlet-name>ProductServlet</servlet-name>
  <dispatcher>INCLUDE</dispatcher>
</filter-mapping>
```

would result in the `Logging Filter` not being invoked by client requests to the `ProductServlet`, nor underneath a request dispatcher `forward()` call to the `ProductServlet`, but would be invoked underneath a request dispatcher `include()` call where the request dispatcher has a name commencing `ProductServlet`. The following code:

```
<filter-mapping>
  <filter-name>Logging Filter</filter-name>
  <url-pattern>/products/*</url-pattern>
  <dispatcher>FORWARD</dispatcher>
  <dispatcher>REQUEST</dispatcher>
</filter-mapping>
```

would result in the `Logging Filter` being invoked by client requests starting `/products/⋯` and underneath a request dispatcher `forward()` call where the request dispatcher has path commencing `/products/⋯`.

Finally, the following code uses the special servlet name `*`:

```
<filter-mapping>
  <filter-name>All Dispatch Filter</filter-name>
  <servlet-name>*</servlet-name>
  <dispatcher>FORWARD</dispatcher>
</filter-mapping>
```

This code would result in the `All Dispatch Filter` being invoked on request dispatcher forward() calls for all request dispatchers obtained by name or by path.

Chapter 7. Sessions

The Hypertext Transfer Protocol (HTTP) is by design a stateless protocol. To build effective web applications, it is imperative that requests from a particular client be associated with each other. Many strategies for session tracking have evolved over time, but all are difficult or troublesome for the programmer to use directly.

This specification defines a simple `HttpSession` interface that allows a servlet container to use any of several approaches to track a user's session without involving the Application Developer in the nuances of any one approach.

7.1. Session Tracking Mechanisms

The following sections describe approaches to tracking a user's sessions

7.1.1. Cookies

Session tracking through HTTP cookies is the most used session tracking mechanism and is required to be supported by all servlet containers.

The container sends a cookie to the client. The client will then return the cookie on each subsequent request to the server, unambiguously associating the request with a session. The standard name of the session tracking cookie must be `JSESSIONID`. Containers may allow the name of the session tracking cookie to be customized through container specific configuration.

All servlet containers MUST provide an ability to configure whether or not the container marks the session tracking cookie as `HttpOnly`. The established configuration must apply to all contexts for which a context specific configuration has not been established (see `SessionCookieConfig` javadoc for more details).

If a web application configures a custom name for its session tracking cookies, the same custom name will also be used as the name of the URI parameter if the session id is encoded in the URL (provided that URL rewriting has been enabled).

7.1.2. SSL Sessions

Secure Sockets Layer, the encryption technology used in the HTTPS protocol, has a built-in mechanism allowing multiple requests from a client to be unambiguously identified as being part of a session. A servlet container can easily use this data to define a session.

7.1.3. URL Rewriting

URL rewriting is the lowest common denominator of session tracking. When a client will not accept a cookie, URL rewriting may be used by the server as the basis for session tracking. URL rewriting involves adding data, a session ID, to the URL path that is interpreted by the container to associate the

request with a session.

The session ID must be encoded as a path parameter in the URL string. The name of the parameter must be `jsessionid`. Here is an example of a URL containing encoded path information:

```
http://www.example.com/catalog/index.html;jsessionid=1234
```

URL rewriting exposes session identifiers in logs, bookmarks, referer headers, cached HTML, and the URL bar. URL rewriting should not be used as a session tracking mechanism where cookies or SSL sessions are supported and suitable.

7.1.4. Session Integrity

Web containers must be able to support the HTTP session while servicing HTTP requests from clients that do not support the use of cookies. To fulfill this requirement, web containers commonly support the URL rewriting mechanism.

7.2. Creating a Session

A session is considered "new" when it is only a prospective session and has not been established. Because HTTP is a request-response based protocol, an HTTP session is considered to be new until a client "joins" it. A client joins a session when session tracking information has been returned to the server indicating that a session has been established. Until the client joins a session, it cannot be assumed that the next request from the client will be recognized as part of a session.

The session is considered to be "new" if either of the following is true:

- The client does not yet know about the session
- The client chooses not to join a session.

These conditions define the situation where the servlet container has no mechanism by which to associate a request with a previous request.

An Application Developer must design the application to handle a situation where a client has not, can not, or will not join a session.

Associated with each session, there is a string containing a unique identifier, which is referred to as the session id. The value of the session id can be obtained by calling `jakarta.servlet.http.HttpSession.getId()` and can be changed after creation by invoking `jakarta.servlet.http.HttpServletRequest.changeSessionId()`.

7.3. Session Scope

`HttpSession` objects must be scoped at the application (or servlet context) level. The underlying

mechanism, such as the cookie used to establish the session, can be the same for different contexts, but the object referenced, including the attributes in that object, must never be shared between contexts by the container.

To illustrate this requirement with an example: if a servlet uses the `RequestDispatcher` to call a servlet in another web application, any sessions created for and visible to the servlet being called must be different from those visible to the calling servlet.

Additionally, sessions of a context must be resumable by requests into that context regardless of whether their associated context was being accessed directly or as the target of a request dispatch at the time the sessions were created.

7.4. Binding Attributes into a Session

A servlet can bind an object attribute into an `HttpSession` implementation by name. Any object bound into a session is available to any other servlet that belongs to the same `ServletContext` and handles a request identified as being a part of the same session.

Some objects may require notification when they are placed into, or removed from, a session. This information can be obtained by having the object implement the `HttpSessionBindingListener` interface. This interface defines the following methods that will signal an object being bound into, or being unbound from, a session.

- `valueBound`
- `valueUnbound`

The `valueBound` method must be called before the object is made available via the `getAttribute` method of the `HttpSession` interface. The `valueUnbound` method must be called after the object is no longer available via the `getAttribute` method of the `HttpSession` interface.

7.5. Session Timeouts

In the HTTP protocol, there is no explicit termination signal when a client is no longer active. This means that the only mechanism that can be used to indicate when a client is no longer active is a time out period.

The default time out period for sessions is defined by the servlet container and can be obtained via the `getSessionTimeout` method of the `ServletContext` interface or the `getMaxInactiveInterval` method of the `HttpSession` interface. This time out can be changed by the Application Developer using the `setSessionTimeout` method of the `ServletContext` interface or the `setMaxInactiveInterval` method of the `HttpSession` interface. The time out periods used by session timeout methods are defined in minutes. The time out periods used by max active interval methods are defined in seconds. See the javadoc for `setSessionTimeout` for additional normative requirements. By definition, if the time out period for a session is set to *0 or lesser value* , the session will never expire. The session invalidation will not take effect until all servlets using that session have exited the service method. Once the session invalidation

is initiated, a new request must not be able to see that session.

7.6. Last Accessed Times

The `getLastAccessedTime` method of the `HttpSession` interface allows a servlet to determine the last time the session was accessed before the current request. The session is considered to be accessed when a request that is part of the session is first handled by the servlet container.

7.7. Important Session Semantics

7.7.1. Threading Issues

Multiple servlets executing request threads may have active access to the same session object at the same time. The container must ensure that manipulation of internal data structures representing the session attributes is performed in a thread safe manner. The Application Developer has the responsibility for thread safe access to the attribute objects themselves. This will protect the attribute collection inside the `HttpSession` object from concurrent access, eliminating the opportunity for an application to cause that collection to become corrupted. Unless explicitly stated elsewhere in the specification, objects vended from the request or response must be assumed to be non thread safe. This includes, but is not limited to the `PrintWriter` returned from `ServletResponse.getWriter()` and the `OutputStream` returned from `ServletResponse.getOutputStream()`.

7.7.2. Distributed Environments

Within an application marked as distributable, all requests that are part of a session must be handled by one JVM at a time. The container must be able to handle all objects placed into instances of the `HttpSession` class using the `setAttribute` or `putValue` methods appropriately. The following restrictions are imposed to meet these conditions:

- The container must accept objects that implement the `Serializable` interface.
- The container may choose to support storage of other designated objects in the `HttpSession`, such as references to Jakarta Enterprise Beans components and transactions.
- Migration of sessions will be handled by container-specific facilities.

The distributed servlet container must throw an `IllegalArgumentException` for objects where the container cannot support the mechanism necessary for migration of the session storing them.

The distributed servlet container must support the mechanism necessary for migrating objects that implement `Serializable`.

These restrictions mean that the Application Developer is ensured that there are no additional concurrency issues beyond those encountered in a non-distributed container.

The Container Provider can ensure scalability and quality of service features like load-balancing and

failover by having the ability to move a session object, and its contents, from any active node of the distributed system to a different node of the system.

If distributed containers persist or migrate sessions to provide quality of service features, they are not restricted to using the native JVM Serialization mechanism for serializing `HttpSessions` and their attributes. Developers are not guaranteed that containers will call `readObject` and `writeObject` methods on session attributes if they implement them, but are guaranteed that the `Serializable` closure of their attributes will be preserved.

Containers must notify any session attributes implementing the `HttpSessionActivationListener` during migration of a session. They must notify listeners of passivation prior to serialization of a session, and of activation after deserialization of a session.

Application Developers writing distributed applications should be aware that since the container may run in more than one Java virtual machine, the developer cannot depend on static variables for storing an application state. They should store such states using an enterprise bean or a database.

7.7.3. Client Semantics

Due to the fact that cookies or SSL certificates are typically controlled by the web browser process and are not associated with any particular window of the browser, requests from all windows of a client application to a servlet container might be part of the same session. For maximum portability, the Application Developer should always assume that all windows of a client are participating in the same session.

Chapter 8. Annotations and Pluggability

This chapter describes the use of annotations and other enhancements to enable pluggability of frameworks and libraries for use within a web application.

8.1. Annotations and Pluggability

In a web application, classes using annotations will have their annotations processed only if they are located in the `WEB-INF/classes` directory, or if they are packaged in a jar file located in `WEB-INF/lib` within the application.

The web application deployment descriptor contains a `metadata-complete` attribute on the `web-app` element. This attribute defines whether this deployment descriptor and associated web fragments, if any, are complete, or whether the class files available to this module and packaged with this application should be examined for annotations that specify deployment information. Deployment information, in this sense, refers to any information that could have been specified by the deployment descriptor or fragments, but instead is specified as annotations on classes.

If the value of the `metadata-complete` attribute is specified as `true`, the deployment tool must ignore any annotations that specify such deployment information in the class files packaged in the web application. Please see Section 8.2.3, "Assembling the Descriptor from web.xml, web-fragment.xml and Annotations", Section 8.4, "Processing Annotations and Fragments" and Section 15.5.1, "Handling of metadata-complete" for additional details on the handling of `metadata-complete`.

If the `metadata-complete` attribute is not specified, or its value is `false`, the deployment tool must examine the class files of the application for such annotations. Note that a `true` value for `metadata-complete` does **not** preempt the processing of **all** annotations, only those listed below.

Annotations that do not have equivalents in the deployment XSD include `jakarta.servlet.annotation.HandlesTypes` and all of the CDI-related annotations. These annotations must be processed during annotation scanning, regardless of the value of `metadata-complete`.

When Jakarta Enterprise Beans are packaged in a `.war` file, and the `.war` file contains an `ejb-jar.xml` file, the `metadata-complete` attribute of the `ejb-jar.xml` file determines the processing of the annotations for enterprise beans. If there is no `ejb-jar.xml` file, and the `web.xml` specifies the `metadata-complete` attribute as `true`, these annotations are processed as though there were an `ejb-jar.xml` file whose `metadata-complete` attribute was specified as `true`. See the Jakarta Enterprise Beans specification for requirements pertaining to annotations for Jakarta Enterprise Beans.

The following are the annotations in jakarta.servlet. All of these have corresponding deployment descriptor metadata covered by the web xsd.

From `jakarta.servlet.annotation`:

- `HttpConstraint`

- HttpMethodConstraint
- MultipartConfig
- ServletSecurity
- WebFilter
- WebInitParam
- WebListener
- WebServlet

The following annotations from related packages are also covered by the web.xml and associated fragments.

From jakarta.annotation:

- PostConstruct
- PreDestroy
- Resource
- Resources

From jakarta.annotation.security:

- DeclareRoles
- RunAs

From jakarta.annotation.sql:

- DataSourceDefinition
- DataSourceDefinitions

From jakarta.ejb:

- EJB
- EJBs

From jakarta.jms:

- JMSConnectionFactoryDefinition
- JMSConnectionFactoryDefinitions
- JMSDestinationDefinition
- JMSDestinationDefinitions

From jakarta.mail:

- `MailSessionDefinition`
- `MailSessionDefinitions`

From `jakarta.persistence`:

- `PersistenceContext`
- `PersistenceContexts`
- `PersistenceUnit`
- `PersistenceUnits`

From `jakarta.resource`:

- `AdministeredObjectDefinition`
- `AdministeredObjectDefinitions`
- `ConnectionFactoryDefinition`
- `ConnectionFactoryDefinitions`

All annotations in the following packages:

- `jakarta.jws`
- `jakarta.jws.soap`
- `jakarta.xml.ws`
- `jakarta.xml.ws.soap`
- `jakarta.xml.ws.spi`

Following are the annotations that MUST be supported by a servlet compliant web container.

8.1.1. @WebServlet

This annotation is used to define a `Servlet` component in a web application. This annotation is specified on a class and contains metadata about the `Servlet` being declared. The `urlPatterns` or the `value` attribute on the annotation MUST be present. All other attributes are optional with default settings (see javadocs for more details). It is recommended to use `value` when the only attribute on the annotation is the url pattern and to use the `urlPatterns` attribute when the other attributes are also used. It is illegal to have both `value` and `urlPatterns` attribute used together on the same annotation. The default name of the `Servlet` if not specified is the fully qualified class name. The annotated servlet MUST specify at least one url pattern to be deployed. If the same servlet class is declared in the deployment descriptor under a different name, a new instance of the servlet MUST be instantiated. If the same servlet class is added with a different name to the `ServletContext` via the programmatic API defined in Section 4.4.1, “Programmatically Adding and Configuring Servlets”, the attribute values declared via the `@WebServlet` annotation MUST be ignored and a new instance of the servlet with the name specified MUST be created.

Classes annotated with `@WebServlet` class MUST extend the `jakarta.servlet.http.HttpServlet` class.

Following is an example of how this annotation would be used.

@WebServlet Annotation Example

```
@WebServlet("/foo")
public class CalculatorServlet extends HttpServlet{
    ...
}
```

Following is an example of how this annotation would be used with some more of the attributes specified.

@WebServlet annotation example using other annotation attributes specified

```
@WebServlet(name="MyServlet", urlPatterns={"/foo", "/bar"})
public class SampleUsingAnnotationAttributes extends HttpServlet{

    public void doGet(HttpServletRequest req, HttpServletResponse res) {
        ...
    }
}
```

8.1.2. @WebFilter

This annotation is used to define a `Filter` in a web application. This annotation is specified on a class and contains metadata about the filter being declared. The default name of the `Filter` if not specified is the fully qualified class name. The `urlPatterns` attribute, `servletNames` attribute or the `value` attribute of the annotation MUST be specified. All other attributes are optional with default settings (see javadocs for more details). It is recommended to use `value` when the only attribute on the annotation is the url pattern and to use the `urlPatterns` attribute when the other attributes are also used. It is illegal to have both `value` and `urlPatterns` attribute used together on the same annotation.

Classes annotated with `@WebFilter` MUST implement `jakarta.servlet.Filter`.

Following is an example of how this annotation would be used.

@WebFilter annotation example

```
@WebFilter("/foo")
public class MyFilter implements Filter {

    public void doFilter(HttpServletRequest req, HttpServletResponse res) {
        ...
    }
}
```

8.1.3. @WebInitParam

This annotation is used to specify any init parameters that must be passed to the `Servlet` or the `Filter`. It is an attribute of the `WebServlet` and `WebFilter` annotation.

8.1.4. @WebListener

The `WebListener` annotation is used to annotate a listener to get events for various operations on the particular web application context. Classes annotated with `@WebListener` MUST implement one of the following interfaces:

- `jakarta.servlet.ServletContextListener`
- `jakarta.servlet.ServletContextAttributeListener`
- `jakarta.servlet.ServletRequestListener`
- `jakarta.servlet.ServletRequestAttributeListener`
- `jakarta.servlet.http.HttpSessionListener`
- `jakarta.servlet.http.HttpSessionAttributeListener`
- `jakarta.servlet.http.HttpSessionIdListener`

An example:

```
@WebListener
public class MyListener implements ServletContextListener{

    public void contextInitialized(ServletContextEvent sce) {
        ServletContext sc = sce.getServletContext();
        sc.addServlet("myServlet", "Sample servlet", "foo.bar.MyServlet", null, -1);
        sc.addServletMapping("myServlet", new String[] { "/urlpattern/*" });
    }
}
```

8.1.5. @MultipartConfig

This annotation, when specified on a `Servlet`, indicates that the request it expects is of type `multipart/form-data`. The `HttpServletRequest` object of the corresponding servlet MUST make available the mime attachments via the `getParts` and `getPart` methods to iterate over the various mime attachments. The `location` attribute of the `jakarta.servlet.annotation.MultipartConfig` and the `<location>` element of the `<multipart-config>` is interpreted as an absolute path and defaults to the value of the `jakarta.servlet.context.tempdir`. If a relative path is specified, it will be relative to the `tempdir` location. The test for absolute path vs relative path MUST be done via `java.io.File.isAbsolute`.

8.1.6. Other Annotations / Conventions

In addition to these annotations all the annotations defined in Section 15.5, "Annotations and Resource Injection" will continue to work in the context of these new annotations.

By default all applications will have `index.htm[l]` and `index.jsp` in the `welcome-file-list`. The descriptor may to be used to override these default settings.

The order in which the listeners, servlets are loaded from the various framework jars / classes in the `WEB-INF/classes` or `WEB-INF/lib` is unspecified when using annotations. If ordering is important then look at the section for modularity of web.xml and ordering of `web.xml` and `web-fragment.xml` below. The order can be specified in the deployment descriptor only.

8.2. Pluggability

8.2.1. Modularity of web.xml

Using the annotations defined above makes the use of web.xml optional. However for overriding either the default values or the values set via annotations, the deployment descriptor is used. As before, if the `metadata-complete` element is set to `true` in the `web.xml` descriptor, annotations that specify deployment information present in the class files and web-fragments bundled in jars will not be processed. It implies that all the metadata for the application is specified via the `web.xml` descriptor.

For better pluggability and less configuration for developers, we introduce the notion of web module deployment descriptor fragments (web fragment). A web fragment is a part or all of the `web.xml` that can be specified and included in a library or framework jar's `META-INF` directory. A plain old jar file in the WEB-INF/lib directory with no web-fragment.xml is also considered a fragment. Any annotations specified in it will be processed according to the rules defined in 8.2.3. The container will pick up and use the configuration as per the rules defined below.

A web fragment is a logical partitioning of the web application in such a way that the frameworks being used within the web application can define all the artifacts without asking developers to edit or add information in the web.xml. It can include almost all the same elements that the web.xml descriptor uses. However the top level element for the descriptor MUST be web-fragment and the corresponding descriptor file MUST be called web-fragment.xml. The ordering related elements also

differ between the web-fragment.xml and web.xml See the corresponding schema for web-fragments in the deployment descriptor section in Chapter 14.

If a framework is packaged as a jar file and has metadata information in the form of deployment descriptor then the `web-fragment.xml` descriptor must be in the `META-INF/` directory of the jar file.

If a framework wants its `META-INF/web-fragment.xml` honored in such a way that it augments a web application's `web.xml`, the framework must be bundled within the web application's `WEB-INF/lib` directory. In order for any other types of resources (e.g., class files) of the framework to be made available to a web application, it is sufficient for the framework to be present anywhere in the classloader delegation chain of the web application. In other words, only JAR files bundled in a web application's `WEB-INF/lib` directory, but not those higher up in the class loading delegation chain, need to be scanned for `web-fragment.xml`.

During deployment the container is responsible for scanning the location specified above and discovering the `web-fragment.xml` files and processing them. The requirements about name uniqueness that exist currently for a single web.xml also apply to the union of a web.xml and all applicable web-fragment.xml files.

An example of what a library or framework can include is shown below

