

JAX-RS: Java™ API for RESTful Web Services

Version 2.0 Early Draft (Third Edition)
May 25, 2012

Editors:
Santiago Pericas-Geertsen
Marek Potociar

Comments to: users@jax-rs-spec.java.net

Oracle Corporation
500 Oracle Parkway, Redwood Shores, CA 94065 USA.

ORACLE IS WILLING TO LICENSE THIS SPECIFICATION TO YOU ONLY UPON THE CONDITION THAT YOU ACCEPT ALL OF THE TERMS CONTAINED IN THIS LICENSE AGREEMENT ("AGREEMENT"). PLEASE READ THE TERMS AND CONDITIONS OF THIS AGREEMENT CAREFULLY. BY DOWNLOADING THIS SPECIFICATION, YOU ACCEPT THE TERMS AND CONDITIONS OF THIS AGREEMENT. IF YOU ARE NOT WILLING TO BE BOUND BY THEM, SELECT THE "DECLINE" BUTTON AT THE BOTTOM OF THIS PAGE AND THE DOWNLOADING PROCESS WILL NOT CONTINUE.

Specification: JSR-339 JAX-RS - Java™ API for RESTful Web Services ("Specification")

Version: 2.0-early-draft-2

Status: 2.0 Early Draft (Second Edition)

Release: May 25, 2012

Copyright 2011 Oracle Corporation

500 Oracle Parkway, Redwood Shores, California 94065, U.S.A

All rights reserved.

NOTICE

The Specification is protected by copyright and the information described therein may be protected by one or more U.S. patents, foreign patents, or pending applications. Except as provided under the following license, no part of the Specification may be reproduced in any form by any means without the prior written authorization of Oracle America, Inc. ("Oracle") and its licensors, if any. Any use of the Specification and the information described therein will be governed by the terms and conditions of this Agreement.

Subject to the terms and conditions of this license, including your compliance with Paragraphs 1 and 2 below, Oracle hereby grants you a fully-paid, non-exclusive, non-transferable, limited license (without the right to sublicense) under Oracle's intellectual property rights to:

1. Review the Specification for the purposes of evaluation. This includes: (i) developing implementations of the Specification for your internal, non-commercial use; (ii) discussing the Specification with any third party; and (iii) excerpting brief portions of the Specification in oral or written communications which discuss the Specification provided that such excerpts do not in the aggregate constitute a significant portion of the Technology.
2. Distribute implementations of the Specification to third parties for their testing and evaluation use, provided that any such implementation:
 - (a) does not modify, subset, superset or otherwise extend the Licensor Name Space, or include any public or protected packages, classes, Java interfaces, fields or methods within the Licensor Name Space other than those required/authorized by the Specification or Specifications being implemented;
 - (b) is clearly and prominently marked with the word "UNTESTED" or "EARLY ACCESS" or "INCOMPATIBLE" or "UNSTABLE" or "BETA" in any list of available builds and in proximity to every link initiating its download, where the list or link is under Licensee's control; and
 - (c) includes the following notice: "This is an implementation of an early-draft specification developed under the Java Community Process (JCP) and is made available for testing and evaluation purposes only. The code is not compatible with any specification of the JCP."

The grant set forth above concerning your distribution of implementations of the specification is contingent upon your agreement to terminate development and distribution of your "early draft" implementation as soon as feasible following final completion of the specification. If you fail to do so, the foregoing grant shall be considered null and void.

No provision of this Agreement shall be understood to restrict your ability to make and distribute to third parties applications written to the Specification.

Other than this limited license, you acquire no right, title or interest in or to the Specification or any other Oracle intellectual property, and the Specification may only be used in accordance with the license terms set forth herein. This license will expire on the earlier of: (a) two (2) years from the date of Release listed above; (b) the date on which the final version of the Specification is publicly released; or (c) the date on which the Java Specification

Request (JSR) to which the Specification corresponds is withdrawn. In addition, this license will terminate immediately without notice from Oracle if you fail to comply with any provision of this license. Upon termination, you must cease use of or destroy the Specification.

"Licensor Name Space" means the public class or interface declarations whose names begin with "java", "javax", "com.oracle" or their equivalents in any subsequent naming convention adopted by Oracle through the Java Community Process, or any recognized successors or replacements thereof.

TRADEMARKS

No right, title, or interest in or to any trademarks, service marks, or trade names of Oracle or Oracle's licensors is granted hereunder. Oracle, the Oracle logo, Java are trademarks or registered trademarks of Oracle USA, Inc. in the U.S. and other countries.

DISCLAIMER OF WARRANTIES

THE SPECIFICATION IS PROVIDED "AS IS" AND IS EXPERIMENTAL AND MAY CONTAIN DEFECTS OR DEFICIENCIES WHICH CANNOT OR WILL NOT BE CORRECTED BY ORACLE. ORACLE MAKES NO REPRESENTATIONS OR WARRANTIES, EITHER EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO, WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, OR NON-INFRINGEMENT THAT THE CONTENTS OF THE SPECIFICATION ARE SUITABLE FOR ANY PURPOSE OR THAT ANY PRACTICE OR IMPLEMENTATION OF SUCH CONTENTS WILL NOT INFRINGE ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER RIGHTS. This document does not represent any commitment to release or implement any portion of the Specification in any product.

THE SPECIFICATION COULD INCLUDE TECHNICAL INACCURACIES OR TYPOGRAPHICAL ERRORS. CHANGES ARE PERIODICALLY ADDED TO THE INFORMATION THEREIN; THESE CHANGES WILL BE INCORPORATED INTO NEW VERSIONS OF THE SPECIFICATION, IF ANY. ORACLE MAY MAKE IMPROVEMENTS AND/OR CHANGES TO THE PRODUCT(S) AND/OR THE PROGRAM(S) DESCRIBED IN THE SPECIFICATION AT ANY TIME. Any use of such changes in the Specification will be governed by the then-current license for the applicable version of the Specification.

LIMITATION OF LIABILITY

TO THE EXTENT NOT PROHIBITED BY LAW, IN NO EVENT WILL ORACLE OR ITS LICENSORS BE LIABLE FOR ANY DAMAGES, INCLUDING WITHOUT LIMITATION, LOST REVENUE, PROFITS OR DATA, OR FOR SPECIAL, INDIRECT, CONSEQUENTIAL, INCIDENTAL OR PUNITIVE DAMAGES, HOWEVER CAUSED AND REGARDLESS OF THE THEORY OF LIABILITY, ARISING OUT OF OR RELATED TO ANY FURNISHING, PRACTICING, MODIFYING OR ANY USE OF THE SPECIFICATION, EVEN IF ORACLE AND/OR ITS LICENSORS HAVE BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

You will hold Oracle (and its licensors) harmless from any claims based on your use of the Specification for any purposes other than the limited right of evaluation as described above, and from any claims that later versions or releases of any Specification furnished to you are incompatible with the Specification provided to you under this license.

RESTRICTED RIGHTS LEGEND

If this Software is being acquired by or on behalf of the U.S. Government or by a U.S. Government prime contractor or subcontractor (at any tier), then the Government's rights in the Software and accompanying documentation shall be only as set forth in this license; this is in accordance with 48 C.F.R. 227.7201 through 227.7202-4 (for Department of Defense (DoD) acquisitions) and with 48 C.F.R. 2.101 and 12.212 (for non-DoD acquisitions)

REPORT

You may wish to report any ambiguities, inconsistencies or inaccuracies you may find in connection with your evaluation of the Specification ("Feedback"). To the extent that you provide Oracle with any Feedback, you hereby: (i) agree that such Feedback is provided on a non-proprietary and non-confidential basis, and (ii) grant Oracle a perpetual, non-exclusive, worldwide, fully paid-up, irrevocable license, with the right to sublicense through multiple levels of sublicensees, to incorporate, disclose, and use without limitation the Feedback for any purpose related to the Specification and future versions, implementations, and test suites thereof.

GENERAL TERMS

Any action related to this Agreement will be governed by California law and controlling U.S. federal law. The U.N. Convention for the International Sale of Goods and the choice of law rules of any jurisdiction will not apply.

The Specification is subject to U.S. export control laws and may be subject to export or import regulations in other countries. Licensee agrees to comply strictly with all such laws and regulations and acknowledges that it has the responsibility to obtain such licenses to export, re-export or import as may be required after delivery to Licensee.

This Agreement is the parties' entire agreement relating to its subject matter. It supersedes all prior or contemporaneous oral or written communications, proposals, conditions, representations and warranties and prevails over any conflicting or additional terms of any quote, order, acknowledgment, or other communication between the parties relating to its subject matter during the term of this Agreement. No modification to this Agreement will be binding, unless in writing and signed by an authorized representative of each party.

Contents

1	Introduction	1
1.1	Status	1
1.2	Goals	2
1.3	Non-Goals	2
1.4	Conventions	2
1.5	Terminology	3
1.6	Expert Group Members	4
1.7	Acknowledgements	5
2	Applications	7
2.1	Configuration	7
2.2	Verification	7
2.3	Publication	7
2.3.1	Java SE	7
2.3.2	Servlet	8
2.3.3	Other Container	10
3	Resources	11
3.1	Resource Classes	11
3.1.1	Lifecycle and Environment	11
3.1.2	Constructors	11
3.2	Fields and Bean Properties	12
3.3	Resource Methods	13
3.3.1	Visibility	13
3.3.2	Parameters	13
3.3.3	Return Type	13
3.3.4	Exceptions	14

3.3.5	HEAD and OPTIONS	15
3.4	URI Templates	15
3.4.1	Sub Resources	16
3.5	Declaring Media Type Capabilities	17
3.6	Annotation Inheritance	19
3.7	Matching Requests to Resource Methods	20
3.7.1	Request Preprocessing	20
3.7.2	Request Matching	20
3.7.3	Converting URI Templates to Regular Expressions	24
3.8	Determining the MediaType of Responses	24
4	Providers	27
4.1	Lifecycle and Environment	27
4.1.1	Automatic Discovery	27
4.1.2	Constructors	27
4.2	Entity Providers	28
4.2.1	Message Body Reader	28
4.2.2	Message Body Writer	29
4.2.3	Declaring Media Type Capabilities	29
4.2.4	Standard Entity Providers	30
4.2.5	Transfer Encoding	30
4.2.6	Content Encoding	31
4.3	Context Providers	31
4.3.1	Declaring Media Type Capabilities	31
4.4	Exception Mapping Providers	31
4.5	Exceptions	32
5	Client API	33
5.1	Bootstrapping a Client Instance	33
5.2	Resource Access	33
5.3	Targets	34
5.4	Typed Entities	34
5.5	Invocations	35
5.6	Configurable Types	35
5.6.1	Filters and Entity Interceptors	36

6	Filters and Interceptors	37
6.1	Introduction	37
6.2	Filters	38
6.3	Entity Interceptors	39
6.4	Lifecycle	40
6.5	Binding	40
6.5.1	Global Binding	40
6.5.2	Name Binding	41
6.5.3	Dynamic Binding	42
6.5.4	Binding in Client API	42
6.6	Priorities	42
6.7	Exceptions	43
7	Validation	45
7.1	Constraint Annotations	45
7.2	Annotations and Validators	47
7.3	Entity Validation	47
7.4	Annotation Inheritance	48
7.5	Validation Phases and Error Reporting	49
7.6	Exceptions	49
8	Asynchronous Processing	51
8.1	Introduction	51
8.2	Server API	51
8.2.1	Suspend Annotation	52
8.3	EJB Resource Classes	53
8.4	Client API	53
9	Context	55
9.1	Concurrency	55
9.2	Context Types	55
9.2.1	Application	55
9.2.2	URIs and URI Templates	55
9.2.3	Headers	56
9.2.4	Content Negotiation and Preconditions	56
9.2.5	Security Context	57

9.2.6	Providers	57
10	Environment	59
10.1	Servlet Container	59
10.2	Java EE Container	59
10.2.1	Servlets	60
10.2.2	Managed Beans	60
10.2.3	Context and Dependency Injection (CDI)	60
10.2.4	Enterprise Java Beans (EJBs)	61
10.2.5	Additional Requirements	62
10.3	Other	62
11	Runtime Delegate	63
11.1	Configuration	63
A	Summary of Annotations	65
B	HTTP Header Support	67
C	Change Log	69
C.1	Changes Since 2.0 Early Draft (Second Edition)	69
C.2	Changes Since 2.0 Early Draft	70
C.3	Changes Since 1.1 Release	71
C.4	Changes Since 1.0 Release	71
C.5	Changes Since Proposed Final Draft	72
C.6	Changes Since Public Review Draft	72
	Bibliography	75

Chapter 1

Introduction

This specification defines a set of Java APIs for the development of Web services built according to the Representational State Transfer[1] (REST) architectural style. Readers are assumed to be familiar with REST; for more information about the REST architectural style and RESTful Web services, see:

- Architectural Styles and the Design of Network-based Software Architectures[1]
- The REST Wiki[2]
- Representational State Transfer on Wikipedia[3]

1.1 Status

This is an early draft; this specification is not yet complete. A list of open issues can be found at:

http://java.net/jira/browse/JAX_RS_SPEC

The corresponding Javadocs can be found online at:

<http://jax-rs-spec.java.net/>

The reference implementation can be obtained from:

<http://jersey.java.net/>

The expert group seeks feedback from the community on any aspect of this specification, please send comments to:

users@jax-rs-spec.java.net

1.2 Goals

The following are the goals of the API:

POJO-based The API will provide a set of annotations and associated classes/interfaces that may be used with POJOs in order to expose them as Web resources. The specification will define object lifecycle and scope.

HTTP-centric The specification will assume HTTP[4] is the underlying network protocol and will provide a clear mapping between HTTP and URI[5] elements and the corresponding API classes and annotations. The API will provide high level support for common HTTP usage patterns and will be sufficiently flexible to support a variety of HTTP applications including WebDAV[6] and the Atom Publishing Protocol[7].

Format independence The API will be applicable to a wide variety of HTTP entity body content types. It will provide the necessary pluggability to allow additional types to be added by an application in a standard manner.

Container independence Artifacts using the API will be deployable in a variety of Web-tier containers. The specification will define how artifacts are deployed in a Servlet[8] container and as a JAX-WS[9] Provider.

Inclusion in Java EE The specification will define the environment for a Web resource class hosted in a Java EE container and will specify how to use Java EE features and components within a Web resource class.

1.3 Non-Goals

The following are non-goals:

Support for Java versions prior to J2SE 6.0 The API will make extensive use of annotations and will require J2SE 6.0 or later.

Description, registration and discovery The specification will neither define nor require any service description, registration or discovery capability.

HTTP Stack The specification will not define a new HTTP stack. HTTP protocol support is provided by a container that hosts artifacts developed using the API.

Data model/format classes The API will not define classes that support manipulation of entity body content, rather it will provide pluggability to allow such classes to be used by artifacts developed using the API.

1.4 Conventions

The keywords ‘MUST’, ‘MUST NOT’, ‘REQUIRED’, ‘SHALL’, ‘SHALL NOT’, ‘SHOULD’, ‘SHOULD NOT’, ‘RECOMMENDED’, ‘MAY’, and ‘OPTIONAL’ in this document are to be interpreted as described in RFC 2119[10].

Figure 1.1: Example Java Code

```

1 package com.example.hello;
2
3 public class Hello {
4     public static void main(String args[]) {
5         System.out.println("Hello World");
6     }
7 }

```

Java code and sample data fragments are formatted as shown in figure 1.1:

URIs of the general form ‘http://example.org/...’ and ‘http://example.com/...’ represent application or context-dependent URIs.

All parts of this specification are normative, with the exception of examples, notes and sections explicitly marked as ‘Non-Normative’. Non-normative notes are formatted as shown below.

Note: *This is a note.*

1.5 Terminology

Resource class A Java class that uses JAX-RS annotations to implement a corresponding Web resource, see Chapter 3.

Root resource class A *resource class* annotated with `@Path`. Root resource classes provide the roots of the resource class tree and provide access to sub-resources, see Chapter 3.

Request method designator A runtime annotation annotated with `@HttpMethod`. Used to identify the HTTP request method to be handled by a *resource method*.

Resource method A method of a *resource class* annotated with a *request method designator* that is used to handle requests on the corresponding resource, see Section 3.3.

Sub-resource locator A method of a *resource class* that is used to locate sub-resources of the corresponding resource, see Section 3.4.1.

Sub-resource method A method of a *resource class* that is used to handle requests on a sub-resource of the corresponding resource, see Section 3.4.1.

Provider An implementation of a JAX-RS extension interface. Providers extend the capabilities of a JAX-RS runtime and are described in Chapter 4.

Filter A class that implements `RequestFilter`, `PreMatchRequestFilter` or `ResponseFilter` (or any combination thereof) and is registered as a provider.

Entity Interceptor A class that implements `ReaderInterceptor` or `WriterInterceptor` (or both) and is registered as a provider.

