RESTEasy

Jakarta RESTFul Web Services
# RESTEasy

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Preface

Commercial development support, production support and training for RESTEasy is available from Red Hat Support. [https://access.redhat.com/support]

In some of the example listings, what is meant to be displayed on one line does not fit inside the available page width. These lines have been broken up. A '"' at the end of a line means that a break has been introduced to fit in the page, with the following lines indented. So:

Let's pretend to have an extremely long line that does not fit
This one is short

Is really:

Let's pretend to have an extremely long line that does not fit
This one is short
Chapter 1. Overview

Originally released in 2009, RESTEasy has tracked and implemented a series of official specifications that provide a Java API for RESTful Web Services over the HTTP protocol:

Table 1.1.

<table>
<thead>
<tr>
<th>RESTEasy version</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1+</td>
<td>Jakarta RESTful Web Services 3.1 [<a href="https://jakarta.ee/specifications/restful-ws/3.1/jakarta-restful-ws-spec-3.1.html">https://jakarta.ee/specifications/restful-ws/3.1/jakarta-restful-ws-spec-3.1.html</a>]</td>
</tr>
<tr>
<td>6.0</td>
<td>Jakarta RESTful Web Services 3.0 [<a href="https://jakarta.ee/specifications/restful-ws/3.0/jakarta-restful-ws-spec-3.0.html">https://jakarta.ee/specifications/restful-ws/3.0/jakarta-restful-ws-spec-3.0.html</a>]</td>
</tr>
<tr>
<td>3.5+</td>
<td>Jakarta RESTful Web Services 2.1 [<a href="https://jakarta.ee/specifications/restful-ws/2.1/restful-ws-spec-2.1.html">https://jakarta.ee/specifications/restful-ws/2.1/restful-ws-spec-2.1.html</a>]</td>
</tr>
<tr>
<td>3+</td>
<td>JAX-RS 2.0 [<a href="https://jcp.org/en/jsr/detail?id=339">https://jcp.org/en/jsr/detail?id=339</a>]</td>
</tr>
<tr>
<td>2+</td>
<td>JAX-RS 1.0 [<a href="https://download.oracle.com/otndocs/jcp/jaxrs-1.0-fr-eval-oth-JSpec/">https://download.oracle.com/otndocs/jcp/jaxrs-1.0-fr-eval-oth-JSpec/</a>]</td>
</tr>
</tbody>
</table>

JAX-RS 1.0 (JSR-311 [https://download.oracle.com/otndocs/jcp/jaxrs-1.0-fr-eval-oth-JSpec/]), JAX-RS 2.0 (JSR-339 [https://jcp.org/en/jsr/detail?id=339]), and JAX-RS 2.1 (JSR-370 [https://jcp.org/en/procedures/overview]) specifications. In 2017, the Java Enterprise Edition (Java EE) specifications, including JAX-RS, were transferred to the Eclipse Foundation (Java EE Moves to the Eclipse Foundation [https://blogs.eclipse.org/post/mike-milinkovich/java-ee-moves-eclipse-foundation]), Java EE became Jakarta Enterprise Edition, and new governing committees under the umbrella of the Eclipse Jakarta EE Platform [https://projects.eclipse.org/proposals/eclipse-jakarta-ee-platform] were constituted. For JAX-RS, the specifications are provided by the Jakarta RESTful Web Services [https://jakarta.ee/specifications/restful-ws/] committee. The first specification released under the authority of Jakarta RESTful Web Services was Jakarta RESTful Web Services 2.1 [https://jakarta.ee/specifications/restful-ws/2.1/], that being essentially identical to JAX-RS 2.1.

RESTEasy is a portable implementation of these specifications which can run in any Servlet container. Tighter integration with the WildFly application server is also available to make the user experience nicer in that environment. RESTEasy also comes with additional features on top of the plain old specifications.
Note

References in this document to JAX-RS refer to the Jakarta RESTful Web Services unless otherwise noted.

Note

References in this document to JAXB refer to the Jakarta XML Binding unless otherwise noted.
Chapter 2. License

RESTEasy is distributed under the Apache License 2.0. Some dependencies are covered by other open source licenses.
Chapter 3. Installation/Configuration

RESTEasy is installed and configured in different ways depending on which environment you are running in. If you are running in WildFly, RESTEasy is already bundled and integrated completely so there is very little you have to do. If you are running in a different environment, there is some manual installation and configuration you will have to do.