```
<web-fragment>

  <servlet>
    <servlet-name>welcome</servlet-name>
    <servlet-class>com.example.WelcomeServlet</servlet-class>
  </servlet>

  <listener>
    <listener-class>com.example.RequestListener</listener-class>
  </listener>

</web-fragment>
```

The above web-fragment.xml would be included in the META-INF/ directory of the framework's jar file. The order in which configuration from web-fragment.xml and annotations should be applied is undefined. If ordering is an important aspect for a particular application please see rules defined below on how to achieve the order desired.

8.2.2. Ordering of web.xml and web-fragment.xml

Since the specification allows the application configuration resources to be composed of multiple configuration files (`web.xml` and `web-fragment.xml`), discovered and loaded from several different places in the application, the question of ordering must be addressed. This section specifies how configuration resource authors may declare the ordering requirements of their artifacts.

A web-fragment.xml may have a top level <name> element of type jakartaee:java-identifierType. There can only be one <name> element in a web-fragment.xml. If a <name> element is present, it must be considered for the ordering of artifacts (unless the duplicate name exception applies, as described below).

Two cases must be considered to allow application configuration resources to express their ordering preferences.

1. Absolute ordering: an <absolute-ordering> element in the web.xml. There can only be one <absolute-ordering> element in a web.xml.
    a. In this case, ordering preferences that would have been handled by case 2 below must be ignored.
    b. The web.xml and WEB-INF/classes MUST be processed before any of the web-fragments listed in the absolute-ordering element.
    c. Any <name> element direct children of the <absolute-ordering> MUST be interpreted as indicating the absolute ordering in which those named web-fragments, which may or may not be present, must be processed.
    d. The <absolute-ordering> element may contain zero or one <others/> element. The required action for this element is described below. If the <absolute-ordering> element does not contain an <others/> element, any web-fragment not specifically mentioned within <name/> elements MUST be ignored. Excluded jars are not scanned for annotated servlets, filters or listeners. However, if a servlet, filter or listener from an excluded jar is listed in web.xml or a non-excluded web-fragment.xml, then it's annotations will apply unless otherwise excluded by metadata-complete. ServletContextListeners discovered in TLD files of excluded jars are not able to configure filters and servlets using the programmatic APIs. Any attempt to do so will result in an IllegalStateException. If a discovered ServletContainerInitializer is loaded from an excluded jar, it will be ignored. Irrespective of the setting of metadata-complete, jars excluded by <absolute-ordering> elements are not scanned for classes to be handled by any ServletContainerInitializer.
    e. Duplicate name exception: if, when traversing the children of <absolute-ordering>, multiple children with the same <name> element are encountered, only the first such occurrence must be considered.
2. Relative ordering: an <ordering> element within the web-fragment.xml. There can only be one <ordering> element in a web-fragment.xml.
    a. A web-fragment.xml may have an <ordering> element. If so, this element must contain zero or one <before> element and zero or one <after> element. The meaning of these elements is explained below.
    b. The web.xml and WEB-INF/classes MUST be processed before any of the web-fragments listed in the ordering element.
    c. Duplicate name exception: if, when traversing the web-fragments, multiple members with the same <name> element are encountered, the application must log an informative error message including information to help fix the problem, and must fail to deploy. For example, one way to

fix this problem is for the user to use absolute ordering, in which case relative ordering is ignored.

d. Consider this abbreviated but illustrative example. 3 web-fragments: `MyFragment1`, `MyFragment2` and `MyFragment3` are part of the application that also includes a `web.xml`

web-fragment.xml

```
<web-fragment>
  <name>MyFragment1</name>
  <ordering>
    <after>
      <name>MyFragment2</name>
    </after>
  </ordering>
  ...
</web-fragment>
```

web-fragment.xml

```
<web-fragment>
  <name>MyFragment2</name>
  ...
</web-fragment>
```

web-fragment.xml

```
<web-fragment>
  <name>MyFragment3</name>
  <ordering>
    <before>
      <others/>
    </before>
  </ordering>
  ...
</web-fragment>
```

web.xml

```
<web-app>
  ...
</web-app>
```

In this example the processing order will be:

1. `web.xml`

2. MyFragment3
3. MyFragment2
4. MyFragment1

The preceding example illustrates some, but not all, of the following principles.

- <before> means the document must be ordered before the document with the name matching what is specified within the nested <name> element.
- <after> means the document must be ordered after the document with the name matching what is specified within the nested <name> element.
- There is a special element <others/> which may be included zero or one time within the <before> or <after> element, or zero or one time directly within the <absolute-ordering> element. The <others/> element must be handled as follows.
  - If the <before> element contains a nested <others/>, the document will be moved to the beginning of the list of sorted documents. If there are multiple documents stating <before><others/>, they will all be at the beginning of the list of sorted documents, but the ordering within the group of such documents is unspecified.
  - If the <after> element contains a nested <others/>, the document will be moved to the end of the list of sorted documents. If there are multiple documents requiring <after><others/>, they will all be at the end of the list of sorted documents, but the ordering within the group of such documents is unspecified.
  - Within a <before> or <after> element, if an <others/> element is present, but is not the only <name> element within its parent element, the other elements within that parent must be considered in the ordering process.
  - If the <others/> element appears directly within the <absolute-ordering> element, the runtime must ensure that any web-fragments not explicitly named in the <absolute-ordering> section are included at that point in the processing order.
- If a web-fragment.xml file does not have an <ordering> or the web.xml does not have an <absolute-ordering> element the artifacts are assumed to not have any ordering dependency.
- If the runtime discovers circular references, an informative message must be logged, and the application must fail to deploy. Again, one course of action the user may take is to use absolute ordering in the web.xml.
- The previous example can be extended to illustrate the case when the web.xml contains an ordering section.

web.xml

```
<web-app>
  <absolute-ordering>
    <name>MyFragment3</name>
    <name>MyFragment2</name>
  </absolute-ordering>
  ...
</web-app>
```

In this example, the ordering for the various elements will be:

1. `web.xml`
2. `MyFragment3`
3. `MyFragment2`

Some additional example scenarios are included below. All of these apply to relative ordering and not absolute ordering.

Example 1

Document A:

```
<after>
  <others/>
  <name>C</name>
</after>
```

Document B:

```
<before>
  <others/>
</before>
```

Document C:

```
<after>
  <others/>
</after>
```

Document D:

no ordering

Document E:

no ordering

Document F:

```
<before>
  <others/>
  <name>B</name>
</before>
```

Resulting parse order:

```
web.xml, F, B, D, E, C, A.
```

Example 2

Document <no id>:

```
<after>
  <others/>
</after>
<before>
  <name>C</name>
</before>
```

Document B:

```
<before>
  <others/>
</before>
```

Document C:

no ordering

Document D:

```
<after>
  <others/>
</after>
```

Document E:

```
<before>
  <others/>
</before>
```

Document F:

no ordering

Resulting parse order can be one of the following:

- B, E, F, <no id>, C, D
- B, E, F, <no id>, D, C
- E, B, F, <no id>, C, D
- E, B, F, <no id>, D, C
- E, B, F, D, <no id>, C
- E, B, F, D, <no id>, D

Example 3

Document A:

```
<after>
  <name>B</name>
</after>
```

Document B:

no ordering

Document C:

```
<before>
  <others/>
</before>
```

Document D:

no ordering

Resulting parse order can be one of the following:

- C, B, D, A
- C, D, B, A
- C, B, A, D

8.2.3. Assembling the Descriptor from web.xml, web-fragment.xml and Annotations

If the order in which the listeners, servlets, filters are invoked is important to an application then a deployment descriptor must be used. Also, if necessary, the ordering element defined above can be

used. As described above, when using annotations to define the listeners, servlets and filters, the order in which they are invoked is unspecified. Below are a set of rules that apply for assembling the final deployment descriptor for the application:

1. The order for listeners, servlets, filters if relevant must be specified in either the `web-fragment.xml` or the `web.xml`.
2. The ordering will be based on the order in which they are defined in the descriptor and on the `absolute-ordering` element in the `web.xml` or an `ordering` element in the `web-fragment.xml`, if present.
   a. Filters that match a request are chained in the order in which they are declared in the `web.xml`.
   b. Servlets are initialized either lazily at request processing time or eagerly during deployment. In the latter case, they are initialized in the order indicated by their `load-on-startup` elements.
   c. The listeners are invoked in the order in which they are declared in the `web.xml` as specified below:
      i. Implementations of `jakarta.servlet.ServletContextListener` are invoked at their `contextInitialized` method in the order in which they have been declared, and at their `contextDestroyed` method in reverse order.
      ii. Implementations of `jakarta.servlet.ServletRequestListener` are invoked at their `requestInitialized` method in the order in which they have been declared, and at their `requestDestroyed` method in reverse order.
      iii. Implementations of `jakarta.servlet.http.HttpSessionListener` are invoked at their `sessionCreated` method in the order in which they have been declared, and at their `sessionDestroyed` method in reverse order.
      iv. The methods of implementation of `jakarta.servlet.ServletContextAttributeListener`, `jakarta.servlet.ServletRequestAttributeListener` and `jakarta.servlet.HttpSessionAttributeListener` are invoked in the order in which they are declared when corresponding events are fired.
3. If a servlet is disabled using the `enabled` element introduced in the `web.xml` then the servlet will not be available at the `url-pattern` specified for the servlet.
4. The `web.xml` of the web application has the highest precedence when resolving conflicts between the `web.xml`, `web-fragment.xml` and annotations.
5. If `metadata-complete` is not specified in the descriptors, or is set to `false` in the deployment descriptor, then the effective metadata for the application is derived by combining the metadata present in the annotations and the descriptors. The rules for merging are specified below:
   a. Configuration settings in web fragments are used to augment those specified in the main web.xml in such a way as if they had been specified in the same web.xml.
   b. The order in which configuration settings of web fragments are added to those in the main web.xml is as specified above in Section 8.2.2, “Ordering of web.xml and web-fragment.xml”
   c. The `metadata-complete` attribute when set to `true` in the main `web.xml`, is considered complete and scanning of annotations and fragments will not occur at deployment time. The `absolute-`

`ordering` and `ordering` elements will be ignored if present. When set to `true` on a fragment, the `metadata-complete` attribute applies only to scanning of annotations in that particular jar.

d. Web fragments are merged into the main `web.xml` unless the `metadata-complete` is set to `true`. The merging takes place after annotation processing on the corresponding fragment.

e. The following are considered configuration conflicts when augmenting a `web.xml` with web fragments:

   i. Multiple `<init-param>` elements with the same `<param-name>` but different `<param-value>`

   ii. Multiple `<mime-mapping>` elements with the same `<extension>` but different `<mime-type>`

f. The above configuration conflicts are resolved as follows:

   i. Configuration conflicts between the main `web.xml` and a web fragment are resolved such that the configuration in the `web.xml` takes precedence.

   ii. Configuration conflicts between two web fragments, where the element at the center of the conflict is not present in the main `web.xml`, will result in an error. An informative message must be logged, and the application must fail to deploy.

g. After the above conflicts have been resolved, these additional rules are applied

   i. Elements that may be declared any number of times are additive across the `web-fragments` in the resulting `web.xml`. For example, `<context-param>` elements with different `<param-name>` are additive.

   ii. Elements that may be declared any number of times, if specified in the `web.xml` overrides the values specified in the `web-fragments` with the same name.

   iii. If an element with a minimum occurrence of zero, and a maximum occurrence of one, is present in a web fragment, and missing in the main `web.xml`, the main `web.xml` inherits the setting from the web fragment. If the element is present in both the main `web.xml` and the web fragment, the configuration setting in the main `web.xml` takes precedence. For example, if both the main `web.xml` and a web fragment declare the same servlet, and the servlet declaration in the web fragment specifies a `<load-on-startup>` element, whereas the one in the main `web.xml` does not, then the `<load-on-startup>` element from the web fragment will be used in the merged `web.xml`.

   iv. It is considered an error if an element with a minimum occurrence of zero, and a maximum occurrence of one, is specified differently in two web fragments, while absent from the main `web.xml`. For example, if two web fragments declare the same servlet, but with different `<load-on-startup>` elements, and the same servlet is also declared in the main `web.xml`, but without any `<load-on-startup>`, then an error must be reported.

   v. `<welcome-file>` declarations are additive.

   vi. `<servlet-mapping>` elements with the same `<servlet-name>` are additive across `web-fragments`. `<servlet-mapping>` specified in the `web.xml` overrides values specified in the `web-fragments` with the same `<servlet-name>`.

   vii. `<filter-mapping>` elements with the same `<filter-name>` are additive across `web-fragments`. `<filter-mapping>` specified in the `web.xml` overrides values specified in the `web-fragments`

with the same <filter-name>.

viii. Multiple <listener> elements with the same <listener-class> are treated as a single <listener> declaration

ix. The web.xml resulting from the merge is considered <distributable> only if the web.xml and all the web fragments are marked as <distributable>.

x. The top-level <icon> and its children elements, <display-name>, and <description> elements of a web fragment are ignored.

xi. jsp-property-group is additive. It is recommended that jsp-config element use the url-pattern as opposed to extension mappings when bundling static resources in the META-INF/resources directory of a jar file. Further more JSP resources for a fragment should be in a sub-directory same as the fragment name, if there exists one. This helps prevent a web-fragment's jsp-property-group from affecting the JSPs in the main docroot of the application and the jsp-property-group from affecting the JSPs in a fragment's META-INF/resources directory.

h. For all the resource reference elements (env-entry, ejb-ref, ejb-local-ref, service-ref, resource-ref, resource-env-ref, message-destination-ref, persistence-context-ref and persistence-unit-ref) the following rules apply:

i. If any resource reference element is present in a web fragment, and is missing in the main web.xml, the main web.xml inherits the value from the web fragment. If the element is present in both the main web.xml and the web fragment, with the same name, the web.xml takes precedence. None of the child elements from the fragment are merged into the main web.xml except for the injection-target as specified below. For example, if both the main web.xml and a web fragment declare a <resource-ref> with the same <resource-ref-name>, the <resource-ref> from the web.xml will be used without any child elements being merged from the fragment except <injection-target> as described below.

ii. If a resource reference element is specified in two fragments, while absent from the main web.xml, and all the attributes and child elements of the resource reference element are identical, the resource reference will be merged into the main web.xml. It is considered an error if a resource reference element has the same name specified in two fragments, while absent from the main web.xml and the attributes and child elements are not identical in the two fragments. An error must be reported and the application MUST fail to deploy. For example, if two web fragments declare a <resource-ref> with the same <resource-ref-name> element but the type in one is specified as jakarta.sql.DataSource while the type in the other is that of a Jakarta Mail resource, it is an error and the application will fail to deploy.

iii. For resource reference element with the same name <injection-target> elements from the fragments will be merged into the main web.xml.

i. In addition to the merging rules for web-fragment.xml defined above, the following rules apply when using the resource reference annotations (@Resource, @Resources, @EJB, @EJBs, @WebServiceRef, @WebServiceRefs, @PersistenceContext, @PersistenceContexts,@PersistenceUnit, and @PersistenceUnits).

If a resource reference annotation is applied on a class, it is equivalent to defining a resource, however it is not equivalent to defining an `injection-target`. The rules above apply for `injection-target` element in this case.

If a resource reference annotation is used on a field it is equivalent to defining the `injection-target` element in the `web.xml`. However if there is no `injection-target` element in the descriptor then the `injection-target` from the fragments will still be merged into the `web.xml` as defined above.

If, on the other hand, there is an `injection-target` in the main `web.xml` and there is a resource reference `annotation` with the same resource name, then it is considered an override for the resource reference annotation. In this case since there is an `injection-target` specified in the descriptor, the rules defined above would apply in addition to overriding the value for the resource reference annotation.

j. If a `data-source` element is specified in two fragments, while absent from the main `web.xml`, and all the attributes and child elements of the `data-source` element are identical, the `data-source` will be merged into the main `web.xml`. It is considered an error if a `data-source` element has the same name specified in two fragments, while absent from the main `web.xml` and the attributes and child elements are not identical in the two fragments. In such a case an error must be reported and the application MUST fail to deploy.

Below are some examples that show the outcome in the different cases.

Example 1

web.xml

no resource-ref definition

Fragment 1 - web-fragment.xml

```
<resource-ref>
  <resource-ref-name="foo">
  ...
  <injection-target>
    <injection-target-class>com.example.Bar</injection-target-class>
    <injection-target-name>baz</injection-target-name>
  </injection-target>
</resource-ref>
```

The effective metadata would be:

```
<resource-ref>
  <resource-ref-name="foo">
  ...
  <injection-target>
    <injection-target-class>com.example.Bar</injection-target-class>
    <injection-target-name>baz</injection-target-name>
  </injection-target>
</resource-ref>
```

Example 2

web.xml

```
<resource-ref>
  <resource-ref-name="foo">
  ...
</resource-ref>
```

Fragment 1 - web-fragment.xml

```
<resource-ref>
  <resource-ref-name="foo">
  ...
  <injection-target>
    <injection-target-class>com.example.Bar</injection-target-class>
    <injection-target-name>baz</injection-target-name>
  </injection-target>
</resource-ref>
```

Fragment 2 - web-fragment.xml

```
<resource-ref>
  <resource-ref-name="foo">
  ...
  <injection-target>
    <injection-target-class>com.example.Bar2</injection-target-class>
    <injection-target-name>baz2</injection-target-name>
  </injection-target>
</resource-ref>
```

The effective metadata would be:

```
<resource-ref>
  <resource-ref-name="foo">
  ...
  <injection-target>
    <injection-target-class>com.example.Bar</injection-target-class>
    <injection-target-name>baz</injection-target-name>
  </injection-target>
  <injection-target>
    <injection-target-class>com.example.Bar2</injection-target-class>
    <injection-target-name>baz2</injection-target-name>
  </injection-target>
</resource-ref>
```

Example 3

web.xml

```
<resource-ref>
  <resource-ref-name="foo">
  ...
  <injection-target>
    <injection-target-class>com.example.Bar3</injection-target-class>
    <injection-target-name>baz3</injection-target-name>
  </injection-target>
</resource-ref>
```

Fragment 1 - web-fragment.xml

```
<resource-ref>
  <resource-ref-name="foo">
  ...
  <injection-target>
    <injection-target-class>com.example.Bar</injection-target-class>
    <injection-target-name>baz</injection-target-name>
  </injection-target>
</resource-ref>
```

Fragment 2 - web-fragment.xml

```
<resource-ref>
  <resource-ref-name="foo">
  ...
  <injection-target>
    <injection-target-class>com.example.Bar2</injection-target-class>
    <injection-target-name>baz2</injection-target-name>
  </injection-target>
</resource-ref>
```

The effective metadata would be:

```
<resource-ref>
  <resource-ref-name="foo">
  ...
  <injection-target>
    <injection-target-class>com.example.Bar3</injection-target-class>
    <injection-target-name>baz3</injection-target-name>
    <injection-target-class>com.example.Bar</injection-target-class>
    <injection-target-name>baz</injection-target-name>
    <injection-target-class>com.example.Bar2</injection-target-class>
    <injection-target-name>baz2</injection-target-name>
  </injection-target>
</resource-ref>
```

The `<injection-target>` from fragment 1 and 2 will be merged into the main web.xml.

k. If the main `web.xml` does not have any `<post-construct>` element specified and web-fragments have specified `<post-construct>` then the `<post-construct>` elements from the fragments will be merged into the main `web.xml`. However if in the main `web.xml` at least one `<post-construct>` element is specified then the `<post-construct>` elements from the fragment will not be merged. It is the responsibility of the author of the `web.xml` to make sure that the `<post-construct>` list is complete.

l. If the main `web.xml` does not have any `<pre-destroy>` element specified and web-fragments have specified `<pre-destroy>` then the `<pre-destroy>` elements from the fragments will be merged into the main `web.xml`. However if in the main `web.xml` at least one `<pre-destroy>` element is specified then the `<pre-destroy>` elements from the fragment will not be merged. It is the responsibility of the author of the `web.xml` to make sure that the `<pre-destroy>` list is complete.

m. After processing the `web-fragment.xml`, annotations from the corresponding fragment are processed to complete the effective metadata for the fragment before processing the next fragment. The following rules are used for processing annotations:

   i. Any metadata specified via an annotation that isn't already present in the descriptor will be used to augment the effective descriptor.

ii. Configuration specified in the main `web.xml` or a web fragment takes precedence over the configuration specified via annotations.

iii. For a servlet defined via the `@WebServlet` annotation, to override values via the descriptor, the name of the servlet in the descriptor MUST match the name of the servlet specified via the annotation (explicitly specified or the default name, if one is not specified via the annotation).

iv. Init params for servlets and filters defined via annotations, will be overridden in the descriptor if the name of the init param exactly matches the name specified via the annotation. Init params are additive between the annotations and descriptors.

v. `url-patterns`, when specified in a descriptor for a given servlet name overrides the url patterns specified via the annotation.

vi. For a filter defined via the `@WebFilter` annotation, to override values via the descriptor, the name of the filter in the descriptor MUST match the name of the filter specified via the annotation (explicitly specified or the default name, if one is not specified via the annotation).

vii. `url-patterns` to which a filter is applied, when specified in a descriptor for a given filter name overrides the url patterns specified via the annotation.

viii. DispatcherTypes to which a filter applies, when specified in a descriptor for a given filter name overrides the DispatcherTypes specified via the annotation.

ix. The following examples demonstrates some of the above rules:

A servlet declared via an annotation and packaged with the corresponding `web.xml` in the descriptor:

```
@WebServlet(urlPatterns="/MyPattern",
        initParams={@WebInitParam(name="ccc", value="333")})
public class com.example.Foo extends HttpServlet {
    ...
}
```

web.xml

```
<servlet>
  <servlet-class>com.example.Foo</servlet-class>
  <servlet-name>Foo</servlet-name>
  <init-param>
    <param-name>aaa</param-name>
    <param-value>111</param-value>
  </init-param>
</servlet>
<servlet>
  <servlet-class>com.example.Foo</servlet-class>
  <servlet-name>Fum</servlet-name>
  <init-param>
    <param-name>bbb</param-name>
    <param-value>222</param-value>
  </init-param>
</servlet>
<servlet-mapping>
  <servlet-name>Foo</servlet-name>
  <url-pattern>/foo/*</url-pattern>
</servlet-mapping>
<servlet-mapping>
  <servlet-name>Fum</servlet-name>
  <url-pattern>/fum/*</url-pattern>
</servlet-mapping>
```

Since the name of the servlet declared via the annotation does not match the name of the servlet declared in the `web.xml`, the annotation specifies a new servlet declaration in addition to the other declarations in `web.xml` and is equivalent to:

web.xml

```
<servlet>
  <servlet-class>com.example.Foo</servlet-class>
  <servlet-name>com.example.Foo</servlet-name>
  <init-param>
    <param-name>ccc</param-name>
    <param-value>333</param-name>
  </init-param>
</servlet>
```

If the above `web.xml` were replaced with the following:

web.xml

```
<servlet>
  <servlet-class>com.example.Foo</servlet-class>
  <servlet-name>com.example.Foo</servlet-name>
  <init-param>
    <param-name>aaa</param-name>
    <param-value>111</param-value>
  </init-param>
</servlet>
<servlet-mapping>
  <servlet-name>com.example.Foo</servlet-name>
  <url-pattern>/foo/*</url-pattern>
</servlet-mapping>
```

Then the effective descriptor would be equivalent to:

web.xml

```
<servlet>
  <servlet-class>com.example.Foo</servlet-class>
  <servlet-name>com.example.Foo</servlet-name>
  <init-param>
    <param-name>aaa</param-name>
    <param-value>111</param-value>
  </init-param>
  <init-param>
    <param-name>ccc</param-name>
    <param-value>333</param-value>
  </init-param>
</servlet>
<servlet-mapping>
  <servlet-name>com.example.Foo</servlet-name>
  <url-pattern>/foo/*</url-pattern>
</servlet-mapping>
```

8.2.4. Shared Libraries / Runtimes Pluggability

In addition to supporting fragments and use of annotations, one of the requirements is that not only we be able to plug-in things that are bundled in the `WEB-INF/lib` but also plugin shared copies of frameworks - including being able to plug-in to the web container things like JAX-WS, JAX-RS and JSF that build on top of the web container. The `ServletContainerInitializer` allows handling such a use case as described below.

The `ServletContainerInitializer` class is looked up via the jar services API. For each application, an instance of the `ServletContainerInitializer` is created by the container at application startup time. The

framework providing an implementation of the `ServletContainerInitializer` MUST bundle in the `META-INF/services` directory of the jar file a file called `jakarta.servlet.ServletContainerInitializer`, as per the jar services API, that points to the implementation class of the `ServletContainerInitializer`.

In addition to the `ServletContainerInitializer` we also have an annotation - `HandlesTypes`. The `HandlesTypes` annotation on the implementation of the `ServletContainerInitializer` is used to express interest in classes that may have annotations (type, method or field level annotations) specified in the value of the `HandlesTypes` or if it extends / implements one those classes anywhere in the class's super types. The `HandlesTypes` annotation is applied irrespective of the setting of `metadata-complete`.

When examining the classes of an application to see if they match any of the criteria specified by the `HandlesTypes` annotation of a `ServletContainerInitializer`, the container may run into class loading problems if one or more of the application's optional JAR files are missing. Since the container is not in a position to decide whether these types of class loading failures will prevent the application from working correctly, it must ignore them, while at the same time providing a configuration option that would log them.

If an implementation of `ServletContainerInitializer` does not have the `@HandlesTypes` annotation, or if there are no matches to any of the `HandlesType` specified, then it will get invoked once for every application with `null` as the value of the `Set`. This will allow for the initializer to determine based on the resources available in the application whether it needs to initialize a servlet / filter or not.

The `onStartup` method of the `ServletContainerInitializer` will be invoked when the application is coming up before any of the servlet listener events are fired.

The `onStartup` method of the `ServletContainerInitializer` is called with a `Set` of Classes that either extend / implement the classes that the initializer expressed interest in or if it is annotated with any of the classes specified via the `@HandlesTypes` annotation.

A concrete example below showcases how this would work.

Let's take the JAX-WS web services runtime.

The implementation of JAX-WS runtime isn't typically bundled in each and every war file. The implementation would bundle an implementation of the `ServletContainerInitializer` (shown below) and the container would look that up using the services API (the jar file will bundle in it's `META-INF/services` directory a file called `jakarta.servlet.ServletContainerInitializer` that will point to the `JAXWSServletContainerInitializer` (shown below).

JAXWSServletContainerInitializer.java

```
@HandlesTypes(WebService.class)
JAXWSServletContainerInitializer implements ServletContainerInitializer {

    public void onStartup(Set<Class<?>> c, ServletContext ctx) throws ServletException {
        // JAX-WS specific code here to initialize the runtime
        // and setup the mapping etc.
        ServletRegistration reg = ctx.addServlet("JAXWSServlet",
                "com.sun.webservice.JAXWSServlet");
        reg.addServletMapping("/foo");
    }
```

The framework jar file can also be bundled in `WEB-INF/lib` directory of the war file. If the `ServletContainerInitializer` is bundled in a JAR file inside the `WEB-INF/lib` directory of an application, its `onStartup` method will be invoked only once during the startup of the bundling application. If, on the other hand, the `ServletContainerInitializer` is bundled in a JAR file outside of the `WEB-INF/lib` directory, but still discoverable by the runtime's service provider lookup mechanism, its `onStartup` method will be invoked every time an application is started.

Implementations of the `ServletContainerInitializer` interface will be discovered by the runtime's service lookup mechanism or a container specific mechanism that is semantically equivalent to it. In either case, `ServletContainerInitializer` services from web fragment JAR files that are excluded from an absolute ordering MUST be ignored, and the order in which these services are discovered MUST follow the application's class loading delegation model.

8.3. JSP Container Pluggability

The `ServletContainerInitializer` and programmatic registration features make it possible to provide a clear separation of responsibilities between the servlet and JSP containers, by making the servlet container responsible for parsing only `web.xml` and `web-fragment.xml` resources, and delegating the parsing of Tag Library Descriptor (TLD) resources to the JSP container.

Previously, a web container had to scan TLD resources for any listener declarations. With Servlet 3.0 and later versions, this responsibility may be delegated to the JSP container. A JSP container that is embedded in a servlet container may provide its own `ServletContainerInitializer` implementation, search the `ServletContext` passed to its `onStartup` method for any TLD resources, scan those resources for listener declarations, and register the corresponding listeners with the `ServletContext`.

In addition, prior to Servlet 3.0, a JSP container used to have to scan an application's deployment descriptor for any `jsp-config` related configuration. With Servlet 3.0 and later versions, the servlet container must make available, via the `ServletContext.getJspConfigDescriptor` method, any `jsp-config` related configuration from the application's `web.xml` and `web-fragment.xml` deployment descriptors.

Any `ServletContextListeners` that were discovered in a TLD and registered programmatically are

limited in the functionality they provide. Any attempt to call a `ServletContext` API methods on them that was added since Servlet 3.0 will result in an `UnsupportedOperationException`.

In addition, a servlet container compliant with Servlet 3.0 or later versions must provide a `ServletContext` attribute with name `jakarta.servlet.context.orderedLibs`, whose value (of type `java.util.List<java.lang.String>`) contains the list of names of JAR files in the `WEB-INF/lib` directory of the application represented by the `ServletContext`, ordered by their web fragment names (with possible exclusions if fragment JAR files have been excluded from `absolute-ordering`), or `null` if the application does not specify any absolute or relative ordering.

8.4. Processing Annotations and Fragments

Web applications can include both annotations and the `web.xml` / `web-fragment.xml` deployment descriptors. The version of the descriptor MUST not affect which annotations the container scans for in a web application. An implementation of a particular version of the specification MUST scan for all annotations supported in that configuration, unless `metadata-complete` is specified. If there is no deployment descriptor, or there is one but does not have the `metadata-complete` set to true, `web.xml`, `web-fragment.xml` and annotations, if used, in the application must be processed. The following table describes whether or not to process annotations and `web.xml` fragments.

Table 8-1 Annotations and web fragment processing requirements

Deployment descriptor	metadata-complete	process annotations and web fragments
web.xml 2.5	yes	no
web.xml 2.5	no	yes
web.xml 3.0 or later	yes	no
web.xml 3.0 or later	no	yes

Chapter 9. Dispatching Requests

When building a web application, it is often useful to forward processing of a request to another servlet, or to include the output of another servlet in the response. The `RequestDispatcher` interface provides a mechanism to accomplish this.

When asynchronous processing is enabled on the request, the `AsyncContext` allows a user to dispatch the request back to the servlet container.

9.1. Obtaining a RequestDispatcher

An object implementing the `RequestDispatcher` interface may be obtained from the `ServletContext` via the following methods:

- `getRequestDispatcher`
- `getNamedDispatcher`

The `getRequestDispatcher` method takes a `String` argument describing a path within the scope of the `ServletContext`. This path must be relative to the root of the `ServletContext` and begin with a `"/"`, or be empty. The method uses the path to look up a servlet, using the servlet path matching rules in Chapter 12, *Mapping Requests to Servlets*, wraps it with a `RequestDispatcher` object, and returns the resulting object. If no servlet can be resolved based on the given path, a `RequestDispatcher` is provided that returns the content for that path.

The `getNamedDispatcher` method takes a `String` argument indicating the name of a servlet known to the `ServletContext`. If a servlet is found, it is wrapped with a `RequestDispatcher` object and the object is returned. If no servlet is associated with the given name, the method must return `null`.

To allow `RequestDispatcher` objects to be obtained using relative paths that are relative to the path of the current request (not relative to the root of the `ServletContext`), the `getRequestDispatcher` method is provided in the `ServletRequest` interface.

The behavior of this method is similar to the method of the same name in the `ServletContext`. The servlet container uses information in the request object to transform the given relative path against the current servlet to a complete path. For example, in a context rooted at `"/"` and a request to `/garden/tools.html`, a request dispatcher obtained via `ServletRequest.getRequestDispatcher("header.html")` will behave exactly like a call to `ServletContext.getRequestDispatcher("/garden/header.html")`.

9.1.1. Query Strings in Request Dispatcher Paths

The `ServletContext` and `ServletRequest` methods that create `RequestDispatcher` objects using path information allow the optional attachment of query string information to the path. For example, an Application Developer may obtain a `RequestDispatcher` by using the following code:

```
String path = "/raisins.jsp?orderno=5";
RequestDispatcher rd = context.getRequestDispatcher(path);
rd.include(request, response);
```

Parameters specified in the query string used to create the `RequestDispatcher` take precedence over other parameters of the same name passed to the included servlet. The parameters associated with a `RequestDispatcher` are scoped to apply only for the duration of the `include` or `forward` call.

9.2. Using a Request Dispatcher

To use a request dispatcher, a servlet calls either the `include` method or `forward` method of the `RequestDispatcher` interface. The parameters to these methods can be either the `request` and `response` arguments that were passed in via the `service` method of the `jakarta.servlet.Servlet` interface, or instances of subclasses of the request and response wrapper classes that were introduced for version 2.3 of the specification. In the latter case, the wrapper instances must wrap the request or response objects that the container passed into the `service` method.

The Container Provider should ensure that the dispatch of the request to a target servlet occurs in the same thread of the same JVM as the original request.

9.3. The Include Method

The `include` method of the `RequestDispatcher` interface may be called at any time. The target servlet of the `include` method has access to all aspects of the request object, but its use of the response object is more limited.

It can only write information to the `ServletOutputStream` or `Writer` of the response object and commit a response by writing content past the end of the response buffer, or by explicitly calling the `flushBuffer` method of the `ServletResponse` interface. It cannot set headers or call any method that affects the headers of the response, with the exception of the `HttpServletRequest.getSession()` and `HttpServletRequest.getSession(boolean)` methods. Any attempt to set the headers must be ignored, and any call to `HttpServletRequest.getSession()` or `HttpServletRequest.getSession(boolean)` that would require adding a Cookie response header must throw an `IllegalStateException` if the response has been committed.

If the default servlet is the target of a RequestDispatch.include() and the requested resource does not exist, then the default servlet MUST throw `FileNotFoundException`. If the exception isn't caught and handled, and the response hasn't been committed, the status code MUST be set to 500.

9.3.1. Included Request Parameters

Except for servlets obtained by using the `getNamedDispatcher` method, a servlet that has been invoked by another servlet using the `include` method of `RequestDispatcher` has access to the path by which it was invoked.

The following request attributes must be set:

```
jakarta.servlet.include.request_uri
jakarta.servlet.include.context_path
jakarta.servlet.include.servlet_path
jakarta.servlet.include.mapping
jakarta.servlet.include.path_info
jakarta.servlet.include.query_string
```

These attributes are accessible from the included servlet via the `getAttribute` method on the request object and their values must be equal to the request URI, context path, servlet path, path info, and query string of the included servlet, respectively. If the request is subsequently included, these attributes are replaced for that include.

If the included servlet was obtained by using the `getNamedDispatcher` method, these attributes must not be set.

9.4. The Forward Method

The `forward` method of the `RequestDispatcher` interface may be called by the calling servlet only when no output has been committed to the client. If output data exists in the response buffer that has not been committed, the content must be cleared before the target servlet's `service` method is called. If the response has been committed, an `IllegalStateException` must be thrown.

The path elements of the request object exposed to the target servlet must reflect the path used to obtain the `RequestDispatcher`.

The only exception to this is if the `RequestDispatcher` was obtained via the `getNamedDispatcher` method. In this case, the path elements of the request object must reflect those of the original request.

Before the `forward` method of the `RequestDispatcher` interface returns without exception, the response content must be sent and committed, and closed by the servlet container, unless the request was put into the asynchronous mode. If an error occurs in the target of the `RequestDispatcher.forward()` the exception may be propagated back through all the calling filters and servlets and eventually back to the container

9.4.1. Query String

The request dispatching mechanism is responsible for aggregating query string parameters when forwarding or including requests.

9.4.2. Forwarded Request Parameters

Except for servlets obtained by using the `getNamedDispatcher` method, a servlet that has been invoked by another servlet using the `forward` method of `RequestDispatcher` has access to the path of the original

request.

The following request attributes must be set:

```
jakarta.servlet.forward.mapping
jakarta.servlet.forward.request_uri
jakarta.servlet.forward.context_path
jakarta.servlet.forward.servlet_path
jakarta.servlet.forward.path_info
jakarta.servlet.forward.query_string
```

The values of these attributes must be equal to the return values of the `HttpServletRequest` methods `getRequestURI` , `getContextPath`, `getServletPath`, `getPathInfo`, `getQueryString` respectively, invoked on the request object passed to the first servlet object in the call chain that received the request from the client.

These attributes are accessible from the forwarded servlet via the `getAttribute` method on the request object. Note that these attributes must always reflect the information in the original request even under the situation that multiple forwards and subsequent includes are called.

If the forwarded servlet was obtained by using the `getNamedDispatcher` method, these attributes must not be set.

9.5. Error Handling

If the servlet that is the target of a request dispatcher throws a runtime exception or a checked exception of type `ServletException` or `IOException`, it should be propagated to the calling servlet. All other exceptions should be wrapped as `ServletExceptions` and the root cause of the exception set to the original exception, as it should not be propagated.

9.6. Obtaining an AsyncContext

An object implementing the `AsyncContext` interface may be obtained from the `ServletRequest` via one of `startAsync` methods. Once you have an `AsyncContext`, you can use it to either complete the processing of the request via the `complete()` method or use one of the `dispatch` methods described below.

9.7. The Dispatch Method

The following methods can be used to dispatch requests from the `AsyncContext`:

`dispatch(path)`

: The `dispatch` method takes a `String` argument describing a path within the scope of the `ServletContext`. This path must be relative to the root of the `ServletContext` and begin with a `"/"`.

`dispatch(servletContext, path)`

The `dispatch` method takes a `String` argument describing a path within the scope of the `ServletContext` specified. This path must be relative to the root of the `ServletContext` specified and begin with a `"/"`.

`dispatch()`

The `dispatch` method takes no argument. It uses the original URI as the path. If the `AsyncContext` was initialized via the `startAsync(ServletRequest, ServletResponse)` and the request passed is an instance of `HttpServletRequest`, then the dispatch is to the URI returned by `HttpServletRequest.getRequestURI()`. Otherwise the dispatch is to the URI of the request when it was last dispatched by the container

One of the `dispatch` methods of the `AsyncContext` interface may be called by the application waiting for the asynchronous event to happen. If `complete()` has been called on the `AsyncContext`, an `IllegalStateException` must be thrown. All the variations of the dispatch methods returns immediately and do not commit the response.

The path elements of the request object exposed to the target servlet must reflect the path specified in the `AsyncContext.dispatch`.

9.7.1. Query String

The request dispatching mechanism is responsible for aggregating query string parameters when dispatching requests.

9.7.2. Dispatched Request Parameters

A servlet that has been invoked by using the `dispatch` method of `AsyncContext` has access to the path of the original request.

The following request attributes must be set:

```
jakarta.servlet.async.mapping
jakarta.servlet.async.request_uri
jakarta.servlet.async.context_path
jakarta.servlet.async.servlet_path
jakarta.servlet.async.path_info
jakarta.servlet.async.query_string
```

The values of these attributes must be equal to the return values of the `HttpServletRequest` methods `getRequestURI` , `getContextPath`, `getServletPath`, `getPathInfo`, `getQueryString` respectively, invoked on the request object passed to the first servlet object in the call chain that received the request from the client.

These attributes are accessible from the dispatched servlet via the `getAttribute` method on the request

object. Note that these attributes must always reflect the information in the original request even under the situation that multiple dispatches are called.

Chapter 10. Web Applications

A web application is a collection of servlets, HTML pages, classes, and other resources that make up a complete application on a web server. The web application can be bundled and run on multiple containers from multiple vendors.

10.1. Web Applications Within Web Servers

A web application is rooted at a specific path within a web server. For example, a catalog application could be located at `http://www.example.com/catalog`. All requests that start with this prefix will be routed to the `ServletContext` which represents the catalog application.

A servlet container can establish rules for automatic generation of web applications. For example a `/~user/` mapping could be used to map to a web application based at `/home/user/public_html/`.

By default, an instance of a web application must run on one JVM at any one time. This behavior can be overridden if the application is marked as “distributable” via its deployment descriptor. An application marked as distributable must obey a more restrictive set of rules than is required of a normal web application. These rules are set out throughout this specification.

10.2. Relationship to ServletContext

The servlet container must enforce a one to one correspondence between a web application and a `ServletContext`. A `ServletContext` object provides a servlet with its view of the application.

10.3. Elements of a Web Application

A web application may consist of the following items:

- Servlets
- JSP Pages [6]
- Utility Classes
- Static documents (HTML, images, sounds, etc.)
- Client side Java applets, beans, and classes
- Descriptive meta information that ties all of the above elements together

10.4. Deployment Hierarchies

This specification defines a hierarchical structure used for deployment and packaging purposes that can exist in an open file system, in an archive file, or in some other form. It is recommended, but not required, that servlet containers support this structure as a runtime representation.

10.5. Directory Structure

A web application exists as a structured hierarchy of directories. The root of this hierarchy serves as the document root for files that are part of the application. For example, for a web application with the context path `/catalog` in a web container, the `index.html` file at the base of the web application hierarchy or in a JAR file inside WEB-INF/lib that includes the `index.html` under `META-INF/resources` directory can be served to satisfy a request from `/catalog/index.html`. If an `index.html` is present both in the root context and in the `META-INF/resources` directory of a JAR file in the `WEB-INF/lib` directory of the application, then the file that is available in the root context MUST be used. The rules for matching URLs to context path are laid out in Chapter 12, *Mapping Requests to Servlets*. Since the context path of an application determines the URL namespace of the contents of the web application, web containers must reject web applications defining a context path that could cause potential conflicts in this URL namespace. This may occur, for example, by attempting to deploy a second web application with the same context path. Since requests are matched to resources in a case-sensitive manner, this determination of potential conflict must be performed in a case-sensitive manner as well.

A special directory exists within the application hierarchy named `WEB-INF`. This directory contains all things related to the application that aren't in the document root of the application. Most of the `WEB-INF` node is not part of the public document tree of the application. Except for static resources and JSPs packaged in the `META-INF/resources` of a JAR file that resides in the `WEB-INF/lib` directory, no other files contained in the `WEB-INF` directory may be served directly to a client by the container. However, the contents of the `WEB-INF` directory are visible to servlet code using the `getResource` and `getResourceAsStream` method calls on the `ServletContext`, and may be exposed using the `RequestDispatcher` calls. Hence, if the Application Developer needs access, from servlet code, to application specific configuration information that should not be exposed directly to the web client, it may be placed under this directory. Since requests are matched to resource mappings in a case-sensitive manner, client requests for `/WEB-INF/foo`, `/WEb-iNf/foo`, for example, should not result in contents of the web application located under `/WEB-INF` being returned, nor any form of directory listing thereof.

The contents of the `WEB-INF` directory are:

- The `/WEB-INF/web.xml` deployment descriptor.
- The `/WEB-INF/classes/` directory for servlet and utility classes. The classes in this directory must be available to the application class loader.
- The `/WEB-INF/lib/*.jar` area for Java ARchive files. These files contain servlets, beans, static resources and JSPs packaged in a JAR file and other utility classes useful to the web application. The web application class loader must be able to load classes from any of these archive files.

The web application class loader must load classes from the `WEB-INF/classes` directory first, and then from library JARs in the `WEB-INF/lib` directory. Also, except for the case where static resources are packaged in JAR files, any requests from the client to access the resources in `WEB-INF/` directory must be returned with a `SC_NOT_FOUND` (404) response.

10.5.1. Example of Application Directory Structure

The following is a listing of all the files in a sample web application:

```
/index.html
/howto.jsp
/feedback.jsp
/images/banner.gif
/images/jumping.gif
/WEB-INF/web.xml
/WEB-INF/lib/jspbean.jar
/WEB-INF/lib/catalog.jar!/META-INF/resources/catalog/moreOffers/books.html
/WEB-INF/classes/com/mycorp/servlets/MyServlet.class
/WEB-INF/classes/com/mycorp/util/MyUtils.class
```

10.6. Web Application Archive File

Web applications can be packaged and signed into a Web ARchive format (WAR) file using the standard Java archive tools. For example, an application for issue tracking might be distributed in an archive file called `issuetrack.war`.

When packaged into such a form, a `META-INF` directory will be present which contains information useful to Java archive tools. This directory must not be directly served as content by the container in response to a web client's request, though its contents are visible to servlet code via the `getResource` and `getResourceAsStream` calls on the `ServletContext`. Also, any requests to access the resources in `META-INF` directory must be returned with a `SC_NOT_FOUND` (404) response.

10.7. Web Application Deployment Descriptor

The web application deployment descriptor (see Chapter 14, *Deployment Descriptor*) includes the following types of configuration and deployment information:

- `ServletContext` Init Parameters
- Session Configuration
- Servlet/JSP Definitions
- Servlet/JSP Mappings
- MIME Type Mappings
- Welcome File list
- Error Pages
- Security

10.7.1. Dependencies On Extensions

When a number of applications make use of the same code or resources, they will typically be installed as library files in the container. These files are often common or standard APIs that can be used without sacrificing portability. Files used only by one or a few applications will be made available for access as part of the web application. The container must provide a directory for these libraries. The files placed within this directory must be available across all web applications. The location of this directory is container-specific. The class loader the servlet container uses for loading these library files must be the same for all web applications within the same JVM. This class loader instance must be somewhere in the chain of parent class loaders of the web application class loader.

Application developers need to know what extensions are installed on a web container, and containers need to know what dependencies servlets in a WAR have on such libraries in order to preserve portability.

The application developer depending on such an extension or extensions must provide a `META-INF/MANIFEST.MF` entry in the WAR file listing all extensions needed by the WAR. The format of the manifest entry should follow standard JAR manifest format. During deployment of the web application, the web container must make the correct versions of the extensions available to the application following the rules defined by the Optional Package Versioning mechanism (http://docs.oracle.com/javase/8/docs/technotes/guides/extensions/versioning.html).

Web containers must also be able to recognize declared dependencies expressed in the manifest entry of any of the library JARs under the `WEB-INF/lib` entry in a WAR.

If a web container is not able to satisfy the dependencies declared in this manner, it should reject the application with an informative error message.

10.7.2. Web Application Class Loader

The class loader that a container uses to load a servlet in a WAR must allow the developer to load any resources contained in library JARs within the WAR following normal Java SE semantics using `getResource`. Servlet containers that are not part of a Jakarta EE product should not allow the application to override Jakarta EE platform classes, such as those in the jakarta.* namespaces, that Jakarta EE does not allow to be modified. The container should not allow applications to override or access the container's implementation classes. It is recommended also that the application class loader be implemented so that classes and resources packaged within the WAR are loaded in preference to classes and resources residing in container-wide library JARs. An implementation MUST also guarantee that for every web application deployed in a container, a call to `Thread.currentThread.getContextClassLoader()` MUST return a `ClassLoader` instance that implements the contract specified in this section. Furthermore, the `ClassLoader` instance MUST be a separate instance for each deployed web application. The container is required to set the thread context `ClassLoader` as described above before making any callbacks (including listener callbacks) into the web application, and set it back to the original `ClassLoader`, once the callback returns.

10.8. Replacing a Web Application

A server should be able to replace an application with a new version without restarting the container. When an application is replaced, the container should provide a robust method for preserving session data within that application.

10.9. Error Handling

10.9.1. Request Attributes

A web application must be able to specify that when errors occur, other resources in the application are used to provide the content body of the error response. The specification of these resources is done in the deployment descriptor.

If the location of the error handler is a servlet or a JSP page:

- The original unwrapped request and response objects created by the container are passed to the servlet or JSP page.
- The request path and attributes are set as if a `RequestDispatcher.forward` to the error resource had been performed.
- The request attributes in Table 10-1 , “Request Attributes and their types” must be set.

Table 10-1 Request Attributes and their types

Request Attributes	Type
`jakarta.servlet.error.status_code`	`java.lang.Integer`
`jakarta.servlet.error.exception_type`	`java.lang.Class`
`jakarta.servlet.error.message`	`java.lang.String`
`jakarta.servlet.error.exception`	`java.lang.Throwable`
`jakarta.servlet.error.request_uri`	`java.lang.String`
`jakarta.servlet.error.servlet_name`	`java.lang.String`

These attributes allow the servlet to generate specialized content depending on the status code, the exception type, the error message, the exception object propagated, and the URI of the request processed by the servlet in which the error occurred (as determined by the `getRequestURI` call), and the logical name of the servlet in which the error occurred.

With the introduction of the exception object to the attributes list for version 2.3 of this specification, the exception type and error message attributes are redundant. They are retained for backwards compatibility with earlier versions of the API.

10.9.2. Error Pages

To allow developers to customize the appearance of content returned to a web client when a servlet generates an error, the deployment descriptor defines a list of error page descriptions. The syntax allows the configuration of resources to be returned by the container either when a servlet or filter calls `sendError` on the response for specific status codes, or if the servlet generates an exception or error that propagates to the container.

If the `sendError` method is called on the response, the container consults the list of error page declarations for the web application that use the error-code syntax and attempts a match. If there is a match, the container returns the resource as indicated by the location entry.

A servlet or filter may throw the following exceptions during processing of a request:

- runtime exceptions or errors
- `ServletExceptions` or subclasses thereof
- `IOExceptions` or subclasses thereof

The web application may have declared error pages using the `exception-type` element. In this case the container matches the exception type by comparing the exception thrown with the list of error-page definitions that use the `exception-type` element. A match results in the container returning the resource indicated in the location entry. The closest match in the class hierarchy wins.

If no `error-page` declaration containing an `exception-type` fits using the class-hierarchy match, and the exception thrown is a `ServletException` or subclass thereof, the container extracts the wrapped exception, as defined by the `ServletException.getRootCause` method. A second pass is made over the error page declarations, again attempting the match against the error page declarations, but using the wrapped exception instead.

Error-page declarations using the `exception-type` element in the deployment descriptor must be unique up to the class name of the exception-type. Similarly, error-page declarations using the `error-code` element must be unique in the deployment descriptor up to the status code.

If an `error-page` element in the deployment descriptor does not contain an `exception-type` or an `error-code` element, the error page is a default error page.

The error page mechanism described does not intervene when errors occur when invoked using the `RequestDispatcher` or `filter.doFilter` method. In this way, a filter or servlet using the `RequestDispatcher` has the opportunity to handle errors generated.

If a servlet generates an error that is not handled by the error page mechanism as described above, the container must ensure to send a response with status 500.

The default servlet and container will use the `sendError` method to send 4xx and 5xx status responses, so that the error mechanism may be invoked. The default servlet and container will use the `setStatus` method for 2xx and 3xx responses and will not invoke the error page mechanism.

If the application is using asynchronous operations as described in Section 2.3.3.3, “Asynchronous processing”, it is the application’s responsibility to handle all errors in application created threads. The container MAY take care of the errors from the thread issued via `AsyncContext.start`. For handling errors that occur during `AsyncContext.dispatch` see dispatch error handling.

10.9.3. Error Filters

The error page mechanism operates on the original unwrapped/unfiltered request and response objects created by the container. The mechanism described in Section 6.2.5, “Filters and the RequestDispatcher” may be used to specify filters that are applied before an error response is generated.

10.10. Welcome Files

Application Developers can define an ordered list of partial URIs called welcome files in the web application deployment descriptor. The deployment descriptor syntax for the list is described in the web application deployment descriptor schema.

The purpose of this mechanism is to allow the deployer to specify an ordered list of partial URIs for the container to use for appending to URIs when there is a request for a URI that corresponds to a directory entry in the WAR not mapped to a web component. This kind of request is known as a valid partial request.

The use for this facility is made clear by the following common example: A welcome file of `index.html` can be defined so that a request to a URL like `host:port/webapp/directory/`, where `directory` is an entry in the WAR that is not mapped to a servlet or JSP page, is returned to the client as `host:port/webapp/directory/index.html`.

If a web container receives a valid partial request, the web container must examine the welcome file list defined in the deployment descriptor. The welcome file list is an ordered list of partial URLs with no trailing or leading `"/"`. The web server must append each welcome file in the order specified in the deployment descriptor to the partial request and check whether a static resource in the WAR is mapped to that request URI. If no match is found, the web server MUST again append each welcome file in the order specified in the deployment descriptor to the partial request and check if a servlet is mapped to that request URI. The web container must send the request to the first resource in the WAR that matches. The container may send the request to the welcome resource with a forward, a redirect, or a container specific mechanism that is indistinguishable from a direct request.

If no matching welcome file is found in the manner described, the container may handle the request in a manner it finds suitable. For some configurations this may mean returning a directory listing or for others returning a `404` response.

Consider a web application where:

- The deployment descriptor lists the following welcome files.

```
<welcome-file-list>
 <welcome-file>index.html</welcome-file>
 <welcome-file>default.jsp</welcome-file>
</welcome-file-list>
```

- The static content in the WAR is as follows

```
/foo/index.html
/foo/default.jsp
/foo/orderform.html
/foo/home.gif
/catalog/default.jsp
/catalog/products/shop.jsp
/catalog/products/register.jsp
```

- A request URI of `/foo` will be redirected to a URI of `/foo/`.
- A request URI of `/foo/` will be returned as `/foo/index.html`.
- A request URI of `/catalog` will be redirected to a URI of `/catalog/`.
- A request URI of `/catalog/` will be returned as `/catalog/default.jsp`.
- A request URI of `/catalog/index.html` will cause a `404 not found`
- A request URI of `/catalog/products` will be redirected to a URI of `/catalog/products/`.
- A request URI of `/catalog/products/` will be passed to the "default" servlet, if any. If no "default" servlet is mapped, the request may cause a `404 not found`, may cause a directory listing including `shop.jsp` and `register.jsp`, or may cause other behavior defined by the container. See Section 12.2, "Specification of Mappings" for the definition of "default" servlet.
- All of the above static content can also be packaged in a JAR file with the content listed above packaged in the `META-INF/resources` directory of the jar file. The JAR file can then be included in the `WEB-INF/lib` directory of the web application.

10.11. Web Application Environment

Servlet containers that are not part of a Jakarta EE technology-compliant implementation are encouraged, but not required, to implement the application environment functionality described in Section 15.2.2, "Web Application Environment" and the Jakarta EE specification. If they do not implement the facilities required to support this environment, upon deploying an application that relies on them, the container should provide a warning.

10.12. Web Application Deployment

When a web application is deployed into a container, the following steps must be performed, in this order, before the web application begins processing client requests.

- Instantiate an instance of each event listener identified by a `<listener>` element in the deployment descriptor.
- For instantiated listener instances that implement `ServletContextListener`, call the `contextInitialized()` method.
- Instantiate an instance of each filter identified by a `<filter>` element in the deployment descriptor and call each filter instance's `init()` method.
- Instantiate an instance of each servlet identified by a `<servlet>` element that includes a `<load-on-startup>` element in the order defined by the load-on-startup element values, and call each servlet instance's `init()` method.

10.13. Inclusion of a web.xml Deployment Descriptor

A web application is NOT required to contain a web.xml if it does NOT contain any servlet, filter, or listener components or is using annotations to declare the same. In other words an application containing only static files or JSP pages does not require a web.xml to be present.

[6] See the Jakarta Server Pages specification available from https://jakarta.ee/specifications/pages/.

Chapter 11. Application Lifecycle Events

11.1. Introduction

The application events facility gives the Application Developer greater control over the lifecycle of the `ServletContext` and `HttpSession` and `ServletRequest`, allows for better code factorization, and increases efficiency in managing the resources that the web application uses.

11.2. Event Listeners

Application event listeners are classes that implement one or more of the servlet event listener interfaces. They are instantiated and registered in the web container at the time of the deployment of the web application. They are provided by the Application Developer in the WAR.

Servlet event listeners support event notifications for state changes in the `ServletContext`, `HttpSession` and `ServletRequest` objects. Servlet context listeners are used to manage resources or state held at a JVM level for the application. HTTP session listeners are used to manage state or resources associated with a series of requests made into a web application from the same client or user. Servlet request listeners are used to manage state across the lifecycle of servlet requests. Async listeners are used to manage async events such as time outs and completion of async processing.

There may be multiple listener classes listening to each event type, and the Application Developer may specify the order in which the container invokes the listener beans for each event type.

11.2.1. Event Types and Listener Interfaces

Events types and the listener interfaces used to monitor them are shown in the following tables:

Table 11-1 Servlet Context Events

Event Type	Description	Listener Interface
Lifecycle	The servlet context has just been created and is available to service its first request, or the servlet context is about to be shut down.	`jakarta.servlet.ServletContextListener`
Changes to attributes	Attributes on the servlet context have been added, removed, or replaced.	`jakarta.servlet.ServletContextAttributeListener`

Table 11-2 HTTP Session Events

Event Type	Description	Listener Interface
Lifecycle	An `HttpSession` has been created, invalidated, or timed out.	`jakarta.servlet.http.HttpSessionListener`

Event Type	Description	Listener Interface
Changes to attributes	Attributes have been added, removed, or replaced on an `HttpSession`.	`jakarta.servlet.http.HttpSessionAttributeListener`
Changes to id	The id of `HttpSession` has been changed.	`jakarta.servlet.http.HttpSessionIdListener`
Session migration	`HttpSession` has been activated or passivated.	`jakarta.servlet.http.HttpSessionActivationListener`
Object binding	Object has been bound to or unbound from `HttpSession`	`jakarta.servlet.http.HttpSessionBindingListener`

Table 11-3 Table 11-3 Servlet Request Events

Event Type	Description	Listener Interface
Lifecycle	A servlet request has started being processed by web components.	`jakarta.servlet.ServletRequestListener`
Changes to attributes	Attributes have been added, removed, or replaced on a `ServletRequest`.	`jakarta.servlet.ServletRequestAttributeListener`
Async events	A timeout, connection termination or completion of async processing	`jakarta.servlet.AsyncListener`

For details of the API, refer to the API reference.

11.2.2. An Example of Listener Use

To illustrate a use of the event scheme, consider a simple web application containing a number of servlets that make use of a database. The Application Developer has provided a servlet context listener class for management of the database connection.

1. When the application starts up, the listener class is notified. The application logs on to the database, and stores the connection in the servlet context.
2. Servlets in the application access the connection as needed during activity in the web application.
3. When the web server is shut down, or the application is removed from the web server, the listener class is notified and the database connection is closed.

11.3. Listener Class Configuration

11.3.1. Provision of Listener Classes

The Application Developer of the web application provides listener classes implementing one or more

of the listener interfaces in the `jakarta.servlet` API. Each listener class must have a public constructor taking no arguments. The listener classes are packaged into the WAR, either under the `WEB-INF/classes` archive entry, or inside a JAR in the `WEB-INF/lib` directory.

11.3.2. Deployment Declarations

Listener classes are declared in the web application deployment descriptor using the `listener` element. They are listed by class name in the order in which they are to be invoked. Unlike other listeners, listeners of type `AsyncListener` may only be registered (with a `ServletRequest`) programmatically.

11.3.3. Listener Registration

The web container creates an instance of each listener class and registers it for event notifications prior to the processing of the first request by the application. The web container registers the listener instances according to the interfaces they implement and the order in which they appear in the deployment descriptor. During web application execution, listeners for the given events are mostly invoked in their registration orders, but there are some exceptions. For instance, `HttpSessionListener.destroy` are invoked in reverse order. See Section 8.2.3, “Assembling the Descriptor from web.xml, web-fragment.xml and Annotations” for details.

11.3.4. Notifications At Shutdown

On application shutdown, listeners are notified in reverse order to their declarations with notifications to session listeners preceding notifications to context listeners. Session listeners must be notified of session invalidations prior to context listeners being notified of application shutdown.

11.4. Deployment Descriptor Example

The following example is the deployment grammar for registering two servlet context lifecycle listeners and an `HttpSession` listener.

Suppose that `com.example.MyConnectionManager` and `com.example.MyLoggingModule` both implement `jakarta.servlet.ServletContextListener`, and that `com.example.MyLoggingModule` additionally implements `jakarta.servlet.http.HttpSessionListener`. Also, the Application Developer wants `com.example.MyConnectionManager` to be notified of servlet context lifecycle events before `com.example.MyLoggingModule`. Here is the deployment descriptor for this application:

web.xml