Invocation A Client API object that can be configured to issue an HTTP request.

Target The recipient of an Invocation, identified by a URI.

Link A URI with additional meta-data such as a media type, a relation, a title, etc.

1.6 Expert Group Members

This specification is being developed as part of JSR 339 under the Java Community Process. It is the result of the collaborative work of the members of the JSR 339 Expert Group. The following are the present expert group members:

- Jan Algermissen (Individual Member)
- Florent Benoit (OW2)
- Sergey Beryozkin (Talend)
- Adam Bien (Individual Member)
- Bill Burke (Red Hat Middleware LLC)
- Clinton Combs (Individual Member)
- Bill De Hora (Individual Member)
- Markus Karg (Individual Member)
- Sastri Malladi (Ebay)
- Julian Reschke (Individual Member)
- Guilherme Silveira (Individual Member)
- Dionysios Synodinos (Individual Member)

The following are former group members of the JSR 339 Expert Group:

- Tony Ng (Ebay)

JAX-RS 1.X has been developed as part of JSR 331 under the Java Community Process. The following were group members of the JSR 311 Expert Group:

- Heiko Braun (Red Hat Middleware LLC)
- Larry Cable (BEA Systems)
- Roy Fielding (Day Software, Inc.)
- Harpreet Geekee (Nortel)
- Nickolas Grabovas (Individual Member)
- Mark Hansen (Individual Member)
- John Harby (Individual Member)
- Hao He (Individual Member)
- Ryan Heaton (Individual Member)
- David Hensley (Individual Member)
- Stephan Koops (Individual Member)
- Changshin Lee (NCsoft Corporation)
- Francois Leygues (Alcatel-Lucent)
- Jerome Louvel (Individual Member)

- Hamid Ben Malek (Fujitsu Limited)
- Ryan J. McDonough (Individual Member)
- Felix Meschberger (Day Software, Inc.)
- David Orchard (BEA Systems)
- Dhanji R. Prasanna (Individual Member)
- Julian Reschke (Individual Member)
- Jan Schulz-Hofen (Individual Member)
- Joel Smith (IBM)
- Stefan Tilkov (innoQ Deutschland GmbH)

1.7 Acknowledgements

During the course of this JSR we received many excellent suggestions. Special thanks to Martin Matula, Gerard Davison, Jakub Podlesak and Pavel Bucek from Oracle as well as Pete Muir and Emmanuel Bernard from Red Hat. Also to Gunnar Morling and Ron Sigal (Red Hat) for their suggestions on how to improve resource validation, and to Mattias Arthursson for his insights on hypermedia.

During the course of the JSR 311 we received many excellent suggestions on the JSR and Jersey (RI) mailing lists, thanks in particular to James Manger (Telstra) and Reto Bachmann-Gmür (Trialox) for their contributions. The following individuals (all Sun Microsystems at the time) have also made invaluable technical contributions: Roberto Chinnici, Dianne Jiao (TCK), Ron Monzillo, Rajiv Mordani, Eduardo Pelegri-Llopert, Jakub Podlesak (RI) and Bill Shannon.

The `GenericEntity` class was inspired by the Google Guice `TypeLiteral` class. Our thanks to Bob Lee and Google for donating this class to JAX-RS.

Chapter 2

Applications

A JAX-RS application consists of one or more resources (see Chapter 3) and zero or more providers (see Chapter 4). This chapter describes aspects of JAX-RS that apply to an application as a whole, subsequent chapters describe particular aspects of a JAX-RS application and requirements on JAX-RS implementations.

2.1 Configuration

The resources and providers that make up a JAX-RS application are configured via an application-supplied subclass of `Application`. An implementation MAY provide alternate mechanisms for locating resource classes and providers (e.g. runtime class scanning) but use of `Application` is the only portable means of configuration.

2.2 Verification

Specific application requirements are detailed throughout this specification and the JAX-RS Javadocs. Implementations MAY perform verification steps that go beyond what it is stated in this document.

A JAX-RS implementation MAY report an error condition if it detects that two or more resources could result in an ambiguity during the execution of the algorithm described Section 3.7.2. For example, if two resource methods in the same resource class have identical (or even intersecting) values in all the annotations that are relevant to the algorithm described in that section. The exact set of verification steps as well as the error reporting mechanism is implementation dependent.

2.3 Publication

Applications are published in different ways depending on whether the application is run in a Java SE environment or within a container. This section describes the alternate means of publication.

2.3.1 Java SE

In a Java SE environment a configured instance of an endpoint class can be obtained using the `createEndpoint` method of `RuntimeDelegate`. The application supplies an instance of `Application` and the

type of endpoint required. An implementation MAY support zero or more endpoint types of any desired type.

How the resulting endpoint class instance is used to publish the application is outside the scope of this specification.

2.3.1.1 JAX-WS

An implementation that supports publication via JAX-WS MUST support `createEndpoint` with an endpoint type of `javax.xml.ws.Provider`. JAX-WS describes how a `Provider` based endpoint can be published in an SE environment.

2.3.2 Servlet

A JAX-RS application is packaged as a Web application in a `.war` file. The application classes are packaged in `WEB-INF/classes` or `WEB-INF/lib` and required libraries are packaged in `WEB-INF/lib`. See the Servlet specification for full details on packaging of web applications.

It is RECOMMENDED that implementations support the Servlet 3 framework pluggability mechanism to enable portability between containers and to avail themselves of container-supplied class scanning facilities. When using the pluggability mechanism the following conditions MUST be met:

- If *no* `Application` subclass is present, JAX-RS implementations are REQUIRED to dynamically add a servlet and set its name to

```
javax.ws.rs.core.Application
```

and to automatically discover all root resource classes and providers which MUST be packaged with the application. Additionally, the application MUST be packaged with a `web.xml` that specifies a servlet mapping for the added servlet. An example of such a `web.xml` file is:

```
1 <web-app version="3.0" xmlns="http://java.sun.com/xml/ns/javaee"
2   xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
3   xsi:schemaLocation="http://java.sun.com/xml/ns/javaee
4     http://java.sun.com/xml/ns/javaee/web-app_3_0.xsd">
5   <servlet>
6     <servlet-name>javax.ws.rs.core.Application</servlet-name>
7   </servlet>
8   <servlet-mapping>
9     <servlet-name>javax.ws.rs.core.Application</servlet-name>
10    <url-pattern>/myresources/*</url-pattern>
11  </servlet-mapping>
12 </web-app>
```

- If an `Application` subclass is present:
 - If there is already a servlet that handles this application. That is, a servlet that has an initialization parameter named

```
javax.ws.rs.Application
```

whose value is the fully qualified name of the `Application` subclass, then no additional configuration steps are required by the JAX-RS implementation.

- If *no* servlet handles this application, JAX-RS implementations are **REQUIRED** to dynamically add a servlet whose fully qualified name must be that of the `Application` subclass. If the `Application` subclass is annotated with `@ApplicationPath`, implementations are **REQUIRED** to use the value of this annotation appended with `"/"` to define a mapping for the added server. Otherwise, the application **MUST** be packaged with a `web.xml` that specifies a servlet mapping. For example, if `org.example.MyApplication` is the name of the `Application` subclass, a sample `web.xml` would be:

```

1  <web-app version="3.0" xmlns="http://java.sun.com/xml/ns/javaee"
2      xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
3      xsi:schemaLocation="http://java.sun.com/xml/ns/javaee
4          http://java.sun.com/xml/ns/javaee/web-app_3_0.xsd">
5      <servlet>
6          <servlet-name>org.example.MyApplication</servlet-name>
7      </servlet>
8      <servlet-mapping>
9          <servlet-name>org.example.MyApplication</servlet-name>
10         <url-pattern>/myresources/*</url-pattern>
11     </servlet-mapping>
12 </web-app>

```

When an `Application` subclass is present in the archive, if both `Application.getClasses` and `Application.getSingletons` return an empty list then all root resource classes and providers packaged in the web application **MUST** be included and the JAX-RS implementation is **REQUIRED** to discover them automatically. If either `getClassess` or `getSingletons` returns a non-empty list then only those classes or singletons returned **MUST** be included in the published JAX-RS application.

The following table summarizes the Servlet 3 framework pluggability mechanism:

Condition	Action	Servlet Name	web.xml
No <code>Application</code> subclass	Add servlet	<code>javax.ws.rs.core.Application</code>	Required for servlet mapping
<code>Application</code> subclass handled by existing servlet	(none)	(already defined)	Not required
<code>Application</code> subclass <i>not</i> handled by existing servlet	Add servlet	Subclass name	If no <code>@ApplicationPath</code> then required for servlet mapping

Table 2.1: Summary of Servlet 3 framework pluggability cases

If not using the Servlet 3 framework pluggability mechanism (e.g. in a pre-Servlet 3.0 container), the `servlet-class` or `filter-class` element of the `web.xml` descriptor **SHOULD** name the JAX-RS implementation-supplied servlet or filter class respectively. The `Application` subclass **SHOULD** be identified using an `init-param` with a `param-name` of `javax.ws.rs.Application`.

Note that the Servlet 3 framework pluggability mechanism described above is based on servlets and not filters. Applications that prefer to use an implementation-supplied filter class must use the pre-Servlet 3.0 configuration mechanism.

2.3.3 Other Container

An implementation MAY provide facilities to host a JAX-RS application in other types of container, such facilities are outside the scope of this specification.

Chapter 3

Resources

Using JAX-RS a Web resource is implemented as a resource class and requests are handled by resource methods. This chapter describes resource classes and resource methods in detail.

3.1 Resource Classes

A resource class is a Java class that uses JAX-RS annotations to implement a corresponding Web resource. Resource classes are POJOs that have at least one method annotated with `@Path` or a request method designator.

3.1.1 Lifecycle and Environment

By default a new resource class instance is created for each request to that resource. First the constructor (see Section 3.1.2) is called, then any requested dependencies are injected (see Section 3.2), then the appropriate method (see Section 3.3) is invoked and finally the object is made available for garbage collection.

An implementation MAY offer other resource class lifecycles, mechanisms for specifying these are outside the scope of this specification. E.g. an implementation based on an inversion-of-control framework may support all of the lifecycle options provided by that framework.

3.1.2 Constructors

Root resource classes are instantiated by the JAX-RS runtime and MUST have a public constructor for which the JAX-RS runtime can provide all parameter values. Note that a zero argument constructor is permissible under this rule.

A public constructor MAY include parameters annotated with one of the following: `@Context`, `@HeaderParam`, `@CookieParam`, `@MatrixParam`, `@QueryParam` or `@PathParam`. However, depending on the resource class lifecycle and concurrency, per-request information may not make sense in a constructor. If more than one public constructor is suitable then an implementation MUST use the one with the most parameters. Choosing amongst suitable constructors with the same number of parameters is implementation specific, implementations SHOULD generate a warning about such ambiguity.

Non-root resource classes are instantiated by an application and do not require the above-described public constructor.

3.2 Fields and Bean Properties

When a resource class is instantiated, the values of fields and bean properties annotated with one the following annotations are set according to the semantics of the annotation:

@MatrixParam Extracts the value of a URI matrix parameter.

@QueryParam Extracts the value of a URI query parameter.

@PathParam Extracts the value of a URI template parameter.

@CookieParam Extracts the value of a cookie.

@HeaderParam Extracts the value of a header.

@Context Injects an instance of a supported resource, see chapters 9 and 10 for more details.

Because injection occurs at object creation time, use of these annotations (with the exception of `@Context`) on resource class fields and bean properties is only supported for the default per-request resource class lifecycle. An implementation **SHOULD** warn if resource classes with other lifecycles use these annotations on resource class fields or bean properties.

An implementation is only required to set the annotated field and bean property values of instances created by the implementation runtime. Objects returned by sub-resource locators (see Section 3.4.1) are expected to be initialized by their creator and field and bean properties are not modified by the implementation runtime.

Valid parameter types for each of the above annotations are listed in the corresponding Javadoc, however in general (excluding `@Context`) the following types are supported:

1. Primitive types.
2. Types that have a constructor that accepts a single `String` argument.
3. Types that have a static method named `valueOf` or `fromString` with a single `String` argument that return an instance of the type. If both methods are present then `valueOf` **MUST** be used unless the type is an enum in which case `fromString` **MUST** be used¹.
4. `List<T>`, `Set<T>`, or `SortedSet<T>`, where `T` satisfies 2 or 3 above.

The `DefaultValue` annotation may be used to supply a default value for some of the above, see the Javadoc for `DefaultValue` for usage details and rules for generating a value in the absence of this annotation and the requested data. The `Encoded` annotation may be used to disable automatic URI decoding for `@MatrixParam`, `@QueryParam`, and `@PathParam` annotated fields and properties.

A `WebApplicationException` thrown during construction of field or property values using 2 or 3 above is processed directly as described in Section 3.3.4. Other exceptions thrown during construction of field or property values using 2 or 3 above are treated as client errors: if the field or property is annotated with `@MatrixParam`, `@QueryParam` or `@PathParam` then an implementation **MUST** generate a `WebApplicationException` that wraps the thrown exception with a not found response (404 status) and no entity; if the field or property is annotated with `@HeaderParam` or `@CookieParam` then an implementation **MUST** generate a `WebApplicationException` that wraps the thrown exception with a client error response (400 status) and no entity. The `WebApplicationException` **MUST** then be processed as described in Section 3.3.4.

¹Due to limitations of the built-in `valueOf` method that is part of all Java enumerations, a `fromString` method is often defined by the enum writers. Consequently, the `fromString` method is preferred when available.

3.3 Resource Methods

Resource methods are methods of a resource class annotated with a request method designator. They are used to handle requests and MUST conform to certain restrictions described in this section.

A request method designator is a runtime annotation that is annotated with the `@HttpMethod` annotation. JAX-RS defines a set of request method designators for the common HTTP methods: `@GET`, `@POST`, `@PUT`, `@DELETE`, `@HEAD`. Users may define their own custom request method designators including alternate designators for the common HTTP methods.

3.3.1 Visibility

Only `public` methods may be exposed as resource methods. An implementation SHOULD warn users if a `non-public` method carries a method designator or `@Path` annotation.

3.3.2 Parameters

When a resource method is invoked, parameters annotated with `@FormParam` or one of the annotations listed in Section 3.2 are mapped from the request according to the semantics of the annotation. Similar to fields and bean properties:

- The `DefaultValue` annotation may be used to supply a default value for parameters
- The `Encoded` annotation may be used to disable automatic URI decoding of parameter values
- Exceptions thrown during construction of parameter values are treated the same as exceptions thrown during construction of field or bean property values, see Section 3.2. Exceptions thrown during construction of `@FormParam` annotated parameter values are treated the same as if the parameter were annotated with `@HeaderParam`.

3.3.2.1 Entity Parameters

The value of a parameter not annotated with `@FormParam` or any of the annotations listed in in Section 3.2, called the entity parameter, is mapped from the request entity body. Conversion between an entity body and a Java type is the responsibility of an entity provider, see Section 4.2. Resource methods MUST have at most one entity parameter.

3.3.3 Return Type

Resource methods MAY return `void`, `Response`, `GenericEntity`, or another Java type, these return types are mapped to a response entity body as follows:

`void` Results in an empty entity body with a 204 status code.

`Response` Results in an entity body mapped from the entity property of the `Response` with the status code specified by the status property of the `Response`. A `null` return value results in a 204 status code. If the status property of the `Response` is not set: a 200 status code is used for a non-`null` entity property and a 204 status code is used if the entity property is `null`.

GenericEntity Results in an entity body mapped from the `Entity` property of the `GenericEntity`. If the return value is not `null` a 200 status code is used, a `null` return value results in a 204 status code.

Other Results in an entity body mapped from the class of the returned instance. If the return value is not `null` a 200 status code is used, a `null` return value results in a 204 status code.

Methods that need to provide additional metadata with a response should return an instance of `Response`, the `ResponseBuilder` class provides a convenient way to create a `Response` instance using a builder pattern.

Conversion between a Java object and an entity body is the responsibility of an entity provider, see Section 4.2. The return type of a resource method and the type of the returned instance are used to determine the raw type and generic type supplied to the `isWritable` method of `MessageBodyWriter` as follows:

Return Type	Returned Instance ²	Raw Type	Generic Type
<code>GenericEntity</code>	<code>GenericEntity</code> or subclass	<code>RawType</code> property	<code>Type</code> property
<code>Response</code>	<code>GenericEntity</code> or subclass	<code>RawType</code> property	<code>Type</code> property
<code>Response</code>	<code>Object</code> or subclass	Class of instance	Class of instance
<code>Other</code>	Return type or subclass	Class of instance	Generic type of return type

Table 3.1: Determining raw and generic types of return values

To illustrate the above consider a method that always returns an instance of `ArrayList<String>` either directly or wrapped in some combination of `Response` and `GenericEntity`. The resulting raw and generic types are shown below.