3.1. RESTEasy modules in WildFly

In WildFly, RESTEasy and the Jakarta RESTful Web Services API are automatically loaded into your deployment's classpath if and only if you are deploying a Jakarta RESTful Web Services application (as determined by the presence of Jakarta RESTful Web Services annotations). However, only some RESTEasy features are automatically loaded. See Table 3.1. If you need any of those libraries which are not loaded automatically, you'll have to bring them in with a jboss-deployment-structure.xml file in the WEB-INF directory of your WAR file. Here's an example:

```
<jboss-deployment-structure>
  <deployment>
    <dependencies>
      <module name="org.jboss.resteasy.resteasy-jackson2-provider" services="import"/>
    </dependencies>
  </deployment>
</jboss-deployment-structure>
```

The `services` attribute must be set to "import" for modules that have default providers in a META-INF/services/jakarta.ws.rs.ext.Providers file.

To get an idea of which RESTEasy modules are loaded by default when Jakarta RESTful Web Services services are deployed, please see the table below, which refers to a recent WildFly distribution patched with the current RESTEasy distribution. Clearly, future and unpatched WildFly distributions might differ a bit in terms of modules enabled by default, as the container actually controls this too.

Table 3.1.

<table>
<thead>
<tr>
<th>Module Name</th>
<th>Loaded by Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>org.jboss.resteasy.resteasy-atom-provider</td>
<td>yes</td>
<td>RESTEasy's atom library</td>
</tr>
<tr>
<td>org.jboss.resteasy.resteasy-cdi</td>
<td>yes</td>
<td>RESTEasy CDI integration</td>
</tr>
<tr>
<td>Module Name</td>
<td>Loaded by Default</td>
<td>Description</td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>-------------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>org.jboss.resteasy.resteasy-crypto</td>
<td>yes</td>
<td>S/MIME, DKIM, and support for other security formats.</td>
</tr>
<tr>
<td>org.jboss.resteasy.resteasy-jackson2-provider</td>
<td>yes</td>
<td>Integration with the JSON parser and object mapper Jackson 2</td>
</tr>
<tr>
<td>org.jboss.resteasy.resteasy-jaxb-provider</td>
<td>yes</td>
<td>Jakarta XML Binding integration.</td>
</tr>
<tr>
<td>org.jboss.resteasy.resteasy-core</td>
<td>yes</td>
<td>Core RESTEasy libraries for server.</td>
</tr>
<tr>
<td>org.jboss.resteasy.resteasy-client</td>
<td>yes</td>
<td>Core RESTEasy libraries for client.</td>
</tr>
<tr>
<td>org.jboss.resteasy.jose-jwt</td>
<td>no</td>
<td>JSON Web Token support.</td>
</tr>
<tr>
<td>org.jboss.resteasy.resteasy-jsapi</td>
<td>yes</td>
<td>RESTEasy's Javascript API</td>
</tr>
<tr>
<td>org.jboss.resteasy.resteasy-json-p-provider</td>
<td>yes</td>
<td>JSON parsing API</td>
</tr>
<tr>
<td>org.jboss.resteasy.resteasy-json-binding-provider</td>
<td>yes</td>
<td>JSON binding API</td>
</tr>
<tr>
<td>jakarta.json.bind-api</td>
<td>yes</td>
<td>JSON binding API</td>
</tr>
<tr>
<td>org.eclipse.yasson</td>
<td>yes</td>
<td>RI implementation of JSON binding API</td>
</tr>
<tr>
<td>org.jboss.resteasy.resteasy-multipart-provider</td>
<td>yes</td>
<td>Support for multipart formats</td>
</tr>
<tr>
<td>org.jboss.resteasy.resteasy-spring</td>
<td>no</td>
<td>Spring provider</td>
</tr>
<tr>
<td>org.jboss.resteasy.resteasy-validator-provider</td>
<td>yes</td>
<td>RESTEasy's interface to Hibernate Bean Validation</td>
</tr>
</tbody>
</table>

### 3.1.1. Other RESTEasy modules

Not all RESTEasy modules are bundled with WildFly. For example, resteasy-fastinfoset-provider and resteasy-wadl are not included among the modules listed in Section 3.1, “RESTEasy modules in WildFly”. If you want to use them in your application, you can include them in your WAR as you would if you were deploying outside of WildFly. See Section 3.3, “Deploying to other servlet containers” for more information.
3.1.2. Upgrading RESTEasy within WildFly

RESTEasy is bundled with WildFly. However you may wish to upgrade to the latest version. With Galleon [https://docs.wildfly.org/24/Galleon_Guide.html] this makes upgrading RESTEasy in WildFly quite easy.

The first requirement is the WildFly installation is provisioned with Galleon. The simplest way to do this for a local installation is with Galleon CLI [https://docs.wildfly.org/galleon/#_galleon_cli_tool].