```
<web-app>
  <display-name>MyListeningApplication</display-name>
  <listener>
    <listener-class>com.example.MyConnectionManager</listener-class>
   </listener>

  <listener>
    <listener-class>com.example.MyLoggingModule</listener-class>
  </listener>

  <servlet>
    <display-name>RegistrationServlet</display-name>
    ...
  </servlet>
</web-app>
```

11.5. Listener Instances and Threading

The container is required to complete instantiation of the listener classes in a web application prior to the start of execution of the first request into the application. The container must maintain a reference to each listener instance until the last request is serviced for the web application.

Attribute changes to `ServletContext` and `HttpSession` objects may occur concurrently. The container is not required to synchronize the resulting notifications to attribute listener classes. Listener classes that maintain state are responsible for the integrity of the data and should handle this case explicitly.

11.6. Listener Exceptions

Application code inside a listener may throw an exception during operation. Some listener notifications occur under the call tree of another component in the application. An example of this is a servlet that sets a session attribute, where the session listener throws an unhandled exception. The container must allow unhandled exceptions to be handled by the error page mechanism described in Section 10.9, “Error Handling”. If there is no error page specified for those exceptions, the container must ensure to send a response back with status 500. In this case no more listeners under that event are called.

Some exceptions do not occur under the call stack of another component in the application. An example of this is a `SessionListener` that receives a notification that a session has timed out and throws an unhandled exception, or of a `ServletContextListener` that throws an unhandled exception during a notification of servlet context initialization, or of a `ServletRequestListener` that throws an unhandled exception during a notification of the initialization or the destruction of the request object. In this case, the Application Developer has no opportunity to handle the exception. The container may respond to all subsequent requests to the web application with an HTTP status code 500 to indicate an application

error.

Developers wishing normal processing to occur after a listener generates an exception must handle their own exceptions within the notification methods.

11.7. Distributed Containers

In distributed web containers, `HttpSession` instances are scoped to the particular JVM servicing session requests, and the `ServletContext` object is scoped to the web container's JVM. Distributed containers are not required to propagate either servlet context events or `HttpSession` events to other JVMs. Listener class instances are scoped to one per deployment descriptor declaration per JVM.

11.8. Session Events

Listener classes provide the Application Developer with a way of tracking sessions within a web application. It is often useful in tracking sessions to know whether a session became invalid because the container timed out the session, or because a web component within the application called the `invalidate` method. The distinction may be determined indirectly using listeners and the `HttpSession` API methods.

Chapter 12. Mapping Requests to Servlets

The mapping techniques described in this chapter are required for web containers mapping client requests to servlets.

12.1. Use of URL Paths

Upon receipt of a client request, the web container determines the web application to which to forward it. The web application selected must have the longest context path that matches the start of the request URL. The matched part of the URL is the context path when mapping to servlets. The request URL is decoded as a UTF-8 encoded string. Implementations may provide container vendor specific configuration to change this encoding or enable more fine-grained encoding such as using a different encoding for the path and query string portions of the URL. Note that the encoding used to process the remainder of the request, after the URL, can be configured as specified in Section 3.12, “Request Data Encoding”.

The web container next must locate the servlet to process the request using the path mapping procedure described below.

The path used for mapping to a servlet is the request URL from the request object minus the context path and the path parameters. The URL path mapping rules below are used in order. The first successful match is used with no further matches attempted:

1. The container will try to find an exact match of the path of the request to the path of the servlet. A successful match selects the servlet.
2. The container will recursively try to match the longest path-prefix. This is done by stepping down the path tree a directory at a time, using the `"/"` character as a path separator. The longest match determines the servlet selected.
3. If the last segment in the URL path contains an extension (e.g. `.jsp`), the servlet container will try to match a servlet that handles requests for the extension. An extension is defined as the part of the last segment after the last `"."` character.
4. If neither of the previous three rules result in a servlet match, the container will attempt to serve content appropriate for the resource requested. If a "default" servlet is defined for the application, it will be used. Many containers provide an implicit default servlet for serving content.

The container must use case-sensitive string comparisons for matching.

12.2. Specification of Mappings

In the web application deployment descriptor, the following syntax is used to define mappings:

- A string beginning with a `"/"` character and ending with a `"/*"` suffix is used for path mapping.
- A string beginning with a `"*."` prefix is used as an extension mapping.

- The empty string ("") is a special URL pattern that exactly maps to the application's context root, i.e., requests of the form `http://host:port/<context-root>/`. In this case the path info is "/" and the servlet path and context path is empty string ("").
- A string containing only the "/" character indicates the "default" servlet of the application. In this case the servlet path is the request URI minus the context path and the path info is null.
- All other strings are used for exact matches only.

If the effective `web.xml` (after merging information from fragments and annotations) contains any url-patterns that are mapped to multiple servlets then the deployment must fail.

12.2.1. Implicit Mappings

If the container has an internal JSP container, the `*.jsp` extension is mapped to it, allowing JSP pages to be executed on demand. This mapping is termed an *implicit* mapping. If a `*.jsp` mapping is defined by the web application, its mapping takes precedence over the implicit mapping.

A servlet container is allowed to make other implicit mappings as long as explicit mappings take precedence. For example, an implicit mapping of `*.shtml` could be mapped to include functionality on the server.

12.2.2. Example Mapping Set

Consider the following set of mappings:

Table 12-1 Example Set of Maps

Path Pattern	Servlet
/foo/bar/*	servlet1
/baz/*	servlet2
/catalog	servlet3
*.bop	servlet4

The following behavior would result:

Table 12-2 Incoming Paths Applied to Example Maps

Incoming Path	Servlet Handling Request
/foo/bar/index.html	servlet1
/foo/bar/index.bop	servlet1
/baz	servlet2
/baz/index.html	servlet2
/catalog	servlet3
/catalog/index.html	"default" servlet
/catalog/racecar.bop	servlet4

Incoming Path	Servlet Handling Request
`/index.bop`	`servlet4`

Note that in the case of `/catalog/index.html` and `/catalog/racecar.bop`, the servlet mapped to `/catalog` is not used because the match is not exact.

12.3. Runtime Discovery of Mappings

Every mapping that causes a servlet to be activated, regardless of whether or not servlet filters are involved, is discoverable at runtime via the servlet mapping API.

12.3.1. Runtime Discovery of Servlet Mappings

The method `getHttpServletMapping()` on `HttpServletRequest` returns an `HttpServletMapping` implementation that provides information for the mapping that caused the current `Servlet` to be invoked. Please see the javadocs for the normative specification. Please see sections Section 9.3.1, "Included Request Parameters", Section 9.4.2, "Forwarded Request Parameters" and Section 9.7.2, "Dispatched Request Parameters" for relevant request attributes. As with the included and forwarded request parameters, the `HttpServletMapping` is not available for servlets that have been obtained with a call to `ServletContext.getNamedDispatcher()`.

Chapter 13. Security

Web applications are created by Application Developers who give, sell, or otherwise transfer the application to a Deployer for installation into a runtime environment. Application Developers communicate the security requirements to the Deployers and the deployment system. This information may be conveyed declaratively via the application's deployment descriptor, by using annotations within the application code, or programmatically via the `setServletSecurity` method of the `ServletRegistration.Dynamic` interface.

This chapter describes the servlet container security mechanisms and interfaces and the deployment descriptor, annotation, and programmatic mechanisms for conveying the security requirements of applications.

13.1. Introduction

A web application contains resources that can be accessed by many users. These resources often traverse unprotected, open networks such as the Internet. In such an environment, a substantial number of web applications will have security requirements.

Although the quality assurances and implementation details may vary, servlet containers have mechanisms and infrastructure for meeting these requirements that share some of the following characteristics:

Authentication

The means by which communicating entities prove to one another that they are acting on behalf of specific identities that are authorized for access.

Access control for resources

The means by which interactions with resources are limited to collections of users or programs for the purpose of enforcing integrity, confidentiality, or availability constraints.

Data Integrity

The means used to prove that information has not been modified by a third party while in transit.

Confidentiality or Data Privacy

The means used to ensure that information is made available only to users who are authorized to access it.

13.2. Declarative Security

Declarative security refers to the means of expressing an application's security model or requirements, including roles, access control, and authentication requirements in a form external to the application. The deployment descriptor is the primary vehicle for declarative security in web applications.

The Deployer maps the application's logical security requirements to a representation of the security policy that is specific to the runtime environment. At runtime, the servlet container uses the security policy representation to enforce authentication and authorization.

The security model applies to the static content part of the web application and to servlets and filters within the application that are requested by the client. The security model does not apply when a servlet uses the `RequestDispatcher` to invoke a static resource or servlet using a `forward` or an `include`.

13.3. Programmatic Security

Programmatic security is used by security aware applications when declarative security alone is not sufficient to express the security model of the application. Programmatic security consists of the following methods of the `HttpServletRequest` interface:

- `authenticate`
- `login`
- `logout`
- `getRemoteUser`
- `isUserInRole`
- `getUserPrincipal`

The `login` method allows an application to perform username and password collection (as an alternative to Form-Based Login).

The `authenticate` methods allow an application to instigate authentication of the request caller by the container from within an unconstrained request context.

The `logout` method is provided to allow an application to reset the caller identity of a request.

The `getRemoteUser` method returns the name of the remote user (that is, the caller) associated, by the container, with the request.

The `isUserInRole` method determines if the remote user (that is, the caller) associated with the request is in a specified security role.

The `getUserPrincipal` method determines the principal name of the remote user (that is, the caller) and returns a `java.security.Principal` object corresponding to the remote user. Calling the `getName` method on the `Principal` returned by `getUserPrincipal` returns the name of the remote user. These APIs allow servlets to make business logic decisions based on the information obtained.

If no user has been authenticated, the `getRemoteUser` method returns `null`, the `isUserInRole` method always returns `false`, and the `getUserPrincipal` method returns `null`.

The `isUserInRole` method takes a `String` argument that references an application role. For each distinct role reference used in a call to isUserInRole, A security-role-ref element with role-name corresponding

to the role reference should be declared in the deployment descriptor. Each security-role-ref should contain a role-link sub-element whose value is the name of the application security role to which the application embedded role reference is linked. The container uses the security-role-ref with role-name equal to the role reference to determine which security-role to test the user for membership in.

For example, to map the security role reference "FOO" to the security role with role-name "manager" the syntax would be:

```
<security-role-ref>
  <role-name>FOO</role-name>
  <role-link>manager</role-link>
</security-role-ref>
```

In this case, if a servlet called by a user belonging to the "manager" security role were to call `isUserInRole("FOO")` the result would be `true`.

If no `matching security-role-ref` exists for a role reference used in a call to `isUserInRole`, the container must default to testing the user for membership in the security-role with `role-name` equal to the role reference used in the call.

The role name `"*"` should never be used as an argument in calling `isUserInRole`. Any call to `isUserInRole` with `"*"` must return false. If the role-name of the security-role to be tested is `"**"`, and the application has NOT declared an application security-role with role-name `"**"`, `isUserInRole` must only return true if the user has been authenticated; that is, only when `getRemoteUser` and `getUserPrincipal` would both return a non-null value. Otherwise, the container must check the user for membership in the application role.

The declaration of `security-role-ref` elements informs the deployer of the role references used by the application and for which mappings must be defined.

13.4. Programmatic Security Policy Configuration

This section defines the annotations and APIs provided to configure the security constraints enforced by the servlet container.

13.4.1. @ServletSecurity Annotation

The `@ServletSecurity` annotation provides an alternative mechanism for defining access control constraints equivalent to those that could otherwise have been expressed declaratively via `security-constraint` elements in the portable deployment descriptor or programmatically via the `setServletSecurity` method of the `ServletRegistration` interface. Servlet containers MUST support the use of the `@ServletSecurity` annotation on classes (and subclasses thereof) that implement the `jakarta.servlet.Servlet` interface.

```
package jakarta.servlet.annotation;

@Inherited
@Documented
@Target(value=TYPE)
@Retention(value=RUNTIME)
public @interface ServletSecurity {
    HttpConstraint value();
    HttpMethodConstraint[] httpMethodConstraints();
}
```

TABLE 13-1 The ServletSecurity Interface

Element	Description	Default
value	the HttpConstraint that defines the protection to be applied to all HTTP methods that are NOT represented in the array returned by httpMethodConstraints.	@HttpConstraint
httpMethodConstraints	the array of HTTP method specific constraints.	{}

`@HttpConstraint`

The `@HttpConstraint` annotation is used within the `@ServletSecurity` annotation to represent the security constraint to be applied to all HTTP protocol methods for which a corresponding `@HttpMethodConstraint` does NOT occur within the `@ServletSecurity` annotation.

For the special case where an `@HttpConstraint` that returns all default values [7] occurs in combination with at least one `@HttpMethodConstraint` that returns other than all default values, the `@HttpConstraint` represents that no security constraint is to be applied to any of the HTTP protocol methods to which a security constraint would otherwise apply. This exception is made to ensure that such potentially non-specific uses of `@HttpConstraint` do not yield constraints that will explicitly establish unprotected access for such methods; given that they would not otherwise be covered by a constraint.

```
package jakarta.servlet.annotation;

@Documented
@Retention(value=RUNTIME)
public @interface HttpConstraint {
    ServletSecurity.EmptyRoleSemantic value();
    java.lang.String[] rolesAllowed();
    ServletSecurity.TransportGuarantee transportGuarantee();
}
```

TABLE 13-2 The HttpConstraint Interface

Element	Description	Default
value	The default authorization semantic that applies (only) when rolesAllowed returns an-empty array.	PERMIT
rolesAllowed	An array containing the names of the authorized roles	{}
transportGuarantee	The data protection requirements that must be satisfied by the connections on which requests arrive.	NONE

@HttpMethodConstraint

The @HttpMethodConstraint annotation is used within the @ServletSecurity annotation to represent security constraints on specific HTTP protocol messages.

```
package jakarta.servlet.annotation;

@Documented
@Retention(value=RUNTIME)
public @interface HttpMethodConstraint {
    ServletSecurity.EmptyRoleSemantic value();
    java.lang.String[] rolesAllowed();
    ServletSecurity.TransportGuarantee transportGuarantee();
}
```

TABLE 13-3 The HttpMethodConstraint Interface

Element	Description	Default
value	The HTTP protocol method name	
emptyRoleSemantic	The default authorization semantic that applies (only) when rolesAllowed returns an empty array.	PERMIT
rolesAllowed	An array containing the names of the authorized roles	{}
transportGuarantee	The data protection requirements that must be satisfied by the connections on which requests arrive.	NONE

The @ServletSecurity annotation may be specified on (that is, targeted to) a Servlet implementation class, and its value is inherited by subclasses according to the rules defined for the @Inherited meta-annotation. At most one instance of the @ServletSecurity annotation may occur on a servlet implementation class, and the @ServletSecurity annotation MUST NOT be specified on (that is, targeted to) a Java method.

When one or more @HttpMethodConstraint annotations are defined within a @ServletSecurity

annotation, each `@HttpMethodConstraint` defines the `security-constraint` that applies to the HTTP protocol method identified within the `@HttpMethodConstraint`. Except for the case where its `@HttpConstraint` returns all default values, and where it contains at least one `@HttpMethodConstraint` that returns other than all default values, the `@ServletSecurity` annotation defines another `security-constraint` that applies to all HTTP protocol methods for which a corresponding `@HttpMethodConstraint` has not been defined.

The `security-constraint` elements defined in the portable deployment descriptors are authoritative for all the `url-patterns` occurring within the constraints.

When a `security-constraint` in the portable deployment descriptor includes a `url-pattern` that is an exact match for a pattern mapped to a class annotated with `@ServletSecurity`, the annotation must have no effect on the constraints enforced by the servlet container on the pattern.

When `metadata-complete=true` is defined for a portable deployment descriptor, the `@ServletSecurity` annotation does not apply to any of the `url-patterns` mapped to (any servlet mapped to) the annotated class in the deployment descriptor.

The `@ServletSecurity` annotation is not applied to the `url-patterns` of a `ServletRegistration` created using the `addServlet(String, Servlet)` method of the `ServletContext` interface, unless the `Servlet` was constructed by the `createServlet` method of the `ServletContext` interface.

With the exceptions listed above, when a servlet class is annotated with `@ServletSecurity`, the annotation defines the security constraints that apply to all the `url-patterns` mapped to all the servlets mapped to the class.

When a class has not been annotated with the `@ServletSecurity` annotation, the access policy that is applied to a servlet mapped from that class is established by the applicable `security-constraint` elements, if any, in the corresponding portable deployment descriptor, or barring any such elements, by the constraints, if any, established programmatically for the target servlet via the `setServletSecurity` method of the `ServletRegistration` interface.

13.4.1.1. Examples

The following examples demonstrate the use of the ServletSecurity annotation.

for all HTTP methods, no constraints

```
@ServletSecurity
public class Example1 extends HttpServlet {

}
```

for all HTTP methods, no auth-constraint, confidential transport required

```
@ServletSecurity(@HttpConstraint(transportGuarantee = TransportGuarantee.CONFIDENTIAL))
public class Example2 extends HttpServlet {

}
```

for all HTTP methods, all access denied

```
@ServletSecurity(@HttpConstraint(EmptyRoleSemantic.DENY))
public class Example3 extends HttpServlet {

}
```

for all HTTP methods, auth-constraint requiring membership in Role R1

```
@ServletSecurity(@HttpConstraint(rolesAllowed = "R1"))
public class Example4 extends HttpServlet {

}
```

for All HTTP methods except GET and POST, no constraints; for methods GET and POST, auth-constraint requiring membership in Role R1; for POST, confidential transport required

```
@ServletSecurity((httpMethodConstraints = {
    @HttpMethodConstraint(value = "GET", rolesAllowed = "R1"),
    @HttpMethodConstraint(value = "POST", rolesAllowed = "R1",
                          transportGuarantee = TransportGuarantee.CONFIDENTIAL)
})
public class Example5 extends HttpServlet {

}
```

for all HTTP methods except GET auth-constraint requiring membership in Role R1; for GET, no constraints

```
@ServletSecurity(value = @HttpConstraint(rolesAllowed = "R1"),
                 httpMethodConstraints = @HttpMethodConstraint("GET"))
public class Example6 extends HttpServlet {

}
```

for all HTTP methods except TRACE,

auth-constraint requiring membership in Role R1; for TRACE, all access denied

```
@ServletSecurity(value = @HttpConstraint(rolesAllowed = "R1"),
                 httpMethodConstraints = @HttpMethodConstraint(value="TRACE",
                         emptyRoleSemantic = EmptyRoleSemantic.DENY))
public class Example7 extends HttpServlet {

}
```

13.4.1.2. Mapping @ServletSecurity to security-constraint

This section describes the mapping of the `@ServletSecurity` annotation to its equivalent representation as `security-constraint` elements. It is provided to facilitate enforcement using the existing `security-constraint` enforcement mechanism of the container. The enforcement by servlet containers, of the `@ServletSecurity` annotation must be equivalent in effect to enforcement, by the container, of the `security-constraint` elements resulting from the mapping defined in this section.

The `@ServletSecurity` annotation is used to define one method-independent `@HttpConstraint` followed by a list of zero or more `@HttpMethodConstraint` specifications. The method-independent constraint is applied to all HTTP methods for which no HTTP method-specific constraint has been defined.

When no `@HttpMethodConstraint` elements are included, a `@ServletSecurity` annotation corresponds to a single `security-constraint` element containing a `web-resource-collection` that contains no `http-method` elements, and thus pertains to all HTTP methods.

The following example depicts the representation of a `@ServletSecurity` annotation with no contained `@HttpMethodConstraint` annotations as a single `security-constraint` element. The `url-pattern` elements defined by the corresponding servlet (registration) would be included in the `web-resource-collection`, and the presence and value of any contained `auth-constraint` and `user-data-constraint` elements would be determined by the mapping of the `@HttpConstraint` value as defined in Section 13.4.1.3, “Mapping @HttpConstraint and @HttpMethodConstraint to XML.”

mapping @ServletSecurity with no contained @HttpMethodConstraint