Return Type	Returned Instance	Raw Type	Generic Type
<code>GenericEntity</code>	<code>GenericEntity<List<String>></code>	<code>ArrayList<?></code>	<code>List<String></code>
<code>Response</code>	<code>GenericEntity<List<String>></code>	<code>ArrayList<?></code>	<code>List<String></code>
<code>Response</code>	<code>ArrayList<String></code>	<code>ArrayList<?></code>	<code>ArrayList<?></code>
<code>List<String></code>	<code>ArrayList<String></code>	<code>ArrayList<?></code>	<code>List<String></code>

Table 3.2: Example raw and generic types of return values

3.3.4 Exceptions

A resource method, sub-resource method or sub-resource locator may throw any checked or unchecked exception. An implementation **MUST** catch all exceptions and process them as follows:

1. Instances of `WebApplicationException` **MUST** be mapped to a response as follows. If the `response` property of the exception does not contain an entity and an exception mapping provider (see Section 4.4) is available for `WebApplicationException` an implementation **MUST** use the provider to create a new `Response` instance, otherwise the `response` property is used directly. The resulting `Response` instance is then processed according to Section 3.3.3.
2. If an exception mapping provider (see Section 4.4) is available for the exception or one of its super-classes, an implementation **MUST** use the provider whose generic type is the nearest superclass of

²Or `Entity` property of returned instance if return type is `Response` or a subclass thereof.

the exception to create a `Response` instance that is then processed according to Section 3.3.3. If the exception mapping provider throws an exception while creating a `Response` then return a server error (status code 500) response to the client.

3. Unchecked exceptions and errors **MUST** be re-thrown and allowed to propagate to the underlying container.
4. Checked exceptions and throwables that cannot be thrown directly **MUST** be wrapped in a container-specific exception that is then thrown and allowed to propagate to the underlying container. Servlet-based implementations **MUST** use `ServletException` as the wrapper. JAX-WS Provider-based implementations **MUST** use `WebServiceException` as the wrapper.

Note: Items 3 and 4 allow existing container facilities (e.g. a Servlet filter or error pages) to be used to handle the error if desired.

3.3.5 HEAD and OPTIONS

`HEAD` and `OPTIONS` requests receive additional automated support. On receipt of a `HEAD` request an implementation **MUST** either:

1. Call a method annotated with a request method designator for `HEAD` or, if none present,
2. Call a method annotated with a request method designator for `GET` and discard any returned entity.

Note that option 2 may result in reduced performance where entity creation is significant.

On receipt of an `OPTIONS` request an implementation **MUST** either:

1. Call a method annotated with a request method designator for `OPTIONS` or, if none present,
2. Generate an automatic response using the metadata provided by the JAX-RS annotations on the matching class and its methods.

3.4 URI Templates

A root resource class is anchored in URI space using the `@Path` annotation. The value of the annotation is a relative URI path template whose base URI is provided by the combination of the deployment context and the application path (see the `@ApplicationPath` annotation).

A URI path template is a string with zero or more embedded parameters that, when values are substituted for all the parameters, is a valid URI[5] path. The Javadoc for the `@Path` annotation describes their syntax. E.g.:

```
1  @Path("widgets/{id}")
2  public class Widget {
3      ...
4  }
```

In the above example the `Widget` resource class is identified by the relative URI path `widgets/xxx` where `xxx` is the value of the `id` parameter.

Note: Because ‘{’ and ‘}’ are not part of either the reserved or unreserved productions of *URI[5]* they will not appear in a valid *URI*.

The value of the annotation is automatically encoded, e.g. the following two lines are equivalent:

```
1  @Path("widget_list/{id}")
2  @Path("widget%20list/{id}")
```

Template parameters can optionally specify the regular expression used to match their values. The default value matches any text and terminates at the end of a path segment but other values can be used to alter this behavior, e.g.:

```
1  @Path("widgets/{path:..+}")
2  public class Widget {
3      ...
4  }
```

In the above example the `Widget` resource class will be matched for any request whose path starts with `widgets` and contains at least one more path segment; the value of the `path` parameter will be the request path following `widgets`. E.g. given the request path `widgets/small/a` the value of `path` would be `small/a`.

The value of a *URI* path parameter is available for injection via `@PathParam` on a field, property or method parameter. Note that if a *URI* template is used on a method, a path parameter injected in a field or property may not be available (set to `null`). The following example illustrates this scenario:

```
1  @Path("widgets")
2  public class WidgetsResource {
3      @PathParam("id") String id;
4
5      @GET
6      public WidgetList getWidgets() {
7          ... // id is null here
8      }
9
10     @GET
11     @Path("{id}")
12     public Widget findWidget() {
13         return new WidgetResource(id);
14     }
15 }
```

3.4.1 Sub Resources

Methods of a resource class that are annotated with `@Path` are either sub-resource methods or sub-resource locators. Sub-resource methods handle a *HTTP* request directly whilst sub-resource locators return an object that will handle a *HTTP* request. The presence or absence of a request method designator (e.g. `@GET`) differentiates between the two:

Present Such methods, known as *sub-resource methods*, are treated like a normal resource method (see Section 3.3) except the method is only invoked for request URIs that match a URI template created by concatenating the URI template of the resource class with the URI template of the method³.

Absent Such methods, known as *sub-resource locators*, are used to dynamically resolve the object that will handle the request. Any returned object is treated as a resource class instance and used to either handle the request or to further resolve the object that will handle the request, see 3.7 for further details. An implementation **MUST** dynamically determine the class of object returned rather than relying on the static sub-resource locator return type since the returned instance may be a subclass of the declared type with potentially different annotations, see Section 3.6 for rules on annotation inheritance. Sub-resource locators may have all the same parameters as a normal resource method (see Section 3.3) except that they **MUST NOT** have an entity parameter.

The following example illustrates the difference:

```

1  @Path("widgets")
2  public class WidgetsResource {
3      @GET
4      @Path("offers")
5      public WidgetList getDiscounted() {...}
6
7      @Path("{id}")
8      public WidgetResource findWidget(@PathParam("id") String id) {
9          return new WidgetResource(id);
10     }
11 }
12
13 public class WidgetResource {
14     public WidgetResource(String id) {...}
15
16     @GET
17     public Widget getDetails() {...}
18 }

```

In the above a GET request for the `widgets/offers` resource is handled directly by the `getDiscounted` sub-resource method of the resource class `WidgetsResource` whereas a GET request for `widgets/xxx` is handled by the `getDetails` method of the `WidgetResource` resource class.

Note: A set of sub-resource methods annotated with the same URI template value are functionally equivalent to a similarly annotated sub-resource locator that returns an instance of a resource class with the same set of resource methods.

3.5 Declaring Media Type Capabilities

Application classes can declare the supported request and response media types using the `@Consumes` and `@Produces` annotations respectively. These annotations **MAY** be applied to a resource method, a resource class, or to an entity provider (see Section 4.2.3). Use of these annotations on a resource method overrides any on the resource class or on an entity provider for a method argument or return type. In the absence of either of these annotations, support for any media type (`"*/*"`) is assumed.

³If the resource class URI template does not end with a `'/'` character then one is added during the concatenation.

The following example illustrates the use of these annotations:

```
1  @Path("widgets")
2  @Produces("application/widgets+xml")
3  public class WidgetsResource {
4
5      @GET
6      public Widgets getAsXML() {...}
7
8      @GET
9      @Produces("text/html")
10     public String getAsHtml() {...}
11
12     @POST
13     @Consumes("application/widgets+xml")
14     public void addWidget(Widget widget) {...}
15 }
16
17 @Provider
18 @Produces("application/widgets+xml")
19 public class WidgetsProvider implements MessageBodyWriter<Widgets> {...}
20
21 @Provider
22 @Consumes("application/widgets+xml")
23 public class WidgetProvider implements MessageBodyReader<Widget> {...}
```

In the above:

- The `getAsXML` resource method will be called for GET requests that specify a response media type of `application/widgets+xml`. It returns a `Widgets` instance that will be mapped to that format using the `WidgetsProvider` class (see Section 4.2 for more information on `MessageBodyWriter`).
- The `getAsHtml` resource method will be called for GET requests that specify a response media type of `text/html`. It returns a `String` containing `text/html` that will be written using the default implementation of `MessageBodyWriter<String>`.
- The `addWidget` resource method will be called for POST requests that contain an entity of the media type `application/widgets+xml`. The value of the `widget` parameter will be mapped from the request entity using the `WidgetProvider` class (see Section 4.2 for more information on `MessageBodyReader`).

An implementation **MUST NOT** invoke a method whose effective value of `@Produces` does not match the request `Accept` header. An implementation **MUST NOT** invoke a method whose effective value of `@Consumes` does not match the request `Content-Type` header.

When accepting multiple media types, clients may indicate preferences by using a relative quality factor known as the *q* parameter. The value of the *q* parameter, or *q*-value, is used to sort the set of accepted types. For example, a client may indicate preference for `application/widgets+xml` with a relative quality factor of 1 and for `application/xml` with a relative quality factor of 0.8. *Q*-values range from 0 (undesirable) to 1 (highly desirable), with 1 used as default when omitted. A GET request matched to the `WidgetsResource` class with an accept header of `text/html; q=1, application/widgets+xml; q=0.8` will result in a call to method `getAsHtml` instead of `getAsXML` based on the value of *q*.

A server can also indicate media type preference using the *qs* parameter; server preference is only examined when multiple media types are accepted by a client *with the same q-value*. Consider the following example:

```

1  @Path("widgets2")
2  public class WidgetsResource2 {
3
4      @GET
5      @Produces("application/xml", "application/json")
6      public Widgets getWidget() {...}
7
8  }

```

Suppose a client issues a GET request with an accept header of `application/*; q=0.5, text/html`. Based on this request, the server determines that both `application/xml` and `application/json` are equally preferred by the client with a q-value of 0.5. By specifying a server relative quality factor as part of the `@Produces` annotation, it is possible to control which response media type to select:

```

1  @Path("widgets2")
2  public class WidgetsResource2 {
3
4      @GET
5      @Produces("application/xml; qs=1", "application/json; qs=0.75")
6      public Widgets getWidget() {...}
7
8  }

```

With the updated value for `@Produces` in this example, and in response to a GET request with an accept header that includes `application/*; q=0.5`, JAX-RS implementations are **REQUIRED** to select the media type `application/xml` given its higher qs-value. Note that qs-values, just like q-values, are relative and as such are only comparable to other qs-values within the same `@Produces` annotation instance. For more information see Section 3.8.

3.6 Annotation Inheritance

JAX-RS annotations **MAY** be used on the methods and method parameters of a super-class or an implemented interface. Such annotations are inherited by a corresponding sub-class or implementation class method provided that method and its parameters do not have any JAX-RS annotations of its own. Annotations on a super-class take precedence over those on an implemented interface. The precedence over conflicting annotations defined in multiple implemented interfaces is implementation specific.

If a subclass or implementation method has any JAX-RS annotations then *all* of the annotations on the super class or interface method are ignored. E.g.:

```

1  public interface ReadOnlyAtomFeed {
2      @GET @Produces("application/atom+xml")
3      Feed getFeed();
4  }
5
6  @Path("feed")
7  public class ActivityLog implements ReadOnlyAtomFeed {
8      public Feed getFeed() {...}
9  }

```

In the above, `ActivityLog.getFeed` inherits the `@GET` and `@Produces` annotations from the interface. Conversely:

```
1  @Path("feed")
2  public class ActivityLog implements ReadOnlyAtomFeed {
3      @Produces("application/atom+xml")
4      public Feed getFeed() {...}
5  }
```

In the above, the `@GET` annotation on `ReadOnlyAtomFeed.getFeed` is not inherited by `ActivityLog.getFeed` and it would require its own request method designator since it redefines the `@Produces` annotation.

For consistency with other Java EE specifications, it is recommended to always repeat annotations instead of relying on annotation inheritance.

3.7 Matching Requests to Resource Methods

This section describes how a request is matched to a resource class and method. Implementations are not required to use the algorithm as written but **MUST** produce results equivalent to those produced by the algorithm.

3.7.1 Request Preprocessing

Prior to matching, request URIs are normalized⁴ by following the rules for case, path segment, and percent encoding normalization described in section 6.2.2 of RFC 3986[5]. The normalized request URI **MUST** be reflected in the URIs obtained from an injected `UriInfo`.

3.7.2 Request Matching

A request is matched to the corresponding resource method or sub-resource method by comparing the normalized request URI (see Section 3.7.1), the media type of any request entity, and the requested response entity format to the metadata annotations on the resource classes and their methods. If no matching resource method or sub-resource method can be found then an appropriate error response is returned. Matching of requests to resource methods proceeds in three stages as follows:

1. Identify the root resource class:

Input U = request URI path, $C = \{\text{root resource classes}\}$

Output U = final capturing group not yet matched, O = instance of resource class matched so far

- (a) Set $E = \{\}$
- (b) For each class in C add a regular expression (computed using the function $R(A)$ described in Section 3.7.3) to E as follows:
 - Add $R(T_{\text{class}})$ where T_{class} is the URI path template specified for the class.
- (c) Filter E by matching each member against U as follows:
 - Remove members that do not match U .

⁴Note: some containers might perform this functionality prior to passing the request to an implementation.

- Remove members for which the final regular expression capturing group (henceforth simply referred to as a capturing group) value is neither empty nor `'/'` and the class associated with $R(T_{\text{class}})$ had no sub-resource methods or locators.
 - (d) If E is empty then no matching resource can be found, the algorithm terminates and an implementation MUST generate a `WebApplicationException` with a not found response (HTTP 404 status) and no entity. The exception MUST be processed as described in Section 3.3.4.
 - (e) Sort E using the number of literal characters⁵ in each member as the primary key (descending order), the number of capturing groups as a secondary key (descending order) and the number of capturing groups with non-default regular expressions (i.e. not `'([^\w]+?)'`) as the tertiary key (descending order).
 - (f) Set R_{match} to be the first member of E , set U to be the value of the final capturing group of R_{match} when matched against U , and instantiate an object O of the associated class.
2. Obtain the object that will handle the request and a set of candidate methods:

Input U = final capturing group not yet matched, O = instance of resource class matched so far

Output O = instance of resource class matched, M = candidate resource methods of O

- (a) If U is null or `'/'`, set

$$M = \{\text{resource methods of } O \text{ (excluding sub resource methods)}\}$$

and if $M \neq \{\}$ go to step 3

- (b) Set $C = \text{class of } O$, $E = \{\}$

- (c) For class C add regular expressions to E for each sub-resource method and locator as follows:

- i. For each sub-resource method, add $R(T_{\text{method}})$ where T_{method} is the URI path template of the sub-resource method.
- ii. For each sub-resource locator, add $R(T_{\text{locator}})$ where T_{locator} is the URI path template of the sub-resource locator.

- (d) Filter E by matching each member against U as follows:

- Remove members that do not match U .
- Remove members derived from T_{method} (those added in step 2(c)i) for which the final capturing group value is neither empty nor `'/'`.

- (e) If E is empty then no matching resource can be found, the algorithm terminates and an implementation MUST generate a `WebApplicationException` with a not found response (HTTP 404 status) and no entity. The exception MUST be processed as described in Section 3.3.4.

- (f) Sort E using the number of literal characters in each member as the primary key (descending order), the number of capturing groups as a secondary key (descending order), the number of capturing groups with non-default regular expressions (i.e. not `'([^\w]+?)'`) as the tertiary key (descending order), and the source of each member as quaternary key sorting those derived from T_{method} ahead of those derived from T_{locator} .

- (g) Set R_{match} to be the first member of E

- (h) If R_{match} was derived from T_{method} , then set

$$M = \{\text{subresource methods of } O \text{ where } R(T_{\text{method}}) = R_{\text{match}}\}$$

and go to step 3.

⁵Here, literal characters means those not resulting from template variable substitution.

- (i) Set U to be the value of the final capturing group of $R(T_{\text{match}})$ when matched against U , invoke the sub-resource locator method of O and set O to the value returned from that method.
- (j) Go to step 2a.

3. Identify the method that will handle the request:

Input O = instance of resource class matched, M = candidate resource methods of O

Output O = instance of resource class matched, m = resource method matched from M

(a) Filter M by removing members that do not meet the following criteria:

- The request method is supported. If no methods support the request method an implementation MUST generate a `WebApplicationException` with a method not allowed response (HTTP 405 status) and no entity. The exception MUST be processed as described in Section 3.3.4. Note the additional support for `HEAD` and `OPTIONS` described in Section 3.3.5.
- The media type of the request entity body (if any) is a supported input data format (see Section 3.5). If no methods support the media type of the request entity body an implementation MUST generate a `WebApplicationException` with an unsupported media type response (HTTP 415 status) and no entity. The exception MUST be processed as described in Section 3.3.4.
- At least one of the acceptable response entity body media types is a supported output data format (see Section 3.5). If no methods support one of the acceptable response entity body media types an implementation MUST generate a `WebApplicationException` with a not acceptable response (HTTP 406 status) and no entity. The exception MUST be processed as described in Section 3.3.4.