$ galleon.sh install wildfly:current

To install the RESTEasy upgrade on top of that you simply need to use the tool again with the Maven GAV:

$ galleon.sh install org.jboss.resteasy:galleon-feature-pack:6.2.3.Final

If you are using Maven to provision WildFly you can simply add the feature pack to your plugin configuration.

```xml
<plugin>
  <groupId>org.jboss.galleon</groupId>
  <artifactId>galleon-maven-plugin</artifactId>
  <configuration>
    <install-dir>${jboss.home}</install-dir>
    <record-state>true</record-state>
    <log-time>true</log-time>
    <offline>false</offline>
    <feature-packs>
      <feature-pack>
        <groupId>org.wildfly</groupId>
        <artifactId>wildfly-ee-galleon-pack</artifactId>
        <version>${version.org.wildfly}</version>
      </feature-pack>
      <feature-pack>
        <groupId>org.jboss.resteasy</groupId>
        <artifactId>galleon-feature-pack</artifactId>
        <version>6.2.3.Final</version>
      </feature-pack>
    </feature-packs>
  </configuration>
  <executions>
    <execution>
      <id>server-provisioning</id>
      <phase>generate-test-resources</phase>
      <goals>
        <goal>provision</goal>
      </goals>
    </execution>
  </executions>
</plugin>
```
3.2. Deploying a RESTEasy application to WildFly

RESTEasy is bundled with WildFly and completely integrated as per the requirements of Jakarta EE. A Jakarta RESTful Web Services application can contain Jakarta Enterprise Beans and CDI. WildFly scans the WAR file for the Jakarta RESTful Web Services services and provider classes packaged in the WAR either as POJOs, CDI beans, or Jakarta Enterprise Beans.

```xml
<web-app version="3.0" xmlns="http://java.sun.com/xml/ns/javaee"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
</web-app>
```

The web.xml can supply to RESTEasy init-params and context-params (see Section 3.5, “Configuration switches”) if you want to tweak or turn on/off any specific RESTEasy feature.

When a `<servlet-mapping>` element is not declared in the web.xml, then a class must be provided that implements `jakarta.ws.rs.core.Application` class (see Section 3.6, “jakarta.ws.rs.core.Application”). This class must be annotated with the `jakarta.ws.rs.ApplicationPath` annotation. If this implementation class returns an empty set for classes and singletons, the WAR will be scanned for resource and provider classes as indicated by the presence of Jakarta RESTful Web Services annotations.

```java
import jakarta.ws.rs.ApplicationPath;
import jakarta.ws.rs.core.Application;

@ApplicationPath("/root-path")
public class MyApplication extends Application
{
}
```

**Note.** If the application WAR contains an `Application` class (or a subclass thereof) which is annotated with an `ApplicationPath` annotation, a web.xml file is not required. If the application WAR contains an `Application` class but the class doesn't have a declared `@ApplicationPath` annotation, then the web.xml must at least declare a `<servlet-mapping>` element.

**Note.** As mentioned in Section 3.1.1, “Other RESTEasy modules”, not all RESTEasy modules are bundled with WildFly. For example, resteasy-fastinfoset-provider and resteasy-wadl are not included among the modules listed in Section 3.1, “RESTEasy modules in WildFly”. If they are required by the application, they can be included in the WAR as is done if you were deploying outside of WildFly. See Section 3.3, “Deploying to other servlet containers” for more information.
3.3. Deploying to other servlet containers

If you are using RESTEasy outside of WildFly, in a standalone servlet container like Tomcat or Jetty, for example, you will need to include the appropriate RESTEasy jars in your WAR file. You will need the core classes in the resteasy-core and resteasy-client modules, and you may need additional facilities like the resteasy-jaxb-provider module. We strongly suggest that you use Maven to build your WAR files as RESTEasy is split into a bunch of different modules:

```
<dependency>
  <groupId>org.jboss.resteasy</groupId>
  <artifactId>resteasy-core</artifactId>
  <version>6.2.3.Final</version>
</dependency>
<dependency>
  <groupId>org.jboss.resteasy</groupId>
  <artifactId>resteasy-client</artifactId>
  <version>6.2.3.Final</version>
</dependency>
<dependency>
  <groupId>org.jboss.resteasy</groupId>
  <artifactId>resteasy-jaxb-provider</artifactId>
  <version>6.2.3.Final</version>
</dependency>
```

You can see sample Maven projects in https://github.com/resteasy/resteasy-examples.

If not using Maven, include the necessary jars by hand. If downloading RESTEasy (from http://resteasy.jboss.org/downloads.html, for example) you will get a file, resteasy-<version>-all.zip. Unzip the file. The resulting directory will contain a lib/ directory that contains the libraries needed by RESTEasy. Copy these, as needed, into your /WEB-INF/lib directory. Place your Jakarta RESTful Web Services annotated class resources and providers within one or more jars within /WEB-INF/lib or your raw class files within /WEB-INF/classes.