```
@ServletSecurity(@HttpConstraint(rolesAllowed = "Role1"))
```

```
<security-constraint>
  <web-resource-collection>
    <url-pattern>...</url-pattern>
  </web-resource-collection>
  <auth-constraint>
    <role-name>Role1</role-name>
  </auth-constraint>
</security-constraint>
```

When one or more `@HttpMethodConstraint` elements are specified, the method-independent constraint

corresponds to a single security-constraint containing a web-resource-collection that contains on http-method-omission for each of the HTTP methods named in the @HttpMethodConstraint elements. The security-constraint containing http-method-omission elements must NOT be created if the method-independent constraint returns all default values and at least one @HttpMethodConstraint does not. Each @HttpMethodConstraint corresponds to another security-constraint containing a web-resource-collection containing an http-method element naming the corresponding HTTP method.

The following example depicts the mapping of a @ServletSecurity annotation with a single contained @HttpMethodConstraint to two security-constraint elements. The url-pattern elements defined by the corresponding servlet (registration) would be included in the web-resource-collection of both constraints, and the presence and value of any contained auth-constraint and user-data-constraint elements would be determined by the mapping of the associated @HttpConstraint and @HttpMethodConstraint values as defined in Section 13.4.1.3, “Mapping @HttpConstraint and @HttpMethodConstraint to XML.”

mapping @ServletSecurity with contained @HttpMethodConstraint

```
@ServletSecurity(value=@HttpConstraint(rolesAllowed = "Role1"),
        httpMethodConstraints = @HttpMethodConstraint(value = "TRACE",
                emptyRoleSemantic = EmptyRoleSemantic.DENY))
```

```
<security-constraint>
  <web-resource-collection>
    <url-pattern>...</url-pattern>
    <http-method-omission>TRACE</http-method-omission>
  </web-resource-collection>
  <auth-constraint>
    <role-name>Role1</role-name>
  </auth-constraint>
</security-constraint>
<security-constraint>
  <web-resource-collection>
    <url-pattern>...</url-pattern>
    <http-method>TRACE</http-method>
  </web-resource-collection>
  <auth-constraint/>
</security-constraint>
```

13.4.1.3. Mapping @HttpConstraint and @HttpMethodConstraint to XML.

This section describes the mapping of the @HttpConstraint and @HttpMethodConstraint annotation values (defined for use within @ServletSecurity) to their corresponding auth-constraint and user-data-constraint representations, These annotations share a common model for expressing the equivalent of the auth-constraint and user-data-constraint elements used within the portable deployment descriptor. That model is composed of the following 3 elements:

`emptyRoleSemantic`

The authorization semantic, either `PERMIT` or `DENY`, that applies when no roles are named in `rolesAllowed`. The default value for this element is `PERMIT`, and `DENY` is not supported in combination with a non-empty `rolesAllowed` list.

`rolesAllowed`

A list containing the names of the authorized roles. When this list is empty, its meaning depends on the value of the `emptyRoleSemantic`. The role name `*` has no special meaning when included in the list of allowed roles. When the special role name `**` appears in `rolesAllowed`, it indicates that user authentication, independent of role, is required and sufficient. The default value for this element is an empty list.

`transportGuarantee`

The data protection requirements, either `NONE` or `CONFIDENTIAL`, that must be satisfied by the connections on which requests arrive. This element is equivalent in meaning to a `user-data-constraint` containing a `transport-guarantee` with the corresponding value. The default value for this element is `NONE`.

The following examples depict the correspondence between the `@HttpConstraint` model described above and `auth-constraint` and `user-data-constraint` elements in web.xml.

emptyRoleSemantic=PERMIT, rolesAllowed={}, transportGuarantee=NONE

```
<!-- no constraints -->
```

emptyRoleSemantic=PERMIT, rolesAllowed={}, transportGuarantee=CONFIDENTIAL

```
<user-data-constraint>
  <transport-guarantee>CONFIDENTIAL</transport-guarantee>
</user-data-constraint>
```

emptyRoleSemantic=PERMIT,rolesAllowed={Role1}, transportGuarantee=NONE

```
<auth-constraint>
  <security-role-name>Role1</security-role-name>
</auth-constraint>
```

emptyRoleSemantic=PERMIT,rolesAllowed={Role1}, transportGuarantee=CONFIDENTIAL

```
<auth-constraint>
  <security-role-name>Role1</security-role-name>
</auth-constraint>
<user-data-constraint>
  <transport-guarantee>CONFIDENTIAL</transport-guarantee>
</user-data-constraint>
```

emptyRoleSemantic=DENY, rolesAllowed={}, transportGuarantee=NONE

```
<auth-constraint/>
```

emptyRoleSemantic=DENY, rolesAllowed={}, transportGuarantee=CONFIDENTIAL

```
<auth-constraint/>
<user-data-constraint>
  <transport-guarantee>CONFIDENTIAL</transport-guarantee>
</user-data-constraint>
```

13.4.2. setServletSecurity of ServletRegistration.Dynamic

The `setServletSecurity` method may be used within a `ServletContextListener` to define the security constraints to be applied to the mappings defined for a `ServletRegistration`.

```
Collection<String> setServletSecurity(ServletSecurityElement arg);
```

The `jakarta.servlet.ServletSecurityElement` argument to `setServletSecurity` is analogous in structure and model to the `ServletSecurity` interface of the `@ServletSecurity` annotation. As such, the mappings defined in Section 13.4.1.2, “Mapping @ServletSecurity to security-constraint”, apply analogously to the mapping of a `ServletSecurityElement` with contained `HttpConstraintElement` and `HttpMethodConstraintElement` values, to its equivalent `security-constraint` representation.

The `setServletSecurity` method returns the (possibly empty) Set of URL patterns that are already the exact target of a `security-constraint` element in the portable deployment descriptor (and thus were unaffected by the call).

This method throws an `IllegalStateException` if the `ServletContext` from which the `ServletRegistration` was obtained has already been initialized.

When a `security-constraint` in the portable deployment descriptor includes a `url-pattern` that is an exact match for a pattern mapped by a `ServletRegistration`, calls to `setServletSecurity` on the `ServletRegistration` must have no effect on the constraints enforced by the servlet container on the pattern.

With the exceptions listed above and including when the servlet class is annotated with `@ServletSecurity`, when `setServletSecurity` is called on a `ServletRegistration` it establishes the security constraints that apply to the `url-patterns` of the registration.

13.5. Roles

A security role is a logical grouping of users defined by the Application Developer or Assembler. When the application is deployed, roles are mapped by a Deployer to principals or groups in the runtime environment.

A servlet container enforces declarative or programmatic security for the principal associated with an incoming request based on the security attributes of the principal. This may happen in either of the following ways:

1. A deployer has mapped a security role to a user group in the operational environment. The user groups to which the calling principal belongs are retrieved from its security attributes. The principal is in the security role only if the principal belongs to the user group to which the security role has been mapped by the deployer.
2. A deployer has mapped a security role to a principal name in a security policy domain. In this case, the principal name of the calling principal is retrieved from its security attributes. The principal is in the security role only if the principal name is the same as a principal name to which the security role was mapped.

13.6. Authentication

A web client can authenticate a user to a web server using one of the following mechanisms:

- HTTP Basic Authentication
- HTTP Digest Authentication
- HTTPS Client Authentication
- Form Based Authentication

13.6.1. HTTP Basic Authentication

HTTP Basic Authentication, which is based on a username and password, is the authentication mechanism defined in RFC 7617. A web server requests a web client to authenticate the user. As part of the request, the web server passes the `realm` (a string) in which the user is to be authenticated. The web client obtains the username and the password from the user and transmits them to the web server. The web server then authenticates the user in the specified realm.

Basic Authentication is not a secure authentication protocol. User passwords are sent in simple base64 encoding, and the target server is not authenticated. Additional protection can alleviate some of these concerns: a secure transport mechanism (HTTPS), or security at the network level (such as the IPSEC

protocol or VPN strategies) is applied in some deployment scenarios.

13.6.2. HTTP Digest Authentication

Like HTTP Basic Authentication, HTTP Digest Authentication authenticates a user based on a username and a password. However, unlike HTTP Basic Authentication, HTTP Digest Authentication does not send user passwords over the network. In HTTP Digest authentication the client sends a one-way cryptographic hash of the password (and additional data). Although passwords are not sent on the wire, HTTP Digest authentication requires that clear text password equivalents [8] be avaialble to the authenticating container so that it can validate received authenticators by calculating the expected digest. Servlet containers SHOULD support HTTP_DIGEST authentication.

13.6.3. Form Based Authentication

The look and feel of the “login screen” cannot be varied using the web browser’s built-in authentication mechanisms. This specification introduces a required form based authentication mechanism which allows an Application Developer to control the look and feel of the login screens.

The web application deployment descriptor contains entries for a login form and error page. The login form must contain fields for entering a username and a password. These fields must be named `j_username` and `j_password`, respectively.

When a user attempts to access a protected web resource, the container checks the user’s authentication. If the user is authenticated and possesses authority to access the resource, the requested web resource is activated and a reference to it is returned. If the user is not authenticated, all of the following steps occur:

1. The login form associated with the security constraint is sent to the client and the URL path and HTTP protocol method triggering the authentication is stored by the container.
2. The user is asked to fill out the form, including the username and password fields.
3. The client posts the form back to the server.
4. The container attempts to authenticate the user using the information from the form.
5. If authentication fails, the error page is returned using either a forward or a redirect, and the status code of the response is set to 200. The error page contains information about the failure.
6. If authentication succeeds, the client is redirected to the resource using the store URL path.
7. When the redirected and authenticated request arrives at the container, the container restores the request and HTTP protocol method, and the authenticated user’s principal is checked to see if it is in an authorized role for accessing the resource.
8. If the user is authorized, the request is accepted for processing by the container.

The HTTP protocol method of the redirected request that arrives in step 7, may differ from the HTTP method of the request that triggered the authentication. As such, following the redirection of step 6, the form authenticator must process the redirected request even if authentication is not required for the

HTTP method with which the request arrives. To improve the predictability of the HTTP method of the redirected request, containers should redirect (in step 6) using the 303 (`SC_SEE_OTHER`) status code, except where interoperability with HTTP/1.0 user agents is required; in which cases the 302 status code should be used.

When conducted over an unprotected transport, Form Based Authentication is subject to some of the same vulnerabilities as Basic Authentication.

When the request that is triggering authentication arrives over a secure transport, or the login page is subject to a user-data-constraint of `CONFIDENTIAL`, the login page must be returned to the user, and submitted to the container over a secure transport.

The login page should be subject to a `user-data-constraint` of `CONFIDENTIAL`, and a `user-data-constraint` of CONFIDENTIAL should be included in every `security-constraint` that contains a requirement for authentication.

The login method of the HttpServletRequest interface provides an alternative means for an application to control the look and feel of its login screens.

13.6.3.1. Login Form Notes

Form based login and URL based session tracking can be problematic to implement. Form based login should be used only when sessions are being maintained by cookies or by SSL session information.

In order for the authentication to proceed appropriately, the action of the login form must always be `j_security_check`. This restriction is made so that the login form will work no matter which resource it is for, and to avoid requiring the server to specify the action field of the outbound form. The login form should specify `autocomplete="off"` on the password form field.

Here is an example showing how the form should be coded into the HTML page:

```
<form method="POST" action="j_security_check">
  <input type="text" name="j_username">
  <input type="password" name="j_password" autocomplete="off">
</form>
```

If the form based login is invoked because of an HTTP request, the original request parameters must be preserved by the container for use if, on successful authentication, it redirects the call to the requested resource.

If the user is authenticated using form login and has created an HTTP session, the timeout or invalidation of that session leads to the user being logged out in the sense that subsequent requests must cause the user to be re-authenticated. The scope of the logout is the same as that of the authentication: for example, if the container supports single signon, such as Jakarta EE technology compliant web containers, the user would need to reauthenticate with any of the web applications hosted on the web container.

13.6.4. HTTPS Client Authentication

End user authentication using HTTPS (HTTP over SSL) is a strong authentication mechanism. This mechanism requires the client to possess a Public Key Certificate (PKC). Currently, PKCs are useful in e-commerce applications and also for a single-signon from within the browser.

13.6.5. Additional Container Authentication Mechanisms

Servlet containers should provide public interfaces that may be used to integrate and configure additional HTTP message layer authentication mechanisms for use by the container on behalf of deployed applications. These interfaces should be offered for use by parties other than the container vendor (including application developers, system administrators, and system integrators).

To facilitate portable implementation and integration of additional container authentication mechanisms, it is recommended that all servlet containers implement the Servlet Container Profile of The Jakarta Authentication Specification. The specification is available for download at: https://jakarta.ee/specifications/authentication/

13.7. Server Tracking of Authentication Information

As the underlying security identities (such as users and groups) to which roles are mapped in a runtime environment are environment specific rather than application specific, it is desirable to:

1. Make login mechanisms and policies a property of the environment the web application is deployed in.
2. Be able to use the same authentication information to represent a principal to all applications deployed in the same container, and
3. Require re-authentication of users only when a security policy domain boundary has been crossed.

Therefore, a servlet container is required to track authentication information at the container level (rather than at the web application level). This allows users authenticated for one web application to access other resources managed by the container permitted to the same security identity.

13.8. Specifying Security Constraints

Security constraints are a declarative way of defining the protection of web content. A security constraint associates authorization and/or user data constraints with HTTP operations on web resources. A security constraint, represented as a `security-constraint` in a deployment descriptor, consists of the following elements:

- web resource collection (`web-resource-collection` in deployment descriptor)
- authorization constraint (`auth-constraint` in deployment descriptor)
- user data constraint (`user-data-constraint` in deployment descriptor)

The HTTP operations and web resources to which a security constraint applies (i.e. the constrained requests) are identified by one or more web resource collections. A web resource collection consists of the following elements:

- URL patterns (`url-pattern` in deployment descriptor)
- HTTP methods (`http-method` or `http-method-omission` elements in the deployment descriptor)

An authorization constraint establishes a requirement for authentication and names the authorization roles permitted to perform the constrained requests. A user must be a member of at least one of the named roles to be permitted to perform the constrained requests. The special role name `"*"` is a shorthand for all role names defined in the deployment descriptor. The special role name `"**"` is a shorthand for any authenticated user independent of role. When the special role name `"**"` appears in an authorization constraint, it indicates that any authenticated user, independent of role, is authorized to perform the constrained requests. An authorization constraint that names no roles indicates that access to the constrained requests must not be permitted under any circumstances. An authorization constraint consists of the following element:

- role name (`role-name` in deployment descriptor)

A user data constraint establishes a requirement that the constrained requests be received over a protected transport layer connection. The strength of the required protection is defined by the value of the transport guarantee. A transport guarantee of `INTEGRAL` is used to establish a requirement for content integrity and a transport guarantee of `CONFIDENTIAL` is used to establish a requirement for confidentiality. The transport guarantee of `NONE` indicates that the container must accept the constrained requests when received on any connection including an unprotected one. Containers may impose a confidential transport guarantee in response to the `INTEGRAL` value. A user data constraint consists of the following element:

- transport guarantee (`transport-guarantee` in deployment descriptor)

If no authorization constraint applies to a request, the container must accept the request without requiring user authentication. If no user data constraint applies to a request, the container must accept the request when received over any connection including an unprotected one.

13.8.1. Combining Constraints

For the purpose of combining constraints, an HTTP method is said to occur within a `web-resource-collection` when no HTTP methods are named in the collection, or the collection specifically names the HTTP method in a contained `http-method` element, or the collection contains one or more `http-method-omission` elements, none of which names the HTTP method.

When a url-pattern and HTTP method pair occurs in combination(i.e, within a `web-resource-collection`) in multiple security constraints, the constraints (on the pattern and method) are defined by combining the individual constraints. The rules for combining constraints in which the same pattern and method occur are as follows:

The combination of authorization constraints that name roles or that imply roles via the name `"*"` shall yield the union of the role names in the individual constraints as permitted roles. An authorization constraint that names the role `"**"` shall combine with authorization constraints that name or imply roles to permit any authenticated user independent of role. A security constraint that does not contain an authorization constraint shall combine with authorization constraints that name or imply roles to allow unauthenticated access. The special case of an authorization constraint that names no roles shall combine with any other constraints to override their affects and cause access to be precluded.

The combination of `user-data-constraints` that apply to a common `url-pattern` and `http-method` shall yield the union of connection types accepted by the individual constraints as acceptable connection types. A security constraint that does not contain a `user-data-constraint` shall combine with other `user-data-constraint` to cause the unprotected connection type to be an accepted connection type.

13.8.2. Example

The following example illustrates the combination of constraints and their translation into a table of applicable constraints. Suppose that a deployment descriptor contained the following security constraints.

```
<security-constraint>
  <web-resource-collection>
    <web-resource-name>precluded methods</web-resource-name>
    <url-pattern>/*</url-pattern>
    <url-pattern>/acme/wholesale/*</url-pattern>
    <url-pattern>/acme/retail/*</url-pattern>
    <http-method-omission>GET</http-method-omission>
    <http-method-omission>POST</http-method-omission>
  </web-resource-collection>
  <auth-constraint/>
</security-constraint>

<security-constraint>
  <web-resource-collection>
    <web-resource-name>wholesale</web-resource-name>
    <url-pattern>/acme/wholesale/*</url-pattern>
    <http-method>GET</http-method>
    <http-method>PUT</http-method>
  </web-resource-collection>
  <auth-constraint>
    <role-name>SALESCLERK</role-name>
  </auth-constraint>
</security-constraint>

<security-constraint>
  <web-resource-collection>
```

```
    <web-resource-name>wholesale 2</web-resource-name>
    <url-pattern>/acme/wholesale/*</url-pattern>
    <http-method>GET</http-method>
    <http-method>POST</http-method>
  </web-resource-collection>
  <auth-constraint>
    <role-name>CONTRACTOR</role-name>
  </auth-constraint>
  <user-data-constraint>
    <transport-guarantee>CONFIDENTIAL</transport-guarantee>
  </user-data-constraint>
</security-constraint>

<security-constraint>
  <web-resource-collection>
    <web-resource-name>retail</web-resource-name>
    <url-pattern>/acme/retail/*</url-pattern>
    <http-method>GET</http-method>
    <http-method>POST</http-method>
  </web-resource-collection>

  <auth-constraint>
    <role-name>CONTRACTOR</role-name>
    <role-name>HOMEOWNER</role-name>
  </auth-constraint>
</security-constraint>
```

The translation of this hypothetical deployment descriptor would yield the constraints defined in Table 13-4 , “Security Constraint Table”.

Table 13-4 Security Constraint Table

url-pattern	http-method	permitted roles	supported connection types
/*	all methods except GET, POST	access precluded	not constrained
/acme/wholesale/*	all methods except GET, POST	access precluded	not constrained
/acme/wholesale/*	GET	CONTRACTOR SALESCLERK	not constrained
/acme/wholesale/*	POST	CONTRACTOR	CONFIDENTIAL
/acme/retail/*	all methods except GET, POST	access precluded	not constrained

url-pattern	http-method	permitted roles	supported connection types
/acme/retail/*	GET	CONTRACTOR HOMEOWNER	not constrained
/acme/retail/*	POST	CONTRACTOR HOMEOWNER	not constrained

13.8.3. Processing Requests

When a servlet container receives a request, it shall use the algorithm described in Section 12.1, “Use of URL Paths” to select the constraints (if any) defined on the `url-pattern` that is the best match to the request URI. If no constraints are selected, the container shall accept the request. Otherwise the container shall determine if the HTTP method of the request is constrained at the selected pattern. If it is not, the request shall be accepted. Otherwise, the request must satisfy the constraints that apply to the HTTP method at the `url-pattern`. Both of the following rules must be satisfied for the request to be accepted and dispatched to the associated servlet.

1. The characteristics of the connection on which the request was received must satisfy at least one of the supported connection types defined by the constraints. If this rule is not satisfied, the container shall reject the request and redirect it to the HTTPS port. [9]
2. The authentication characteristics of the request must satisfy any authentication and role requirements defined by the constraints. If this rule is not satisfied because access has been precluded (by an authorization constraint naming no roles), the request shall be rejected as forbidden and a 403 (SC_FORBIDDEN) status code shall be returned to the user. If access is restricted to permitted roles and the request has not been authenticated, the request shall be rejected as unauthorized and a 401 (SC_UNAUTHORIZED) status code shall be returned to cause authentication. If access is restricted to permitted roles and the authentication identity of the request is not a member of any of these roles, the request shall be rejected as forbidden and a 403 (SC_FORBIDDEN) status code shall be returned to the user.

13.8.4. Uncovered HTTP Protocol Methods

The `security-constraint` schema provides the ability to enumerate (including by omission) the HTTP protocol methods to which the protection requirements defined in a `security-constraint` apply. When HTTP methods are enumerated within a `security-constraint`, the protections defined by the constraint apply only to the methods established by the enumeration. We refer to the HTTP methods that are not established by the enumeration as "uncovered" HTTP methods. Uncovered HTTP methods are NOT protected at all request URLs for which a `url-pattern` of the `security-constraint` is a best match.

When HTTP methods are not enumerated within a `security-constraint`, the protections defined by the constraint apply to the complete set of HTTP (extension) methods. In that case, there are no uncovered HTTP methods at all request URLs for which a `url-pattern` of the `security-constraint` is a best match.

The examples that follow depict the three ways in which HTTP protocol methods may be left

uncovered. The determination of whether methods are uncovered is made after all the constraints that apply to a `url-pattern` have been combined as described in Section 13.8.1, "Combining Constraints".

1. A `security-constraint` names one or more HTTP methods in `http-method` elements. All HTTP methods other than those named in the constraint are uncovered.