(b) If M has more than one element, sort it in descending order. Let a *client* media type be of the form $n/m;q=v_1$, a *server* media type be of the form $n/m;q=v_2$ and a *combined* media type be of the form $n/m;q=v_1;q=v_2;d=v_3$, where the distance factor d is defined below. For any of these types, m could be $*$, or m and n could be $*$ and the values of q and qs are assumed to be 1.0 if absent.

Let $S(p_1, p_2)$ be defined over a client media type p_1 and a server media type p_2 as the function that returns the *most* specific combined type with a distance factor if p_1 and p_2 are compatible and \perp otherwise. For example:

- $S(\text{text/html};q=1, \text{text/html};qs=1) = \text{text/html};q=1;qs=1;d=0$,
- $S(\text{text}/*;q=0.5, \text{text/html};qs=0.8) = \text{text/html};q=0.5;qs=0.8;d=1$,
- $S(*/*;q=0.2, \text{text}/*;qs=0.9) = \text{text}/*;q=0.2;qs=0.9;d=1$,
- $S(\text{text}/*;q=0.4, \text{application}/*;qs=0.3) = \perp$.

where the d factor corresponds to the number of wildcards matched with a concrete type or subtype. Note that q and qs are not matched, but simply combined in the resulting media type. A total ordering can be defined over combined media types as follows.

We write $n_1/m_1;q=v_1;qs=v'_1;d=v''_1 \geq n_2/m_2;q=v_2;qs=v'_2;d=v''_2$ if one of these ordered conditions holds:

- i. $n_1/m_1 \succ n_2/m_2$ where the partial order \succ is defined as $n/m \succ n/* \succ */*$,
- ii. $n_2/m_2 \not\succ n_1/m_1$ and $v_1 > v_2$,
- iii. $n_2/m_2 \not\succ n_1/m_1$ and $v_1 = v_2$ and $v'_1 > v'_2$.
- iv. $n_2/m_2 \not\succ n_1/m_1$ and $v_1 = v_2$ and $v'_1 = v'_2$ and $v''_1 \leq v''_2$.

Note that \geq is a total order even though \succ is a partial order. For example, the following holds $\text{text/html;q=1.0;q=0.7;d=0} \geq \text{application/xml;q=1.0;q=0.2;d=0}$ even though text/html is incomparable to application/xml according to \succ . Additionally, it is possible under \geq for two types to be equal even though they are not identical⁶. For convenience, we defined $p \geq \perp$ for every media type p .

Given these definitions, we can now sort M in descending order based on \geq as follows⁷:

- Let t be the request content type and C_M a resource method's `@Consumes` set of server media types, we use the media type $\max_{\geq}\{S(t, c) \mid (t, c) \in \{t\} \times C_M\}$ as primary key.
 - Let A be the request accept header set of client media types and P_M a resource method's `@Produces` set of server media types, we use the media type $\max_{\geq}\{S(a, p) \mid (a, p) \in A \times P_M\}$ as secondary key. If there is more than one maximum element⁶, implementations SHOULD report a warning and select one of these types in an implementation dependent manner.
- (c) The request is dispatched to the first resource method m in the set M ⁸. If after sorting, there is more than one maximum element in M , implementations SHOULD report a warning and select one of these methods in an implementation dependent manner.

Consider the following example and assume the request to be `GET widgets/1`:

```

1  @Path("widget")
2  public class WidgetResource {
3      private String id;
4
5      public WidgetResource() {
6          this("0");
7      }
8
9      public WidgetResource(String id) {
10         this.id = id;
11     }
12
13     @GET
14     public Widget findWidget() {
15         return Widget.findWidgetById(id);
16     }
17 }
18
19 @Path("widgets")
20 public class WidgetsResource {
21
22     @Path("{id}")
23     public WidgetResource getWidget(@PathParam("id") String id) {
24         return new WidgetResource(id);
25     }
26 }

```

The input and output values for each of the 3 steps in the matching algorithm are as follows:

⁶E.g., $\text{text/html;q=1.0;q=0.7;d=0} \geq \text{application/xml;q=1.0;q=0.7;d=0}$ and $\text{application/xml;q=1.0;q=0.7;d=0} \geq \text{text/html;q=1.0;q=0.7;d=0}$.

⁷If any of these types or sets of types are unspecified, `/*` and `{/*}` are assumed.

⁸Step 3a ensures the set contains at least one member.

Step 1 Match root resource class using $R(\text{widgets}) = \text{widgets}(/.*)?$ and $R(\text{widget}) = \text{widget}(/.*)?$

Input $U = \text{widgets}/1$ and $C = \{\text{WidgetResource}, \text{WidgetsResource}\}$

Output $U = /1$ and $O = \text{WidgetsResource}$ instance

Step 2 Match resource class instance using $R(\{\text{id}\}) = ([^/]+?)(/.*)?$

Input $U = /1$ and $O = \text{WidgetsResource}$ instance

Output $O = \text{WidgetResource}$ instance and $M = \{\text{findWidget}\}$

Step 3 Match resource class method

Input $O = \text{WidgetResource}$ instance and $M = \{\text{findWidget}\}$

Output $O = \text{WidgetResource}$ instance and $m = \text{findWidget}$

Note that the algorithm matches a single root resource class (`WidgetsResource`) and, consequently, the `@Path` annotation on `WidgetResource` is ignored for the request `GET widgets/1`.

3.7.3 Converting URI Templates to Regular Expressions

The function $R(A)$ converts a URI path template annotation A into a regular expression as follows:

1. URI encode the template, ignoring URI template variable specifications.
2. Escape any regular expression characters in the URI template, again ignoring URI template variable specifications.
3. Replace each URI template variable with a capturing group containing the specified regular expression or `'([^/]+?)'` if no regular expression is specified⁹.
4. If the resulting string ends with `'/'` then remove the final character.
5. Append `'(/.*)?'` to the result.

Note that the above renders the name of template variables irrelevant for template matching purposes. However, implementations will need to retain template variable names in order to facilitate the extraction of template variable values via `@PathParam` or `UriInfo.getPathParameters`.

3.8 Determining the MediaType of Responses

In many cases it is not possible to statically determine the media type of a response. The following algorithm is used to determine the response media type, M_{selected} , at run time:

1. If the method returns an instance of `Response` whose metadata includes the response media type ($M_{\text{specified}}$) then set $M_{\text{selected}} = M_{\text{specified}}$, finish.
2. Gather the set of producible media types P :
 - If the method is annotated with `@Produces`, set $P = \{V(\text{method})\}$ where $V(t)$ represents the values of `@Produces` on the specified target t .
 - Else if the class is annotated with `@Produces`, set $P = \{V(\text{class})\}$.

⁹Note that the syntax `+?` denotes a reluctant quantifier as defined in the `java.util.regex.Pattern` class.

- Else set $P = \{V(\text{writers})\}$ where ‘writers’ is the set of `MessageBodyWriter` that support the class of the returned entity object.
3. If $P = \{\}$, set $P = \{‘*/*’\}$
 4. Obtain the acceptable media types A . If $A = \{\}$, set $A = \{‘*/*’\}$
 5. Set $M = \{\}$. For each member of A , a :
 - For each member of P , p :
 - If a is compatible with p , add $S(a, p)$ to M , where the function S returns the most specific media type of the pair with the q-value of a and server-side qs-value of p .
 6. If $M = \{\}$ then generate a `WebApplicationException` with a not acceptable response (HTTP 406 status) and no entity. The exception MUST be processed as described in Section 3.3.4. Finish.
 7. Sort M in descending order, with a primary key of specificity ($n/m > n/* > */*$), a secondary key of q-value and a tertiary key of qs-value.
 8. For each member of M , m :
 - If m is a concrete type, set $M_{\text{selected}} = m$, finish.
 9. If M contains ‘*/*’ or ‘application/*’, set $M_{\text{selected}} = \text{‘application/octet-stream’}$, finish.
 10. Generate a `WebApplicationException` with a not acceptable response (HTTP 406 status) and no entity. The exception MUST be processed as described in Section 3.3.4. Finish.

Note that the above renders a response with a default media type of ‘application/octet-stream’ when a concrete type cannot be determined. It is RECOMMENDED that `MessageBodyWriter` implementations specify at least one concrete type via `@Produces`.

Chapter 4

Providers

The JAX-RS runtime is extended using application-supplied provider classes. A provider is a class that implements one or more JAX-RS interfaces introduced in this specification and that may be annotated with `@Provider` for automatic discovery. This chapter introduces some of the basic JAX-RS providers; other providers are introduced in Chapter 5 and Chapter 6.

4.1 Lifecycle and Environment

By default a single instance of each provider class is instantiated for each JAX-RS application. First the constructor (see Section 4.1.2) is called, then any requested dependencies are injected (see Chapter 9), then the appropriate provider methods may be called multiple times (simultaneously), and finally the object is made available for garbage collection. Section 9.2.6 describes how a provider obtains access to other providers via dependency injection.

An implementation MAY offer other provider lifecycles, mechanisms for specifying these are outside the scope of this specification. E.g. an implementation based on an inversion-of-control framework may support all of the lifecycle options provided by that framework.

4.1.1 Automatic Discovery

The annotation `@Provider` is used by a JAX-RS runtime to automatically discover provider classes via mechanisms such as class scanning. A JAX-RS implementation that supports automatic discovery of classes MUST process only those classes that are annotated with `@Provider`.

4.1.2 Constructors

Provider classes that are instantiated by the JAX-RS runtime and MUST have a public constructor for which the JAX-RS runtime can provide all parameter values. Note that a zero argument constructor is permissible under this rule.

A public constructor MAY include parameters annotated with `@Context`—Chapter 9 defines the parameter types permitted for this annotation. Since providers may be created outside the scope of a particular request, only deployment-specific properties may be available from injected interfaces at construction time; request-specific properties are available when a provider method is called. If more than one public constructor can be used then an implementation MUST use the one with the most parameters. Choosing amongst constructors

with the same number of parameters is implementation specific, implementations **SHOULD** generate a warning about such ambiguity.

4.2 Entity Providers

Entity providers supply mapping services between representations and their associated Java types. Entity providers come in two flavors: `MessageBodyReader` and `MessageBodyWriter` described below. In the absence of a suitable entity provider, JAX-RS implementations are **REQUIRED** to use the JavaBeans Activation Framework[11] to try to obtain a suitable data handler to perform the mapping instead.

4.2.1 Message Body Reader

The `MessageBodyReader` interface defines the contract between the JAX-RS runtime and components that provide mapping services from representations to a corresponding Java type. A class wishing to provide such a service implements the `MessageBodyReader` interface and may be annotated with `@Provider` for automatic discovery.

The following describes the logical¹ steps taken by a JAX-RS implementation when mapping a request entity body to a Java method parameter:

1. Obtain the media type of the request. If the request does not contain a `Content-Type` header then use `application/octet-stream`.
2. Identify the Java type of the parameter whose value will be mapped from the entity body. Section 3.7 describes how the Java method is chosen.
3. Select the set of `MessageBodyReader` classes that support the media type of the request, see Section 4.2.3.
4. Iterate through the selected `MessageBodyReader` classes and, utilizing the `isReadable` method of each, choose a `MessageBodyReader` provider that supports the desired Java type.
5. If step 4 locates a suitable `MessageBodyReader` then use its `readFrom` method to map the entity body to the desired Java type.
6. Else if a suitable data handler can be found using the JavaBeans Activation Framework[11] then use it to map the entity body to the desired Java type.
7. Else generate a `WebApplicationException` that contains an unsupported media type response (HTTP 415 status) and no entity. The exception **MUST** be processed as described in Section 3.3.4.

A `MessageBodyReader.readFrom` method **MAY** throw `WebApplicationException`. See Section 4.5 for more information on exception handling.

¹Implementations are free to optimize their processing provided the results are equivalent to those that would be obtained if these steps are followed.

4.2.2 Message Body Writer

The `MessageBodyWriter` interface defines the contract between the JAX-RS runtime and components that provide mapping services from a Java type to a representation. A class wishing to provide such a service implements the `MessageBodyWriter` interface and may be annotated with `@Provider` for automatic discovery.

The following describes the logical steps taken by a JAX-RS implementation when mapping a return value to a response entity body:

1. Obtain the object that will be mapped to the response entity body. For a return type of `Response` or subclasses the object is the value of the `entity` property, for other return types it is the returned object.
2. Determine the media type of the response, see Section 3.8.
3. Select the set of `MessageBodyWriter` providers that support (see Section 4.2.3) the object and media type of the response entity body.
4. Sort the selected `MessageBodyWriter` providers with a primary key of media type (see Section 4.2.3) and a secondary key of generic type where providers whose generic type is the nearest super-class of the object class are sorted first.
5. Iterate through the sorted `MessageBodyWriter` providers and, utilizing the `isWriteable` method of each, choose an `MessageBodyWriter` that supports the object that will be mapped to the entity body.
6. If step 5 locates a suitable `MessageBodyWriter` then use its `writeTo` method to map the object to the entity body.
7. Else if a suitable data handler can be found using the JavaBeans Activation Framework[11] then use it to map the object to the entity body.
8. Else generate a `WebApplicationException` with an internal server error response (HTTP 500 status) and no entity. The exception MUST be processed as described in Section 3.3.4.

A `MessageBodyWriter.write` method MAY throw `WebApplicationException`. See Section 4.5 for more information on exception handling.

4.2.3 Declaring Media Type Capabilities

Message body readers and writers MAY restrict the media types they support using the `@Consumes` and `@Produces` annotations respectively. The absence of these annotations is equivalent to their inclusion with media type ("*/*"), i.e. absence implies that any media type is supported. An implementation MUST NOT use an entity provider for a media type that is not supported by that provider.

When choosing an entity provider an implementation sorts the available providers according to the media types they declare support for. Sorting of media types follows the general rule: $x/y < x/* < */*$, i.e. a provider that explicitly lists a media types is sorted before a provider that lists `*/*`.

4.2.4 Standard Entity Providers

An implementation **MUST** include pre-packaged `MessageBodyReader` and `MessageBodyWriter` implementations for the following Java and media type combinations:

`byte[]` All media types (`*/*`).

`java.lang.String` All media types (`*/*`).

`java.io.InputStream` All media types (`*/*`).

`java.io.Reader` All media types (`*/*`).

`java.io.File` All media types (`*/*`).

`javax.activation.DataSource` All media types (`*/*`).

`javax.xml.transform.Source` XML types (`text/xml`, `application/xml` and `application/*+xml`).

`javax.xml.bind.JAXBElement` and application-supplied JAXB classes XML media types (`text/xml`, `application/xml` and `application/*+xml`).

`MultivaluedMap<String, String>` Form content (`application/x-www-form-urlencoded`).

`StreamingOutput` All media types (`*/*`), `MessageBodyWriter` only.

When reading zero-length request entities, all implementation-supplied `MessageBodyReader` implementations except the JAXB-related one **MUST** create a corresponding Java object that represents zero-length data; they **MUST NOT** return null. The implementation-supplied JAXB `MessageBodyReader` implementation **MUST** throw a `WebApplicationException` with a client error response (HTTP 400) for zero-length request entities.

The implementation-supplied entity provider(s) for `javax.xml.bind.JAXBElement` and application-supplied JAXB classes **MUST** use `JAXBContext` instances provided by application-supplied context resolvers, see Section 4.3. If an application does not supply a `JAXBContext` for a particular type, the implementation-supplied entity provider **MUST** use its own default context instead.

When writing responses, implementations **SHOULD** respect application-supplied character set metadata and **SHOULD** use UTF-8 if a character set is not specified by the application or if the application specifies a character set that is unsupported.

An implementation **MUST** support application-provided entity providers and **MUST** use those in preference to its own pre-packaged providers when either could handle the same request.

4.2.5 Transfer Encoding

Transfer encoding for inbound data is handled by a component of the container or the JAX-RS runtime. `MessageBodyReader` providers always operate on the decoded HTTP entity body rather than directly on the HTTP message body.

A JAX-RS runtime or container **MAY** transfer encode outbound data or this **MAY** be done by application code.

4.2.6 Content Encoding

Content encoding is the responsibility of the application. Application-supplied entity providers MAY perform such encoding and manipulate the HTTP headers accordingly.

4.3 Context Providers

Context providers supply context to resource classes and other providers. A context provider class implements the `ContextResolver<T>` interface and may be annotated with `@Provider` for automatic discovery. E.g., an application wishing to provide a customized `JAXBContext` to the default JAXB entity providers would supply a class implementing `ContextResolver<JAXBContext>`.

Context providers MAY return `null` from the `getContext` method if they do not wish to provide their context for a particular Java type. E.g. a JAXB context provider may wish to only provide the context for certain JAXB classes. Context providers MAY also manage multiple contexts of the same type keyed to different Java types.

4.3.1 Declaring Media Type Capabilities

Context provider implementations MAY restrict the media types they support using the `@Produces` annotation. The absence of this annotation is equivalent to its inclusion with media type ("`*/*`"), i.e. absence implies that any media type is supported.

When choosing a context provider an implementation sorts the available providers according to the media types they declare support for. Sorting of media types follows the general rule: `x/y < x/* < */*`, i.e. a provider that explicitly lists a media type is sorted before a provider that lists `/*/*`.

4.4 Exception Mapping Providers

Exception mapping providers map a checked or runtime exception to an instance of `Response`. An exception mapping provider implements the `ExceptionHandler<T>` interface and may be annotated with `@Provider` for automatic discovery. When a resource class or provider method throws an exception for which there is an exception mapping provider, the matching provider is used to obtain a `Response` instance. The resulting `Response` is processed as if the web resource method matching the request had returned the `Response`, see Section 3.3.3. Exception mapping providers are *not* supported as part of the Client API.

When choosing an exception mapping provider to map an exception, an implementation MUST use the provider whose generic type is the nearest superclass of the exception.

To avoid a potentially infinite loop, a single exception mapper should be used during the processing of a request and its corresponding response. JAX-RS implementations SHOULD NOT attempt to map exceptions thrown while processing a response previously mapped from an exception and SHOULD instead simply return a server error (status code 500) response.

4.5 Exceptions

When a provider method throws an exception, the JAX-RS runtime will attempt to map the exception to a suitable HTTP response in the same way as described for methods and locators in Section 3.3.4.

As explained in Section 4.4, an application can supply exception mapping providers to customize this mapping, but these exception mappers may be ignored during the processing of a *previously mapped* response to avoid entering a potentially infinite loop. For example, suppose a method in a message body reader throws an exception that is mapped to a response via an exception mapping provider; if the message body writer throws an exception while trying to write the mapped response, a JAX-RS implementation may simply return a server error (status code 500) instead of mapping the exception one more time.

Chapter 5

Client API

The Client API is used to access Web resources. It provides a higher-level API than `URLConnection` as well as integration with JAX-RS providers. Unless otherwise stated, types presented in this chapter live in the `javax.ws.rs.client` package.

5.1 Bootstrapping a Client Instance

An instance of `Client` is required to access a Web resource using the Client API. The default instance of `Client` can be obtained by calling `newClient` on `ClientFactory`. `Client` instances can be configured by calling the `configuration` method which returns an object of type `Configuration`. Applications use configuration objects to set properties as well as register providers (including features):

```
1 // Default instance of client
2 Client client = ClientFactory.newClient();
3
4 // Additional configuration of default client
5 client.configuration()
6     .setProperty("MyProperty", "MyValue")
7     .register(MyProvider.class)
8     .register(MyFeature.class);
```

See Chapter 4 for more information on providers. Properties are simply name-value pairs where the value is an arbitrary object. Features are also providers and must implement the `Feature` interface; they are useful for grouping sets of properties and providers (including other features) that are logically related and must be enabled as a unit.

5.2 Resource Access

A Web resource can be accessed using a fluent API in which method invocations are chained to build and ultimately submit an HTTP request. The following example gets a `text/plain` representation of the resource identified by `http://example.org/hello`:

```
1 Client client = ClientFactory.newClient();
2 Response res = client.target("http://example.org/hello")
3     .request("text/plain").get();
```

Conceptually, the steps required to submit a request are the following: (i) obtain an instance of `Client` (ii) create a `WebTarget` (iii) create a request from the `WebTarget` and (iv) submit a request or get a prepared `Invocation` for later submission. See Section 5.5 for more information on using `Invocation`.

Method chaining is not limited to the example shown above. A request can be further specified by setting headers, cookies, query parameters, etc. For example:

```
1 Response res = client.target("http://example.org/hello")
2     .queryParam("MyParam", "...")
3     .request("text/plain")
4     .header("MyHeader", "...")
5     .get();
```

See the Javadoc for the classes in the `javax.ws.rs.client` package for more information.

5.3 Targets

The benefits of using a `WebTarget` become apparent when building complex URIs, for example by extending base URIs with additional path segments or templates. The following example highlights these cases:

```
1 WebTarget base = client.target("http://example.org/");
2 WebTarget hello = base.path("hello").path("{whom}");
3 Response res = hello.pathParam("whom", "world").request("...").get();
```

Note the use of the URI template parameter `{whom}`. The example above gets a representation for the resource identified by `http://example.org/hello/world`.

`WebTarget` instances are *immutable* with respect to their URI (or URI template): methods for specifying additional path segments and parameters return a new instance of `WebTarget`. However, `WebTarget` instances are *mutable* with respect to their configuration. Thus, configuring a `WebTarget` does not create new instances.

```
1 // Create WebTarget instance base
2 WebTarget base = client.target("http://example.org/");
3 // Create new WebTarget instance hello and configure
4 WebTarget hello = base.path("hello");
5 hello.configuration().register(MyProvider.class);
```

In this example, two instances of `WebTarget` are created. The instance `hello` inherits the configuration from `base` and it is further configured by registering `MyProvider.class`. Note that changes to `hello`'s configuration do not affect `base`, i.e. configuration inheritance performs a *deep* copy of the configuration. See Section 5.6 for additional information on configurable types.

5.4 Typed Entities

The response to a request is not limited to be of type `Response`. The following example upgrades the status of customer number 123 to “gold status” by first obtaining an entity of type `Customer` and then posting that entity to a different URI:

```

1  Customer c = client.target("http://examples.org/customers/123")
2      .request("application/xml").get(Customer.class);
3  String newId = client.target("http://examples.org/gold-customers/")
4      .request().post(xml(c), String.class);

```

Note the use of the *variant* `xml()` in the call to `post`. The class `javax.ws.rs.client.Entity` defines variants for the most popular media types used in JAX-RS applications.

In the example above, just like in the Server API, JAX-RS implementations are **REQUIRED** to use entity providers to map a representation of type `application/xml` to an instance of `Customer` and vice versa. See Section 4.2.4 for a list of entity providers that **MUST** be supported by all JAX-RS implementations.

5.5 Invocations

An invocation is a request that has been prepared and is ready for execution. Invocations provide a *generic interface* that enables a separation of concerns between the creator and the submitter. In particular, the submitter does not need to know how the invocation was prepared, but only how it should be executed: namely, synchronously or asynchronously.

Let us consider the following example¹:

```

1  // Executed by the creator
2  Invocation inv1 = client.target("http://examples.org/atm/balance")
3      .queryParams("card", "111122223333").queryParams("pin", "9876")
4      .request("text/plain").buildGet();
5  Invocation inv2 = client.target("http://examples.org/atm/withdrawal")
6      .queryParams("card", "111122223333").queryParams("pin", "9876")
7      .request().buildPost(text("50.0"));
8  Collection<Invocation> invs = Arrays.asList(inv1, inv2);
9
10 // Executed by the submitter
11 Collection<Response> ress =
12     Collections.transform(invs,
13         new F<Invocation, Response>() {
14             @Override
15             public Response apply(Invocation inv) {
16                 return inv.invoke(); } });

```

In this example, two invocations are prepared and stored in a collection by the creator. The submitter then traverses the collection applying a transformation that maps an `Invocation` to a `Response`. The mapping calls `Invocation.invoke()` to execute the invocation synchronously; asynchronous execution is also supported by calling `Invocation.submit()`. Refer to Chapter 8 for more information on asynchronous invocations.

5.6 Configurable Types

The following Client API types are configurable: `Client`, `Invocation`, `Invocation.Builder` and `WebTarget`. In all cases, the configuration can be accessed by calling the `configuration` method. This

¹The `Collections` class in this example is arbitrary and does not correspond to any specific implementation. There are a number of Java collection libraries available that provide this type of functionality.

interface supports configuration of:

Features A special type of provider that implement the `Feature` interface and can be used to configure a JAX-RS implementation.

Properties Name-value pairs for additional configuration of features or other components of a JAX-RS implementation.

Providers Classes or instances of classes that implement one or more of the provider interfaces from Chapter 4. A provider can be a message body reader, a filter, a context resolver, etc.

A configuration defined on an instance of any of the aforementioned types is inherited by other instances created from it. For example, an instance of `WebTarget` created from a `Client` will inherit the `Client`'s configuration. However, any additional changes to the instance of `WebTarget` will not impact the `Client`'s configuration and vice versa. Therefore, once a configuration is inherited it is also detached (deep copied) from its parent configuration and changes to the parent and child configurations are not be visible to each other.

5.6.1 Filters and Entity Interceptors

As explained in Chapter 6, filters and interceptors are defined as JAX-RS providers. Therefore, they can be registered in any of the configurable types listed in the previous section. The following example shows how to register filters and interceptors on instances of `Client`, `WebTarget` and `Invocation`:

```
1  // Create client and register logging filter
2  Client client = ClientFactory.newClient();
3  client.configuration().register(LoggingFilter.class);
4
5  // Executes logging filter from client and caching filter from target
6  WebTarget wt = client.target("http://examples.org/customers/123");
7  wt.configuration().register(CachingFilter.class);
8  Customer c = wt.request("application/xml").get(Customer.class);
9
10 // Executes logging filter from client and gzip interceptor from invocation
11 Invocation i = client.target("http://examples.org/gold-customers/")
12     .request().buildPost(xml(c));
13 i.configuration().register(GzipInterceptor.class);
14 String newId = i.invoke(String.class);
```

In this example, `LoggingFilter` is inherited by each instance of `WebTarget` created from `client`; the providers `CachingFilter` and `GzipInterceptor` are defined on a `WebTarget` and an `Invocation`, respectively.

Chapter 6

Filters and Interceptors

Filters and entity interceptors can be registered for execution at well-defined extension points in JAX-RS implementations. They are used to extend an implementation in order to provide capabilities such as logging, confidentiality, authentication, entity compression, etc.

6.1 Introduction

Entity interceptors wrap around a method invocation at a specific extension point. Filters execute code at an extension point but without wrapping a method invocation. There are four extension points for filters: `ClientRequest`, `ClientResponse`, `ContainerRequest` and `ContainerResponse`. There are two extension points for entity interceptors: `ReadFrom` and `WriteTo`. For each of these extension points, there is a corresponding interface:

```
1 public interface ClientRequestFilter {
2     void filter(ClientRequestContext requestContext) throws IOException;
3 }
4 public interface ClientResponseFilter {
5     void filter(ClientRequestContext requestContext,
6         ClientResponseContext responseContext) throws IOException;
7 }
8 public interface ContainerRequestFilter {
9     void filter(ContainerRequestContext requestContext) throws IOException;
10 }
11 public interface ContainerResponseFilter {
12     void filter(ContainerRequestContext requestContext,
13         ContainerResponseContext responseContext) throws IOException;
14 }

1 public interface ReaderInterceptor {
2     Object aroundReadFrom(ReaderInterceptorContext context)
3         throws java.io.IOException, javax.ws.rs.WebApplicationException;
4 }
5 public interface WriterInterceptor {
6     void aroundWriteTo(WriterInterceptorContext context)
7         throws java.io.IOException, javax.ws.rs.WebApplicationException;
8 }
```

A *client* filter is a class that implements `ClientRequestFilter` or `ClientResponseFilter` or both. A *container* filter is a class that implements `ContainerRequestFilter` or `ContainerResponseFilter`, or both. An entity interceptor is a class that implements `ReaderInterceptor` or `WriterInterceptor`, or both. Filters and entity interceptors are providers and, as such, may be annotated with `@Provider` for automatic discovery.

In the Client API, a `ClientRequestFilter` is executed as part of the invocation pipeline, before the HTTP request is delivered to the network; a `ClientResponseFilter` is executed upon receiving a server response, before control is returned to the application. In the Server API, a `ContainerRequestFilter` is executed upon receiving a request from a client; a `ContainerResponseFilter` is executed as part of the response pipeline, before the HTTP response is delivered to the network.

A globally-bound (see Section 6.5.1) `ContainerRequestFilter` is a container filter executed before resource matching *unless* it is annotated with `@PostMatching`. The use of this annotation on this type of filters defines a new extension point for applications to use, namely `PostContainerRequest`. Certain `ContainerRequestContext` methods may not be available at this extension point.

An entity interceptor implementing `ReaderInterceptor` wraps around calls to `MessageBodyReader`'s method `readFrom`. An entity interceptor implementing `WriterInterceptor` wraps around calls to `MessageBodyWriter`'s method `writeTo`. JAX-RS implementations are **REQUIRED** to call registered interceptors when mapping representations to Java types and vice versa. See Section 4.2 for more information on entity providers.

6.2 Filters

Filters are grouped into *filter chains*. There is a separate filter chain for each extension points introduced in the previous section, namely: `ClientRequest`, `ClientResponse`, `ContainerRequest`, `ContainerResponse` and `PostContainerRequest`. Filters in a chain are sorted based on their priorities (see Section 6.6) and are executed in order.

The following example shows an implementation of a container logging filter: each method simply logs the message and returns.

```
1  @Provider
2  class LoggingFilter implements ContainerRequestFilter,
3                                ContainerResponseFilter {
4
5      @Override
6      public void filter(ContainerRequestContext requestContext)
7          throws IOException {
8          log(requestContext);
9      }
10
11     @Override
12     public void filter(ContainerRequestContext requestContext,
13                       ContainerResponseContext responseContext) throws IOException {
14         log(responseContext);
15     }
16     ...
17 }
```

`ContainerRequestContext` is a mutable class that provides request-specific information for the filter, such as request URI, message headers, message entity or request-scoped properties. The exposed setters

allow (certain) modification of the request before its processing by a resource method. The dual class `ContainerResponseContext` provides response-specific information.

Request filters implementing `ClientRequestFilter` or `ContainerRequestFilter` can stop the execution of their corresponding chains by calling `abortWith(Response)` in their corresponding context object. If this method is invoked, JAX-RS implementations are **REQUIRED** to abort execution of the chain and treat the response object as if produced by calling the resource method (Server API) or executing the HTTP invocation (Client API). For example, upon a cache hit, a client *caching* filter may call `abortWith(Response)` to abort execution and optimize network access.

As stated above, a `ContainerRequestFilter` that is *not* annotated with `@PostMatching` is executed upon receiving a client request but *before* a resource method is matched. Thus, this type of filter has the ability to modify the input to the matching algorithm (see Section 3.7.2) and, consequently, alter its outcome. The following example uses a `ContainerRequestFilter` to tunnel requests via POST by using the `X-HTTP-Method-Override` header to overwrite the HTTP method prior to resource matching.

```

1  @Provider
2  public class PostMethodOverrideFilter implements ContainerRequestFilter {
3
4      @Override
5      public void filter(ContainerRequestContext requestContext)
6          throws IOException {
7          if (requestContext.getMethod().equalsIgnoreCase("POST")) {
8              String override = requestContext.getHeaders()
9                  .getFirst("X-HTTP-Method-Override");
10             if (override != null) {
11                 requestContext.setMethod(override);
12             }
13         }
14     }
15 }

```

6.3 Entity Interceptors

An entity interceptor implements interface `ReaderInterceptor` or `WriterInterceptor`, or both. There is an *interceptor chain* for each kind of entity interceptor. Entity interceptors in a chain are sorted based on their priorities (see Section 6.6) and are executed in order.

Entity interceptors wrap calls to the methods `readFrom` in classes implementing `MessageBodyReader` and `writeTo` in classes implementing `MessageBodyWriter`. An interceptor **SHOULD** explicitly call the context method `proceed` to continue the execution of the chain. Because of their wrapping nature, failure to call this method will prevent execution of the wrapped method in the corresponding message body reader or message body writer.

The following example shows an implementation of a GZIP entity interceptor that provides deflate and inflate capabilities ¹.

```

1  @Provider
2  class GzipInterceptor implements ReaderInterceptor, WriterInterceptor {
3
4      @Override

```

¹This class is not intended to be a complete implementation of this interceptor.

```
5      Object aroundReadFrom(ReaderInterceptorContext ctx) ... {
6          InputStream old = ctx.getInputStream();
7          ctx.setInputStream(new GZIPInputStream(old));
8          try {
9              return ctx.proceed();
10         } finally {
11             ctx.setInputStream(old);
12         }
13     }
14
15     @Override
16     void aroundWriteTo(WriterInterceptorContext context) ... {
17         OutputStream old = ctx.getOutputStream();
18         GZIPOutputStream gzipOutputStream = new GZIPOutputStream(old);
19         ctx.setOutputStream(gzipOutputStream);
20         try {
21             ctx.proceed();
22         } finally {
23             gzipOutputStream.finish();
24             ctx.setOutputStream(old);
25         }
26     }
27     ...
28 }
```

The context types, `ReaderInterceptorContext` and `WriterInterceptorContext`, provide read and write access to the parameters of the corresponding wrapped methods. In the example shown above, the input and output streams are wrapped and updated in the context object before proceeding. JAX-RS implementations **MUST** use the last parameter values set in the context object when calling the wrapped methods `MessageBodyReader.readFrom` and `MessageBodyWriter.writeTo`.