```
<security-constraint>
  <web-resource-collection>
    <web-resource-name>wholesale</web-resource-name>
    <url-pattern>/acme/wholesale/*</url-pattern>
    <http-method>GET</http-method>
  </web-resource-collection>
  <auth-constraint>
    <role-name>SALESCLERK</role-name>
  </auth-constraint>
</security-constraint>
```

   All HTTP Methods except GET are uncovered.

2. A `security-constraint` names one or more HTTP methods in `http-method-omission` elements. All HTTP methods named in the constraint are uncovered.

```
<security-constraint>
  <web-resource-collection>
    <web-resource-name>wholesale</web-resource-name>
    <url-pattern>/acme/wholesale/*</url-pattern>
    <http-method-omission>GET</http-method-omission>
  </web-resource-collection>
  <auth-constraint/>
</security-constraint>
```

   GET is uncovered. All other methods are covered by the excluding `auth-constraint`.

3. A `@ServletSecurity` annotation includes an `@HttpConstraint` that returns all default values and it also includes at least one `@HttpMethodConstraint` that returns other than all default values. All HTTP methods other than those named in an `@HTTPMethodConstraint` are uncovered by the annotation. This case is analogous to case 1, and equivalent use of the `setServletSecurity` method of the `ServletRegistration` interface will also produce an analogous result.

```
@ServletSecurity((httpMethodConstraints = {
    @HttpMethodConstraint(value = "GET", rolesAllowed = "R1"),
    @HttpMethodConstraint(value = "POST", rolesAllowed = "R1",
            transportGuarantee = TransportGuarantee.CONFIDENTIAL)
    })
public class Example5 extends HttpServlet {

}
```

All HTTP Methods except GET and POST are uncovered.

13.8.4.1. Rules for Security Constraint Configuration

Objective: Make sure all HTTP methods at all constrained URL patterns have the intended security protections (that is, are covered).

1. Do not name HTTP methods in constraints; in which case, the security protections defined for the URL patterns will apply to all HTTP methods.
2. If you can't follow rule #1, add the `<deny-uncovered-http-methods>` and declare (using the `<http-method>` element, or equivalent annotation) all the HTTP methods (with security protections) that are to be allowed at the constrained URL patterns.
3. If you can't follow rule #2, declare constraints to cover all HTTP methods at each constrained URL pattern. Use the `<http-method-omission>` element or the `HttpMethodConstraint` annotation to represent the set of all HTTP methods other than those named by `<http-method>` or `HttpMethodConstraint`. When using annotations, use the `HttpConstraint` annotation to define the security semantic to be applied to all other HTTP methods and configure `EmptyRoleSemantic=DENY` to cause all other HTTP methods to be denied.

13.8.4.2. Handling Uncovered HTTP Methods

During application deployment, the container must inform the deployer of any uncovered HTTP methods present in the application security constraint configuration resulting from the combination of the constraints defined for the application. The provided information must identify the uncovered HTTP protocol methods, and the corresponding URL patterns at which the HTTP methods are uncovered. The requirement to notify the deployer may be satisfied by logging the required information.

When the `deny-uncovered-http-methods` flag is set in the web.xml of an application, the container must deny any HTTP protocol method when it is used with a request URL for which the HTTP method is uncovered at the combined security constraint that applies to the url-pattern that is the best match for the request URL. The denied request shall be rejected as forbidden and a 403 (SC_FORBIDDEN) status code shall be returned.

To cause uncovered HTTP methods to be denied, the deployment system should establish additional

excluding auth-constraints, to cover these HTTP methods at the constrained url-patterns at which the HTTP methods are uncovered.

When an application's security configuration contains no uncovered methods, the `deny-uncovered-http-methods` flag must have no effect on the effective security configuration of the application.

Applying the `deny-uncovered-http-methods` flag to an application whose security configuration contains uncovered methods, may, in some cases, deny access to resources that must be accessible in order for the application to function. In such cases, the security configuration of the application should be completed such that all uncovered methods are covered by an appropriate constraint configuration.

Application Developers should define security constraint configurations that leave no HTTP methods uncovered, and they should set the `deny-uncovered-http-methods` flag to ensure that their applications do not become dependent on being accessible via uncovered methods.

A servlet container may provide a configurable option to select whether the default behavior for uncovered methods is ALLOW or DENY. This option may be configured on a per-application granularity or larger. Note that setting this default to DENY may cause some applications to fail.

13.9. Default Policies

By default, authentication is not needed to access resources. Authentication is required when the security constraints (if any) that contain the `url-pattern` that is the best match for the request URI combine to impose an `auth-constraint` (naming roles) on the HTTP method of the request. Similarly, a protected transport is not required unless the security constraints that apply to the request combine to impose a `user-data-constraint` (with a protected `transport-guarantee`) on the HTTP method of the request.

13.10. Login and Logout

The container establishes the caller identity of a request prior to dispatching the request to the servlet engine. The caller identity remains unchanged throughout the processing of the request or until the application sucessfully calls `authenticate`, `login` or `logout` on the request. For asynchronous requests, the caller identity established at the initial dispatch remains unchanged until the processing of the overall request completes, or the application successfully calls `authenticate`, `login` or `logout` on the request.

Being logged into an application during the processing of a request, corresponds precisely to there being a valid non-null caller identity associated with the request as may be determined by calling `getRemoteUser` or `getUserPrincipal` on the request. A `null` return value from either of these methods indicates that the caller is not logged into the application with respect to the processing of the request.

Containers may create HTTP Session objects to track login state. If a developer creates a session while a user is not authenticated, and the container then authenticates the user, the session visible to developer code after login must be the same session object that was created prior to login occurring so

that there is no loss of session information.

[7] From methods value(), rolesAllowed(), and transportGuarantee().
[8] The password equivalents can be such that they can only be used to authenticate as the user at a specific realm.
[9] As an optimization, a container should reject the request as forbidden and return a 403 (`SC_FORBIDDEN`) status code if it knows that access will ultimately be precluded (by an authorization constraint naming no roles).

Chapter 14. Deployment Descriptor

This chapter specifies the Jakarta Servlet Specification requirements for web container support of deployment descriptors. The deployment descriptor conveys the elements and configuration information of a web application between Application Developers, Application Assemblers, and Deployers.

For Servlet 5.0, the deployment descriptor is defined in terms of an XML schema document.

For backwards compatibility of applications written to previous versions of the API, any deployment descriptors written to comply with earlier versions of the specification, must still be supported such that applications continue to deploy. For the actual XSD files please visit `https://jakarta.ee/xml/ns/jakartaee/`.

14.1. Deployment Descriptor Elements

The following types of configuration and deployment information are required to be supported in the web application deployment descriptor for all servlet containers:

- `ServletContext` Init Parameters
- Session Configuration
- Servlet Declaration
- Servlet Mappings
- Application Lifecyle Listener classes
- Filter Definitions and Filter Mappings
- MIME Type Mappings
- Welcome File list
- Error Pages
- Locale and Encoding Mappings
- Security configuration, including `login-config`, `security-constraint`, `deny-uncovered-http-methods`, `security-role`, `security-role-ref` and `run-as`

14.2. Rules for Processing the Deployment Descriptor

This section lists some general rules that web containers and developers must note concerning the processing of the deployment descriptor for a web application.

- Web containers must remove all leading and trailing whitespace, which is defined as `S(white space)` in XML 1.0 (http://www.w3.org/TR/2000/WD-xml-2e-20000814), for the element content of the text nodes of a deployment descriptor.

- The deployment descriptor must be valid against the schema. Web containers and tools that manipulate web applications have a wide range of options for checking the validity of a WAR. This includes checking the validity of the deployment descriptor document held within.

  Additionally, it is recommended that web containers and tools that manipulate web applications provide a level of semantic checking. For example, it should be checked that a role referenced in a security constraint has the same name as one of the security roles defined in the deployment descriptor.

  In cases of non-conformant web applications, tools and containers should inform the developer with descriptive error messages. High-end application server vendors are encouraged to supply this kind of validity checking in the form of a tool separate from the container.

- The sub elements under `web-app` can be in an arbitrary order in this version of the specification. Because of the restriction of XML Schema, The multiplicity of the elements `distributable`, `session-config`, `welcome-file-list`, `jsp-config`, `login-config`, and `locale-encoding-mapping-list` was changed from `optional` to `0 or more`. The containers must inform the developer with a descriptive error message when the deployment descriptor contains more than one element of `session-config`, `jsp-config`, and `login-config`. The container must concatenate the items in `welcome-file-list` and `locale-encoding-mapping-list` when there are multiple occurrences. The multiple occurrence of `distributable` must be treated exactly in the same way as the single occurrence of `distributable`.
- URI paths specified in the deployment descriptor are assumed to be in URL-decoded form. The containers must inform the developer with a descriptive error message when URL contains `CR(#xD)` or `LF(#xA)`. The containers must preserve all other characters including whitespace in URL.
- Containers must attempt to canonicalize paths in the deployment descriptor. For example, paths of the form `/a/../b` must be interpreted as `/b`. Paths beginning or resolving to paths that begin with `../` are not valid paths in the deployment descriptor.
- URI paths referring to a resource relative to the root of the WAR, or a path mapping relative to the root of the WAR, unless otherwise specified, should begin with a leading `"/"`.
- In elements whose value is an enumerated type, the value is case sensitive.

14.3. Deployment Descriptor

The deployment descriptor for this revision of the specification is available at `https://jakarta.ee/xml/ns/jakartaee/web-app_5_0.xsd`

14.4. Examples

The following examples illustrate the usage of the definitions listed in the deployment descriptor schema.

14.4.1. A Basic Example

Basic Deployment Descriptor Example

```
<?xml version="1.0" encoding="UTF-8"?>
<web-app xmlns="https://jakarta.ee/xml/ns/jakartaee"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="https://jakarta.ee/xml/ns/jakartaee
         web-app_5_0.xsd"
         version="5.0">

  <display-name>A Simple Application</display-name>

  <context-param>
    <param-name>Webmaster</param-name>
    <param-value>webmaster@example.com</param-value>
  </context-param>

  <servlet>
    <servlet-name>catalog</servlet-name>
    <servlet-class>com.example.CatalogServlet</servlet-class>
    <init-param>
      <param-name>catalog</param-name>
      <param-value>Spring</param-value>
    </init-param>
  </servlet>

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

  <session-config>
    <session-timeout>30</session-timeout>
  </session-config>

  <mime-mapping>
    <extension>pdf</extension>
    <mime-type>application/pdf</mime-type>
  </mime-mapping>

  <welcome-file-list>
    <welcome-file>index.jsp</welcome-file>
    <welcome-file>index.html</welcome-file>
    <welcome-file>index.html</welcome-file>
  </welcome-file-list>

  <error-page>
```

```
    <error-code>404</error-code>
    <location>/404.html</location>
  </error-page>

</web-app>
```

14.4.2. An Example of Security

Deployment Descriptor Example Using Security

```
<?xml version="1.0" encoding="UTF-8"?>

<web-app xmlns="https://jakarta.ee/xml/ns/jakartaee"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="https://jakarta.ee/xml/ns/jakartaee
         web-app_5_0.xsd"
         version="5.0">

  <display-name>A Secure Application</display-name>

  <servlet>
    <servlet-name>catalog</servlet-name>
    <servlet-class>com.example.CatalogServlet</servlet-class>
    <init-param>
      <param-name>catalog</param-name>
      <param-value>Spring</param-value>
    </init-param>
    <security-role-ref>
      <role-name>MGR</role-name>
      <!-- role name used in code -->
      <role-link>manager</role-link>
    </security-role-ref>
  </servlet>

  <security-role>
    <role-name>manager</role-name>
  </security-role>

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

  <security-constraint>
    <web-resource-collection>
      <web-resource-name>SalesInfo</web-resource-name>
      <url-pattern>/salesinfo/*</url-pattern>
```

```
      <http-method>GET</http-method>
      <http-method>POST</http-method>
    </web-resource-collection>
    <auth-constraint>
      <role-name>manager</role-name>
    </auth-constraint>
    <user-data-constraint>
      <transport-guarantee>CONFIDENTIAL</transport-guarantee>
    </user-data-constraint>
  </security-constraint>
</web-app>
```

Chapter 15. Requirements related to other Specifications

This chapter lists the requirements for web containers that are included in products that also include other Jakarta technologies.

In the following sections any reference to Jakarta applies to not only the full Jakarta EE profile but also any profile that includes support for servlet, like the Jakarta Web Profile. For more information on profiles please refer to the Jakarta EE Platform Specification.

15.1. Sessions

Distributed servlet containers that are part of a Jakarta EE Platform implementation must support the mechanism necessary for migrating other Jakarta objects from one JVM to another.

15.2. Web Applications

15.2.1. Web Application Class Loader

Servlet containers that are part of a Jakarta EE Platform product should not allow the application to override Java SE or Jakarta EE platform classes, such as those in `java.*`, `javax.*`, and `jakarta.*` namespaces, that either Java SE or Jakarta EE do not allow to be modified.

15.2.2. Web Application Environment

The Jakarta EE Platform defines a naming environment that allows applications to easily access resources and external information without explicit knowledge of how the external information is named or organized.

As servlets are an integral component type of Jakarta technology, provision has been made in the web application deployment descriptor for specifying information allowing a servlet to obtain references to resources and enterprise beans. The deployment elements that contain this information are:

- `env-entry`
- `ejb-ref`
- `ejb-local-ref`
- `resource-ref`
- `resource-env-ref`
- `service-ref`
- `message-destination-ref`

- `persistence-context-ref`
- `persistence-unit-ref`

The developer uses these elements to describe certain objects that the web application requires to be registered in the JNDI namespace in the web container at runtime.

The requirements of the Jakarta environment with regard to setting up the environment are described in Chapter 5 of the Jakarta EE Platform Specification.

Servlet containers that are part of a Jakarta technology-compliant implementation are required to support this syntax. Consult the Jakarta EE Platform Specification for more details. This type of servlet container must support lookups of such objects and calls made to those objects when performed on a thread managed by the servlet container. This type of servlet container should support this behavior when performed on threads created by the developer, but are not currently required to do so. Such a requirement may be added to a future version of this specification. Developers are cautioned that depending on this capability for application-created threads is not recommended, as it is non-portable.

15.2.3. JNDI Name for Web Module Context Root URL

The Jakarta EE Platform Specification defines a standardized global JNDI namespace and a series of related namespaces that map to various scopes of a Jakarta application. These namespaces can be used by applications to portably retrieve references to components and resources. This section defines the JNDI names by which the base url for a web application is required to be registered.

The name of the pre-defined `java.net.URL` resource for the context root of a web application has the following syntax:

`java:global[/<app-name>]/<module-name>!ROOT` in the global namespace and

`java:app/<module-name>!ROOT` in the application-specific namespace.

Please see section EE 8.1.1 (Component creation) and EE 8.1.2 (Application assembly) for the rules to determine the `app-name` and `module-name`.

The `<app-name>` is applicable only when the web application is packaged within a `.ear` file.

The `java:app` prefix allows a component executing within a Jakarta application to access an application-specific namespace. The `java:app` name allows a module in an enterprise application to reference the context root of another module in the same enterprise application. The `<module-name>` is a required part of the syntax for `java:app` url.

Examples

The above URL can then be used within an application as follows:

If a web application is deployed standalone with `module-name` as `myWebApp.` The URL can then be injected into another web module as follows:

```
@Resource(lookup="java:global/myWebApp!ROOT")
URL myWebApp;
```

When packaged in an ear file named `myApp` it can be used as follows:

```
@Resource(lookup="java:global/myApp/myWebApp!ROOT")
URL myWebApp;
```

15.3. Security

This section details the additional security requirements for web containers when included in a product that also contains Jakarta Enterprise Beans, Jakarta Authorisation and/or Jakarta Authentication. The following sections call out the requirements

15.3.1. Propagation of Security Identity in Jakarta Enterprise Bean Calls

A security identity, or principal, must always be provided for use in a call to an enterprise bean. The default mode in calls to enterprise beans from web applications is for the security identity of a web user to be propagated to the Jakarta Enterprise Bea container.

In other scenarios, web containers are required to allow web users that are not known to the web container or to the Jakarta Enterprise Bean container to make calls:

- Web containers are required to support access to web resources by clients that have not authenticated themselves to the container. This is the common mode of access to web resources on the Internet.
- Application code may be the sole processor of signon and customization of data based on caller identity.

In these scenarios, a web application deployment descriptor may specify a `run-as` element. When a `run-as` role is specified for a servlet, the servlet container must propagate a principal mapped to the role as the security identity in any call from the servlet to an Jakarta Enterprise Beans, including calls originating from the servlet's `init` and `destroy` methods. The security role name must be one of the security role names defined for the web application.

For web containers running as part of a Jakarta EE platform, the use of `run-as` elements must be supported both for calls to Jakarta Enterprise Bean components within the same Jakarta application, and for calls to Jakarta Enterprise Bean components deployed in other Jakarta applications.

15.3.2. Container Authorization Requirements

In a Jakarta product or in a product that includes support for Jakarta Authorization, all servlet containers MUST implement support for Jakarta Authorization. The Jakarta Authorization Specification

is available for download at https://jakarta.ee/specifications/authorization/

15.3.3. Container Authentication Requirements

In a Jakarta product, or a product that includes support for Jakarta Authentication, all servlet containers MUST implement the Servlet Container Profile of the Jakarta Authentication specification. The Jakarta Authentication specification is available for download at https://jakarta.ee/specifications/authentication/

15.4. Deployment

This section details the deployment descriptor, packaging and deployment descriptor processing requirements of a Jakarta EE Platform technology compliant container and products that include support for JSP and or web services.

15.4.1. Deployment Descriptor Elements

The following additional elements exist in the web application deployment descriptor to meet the requirements of web containers that are JSP pages enabled or part of a Jakarta application server. They are not required to be supported by containers wishing to support only the servlet specification:

- `jsp-config`
- Syntax for declaring resource references (`env-entry`, `ejb-ref`, `ejb-local-ref`, `resource-ref`, `resource-env-ref`)
- Syntax for specifying the message destination(`message-destination`, `message-destination-ref`)
- Reference to a web service (`service-ref`)
- Reference to a Persistence context (`persistence-context-ref`)
- Reference to a Persistence Unit (`persistence-unit-ref`)

The syntax for these elements is now held in the Jakarta Server Pages specification version 3.0, and the Jakarta EE Platform specification.

15.4.2. Packaging and Deployment of JAX-WS Components

Web containers may choose to support running components written to implement a web service endpoint as defined by the JAX-RPC and/or JAX-WS specifications. Web containers embedded in a Jakarta conformant implementation are required to support JAX-RPC and JAX-WS web service components. This section describes the packaging and deployment model for web containers when included in a product which also supports JAX-RPC and JAX-WS.

Jakarta Enterprise Web Services specification https://jakarta.ee/specifications/enterprise-ws/ defines the model for packaging a web service interface with its associated WSDL description and associated classes. It defines a mechanism for JAX-WS and JAX-RPC enabled web containers to link to a component that implements this web service. A JAX-WS or JAX-RPC web service implementation

component uses the APIs defined by the JAX-WS and/or JAX-RPC specifications, which defines its contract with the JAX-WS and/or JAX-RPC enabled web containers. It is packaged into the WAR file. The web service developer makes a declaration of this component using the usual `<servlet>` declaration.

JAX-WS and JAX-RPC enabled web containers must support the developer in using the web deployment descriptor to define the following information for the endpoint implementation component, using the same syntax as for HTTP servlet components using the `servlet` element. The child elements are used to specify endpoint information in the following way:

- the `servlet-name` element defines a logical name which may be used to locate this endpoint description among the other web components in the WAR
- the `servlet-class` element provides the fully qualified Java class name of this endpoint implementation
- the `description` element(s) may be used to describe the component and may be displayed in a tool
- the `load-on-startup` element specifies the order in which the component is initialized relative to other web components in the web container
- the `security-role-ref` element may be used to test whether the authenticated user is in a logical security role
- the `run-as` element may be used to override the identity propagated to Jakarta Enterprise Beans called by this component

Any servlet initialization parameters defined by the developer for this web component may be ignored by the container. Additionally, the JAX-WS and JAX-RPC enabled web component inherits the traditional web component mechanisms for defining the following information:

- mapping of the component to the web container's URL namespace using the servlet mapping technique
- authorization constraints on web components using security constraints
- the ability to use servlet filters to provide low-level byte stream support for manipulating JAX-WS and/or JAX-RPC messages using the filter mapping technique
- the time out characteristics of any HTTP sessions that are associated with the component
- links to Jakarta objects stored in the JNDI namespace

All of the above requirements can be met using the pluggability mechanism defined in Section 8.2, "Pluggability".

15.4.3. Rules for Processing the Deployment Descriptor

The containers and tools that are part of Jakarta EE Platform technology-compliant implementation are required to validate the deployment descriptor against the XML schema for structural correctness. The validation is recommended, but not required for the web containers and tools that are not part of a Jakarta EE Platform technology compliant implementation.

15.5. Annotations and Resource Injection

The Java Metadata specification (JSR-175), which is part of J2SE 5.0 and later versions, provides a means of specifying configuration data in Java code. Metadata in Java code is also referred to as annotations. In the Jakarta EE Platform, annotations are used to declare dependencies on external resources and configuration data in Java code without the need to define that data in a configuration file.

This section describes the behavior of annotations and resource injection in Jakarta technology compliant servlet containers. This section expands on the Jakarta EE Platform specification section 5 titled “Resources, Naming, and Injection”.

Annotations must be supported on container managed classes that implement the following interfaces and are declared in the web application deployment descriptor or using the annotations defined in Section 8.1, “Annotations and Pluggability” or added programmatically.

Table 15-1 Components and Interfaces supporting Annotations and Resource Injection

Component Type	Classes implementing the following interfaces
Servlets	jakarta.servlet.Servlet
Filters	jakarta.servlet.Filter

Listeners	`jakarta.servlet.ServletContextListener`
	`jakarta.servlet.ServletContextAttributeListener`
	`jakarta.servlet.ServletRequestListener`
	`jakarta.servlet.ServletRequestAttributeListener`
	`jakarta.servlet.http.HttpSessionListener`
	`jakarta.servlet.http.HttpSessionAttributeListener`
	`jakarta.servlet.http.HttpSessionIdListener` `jakarta.servlet.AsyncListener`

Handlers	`jakarta.servlet.http.HttpUgradeHandler`

Web containers are not required to perform resource injection for annotations occurring in classes other than those listed above in TABLE 15-1.

References must be injected prior to any lifecycle methods being called and the component instance being made available the application.

In a web application, classes using resource injection will have their annotations processed only if they are located in the `WEB-INF/classes` directory, or if they are packaged in a jar file located in `WEB-INF/lib`. Containers may optionally process resource injection annotations for classes found elsewhere in the application’s classpath.

15.5.1. Handling of metadata-complete

The web application deployment descriptor contains a `metadata-complete` attribute on the `web-app` element. The `metadata-complete` attribute defines whether the `web.xml` descriptor is complete, or

whether other sources of metadata used by the deployment process should be considered. Metadata may come from the `web.xml` file, `web-fragment.xml` files, annotations on class files in `WEB-INF/classes`, and annotations on classes in jar files in the `WEB-INF/lib` directory. If `metadata-complete` is set to `true`, the deployment tool only examines the `web.xml` file and must ignore annotations such as `@WebServlet`, `@WebFilter`, and `@WebListener` present in the class files of the application, and must also ignore any `web-fragment.xml` descriptor packaged in a jar file in `WEB-INF/lib`. If the `metadata-complete` attribute is not specified or is set to `false`, the deployment tool must examine the class files and `web-fragment.xml` files for metadata, as previously specified.

The `web-fragment.xml` also contains the `metadata-complete` attribute on the `web-fragment` element. The attribute defines whether the `web-fragment.xml` descriptor is complete for the given fragment, or whether the deployment tool should scan for annotations in the classes in the associated jar file. If `metadata-complete` is set to `true` the deployment tool only examines the `web-fragment.xml` and must ignore annotations such as `@WebServlet`, `@WebFilter` and `@WebListener` present in the class files of the fragment. If `metadata-complete` is not specified or is set to `false` the deployment tool must examine the class files for metadata.

Following are the annotations that are required by a Jakarta technology compliant web container.

15.5.2. @DeclareRoles

This annotation is used to define the security roles that comprise the security model of the application. This annotation is specified on a class, and it is used to define roles that could be tested (i.e., by calling `isUserInRole`) from within the methods of the annotated class. Roles that are implicitly declared as a result of their use in a `@RolesAllowed` need not be explicitly declared using the `@DeclareRoles` annotaion. The `@DeclareRoles` annotation may only be defined in classes implementing the `jakarta.servlet.Servlet` interface or a subclass thereof.

Following is an example of how this annotation would be used.

@DeclareRoles Annotation Example

```
@DeclareRoles("BusinessAdmin")
public class CalculatorServlet extends HttpServlet {
    ...
}
```

Declaring `@DeclareRoles` ("BusinessAdmin") is equivalent to defining the following in the web.xml.

@DeclareRoles web.xml

```
<web-app>
  <security-role>
    <role-name>BusinessAdmin</role-name>
  </security-role>
</web-app>
```

This annotation is not used to relink application roles to other roles. When such linking is necessary, it is accomplished by defining an appropriate security-role-ref in the associated deployment descriptor.

When a call is made to `isUserInRole` from the annotated class, the caller identity associated with the invocation of the class is tested for membership in the role with the same name as the argument to `isCallerInRole`. If a `security-role-ref` has been defined for the argument role-name the caller is tested for membership in the role mapped to the `role-name`.

For further details on the `@DeclareRoles` annotation refer to the Jakarta Annotations for the Jakarta EE Platform specification section 2.12.

15.5.3. @EJB Annotation

Jakarta Enterprise Beans 4.0 components may be referenced from a web component using the `@EJB` annotation. The `@EJB` annotation provides the equivalent functionality of declaring the `ejb-ref` or `ejb-local-ref` elements in the deployment descriptor. Fields that have a corresponding `@EJB` annotation are injected with the a reference to the corresponding Jakarta Enterprise Bean component.

An example:

```
@EJB private ShoppingCart myCart;
```

In the case above a reference to the Jakarta Enterprise Bean component `myCart` is injected as the value of the private field `myCart` prior to the classs declaring the injection being made available.

The behavior the `@EJB` annotation is further detailed in section 11.5.1 of the Jakarta Enterprise Bean 4.0 specification.

15.5.4. @EJBs Annotation

The `@EJBs` annotation allows more than one `@EJB` annotations to be declared on a single resource.

An example:

@EJBs Annotation Example

```
@EJBs({@EJB(Calculator),@EJB(ShoppingCart)})
public class ShoppingCartServlet extends HttpServlet {
    ...
}
```

The example above the Jakarta Enterprise Bean components `ShoppingCart` and `Calculator` are made available to `ShoppingCartServlet`. The `ShoppingCartServlet` must still look up the references using JNDI but the Jakarta Enterprise Beans do not need to declared in the web.xml file.

15.5.5. @Resource Annotation

The `@Resource` annotation is used to declare a reference to a resource such as a data source, Jakarta Messaging (JMS) destination, or environment entry. This annotation is equivalent to declaring a `resource-ref`, `message-destination-ref` or `env-ref`, or `resource-env-ref` element in the deployment descriptor.

The `@Resource` annotation is specified on a class, method or field. The container is responsible injecting references to resources declared by the `@Resource` annotation and mapping it to the proper JNDI resources. See the Jakarta EE Platform Specification Chapter 5 for further details.

An example of a @Resource annotation follows:

@Resource Example

```
@Resource
private jakarta.sql.DataSource catalogDS;

public getProductsByCategory() {

    // get a connection and execute the query
    Connection conn = catalogDS.getConnection();
    ...
}
```

In the example code above, a servlet, filter, or listener declares a field `catalogDS` of type `jakarta.sql.DataSource` for which the reference to the data source is injected by the container prior to the component being made available to the application. The data source JNDI mapping is inferred from the field name `catalogDS` and type (`javax.sql.DataSource`). Moreover, the `catalogDS` resource no longer needs to be defined in the deployment descriptor.

The semantics of the `@Resource` annotation are further detailed in the Jakarta Annotations for the Jakarta EE Platform specification Section 5.2.5.

15.5.6. @PersistenceContext Annotation

This annotation specifies the container managed entity manager for referenced persistence units.

An example:

@PersistenceContext Example

```
@PersistenceContext(type=EXTENDED)
EntityManager em;
```

The behavior the `@PersistenceContext` annotation is further detailed in section 10.5.1 of the Jakarta Persistence API, Version 3.0.

15.5.7. @PersistenceContexts Annotation

The `PersistenceContexts` annotation allows more than one `@PersistenceContext` to be declared on a resource. The behavior the `@PersistenceContexts` annotation is further detailed in section 10.5.1 of the Jakarta Persistence API, version 3.0.

15.5.8. @PersistenceUnit Annotation

The `@PersistenceUnit` annotation provides Jakarta Enterprise Beans components declared in a servlet a reference to a entity manager factory. The entity manager factory is bound to a separate persistence.xml configuration file as described in section 11.10 of the Jakarta Enterprise Bean 4.0 specification.

An example:

@PersistenceUnit Example

```
@PersistenceUnit
EntityManagerFactory emf;
```

The behavior the `@PersistenceUnit` annotation is further detailed in section 10.5.2 of the Jakarta Persistence API, version 3.0.

15.5.9. @PersistenceUnits Annotation

This annotation allows for more than one `@PersistentUnit` annotations to be declared on a resource. The behavior the `@PersistenceUnits` annotation is further detailed in section 10.5.2 of the Jakarta Persistence API, version 3.0.

15.5.10. @PostConstruct Annotation

The `@PostConstruct` annotation is declared on a method that does not take any arguments, and must not throw any checked exceptions. The return value must be void. The method MUST be called after the resources injections have been completed and before any lifecycle methods on the component are called.

An example:

@PostConstruct Example

```
@PostConstruct
public void postConstruct() {
    ...
}
```

The example above shows a method using the `@PostConstruct` annotation.

The `@PostConstruct` annotation MUST be supported by all classes that support dependency injection and called even if the class does not request any resources to be injected. If the method throws an unchecked exception the class MUST not be put into service and no method on that instance can be called.

Refer to the Jakarta EE Platform specification section 2.5 and the Jakarta Annotations specification section 2.5 for more details.

15.5.11. @PreDestroy Annotation

The @PreDestroy annotation is declared on a method of a container managed component. The method is called prior to component being removed by the container.

An example:

@PreDestroy Example

```
@PreDestroy
public void cleanup() {
    // clean up any open resources
    ...
}
```

The method annotated with `@PreDestroy` must return void and must not throw a checked exception. The method may be public, protected, package private or private. The method must not be static however it may be final.

Refer to the Jakarta Annotations specification section 2.6 for more details.

15.5.12. @Resources Annotation

The `@Resources` annotation acts as a container for multiple `@Resource` annotations because the Jakarta MetaData specification does not allow for multiple annotations with the same name on the same annotation target.

An example:

@Resources Example

```
@Resources ({
    @Resource(name="myDB" type=javax.sql.DataSource),
    @Resource(name="myMQ" type=jakarta.jms.ConnectionFactory)
})
public class CalculatorServlet extends HttpServlet {
    ...
}
```

In the example above a JMS connection factory and a data source are made available to the `CalculatorServlet` by means of an `@Resources` annotation.

The semantics of the `@Resources` annotation are further detailed in the Jakarta Annotations specification specification section 2.0

15.5.13. @RunAs Annotation

The `@RunAs` annotation is equivalent to the `run-as` element in the deployment descriptor. The `@RunAs` annotation may only be defined in classes implementing the `jakarta.servlet.Servlet` interface or a subclass thereof.

An example:

@RunAs Example

```
@RunAs("Admin")
public class CalculatorServlet extends HttpServlet {

    @EJB private ShoppingCart myCart;

    public void doGet(HttpServletRequest, req, HttpServletResponse res) {
        ...
        myCart.getTotal();
        ...
    }

    ...
}
```

The `@RunAs("Admin")` statement would be equivalent to defining the following in the web.xml.

@RunAs web.xml Example

```
<servlet>
  <servlet-name>CalculatorServlet</servlet-name>
  <run-as>Admin</run-as>
</servlet>
```

The example above shows how a servlet uses the `@RunAs` annotation to propagate the security identity `Admin` to an Jakarta Enterprise Bean component when the `myCart.getTotal()` method is called. For further details on propagating identities see Section 15.3.1, “Propagation of Security Identity in Jakarta Enterprise Bean Calls”.

For further details on the `@RunAs` annotation refer to the Jakarta Annotations specification section 2.7.

15.5.14. @WebServiceRef Annotation

The @WebServiceRef annotation provides a reference to a web service in a web component in same way as a `resource-ref` element would in the deployment descriptor.

An example:

```
@WebServiceRef
private MyService service;
```

In this example a reference to the web service `MyService` will be injected to the class declaring the annotation.

This annotation and behavior are further detailed in the JAX-WS Specification section 7.

15.5.15. @WebServiceRefs Annotation

This annotation allows for more than one `@WebServiceRef` annotations to be declared on a single resource. The behavior of this annotation is further detailed in the JAX-WS Specification section 7.

15.5.16. Contexts and Dependency Injection for Jakarta EE Platform Requirements

In a product that supports Contexts and Dependency Injection (CDI) for Jakarta EE Platform and in which CDI is enabled, implementations MUST support the use of CDI managed beans. Servlets, filters, listeners and HttpUpgradeHandlers MUST support CDI injection and the use of interceptors as described in Section 5.24, "Support for Dependency Injection" of the Jakarta EE Platform 9 specification.

Appendix A: Change Log

This document is the final release of the Jakarta Servlet 5.0 specification developed under the Jakarta EE Working Group.

A.1. Compatibility with Jakarta Servlet Specification Version 4.0

Jakarta Servlet version 5.0 is only a change of namespaces (see Section A.2, “Changes Since Jakarta Servlet 4.0”). Thus, migrating a Servlet 4.0 project to Servlet 5.0 and above, requires the replacement of the namespace `javax.*` with `jakarta.*`.

A.2. Changes Since Jakarta Servlet 4.0

The only major change was a change of namespaces. The `javax.*` namespaces have been replaced with `jakarta.*`.

Glossary

Application Developer

The producer of a web application. The output of an Application Developer is a set of servlet classes, JSP pages, HTML pages, and supporting libraries and files (such as images, compressed archive files, etc.) for the web application. The Application Developer is typically an application domain expert. The developer is required to be aware of the servlet environment and its consequences when programming, including concurrency considerations, and create the web application accordingly.

Application Assembler

Takes the output of the Application Developer and ensures that it is a deployable unit. Thus, the input of the Application Assembler is the servlet classes, JSP pages, HTML pages, and other supporting libraries and files for the web application. The output of the Application Assembler is a web application archive or a web application in an open directory structure.

Deployer

The Deployer takes one or more web application archive files or other directory structures provided by an Application Developer and deploys the application into a specific operational environment. The operational environment includes a specific servlet container and web server. The Deployer must resolve all the external dependencies declared by the developer. To perform this role, the deployer uses tools provided by the Servlet Container Provider.

The Deployer is an expert in a specific operational environment. For example, the Deployer is responsible for mapping the security roles defined by the Application Developer to the user groups and accounts that exist in the operational environment where the web application is deployed.

principal

A principal is an entity that can be authenticated by an authentication protocol. A principal is identified by a *principal name* and authenticated by using *authentication data*. The content and format of the principal name and the authentication data depend on the authentication protocol.

role (development)

The actions and responsibilities taken by various parties during the development, deployment, and running of a web application. In some scenarios, a single party may perform several roles; in others, each role may be performed by a different party.

role (security)

An abstract notion used by an Application Developer in an application that can be mapped by the Deployer to a user, or group of users, in a security policy domain.

security policy domain

The scope over which security policies are defined and enforced by a security administrator of the security service. A security policy domain is also sometimes referred to as a *realm*.

security technology domain

The scope over which the same security mechanism, such as Kerberos, is used to enforce a security policy. Multiple security policy domains can exist within a single technology domain.

Servlet Container Provider

A vendor that provides the runtime environment, namely the servlet container and possibly the web server, in which a web application runs as well as the tools necessary to deploy web applications.

The expertise of the Container Provider is in HTTP-level programming. Since this specification does not specify the interface between the web server and the servlet container, it is left to the Container Provider to split the implementation of the required functionality between the container and the server.

servlet definition

A unique name associated with a fully qualified class name of a class implementing the `Servlet` interface. A set of initialization parameters can be associated with a servlet definition.

servlet mapping

A servlet definition that is associated by a servlet container with a URL path pattern. All requests to that path pattern are handled by the servlet associated with the servlet definition.

System Administrator

The person responsible for the configuration and administration of the servlet container and web server. The administrator is also responsible for overseeing the well-being of the deployed web applications at run time.

This specification does not define the contracts for system management and administration. The administrator typically uses runtime monitoring and management tools provided by the Container Provider and server vendors to accomplish these tasks.

uniform resource locator (URL)

A compact string representation of resources available via the network. Once the resource represented by a URL has been accessed, various operations may be performed on that resource. [10] A URL is a type of uniform resource identifier (URI). URLs are typically of the form:

```
<protocol>//<servername>/<resource>
```

For the purposes of this specification, we are primarily interested in HTTP based URLs which are of the form:

```
http[s]://<servername>[:port]/<url-path>[?<query-string>]
```

For example:

```
http://www.example.com/products/servlet/index.html
```

```
https://example.com/purchase
```

In HTTP-based URLs, the `"/"` character is reserved to separate a hierarchical path structure in the URL-path portion of the URL. The server is responsible for determining the meaning of the hierarchical structure. There is no correspondence between a URL-path and a given file system path.

web application

A collection of servlets, JSP pages , HTML documents, and other web resources which might include image files, compressed archives, and other data. A web application may be packaged into an archive or exist in an open directory structure.

All compatible servlet containers must accept a web application and perform a deployment of its contents into their runtime. This may mean that a container can run the application directly from a web application archive file or it may mean that it will move the contents of a web application into the appropriate locations for that particular container.

web application archive

A single file that contains all of the components of a web application. This archive file is created by using standard JAR tools which allow any or all of the web components to be signed.

Web application archive files are identified by the `.war` extension. A new extension is used instead of `.jar` because that extension is reserved for files which contain a set of class files and that can be placed in the classpath or double clicked using a GUI to launch an application. As the contents of a web application archive are not suitable for such use, a new extension was in order.

web application, distributable

A web application that is written so that it can be deployed in a web container distributed across multiple Java virtual machines running on the same host or different hosts. The deployment descriptor for such an application uses the `distributable` element.

[10] See RFC 1738