6.4 Lifecycle

By default, just like all the other providers, a single instance of each filter or entity interceptor is instantiated for each JAX-RS application. First the constructor is called, then any requested dependencies are injected, then the appropriate methods are called (simultaneously) as needed. Implementations **MAY** offer alternative lifecycle options beyond the default one. See Section 4.1 for additional information.

6.5 Binding

Binding is the process by which a filter or interceptor is associated with a resource class or method (Server API) or an invocation (Client API). The forms of binding presented in the next sections are only supported as part of the Server API. See Section 6.5.4 for binding in the Client API.

6.5.1 Global Binding

Global binding is the default type of binding. A filter or interceptor that has no annotations is assumed to be bound globally, i.e. it applies to all the resource methods in an application. Like any other provider, a filter or interceptor can be registered manually (e.g., via `Application` or `Configuration`) or be discovered

automatically. Note that for a filter or interceptor to be automatically discovered it must be annotated with `@Provider` (see Section 4.1.1).

For example, the `LoggingFilter` defined in Section 6.2 is both automatically discovered (it is annotated with `@Provider`) and bound globally. If this filter is part of an application, requests and responses will be logged for all resource methods.

As stated in Section 6.1, a global `ContainerRequestFilter` is executed before resource matching unless annotated with `@PostMatching`. A global filter that injects `ResourceInfo`, and generally depends on resource information for its execution, must be annotated with `@PostMatching`.

6.5.2 Name Binding

A filter or interceptor can be associated with a resource class or method by declaring a new *binding* annotation à la CDI [12]. These annotations are declared using the JAX-RS meta-annotation `@NameBinding` and are used to decorate both the filter (or interceptor) and the resource method or resource class. For example, the `LoggingFilter` defined in Section 6.2 can be bound to the method `hello` in `MyResourceClass`, instead of globally, as follows:

```

1  @Provider
2  @Logged
3  class LoggingFilter implements ContainerRequestFilter,
4                                ContainerResponseFilter {
5      ...
6  }

1  @Path("/")
2  public class MyResourceClass {
3      @Logged
4      @GET
5      @Produces("text/plain")
6      @Path("{name}")
7      public String hello(@PathParam("name") String name) {
8          return "Hello " + name;
9      }
10 }
```

According to the semantics of `LoggingFilter`, the request will be logged before the `hello` method is called and the response will be logged after it returns. The declaration of the `@Logged` annotation is shown next.

```

1  @NameBinding
2  @Target({ ElementType.TYPE, ElementType.METHOD })
3  @Retention(value = RetentionPolicy.RUNTIME)
4  public @interface Logged { }
```

Binding annotations that decorate resource classes apply to all the resource methods defined in them. A filter or interceptor class can be decorated with multiple binding annotations. Similarly, a resource method can be decorated with multiple binding annotations. Each binding annotation instance in a resource method denotes a set of filters and interceptors whose class definitions are decorated with that annotation (possibly

among others). The final set of (static) filters and interceptors is the union of all these sets ²; this set must be sorted based on priorities as explained in Section 6.6.

6.5.3 Dynamic Binding

The annotation-based forms of binding presented thus far are *static*. Dynamic binding is also supported by using dynamic binders. A dynamic binder is a provider that implements the `DynamicBinder` interface. Dynamic binder providers are used to augment the set of filters and entity interceptors bound to a resource method.

The following example defines a dynamic binder that binds the filter `LoggingFilter` —assumed not globally bound for the purpose of this example— with all the resource methods in `MyResourceClass` that are annotated with `@GET`.

```
1  @Provider
2  class DynamicLoggingFilterBinder implements DynamicBinder<LoggingFilter> {
3
4      @Override
5      public LoggingFilter getBoundProvider(ResourceInfo resourceInfo) {
6          if (MyResourceClass.class.isAssignableFrom(
7              resourceInfo.getResourceClass()) &&
8              resourceInfo.getResourceMethod().isAnnotationPresent(GET.class)) {
9              return new LoggingFilter();
10         }
11         return null;
12     }
13 }
```

The method `getBoundProvider` can return either an instance or a class. The parameter `T` in the type `DynamicBinder<T>` determines the return type. Returning a class, such as `LoggingFilter.class` in the example above, delegates the responsibility of instantiation (and injection) to the JAX-RS implementation. JAX-RS implementations SHOULD resolve dynamic binders for filters and interceptors once for each resource method. It is RECOMMENDED to process dynamic binders at application deployment time.

6.5.4 Binding in Client API

Binding in the Client API is accomplished via API calls instead of annotations. `Client`, `Invocation`, `Invocation.Builder` and `WebTarget` are all configurable types: their configuration can be accessed by calling the `configure` method. See Sections 5.6 for more information.

6.6 Priorities

The order in which filters and interceptors are executed as part of their corresponding chains is controlled by the `@BindingPriority` annotation. Priorities are represented by integer numbers. Execution chains for extension points `ContainerRequest`, `PostContainerRequest` and `ClientRequest` are sorted in *ascending order*; the lower the number the higher the priority. Execution chains for extension points `ContainerResponse` and

²By definition of *set*, any duplicate filters or interceptors in each individual set or the final set are eliminated.

`ClientResponse` are sorted in *descending order*; the higher the number the higher the priority. These rules ensure that response filters are executed in reversed order of request filters.

The `BindingPriority` class defines a set of built-in priorities for security, header decorators, decoders and encoders. The default binding priority is `BindingPriority.USER`. For example, the priority of an authentication filter can be set as follows:

```
1  @Provider
2  @Authenticated
3  @BindingPriority(BindingPriority.SECURITY)
4  public class AuthenticationFilter implements ContainerRequestFilter {
5      ...
6  }
```

Note that even though, as explained in Section 6.5.4, annotations are not used for binding in the Client API, they are still used to define priorities. Therefore, if a priority other than the default is required, the `@BindingPriority` annotation must be used for a filter or interceptor registered using the Client API.

The order in which filters and interceptors that belong to the same priority class are executed is implementation dependent.

6.7 Exceptions

When a filter or interceptor method throws an exception, the JAX-RS runtime will attempt to map the exception as described in Section 4.5. As explained in Section 4.4, an application can supply exception mapping providers to customize this mapping.

Chapter 7

Validation

Validation is the process of verifying that some data obeys one or more pre-defined constraints. The Bean Validation specification [13] defines an API to validate Java Beans. This chapter describes how JAX-RS provides native support for validating resource classes based on the concepts presented in [13].

7.1 Constraint Annotations

The Server API provides support for extracting request values and mapping them into Java fields, properties and parameters using annotations such as `@HeaderParam`, `@QueryParam`, etc. It also supports mapping of request entity bodies into Java objects via non-annotated parameters (i.e., parameters without any JAX-RS annotations). See Chapter 3 for additional information.

In earlier versions of JAX-RS, any additional validation of these values would need to be performed programmatically. This version of JAX-RS introduces support for declarative validation based on the Bean Validation specification [13].

The Bean Validation specification [13] supports the use of *constraint annotations* as a way of declaratively validating beans, method parameters and method returned values. For example, consider the following resource class augmented with constraint annotations:

```
1  @Path("/")
2  class MyResourceClass {
3
4      @POST
5      @Consumes("application/x-www-form-urlencoded")
6      public void registerUser(
7          @NotNull @FormParam("firstName") String firstName,
8          @NotNull @FormParam("lastName") String lastName,
9          @Email @FormParam("email") String email) {
10         ...
11     }
12 }
```

The annotations `@NotNull` and `@Email` impose additional constraints on the form parameters `firstName`, `lastName` and `email`. The `@NotNull` constraint is built-in to the Bean Validation API; the `@Email` constraint is assumed to be user defined in the example above. These constraint annotations are not restricted

to method parameters, they can be used in any location in which the JAX-RS binding annotations are allowed with the exception of constructors and property setters. Rather than using method parameters, the `MyResourceClass` shown above could have been written as follows:

```
1  @Path("/")
2  class MyResourceClass {
3
4      @NotNull @FormParam("firstName")
5      private String firstName;
6
7      @NotNull @FormParam("lastName")
8      private String lastName;
9
10     private String email;
11
12     @FormParam("email")
13     public void setEmail(String email) {
14         this.email = email;
15     }
16
17     @Email
18     public String getEmail() {
19         return email;
20     }
21     ...
22 }
```

Note that in this version, `firstName` and `lastName` are fields initialized via injection and `email` is a resource class property. Constraint annotations on properties are specified in their corresponding getters.

Constraint annotations are also allowed on resource classes. In addition to annotating fields and properties, an annotation can be defined for the entire class. Let us assume that `@NonEmptyNames` validates that one of the two *name* fields in `MyResourceClass` is provided. Using such an annotation, the example above can be extended as follows:

```
1  @Path("/")
2  @NonEmptyNames
3  class MyResourceClass {
4
5      @NotNull @FormParam("firstName")
6      private String firstName;
7
8      @NotNull @FormParam("lastName")
9      private String lastName;
10
11     private String email;
12     ...
13 }
```

Constraint annotations on resource classes are useful for defining cross-field and cross-property constraints.

7.2 Annotations and Validators

Annotation constraints and validators are defined in accordance with the Bean Validation specification [13]. The `@Email` annotation shown above is defined using the Bean Validation `@Constraint` meta-annotation:

```

1  @Target( { METHOD, FIELD, PARAMETER })
2  @Retention(RUNTIME)
3  @Constraint(validatedBy = EmailValidator.class)
4  public @interface Email {
5      String message() default "{com.example.validation.constraints.email}";
6      Class<?>[] groups() default {};
7      Class<? extends Payload>[] payload() default {};
8  }

```

The `@Constraint` annotation must include a reference to the validator class that will be used to validate decorated values. The `EmailValidator` class must implement `ConstraintValidator<Email, T>` where `T` is the type of values being validated. For example,

```

1  public class EmailValidator implements ConstraintValidator<Email, String> {
2      public void initialize(Email email) {
3          ...
4      }
5
6      public boolean isValid(String value, ConstraintValidatorContext context) {
7          ...
8      }
9  }

```

Thus, `EmailValidator` applies to values annotated with `@Email` that are of type `String`. Validators for different types can be defined for the same constraint annotation.

7.3 Entity Validation

Request entity bodies can be mapped to resource method parameters. There are two ways in which these entities can be validated. If the request entity is mapped to a Java bean whose class is decorated with Bean Validation annotations, then validation can be enabled using `@Valid`:

```

1  @StandardUser
2  class User { ... }
3
4  @Path("/")
5  class MyResourceClass {
6
7      @POST
8      @Consumes("application/xml")
9      public void registerUser(@Valid User user) {
10         ...
11     }
12 }

```

In this case, the validator associated with `@StandardUser` will be called to verify the request entity mapped to `user`. Alternatively, a new annotation can be defined and used directly on the resource method parameter.

```
1  @Path("/")
2  class MyResourceClass {
3
4      @POST
5      @Consumes("application/xml")
6      public void registerUser(@PremiumUser User user) {
7          ...
8      }
9  }
```

In the example above, `@PremiumUser` rather than `@StandardUser` will be used to validate the request entity. These two ways in which validation of entities can be triggered can also be combined by including `@Valid` in the list of constraints. The presence of `@Valid` will trigger validation of *all* the constraint annotations decorating a Java bean class.

Response entity bodies returned from resource methods can be validated in a similar manner by annotating the resource method itself. To exemplify, assuming both `@StandardUser` and `@PremiumUser` are required to be checked before returning a user, the `getUser` method can be annotated as shown next:

```
1  @Path("/")
2  class MyResourceClass {
3
4      @GET
5      @Path("{id}")
6      @Produces("application/xml")
7      @Valid @PremiumUser
8      public User getUser(@PathParam("id") String id) {
9          User u = findUser(id);
10         return u;
11     }
12     ...
13 }
```

Note that `@PremiumUser` is explicitly listed and `@StandardUser` is triggered by the presence of the `@Valid` annotation —see definition of `User` class earlier in this section.

7.4 Annotation Inheritance

The rules for inheritance of constraint annotation are defined in [13]. It is worth noting that these rules are incompatible with those defined in Section 3.6. Generally speaking, constraint annotations in [13] are cumulative (can be strengthen) across a given type hierarchy while JAX-RS annotations are inherited or, overridden and ignored.

The goal of this specification is to enable validation of JAX-RS resources by leveraging existing bean validation implementations. Therefore, JAX-RS implementations **MUST** follow the constraint annotation rules defined in [13].

7.5 Validation Phases and Error Reporting

Constraint annotations are allowed in the same locations as the following annotations: `@MatrixParam`, `@QueryParam`, `@PathParam`, `@CookieParam`, `@HeaderParam` and `@Context`, *except* in class constructors and property setters. Specifically, they are allowed in resource method parameters, fields and property getters as well as resource classes, entity parameters and resource methods (return values).

The default resource class instance lifecycle is per-request in JAX-RS. Implementations MAY support other lifecycles; the same caveats related to the use of other JAX-RS annotations in resource classes apply to constraint annotations. For example, a constraint validation annotating a constructor parameter in a resource class whose lifecycle is singleton will only be executed once.

When processing a request, is it desirable to collect and return as many violations as possible rather than to abort execution after the first violation is encountered. JAX-RS implementations are REQUIRED to use the following process to validate resource class instances after they have been instantiated:

Phase 1 Inject field values and initialize bean properties as described in Section 3.2.

Phase 2 Validate annotations on resource classes, fields and property getters. The order in which these validations are executed is implementation dependent.

Phase 3 Validate annotations on parameters passed to the resource method matched. Note that `@Valid` is supported for method parameters.

Phase 4 If no constraint violations found thus far, invoke resource method and validate returned value. Note that just like for method parameters, `@Valid` is supported for returned values.

The set of constraint violations is cumulative. If at the beginning of phase 4, the set of constraint violations is non-empty, implementations MUST throw a `ViolationException` (as subclass of `WebApplicationException`) with a status code 400 (Bad Request) and a list of all the violations encountered. If after phase 4, the set of constraint violations is non-empty, implementations MUST throw a `ViolationException` with a status code 500 (Internal Server Error) and a list of all the violations encountered. As described in Section 4.4, an exception mapper can be defined for `ViolationException`; it is RECOMMENDED that JAX-RS implementations provide a default exception mapper for this type of exception.

Editors Note 7.1 *Should we require constructor parameter validation for beans that are not managed beans, CDI beans or EJBs? I.e., for beans directly managed by the JAX-RS implementation?*

Instances returned by sub-resource locators are validated in the same manner but excluding phase 1 (see Section 3.2 for more information). Note that sub-resource locators can return instances containing other sub-resource locators: only the instance that is matched on step 3 in Section 3.7.2 is validated. This is the instance on which a resource method, as opposed to an intermediate resource locator, is matched.

7.6 Exceptions

When a validator method throws an exception, the JAX-RS runtime will attempt to map the exception to a suitable HTTP response in the same way as described for methods and locators in Section 3.3.4. As explained in Section 4.4, an application can supply exception mapping providers to customize this mapping.

Chapter 8

Asynchronous Processing

This chapter describes the asynchronous processing capabilities in JAX-RS. Asynchronous processing is supported both in the Client API and in the Server API.

8.1 Introduction

Asynchronous processing is a technique that enables a better and more efficient use of processing threads. On the client side, a thread that issues a request may also be responsible for updating a UI component; if that thread is blocked waiting for a response, the user's perceived performance of the application will suffer. Similarly, on the server side, a thread that is processing a request should avoid blocking while waiting for an external event to complete so that it can process other requests that may be arriving to the server during that period¹.

8.2 Server API

Synchronous processing requires a resource method to produce a response upon returning control back to the JAX-RS implementation. Asynchronous processing enables a resource method to inform the JAX-RS implementation that a response is not readily available upon return but will be produced at a future time. This can be accomplished by first *suspending* and later *resuming* the client connection on which the request was received.

Let us illustrate these concepts via an example:

```
1  @Path("/async/longRunning")
2  public class MyResource {
3      @Context
4      private ExecutionContext ctx;
5
6      @GET
7      public void longRunningOp() {
8          ctx.suspend();    // Suspend connection
9          Executors.newSingleThreadExecutor().submit(
10             new Runnable() {
```

¹The maximum number of request threads is typically set by the administrator; if that upper bound is reached, subsequent requests will be rejected.

```
11         public void run() {
12             executeLongRunningOp();
13             ctx.resume("Hello async world!");
14         } });
15     }
16 }
```

Resource classes that support asynchronous processing must inject an instance of `ExecutionContext` in order to suspend and resume connections. In the example above, the method `longRunningOp` is called upon receiving a GET request. Rather than producing a response immediately, this method: (i) calls `suspend` on the injected `ExecutionContext`, (ii) forks a (non-request) thread to execute a long running operation and (iii) returns immediately. Once the execution of the long running operation is complete, the connection is resumed and the response returned by calling the method `resume` on `ExecutionContext`.

8.2.1 Suspend Annotation

An alternative to calling `ctx.suspend()` as the first step after entering an asynchronous method is to annotate the method with `@Suspend`. Thus, the `longRunningOp` method above is equivalent to:

```
1  @GET @Suspend
2  public void longRunningOp() {
3      Executors.newSingleThreadExecutor().submit(
4          new Runnable() {
5              public void run() {
6                  executeLongRunningOp();
7                  ctx.resume("Hello async world!");
8              } });
9  }
10 }
```

The `@Suspend` annotation supports a timeout value that can be used to avoid waiting for a response indefinitely. The default unit is milliseconds, but any unit of type `java.util.concurrent.TimeUnit` can be used:

```
1  @GET @Suspend(timeOut = 15, timeUnit = TimeUnit.SECONDS)
2  public void longRunningOp() {
3      Executors.newSingleThreadExecutor().submit(
4          new Runnable() {
5              public void run() {
6                  executeLongRunningOp();
7                  ctx.resume("Hello async world!");
8              } });
9  }
10 }
```

JAX-RS implementations are **REQUIRED** to generate a `WebApplicationException` with a service unavailable error response (HTTP 503 status) if the timeout value is reached and no fallback response is set in `ExecutionContext`. The exception **MUST** be processed as described in section 3.3.4. If a fallback response is set in `ExecutionContext`, via the method `setResponse`, JAX-RS implementations are **REQUIRED** to return the fallback response without generating a `WebApplicationException` when the timeout is reached.

Overloaded versions of the method `suspend` in `ExecutionContext` also accept a timeout value and a unit, thus providing the same functionality as the `@Suspend` annotation. Note that it is forbidden to call `suspend` more than once or to call it from within a method that is already annotated with `@Suspend`.

8.3 EJB Resource Classes

As stated in Section 10.2.4, JAX-RS implementations in products that support EJB must also support the use of stateless and singleton session beans as root resource classes. When an EJB method is annotated with `@Asynchronous`, the EJB container automatically allocates the necessary resources for its execution. Thus, in this scenario, the use of an `Executor` is unnecessary to generate an asynchronous response.

Consider the following example:

```

1  @Stateless
2  @Path("/")
3  class EJBResource {
4
5      @GET @Suspend @Asynchronous
6      public void longRunningOp(@Context ExecutionContext ctx) {
7          executeLongRunningOp();
8          ctx.resume("Hello async world!");
9      }
10 }
```

There is no explicit thread management is needed in this case since that is under the control of the EJB container. Just like the other examples in this chapter, the response is produced by calling `resume` on the `ExecutionContext`. Hence, the return type of `longRunningOp` is simply `void`.

8.4 Client API

The fluent API supports asynchronous invocations as part of the invocation building process. By default, invocations are synchronous but can be set to run asynchronously by calling the `async` method and (optionally) registering an instance of `InvocationCallback` as shown next:

```

1  Client client = ClientFactory.newClient();
2  Target target = client.target("http://example.org/customers/{id}");
3  target.pathParam("id", 123).request().async().get(
4      new InvocationCallback<Customer>() {
5          @Override
6          public void completed(Customer customer) {
7              // Do something
8          }
9          @Override
10         public void failed(InvocationException error) {
11             // Process error
12         }
13     });
```

Note that in this example, the call to `get` after calling `async` returns immediately without blocking the caller's thread. The response type is specified as a type parameter to `InvocationCallback`. The method

`completed` is called when the invocation completes successfully and a response is available; the method `failed` is called with an instance of `InvocationException` when the invocation fails.

All asynchronous invocations return an instance of `Future<T>` here the type parameter `T` matches the type specified in `InvocationCallback`. This instance can be used to monitor or cancel the asynchronous invocation:

```
1  Future<Customer> ff = target.pathParam("id", 123).request().async().get(
2      new InvocationCallback<Customer>() {
3          @Override
4          public void completed(Customer customer) {
5              // Do something
6          }
7          @Override
8          public void failed(InvocationException error) {
9              // Process error
10         }
11     });
12
13 // After waiting for a while ...
14 if (!ff.isDone()) {
15     ff.cancel(true);
16 }
```

Even though it is recommended to pass an instance of `InvocationCallback` when executing an asynchronous call, it is not mandated. When omitted, the `Future<T>` returned by the invocation can be used to gain access to the response by calling the method `Future.get()`, which will return an instance of `T` if the invocation was successful or `null` if the invocation failed.

Chapter 9

Context

JAX-RS provides facilities for obtaining and processing information about the application deployment context and the context of individual requests. Such information is available to `Application` subclasses (see Section 2.1), root resource classes (see Chapter 3), and providers (see Chapter 4). This chapter describes these facilities.

9.1 Concurrency

Context is specific to a particular request but instances of certain JAX-RS components (providers and resource classes with a lifecycle other than per-request) may need to support multiple concurrent requests. When injecting an instance of one of the types listed in Section 9.2, the instance supplied **MUST** be capable of selecting the correct context for a particular request. Use of a thread-local proxy is a common way to achieve this.

9.2 Context Types

This section describes the types of context available to resource classes, providers and `Application` subclasses.

9.2.1 Application

The instance of the application-supplied `Application` subclass can be injected into a class field or method parameter using the `@Context` annotation. Access to the `Application` subclass instance allows configuration information to be centralized in that class. Note that this cannot be injected into the `Application` subclass itself since this would create a circular dependency.

9.2.2 URIs and URI Templates

An instance of `UriInfo` can be injected into a class field or method parameter using the `@Context` annotation. `UriInfo` provides both static and dynamic, per-request information, about the components of a request URI. E.g. the following would return the names of any query parameters in a request:

```
1  @GET
2  @Produces{"text/plain"}
3  public String listQueryParamNames(@Context UriInfo info) {
4      StringBuilder buf = new StringBuilder();
5      for (String param: info.getQueryParameters().keySet()) {
6          buf.append(param);
7          buf.append("\n");
8      }
9      return buf.toString();
10 }
```

Note that the methods of `UriInfo` provide access to request URI information following the pre-processing described in Section 3.7.1.

9.2.3 Headers

An instance of `HttpHeaders` can be injected into a class field or method parameter using the `@Context` annotation. `HttpHeaders` provides access to request header information either in map form or via strongly typed convenience methods. E.g. the following would return the names of all the headers in a request:

```
1  @GET
2  @Produces{"text/plain"}
3  public String listHeaderNames(@Context HttpHeaders headers) {
4      StringBuilder buf = new StringBuilder();
5      for (String header: headers.getRequestHeaders().keySet()) {
6          buf.append(header);
7          buf.append("\n");
8      }
9      return buf.toString();
10 }
```

Note that the methods of `HttpHeaders` provide access to request information following the pre-processing described in Section 3.7.1.

Response headers may be provided using the `Response` class, see 3.3.3 for more details.

9.2.4 Content Negotiation and Preconditions

JAX-RS simplifies support for content negotiation and preconditions using the `Request` interface. An instance of `Request` can be injected into a class field or method parameter using the `@Context` annotation. The methods of `Request` allow a caller to determine the best matching representation variant and to evaluate whether the current state of the resource matches any preconditions in the request. Precondition support methods return a `ResponseBuilder` that can be returned to the client to inform it that the request preconditions were not met. E.g. the following checks if the current entity tag matches any preconditions in the request before updating the resource:

```
1  @PUT
2  public Response updateFoo(@Context Request request, Foo foo) {
3      EntityTag tag = getCurrentTag();
4      ResponseBuilder responseBuilder = request.evaluatePreconditions(tag);
5      if (responseBuilder != null)
```

```
6         return responseBuilder.build();
7     else
8         return doUpdate(foo);
9 }
```

The application could also set the content location, expiry date and cache control information into the returned `ResponseBuilder` before building the response.

9.2.5 Security Context

The `SecurityContext` interface provides access to information about the security context of the current request. An instance of `SecurityContext` can be injected into a class field or method parameter using the `@Context` annotation. The methods of `SecurityContext` provide access to the current user principal, information about roles assumed by the requester, whether the request arrived over a secure channel and the authentication scheme used.

9.2.6 Providers

The `Providers` interface allows for lookup of provider instances based on a set of search criteria. An instance of `Providers` can be injected into a class field or method parameter using the `@Context` annotation.

This interface is expected to be primarily of interest to provider authors wishing to use other providers functionality.

Chapter 10

Environment

The container-managed resources available to a JAX-RS root resource class or provider depend on the environment in which it is deployed. Section 9.2 describes the types of context available regardless of container. The following sections describe the additional container-managed resources available to a JAX-RS root resource class or provider deployed in a variety of environments.

10.1 Servlet Container

The `@Context` annotation can be used to indicate a dependency on a Servlet-defined resource. A Servlet-based implementation **MUST** support injection of the following Servlet-defined types: `ServletConfig`, `ServletContext`, `HttpServletRequest` and `HttpServletResponse`.

An injected `HttpServletRequest` allows a resource method to stream the contents of a request entity. If the resource method has a parameter whose value is derived from the request entity then the stream will have already been consumed and an attempt to access it **MAY** result in an exception.

An injected `HttpServletResponse` allows a resource method to commit the HTTP response prior to returning. An implementation **MUST** check the committed status and only process the return value if the response is not yet committed.

Servlet filters may trigger consumption of a request body by accessing request parameters. In a servlet container the `@FormParam` annotation and the standard entity provider for `application/x-www-form-urlencoded` **MUST** obtain their values from the servlet request parameters if the request body has already been consumed. Servlet APIs do not differentiate between parameters in the URI and body of a request so URI-based query parameters may be included in the entity parameter.

10.2 Java EE Container

This section describes the additional requirements that apply to a JAX-RS implementation when combined in a product that supports the following specifications.

10.2.1 Servlets

In a product that also supports the Servlet specification, implementations **MUST** support JAX-RS applications that are packaged as a web application. Implementations **MUST** behave as if built using the Servlet 3 pluggability mechanism, see Section 2.3.2.

It is **RECOMMENDED** for JAX-RS implementations to provide asynchronous processing support, as defined in Chapter 8, by enabling asynchronous processing (i.e., `asyncSupported=true`) in the underlying Servlet 3 container. As explained in Section 10.1, injection of Servlet-defined types is possible using the `@Context` annotation.

10.2.2 Managed Beans

In a product that supports Managed Beans, implementations **MUST** support the use of Managed Beans as root resource classes, providers and `Application` subclasses.

For example, a bean that uses a managed-bean interceptor can be defined as a JAX-RS resource as follows:

```
1  @ManagedBean
2  @Path("/managedbean")
3  public class ManagedBeanResource {
4
5      public static class MyInterceptor {
6          @AroundInvoke
7          public String around(InvocationContext ctx) throws Exception {
8              System.out.println("around() called");
9              return (String) ctx.proceed();
10         }
11     }
12
13     @GET
14     @Produces("text/plain")
15     @Interceptors(MyInterceptor.class)
16     public String getIt() {
17         return "Hi managedbean!";
18     }
19 }
```

The example above uses a managed-bean interceptor to intercept calls to the resource method `getIt`. See Section 10.2.5 for additional requirements on Managed Beans.

10.2.3 Context and Dependency Injection (CDI)

In a product that supports CDI, implementations **MUST** support the use of CDI-style Beans as root resource classes, providers and `Application` subclasses. Providers and `Application` subclasses **MUST** be singletons or use application scope.

For example, assuming CDI is enabled via the inclusion of a `beans.xml` file, a CDI-style bean that can be defined as a JAX-RS resource as follows:

```
1  @Path("/cdibean")
2  public class CdiBeanResource {
```

```

3
4     @Inject MyOtherCdiBean bean;           // CDI injected bean
5
6     @GET
7     @Produces("text/plain")
8     public String getIt() {
9         return bean.getIt();
10    }
11 }

```

The example above takes advantage of the type-safe dependency injection provided in CDI by using another bean, of type `MyOtherCdiBean`, in order to return a resource representation. See Section 10.2.5 for additional requirements on CDI-style Beans.

10.2.4 Enterprise Java Beans (EJBs)

In a product that supports EJBs, an implementation **MUST** support the use of stateless and singleton session beans as root resource classes, providers and `Application` subclasses. JAX-RS annotations can be applied to a EJB's local interface or directly to a no-interface EJB. Resource class annotations (like `@Path`) **MUST** be applied to an EJB's class directly following the annotation inheritance rules defined in Section 3.6.

For example, a stateless EJB that implements a local interface can be defined as a JAX-RS resource class as follows:

```

1  @Local
2  public interface LocalEjb {
3
4      @GET
5      @Produces("text/plain")
6      public String getIt();
7  }
8
9  @Stateless
10 @Path("/stateless")
11 public class StatelessEjbResource implements LocalEjb {
12
13     @Override
14     public String getIt() {
15         return "Hi stateless!";
16     }
17 }

```

JAX-RS implementations are **REQUIRED** to discover EJBs by inspecting annotations on classes and local interfaces; they are not **REQUIRED** to read EJB deployment descriptors (`ejb-jar.xml`). Therefore, any information in an EJB deployment descriptor for the purpose of overriding EJB annotations or providing additional meta-data will likely result in a non-portable JAX-RS application.

If an `ExceptionHandler` for a `EJBException` or subclass is not included with an application then exceptions thrown by an EJB resource class or provider method **MUST** be unwrapped and processed as described in Section 3.3.4.

See Section 8.3 for more information on asynchronous EJB methods and Section 10.2.5 for additional requirements on EJBs.

10.2.5 Additional Requirements

The following additional requirements apply when using Managed Beans, CDI-style Beans or EJBs as resource classes, providers or `Application` subclasses:

- Field and property injection of JAX-RS resources **MUST** be performed prior to the container invoking any `@PostConstruct` annotated method.
- Support for constructor injection of JAX-RS resources is **OPTIONAL**. Portable applications **MUST** instead use fields or bean properties in conjunction with a `@PostConstruct` annotated method. Implementations **SHOULD** warn users about use of non-portable constructor injection.
- Implementations **MUST NOT** require use of `@Inject` or `@Resource` to trigger injection of JAX-RS annotated fields or properties. Implementations **MAY** support such usage but **SHOULD** warn users about non-portability.

10.3 Other

Other container technologies **MAY** specify their own set of injectable resources but **MUST**, at a minimum, support access to the types of context listed in Section 9.2.

Chapter 11

Runtime Delegate

`RuntimeDelegate` is an abstract factory class that provides various methods for the creation of objects that implement JAX-RS APIs. These methods are designed for use by other JAX-RS API classes and are not intended to be called directly by applications. `RuntimeDelegate` allows the standard JAX-RS API classes to use different JAX-RS implementations without any code changes.

An implementation of JAX-RS **MUST** provide a concrete subclass of `RuntimeDelegate`. Using the supplied `RuntimeDelegate` this can be provided to JAX-RS in one of two ways:

1. An instance of `RuntimeDelegate` can be instantiated and injected using its static method `setInstance`. In this case the implementation is responsible for creating the instance; this option is intended for use with implementations based on IoC frameworks.
2. The class to be used can be configured, see Section 11.1. In this case JAX-RS is responsible for instantiating an instance of the class and the configured class **MUST** have a public constructor which takes no arguments.

Note that an implementation **MAY** supply an alternate implementation of the `RuntimeDelegate` API class (provided it passes the TCK signature test and behaves according to the specification) that supports alternate means of locating a concrete subclass.

A JAX-RS implementation may rely on a particular implementation of `RuntimeDelegate` being used – applications **SHOULD NOT** override the supplied `RuntimeDelegate` instance with an application-supplied alternative and doing so may cause unexpected problems.

11.1 Configuration

If not supplied by injection, the supplied `RuntimeDelegate` API class obtains the concrete implementation class using the following algorithm. The steps listed below are performed in sequence and, at each step, at most one candidate implementation class name will be produced. The implementation will then attempt to load the class with the given class name using the current context class loader or, missing one, the `java.lang.Class.forName(String)` method. As soon as a step results in an implementation class being successfully loaded, the algorithm terminates.

1. If a resource with the name of `META-INF/services/javax.ws.rs.ext.RuntimeDelegate` exists, then its first line, if present, is used as the UTF-8 encoded name of the implementation class.

2. If the `{java.home}/lib/jaxrs.properties` file exists and it is readable by the `java.util.Properties.load(InputStream)` method and it contains an entry whose key is `javax.ws.rs.ext.RuntimeDelegate`, then the value of that entry is used as the name of the implementation class.
3. If a system property with the name `javax.ws.rs.ext.RuntimeDelegate` is defined, then its value is used as the name of the implementation class.
4. Finally, a default implementation class name is used.

Appendix A

Summary of Annotations

Annotation	Target	Description
Consumes	Type or method	Specifies a list of media types that can be consumed.
Produces	Type or method	Specifies a list of media types that can be produced.
GET	Method	Specifies that the annotated method handles HTTP GET requests.
POST	Method	Specifies that the annotated method handles HTTP POST requests.
PUT	Method	Specifies that the annotated method handles HTTP PUT requests.
DELETE	Method	Specifies that the annotated method handles HTTP DELETE requests.
HEAD	Method	Specifies that the annotated method handles HTTP HEAD requests. Note that HEAD may be automatically handled, see Section 3.3.5.
ApplicationPath	Type	Specifies the resource-wide application path that forms the base URI of all root resource classes.
Path	Type or method	Specifies a relative path for a resource. When used on a class this annotation identifies that class as a root resource. When used on a method this annotation identifies a sub-resource method or locator.
PathParam	Parameter, field or method	Specifies that the value of a method parameter, class field, or bean property is to be extracted from the request URI path. The value of the annotation identifies the name of a URI template parameter.
QueryParam	Parameter, field or method	Specifies that the value of a method parameter, class field, or bean property is to be extracted from a URI query parameter. The value of the annotation identifies the name of a query parameter.
FormParam	Parameter, field or method	Specifies that the value of a method parameter is to be extracted from a form parameter in a request entity body. The value of the annotation identifies the name of a form parameter. Note that whilst the annotation target allows use on fields and methods, the specification only requires support for use on resource method parameters.

Annotation	Target	Description
<code>MatrixParam</code>	Parameter, field or method	Specifies that the value of a method parameter, class field, or bean property is to be extracted from a URI matrix parameter. The value of the annotation identifies the name of a matrix parameter.
<code>CookieParam</code>	Parameter, field or method	Specifies that the value of a method parameter, class field, or bean property is to be extracted from a HTTP cookie. The value of the annotation identifies the name of a the cookie.
<code>HeaderParam</code>	Parameter, field or method	Specifies that the value of a method parameter, class field, or bean property is to be extracted from a HTTP header. The value of the annotation identifies the name of a HTTP header.
<code>Encoded</code>	Type, constructor, method, field or parameter	Disables automatic URI decoding for path, query, form and matrix parameters.
<code>DefaultValue</code>	Parameter, field or method	Specifies a default value for a field, property or method parameter annotated with <code>@QueryParam</code> , <code>@MatrixParam</code> , <code>@CookieParam</code> , <code>@FormParam</code> or <code>@HeaderParam</code> . The specified value will be used if the corresponding query or matrix parameter is not present in the request URI, if the corresponding form parameter is not in the request entity body, or if the corresponding HTTP header is not included in the request.
<code>Context</code>	Field, method or parameter	Identifies an injection target for one of the types listed in Section 9.2 or the applicable section of Chapter 10.
<code>HttpMethod</code>	Annotation	Specifies the HTTP method for a request method designator annotation.
<code>Provider</code>	Type	Specifies that the annotated class implements a JAX-RS extension interface.
Since JAX-RS 2.0		
<code>BindingPriority</code>	Type	Specifies a binding priority for a filter or interceptor. Binding priorities are represented by integer numbers. The default binding priority is 500 (<code>BindingPriority.USER</code>).
<code>NameBinding</code>	Annotation	Meta-annotation to create annotations for binding filters or interceptors to resource methods. Name binding is only supported as part of the Server API.
<code>Suspend</code>	Method	Indicates that a resource method is asynchronous. I.e., that it does not produce a response upon returning. JAX-RS implementations will suspend the incoming connection until a response becomes available.
<code>Uri</code>	Parameter, field or method	Injects a <code>WebTarget</code> pointing at a resource identified by the resolved URI.
<code>PostMatching</code>	Type	Global binding annotation that can be applied to a container filter to indicate that it should be applied globally and after the resource method is matched.

Appendix B

HTTP Header Support

The following table lists HTTP headers that are directly supported, either automatically by a JAX-RS implementation runtime or by an application using the JAX-RS API. Any request header may be obtained using `HttpHeaders`, see Section 9.2.3; response headers not listed here may be set using the `ResponseBuilder.header` method.

Header	Description
Accept	Used by runtime when selecting a resource method, compared to value of <code>@Produces</code> annotation, see Section 3.5.
Accept-Charset	Processed by runtime if application uses <code>Request.selectVariant</code> method, see Section 9.2.4.
Accept-Encoding	Processed by runtime if application uses <code>Request.selectVariant</code> method, see Section 9.2.4.
Accept-Language	Processed by runtime if application uses <code>Request.selectVariant</code> method, see Section 9.2.4.
Allow	Included in automatically generated 405 error responses (see Section 3.7.2) and automatically generated responses to OPTIONS requests (see Section 3.3.5).
Authorization	Depends on container, information available via <code>SecurityContext</code> , see Section 9.2.5.
Cache-Control	See <code>CacheControl</code> class and <code>ResponseBuilder.cacheControl</code> method.
Content-Encoding	Response header set by application using <code>Response.ok</code> or <code>ResponseBuilder.variant</code> .
Content-Language	Response header set by application using <code>Response.ok</code> , <code>ResponseBuilder.language</code> , or <code>ResponseBuilder.variant</code> .
Content-Length	Processed automatically for requests, set automatically in responses if value is provided by the <code>MessageBodyWriter</code> used to serialize the response entity.
Content-Type	Request header used by runtime when selecting a resource method, compared to value of <code>@Consumes</code> annotation, see Section 3.5. Response header either set by application using <code>Response.ok</code> , <code>ResponseBuilder.type</code> , or <code>ResponseBuilder.variant</code> , or set automatically by runtime (see Section 3.8).
Cookie	See <code>Cookie</code> class and <code>HttpHeaders.getCookies</code> method.
Date	Included in responses automatically as per HTTP/1.1.

Header	Description
ETag	See <code>EntityTag</code> class, <code>Response.notModified</code> method and <code>ResponseBuilder.tag</code> method.
Expect	Depends on underlying container.
Expires	Set by application using the <code>ResponseBuilder.expires</code> method.
If-Match	Processed by runtime if application uses corresponding <code>Request.evaluatePreconditions</code> method, see Section 9.2.4.
If-Modified-Since	Processed by runtime if application uses corresponding <code>Request.evaluatePreconditions</code> method, see Section 9.2.4.
If-None-Match	Processed by runtime if application uses corresponding <code>Request.evaluatePreconditions</code> method, see Section 9.2.4.
If-Unmodified-Since	Processed by runtime if application uses corresponding <code>Request.evaluatePreconditions</code> method, see Section 9.2.4.
Last-Modified	Set by application using the <code>ResponseBuilder.lastModified</code> method.
Location	Set by application using the applicable <code>Response</code> method or directly using the <code>ResponseBuilder.location</code> method.
Set-Cookie	See <code>NewCookie</code> class and <code>ResponseBuilder.cookie</code> method.
Transfer-Encoding	See Section 4.2.5.
Vary	Set by application using <code>Response.notAcceptable</code> method or <code>ResponseBuilder.variants</code> method.
WWW-Authenticate	Depends on container.

Appendix C

Change Log

C.1 Changes Since 2.0 Early Draft (Second Edition)

- Section 3.4: New example showing a scenario in which a `@PathParam` is not be available for injection.
- Section 3.7.2: Formalization of certain parts of the matching algorithm that were vague. Defined formal ordering between media types and highlighted situations in which implementations should report a warning if the matching is ambiguous.
- Section 3.7.2: New sample showing the resource matching algorithm in action.
- Section 3.7.3: New footnote about syntax of regular expression.
- Chapter 4: The annotation `@Provider` is now only required for automatic discovery of providers (typically via class scanning). It is no longer required for a provider that is manually registered in classes such as `Application` or `Configuration`.
- Section 4.1.1: New section about automatic discovery of provider classes. Only those annotated with `@Provider` must be discovered automatically.
- Chapter 5: Features are now providers and can be registered as such. A feature can no longer be disabled.
- Chapter 5: Class `Target` renamed to `WebTarget`. Removed text describing how to use a builder factory class (no longer supported). A few other minor updates and typos fixed.
- Chapter 6: Extension points for filters revised. New filter interfaces `ClientRequestFilter` and `ClientResponseFilter` in Client API and new filter interfaces `ContainerRequestFilter` and `ContainerResponseFilter` in Server API. Corresponding context classes also updated in chapter. A `ContainerRequestFilter` is executed before resource matching unless annotated with `@PostMatching`. It is no longer possible to share a filter implementation between the Client and Server APIs; entity interceptors are still shareable.
- Chapter 6: Section on the relationship between filters and entity interceptors (including diagram) dropped.
- Section 6.5.1: Clarified global binding in relation to the new semantics of `@Provider` for automatic discovery.

- Section 6.5.3: The `DynamicBinding` interface, intended to be implemented by filters and entity interceptors, is replaced by `DynamicBinder`. A dynamic binder is a new type of provider that binds filters and entity interceptors with resource methods.
- Section 7.1: Use media type names instead of Java constants for clarity.
- Section 7.3: More descriptive names for constraint annotations.
- Section 7.4: Changed inheritance rules for constraint annotations to follow those defined in [13].
- Section 7.5: New note about `@Valid` support for return values. Fixed phase number typo.
- Section 8.2.1: New sentence about calling `suspend` more than once or in a method annotated with `@Suspend`.
- Section 8.3: New section about EJB resource classes with methods annotated with `@Asynchronous`.
- Chapter 10: Re-structured chapter with sub-sections for each of the EE technologies with which JAX-RS integrates. New examples added.

C.2 Changes Since 2.0 Early Draft

- Section 1.6: Updated 2.0 expert group member list.
- Section 1.7: Updated acknowledgements for 2.0 version.
- Section 4.5: New section that describes exception handling for all providers. Related changes to reference this new section.
- Section 6.7: New section for filter and interceptor exceptions. Related changes to reference this new section.
- Section 3.7.2: Updated step 2a so that it only goes to step 3 when $M \neq \{\}$.
- Section 3.7.2: New sentence about the use of a server quality parameter (qs-value) during request matching.
- Chapter 6: New extension point for pre-match filters that are executed before resource matching.
- Chapter 6: Filter methods no longer return a next action; the execution of a request filter chain is stopped by setting a response in the associated context.
- Chapter 6: Handlers renamed to entity interceptors for clarity (in this log included).
- Section 6.5.1: Global binding is now the default for filters and entity interceptors. The annotation `@GlobalBinding` has been dropped.
- Section 6.6: Clarified reverse ordering of the response filter chain based on binding priorities.
- Appendix C: Removed from this version after changes to Chapter 6.
- Chapter 7: Moved to an instantiate-then-validate strategy in which validation of constructor parameters and setters is no longer supported.
- Section 7.5: Simplified validation process to better align with Bean Validation 1.1 [13]. In particular, validation of resource classes, fields and property getters are all carried out in a single step.

C.3 Changes Since 1.1 Release

- Section 1.1: Updated URLs to JSR pages, etc.
- Section 1.3: Removed Client APIs as non-goal.
- Section 1.5: Added new terminology.
- Section 1.6: List 2.0 expert group members.
- Section 1.7: acknowledgements for 2.0 version.
- Chapter 2: Somewhat generic section on validation removed to avoid confusion with the type of validation defined in Chapter 7.
- Section 2.3.2: Clarified used of Servlet 3 framework pluggability. Added sample web.xml files and a table summarizing all cases.
- Section 3.3.2.1: Clarified notion of entity parameter as a parameter not annotated with any JAX-RS annotation.
- Section 3.5: Explained use of quality factor q . Introduced server-side quality factor q_s and included example.
- Section 3.6: Added sentence about conflicting annotations and recommendation to repeat annotations for consistency with other Java EE specifications.
- Section 3.7.1: Highlighted input and output for each step in algorithm. Minor edits to simplify presentation.
- Section 3.8: Updated algorithm to support server-side quality factor q_s .
- Chapter 5: New chapter Client API.
- Chapter 6: New chapter Filters and Interceptors.
- Chapter 7: New chapter Validation.
- Chapter 8: New chapter Asynchronous Processing.
- Appendix A: New section for 2.0 annotations.
- Appendix C: New appendix describing filter and interceptor extension points.

C.4 Changes Since 1.0 Release

- Section 2.3.2: New requirements for Servlet 3 containers.
- Section 10.2: Requirements for Java EE 6 containers.
- Section 4.2.4: Requirements on standard entity providers when presented with an empty request entity.
- Section 4.2.2: Add closeness of generic type as secondary sort key.
- Section 4.2.1: Default to application/octet-stream if a request does not contain a content-type header.

- Section 3.2: Add support for static `fromString` method.
- Section 3.6: Clarify annotation inheritance.
- Section 9.2.5: Fix typo.
- Section 10.1: Additional considerations related to filters consuming request bodies.

C.5 Changes Since Proposed Final Draft

- Section 3.7.2: Additional sort criteria so that templates with explicit regexs are sorted ahead of those with the default.
- Sections 3.7.2, 3.8, 4.2.3 and 4.3.1: Q-values not used in `@Consumes` or `@Produces`.
- Section 4.2.2: Fixed algorithm to refer to Section 3.8 instead of restating it. Fixed status code returned when the media type has been determined but an appropriate message body writer cannot be located.
- Chapter 11: Clarify that an implementation can supply an alternate `RuntimeDelegate` API class.

C.6 Changes Since Public Review Draft

- Chapter 2: Renamed `ApplicationConfig` class to `Application`.
- Chapter 3: `UriBuilder` reworked to always encode components.
- Sections 3.1.2 and 4.1.2: Added requirement to warn when choice of constructor is ambiguous.
- Section 3.2: `FormParam` no longer required to be supported on fields or properties.
- Section 3.3.3: Added text describing how to determine raw and generic types from method return type and returned instance.
- Section 3.4: Template parameters can specify the regular expression that forms their capturing group.
- Section 3.7.1: Make pre-processed URIs available rather than original request URI. Added URI normalization.
- Section 3.7.1: Removed URI-based content negotiation.
- Section 3.7.2: Reorganized the request matching algorithm to remove redundancy and improve readability, no functional change.
- Section 3.7.3: Changes to regular expressions to eliminate edge cases.
- Section 4.2: Added requirement to use JavaBean Activation Framework when no entity provider can be found.
- Section 4.2.4: Require standard JAXB entity providers to use application-supplied JAXB contexts in preference to their own.
- Section 4.3: Added support for specifying media type capabilities of context providers.
- Section 9.2: Removed `ContextResolver` from list of injectable resources.

- Section 9.2.6: Changed name to Providers, removed entity provider-specific text to reflect more generic capabilities.
- Chapter B: New appendix describing where particular HTTP headers are supported.

Bibliography

- [1] R. Fielding. Architectural Styles and the Design of Network-based Software Architectures. Ph.d dissertation, University of California, Irvine, 2000. See <http://roy.gbiv.com/pubs/dissertation/top.htm>.
- [2] REST Wiki. Web site. See <http://rest.blueoxen.net/cgi-bin/wiki.pl>.
- [3] Representational State Transfer. Web site, Wikipedia. See http://en.wikipedia.org/wiki/Representational_State_Transfer.
- [4] R. Fielding, J. Gettys, J. C. Mogul, H. Frystyk, and T. Berners-Lee. RFC 2616: Hypertext Transfer Protocol – HTTP/1.1. RFC, IETF, January 1997. See <http://www.ietf.org/rfc/rfc2616.txt>.
- [5] T. Berners-Lee, R. Fielding, and L. Masinter. RFC 3986: Uniform Resource Identifier (URI): Generic Syntax. RFC, IETF, January 2005. See <http://www.ietf.org/rfc/rfc3986.txt>.
- [6] L. Dusseault. RFC 4918: HTTP Extensions for Web Distributed Authoring and Versioning (WebDAV). RFC, IETF, June 2007. See <http://www.ietf.org/rfc/rfc4918.txt>.
- [7] J.C. Gregorio and B. de hOra. The Atom Publishing Protocol. Internet Draft, IETF, March 2007. See <http://bitworking.org/projects/atom/draft-ietf-atompub-protocol-14.html>.
- [8] G. Murray. Java Servlet Specification Version 2.5. JSR, JCP, October 2006. See <http://java.sun.com/products/servlet>.
- [9] R. Chinnici, M. Hadley, and R. Mordani. Java API for XML Web Services. JSR, JCP, August 2005. See <http://jcp.org/en/jsr/detail?id=224>.
- [10] S. Bradner. RFC 2119: Keywords for use in RFCs to Indicate Requirement Levels. RFC, IETF, March 1997. See <http://www.ietf.org/rfc/rfc2119.txt>.
- [11] Bill Shannon. JavaBeans Activation Framework. JSR, JCP, May 2006. See <http://jcp.org/en/jsr/detail?id=925>.
- [12] Gavin King. Context and Dependency Injection for the Java Platform. JSR, JCP, December 2009. See <http://jcp.org/en/jsr/detail?id=299>.
- [13] Emmanuel Bernard. Bean Validation 1.1. JSR, JCP, September 2012. See <http://jcp.org/en/jsr/detail?id=349>.