3.3.1. Servlet 3.0 containers

RESTEasy provides an implementation of the Servlet 3.0 ServletContainerInitializer integration interface for containers to use in initializing an application. The container calls this interface during the application's startup phase. The RESTEasy implementation performs automatic scanning for resources and providers, and programmatic registration of a servlet. RESTEasy's implementation is provided in maven artifact, resteasy-servlet-initializer. Add this artifact dependency to your project's pom.xml file so the JAR file will be included in your WAR file.

```
<dependency>
  <groupId>org.jboss.resteasy</groupId>
  <artifactId>resteasy-servlet-initializer</artifactId>
  <version>6.2.3.Final</version>
</dependency>
```
3.3.2. Pre-Servlet 3.0 containers

**Note.** It is likely that support for pre-3.0 Servlet specifications will be deprecated and eliminated in the future.

If using Servlet versions older than 3.0, you will have to manually declare the RESTEasy servlet in the WEB-INF/web.xml file of your WAR project, and provide an Application class (see Section 3.6, "jakarta.ws.rs.core.Application") that explicitly lists resources and providers, because the resteasy-servlet-initializer artifact does not work in Servlet versions older than 3.0. For example:

```xml
<web-app>
  <display-name>Archetype Created Web Application</display-name>

  <servlet>
    <servlet-name>Resteasy</servlet-name>
    <servlet-class>
      org.jboss.resteasy.plugins.server.servlet.HttpServletDispatcher
    </servlet-class>
    <init-param>
      <param-name>jakarta.ws.rs.Application</param-name>
      <param-value>com.restfully.shop.services.ShoppingApplication</param-value>
    </init-param>
  </servlet>

  <servlet-mapping>
    <servlet-name>Resteasy</servlet-name>
    <url-pattern>/</url-pattern>
  </servlet-mapping>

</web-app>
```

The RESTEasy servlet is responsible for initializing some basic components of RESTEasy.

3.3.3. Pre-Servlet 3.0 RESTEasy as a ServletContextListener

If using Servlet versions older than 3.0, the initialization of RESTEasy can be performed within a ServletContextListener instead of within the Servlet. You may need this if you are writing custom Listeners that need to interact with RESTEasy at boot time. An example of this is the RESTEasy Spring integration that requires a Spring ServletContextListener. The org.jboss.resteasy.plugins.server.servlet.ResteasyBootstrap class is a ServletContextListener that configures an instance of an ResteasyProviderFactory and Registry. You can obtain instances of a ResteasyProviderFactory and Registry from the ServletContext attributes org.jboss.resteasy.spi.ResteasyProviderFactory and org.jboss.resteasy.spi.Registry. From these instances you can programmatically interact with RESTEasy registration interfaces.
3.3.4. Pre-Servlet 3.0 RESTEasy as a Servlet Filter

If using Servlet versions older than 3.0, the downside of running RESTEasy as a Servlet is that you cannot have static resources like .html and .jpeg files in the same path as your Jakarta RESTful Web Services services. RESTEasy allows you to run as a Filter instead. If a Jakarta RESTful Web Services resource is not found under the URL requested, RESTEasy will delegate back to the base servlet container to resolve URLs.
3.4. Configuration

RESTEasy has two mutually exclusive mechanisms for retrieving configuration parameters (see Section 3.5, “Configuration switches”). The classic mechanism depends on context-params and init-params in a web.xml file. Alternatively, the Eclipse MicroProfile Config project (https://github.com/eclipse/microprofile-config) provides a flexible parameter retrieval mechanism that RESTEasy will use if the necessary dependencies are available. See Section 3.4.4, “Configuring MicroProfile Config” for more about that. If they are not available, it will fall back to an extended form of the classic mechanism.

3.4.1. RESTEasy with MicroProfile Config

In the presence of the Eclipse MicroProfile Config API jar and an implementation of the API (see Section 3.4.4, “Configuring MicroProfile Config”), RESTEasy will use the facilities of MicroProfile Config for accessing configuration properties (see Section 3.5, “Configuration switches”). MicroProfile Config offers to both RESTEasy users and RESTEasy developers a great deal of flexibility in controlling runtime configuration.

In MicroProfile Config, a `ConfigSource` represents a `Map<String, String>` of property names to values, and a `Config` represents a sequence of `ConfigSource`s, ordered by priority. The priority of a `ConfigSource` is given by an ordinal (represented by an `int`), with a higher value indicating a higher priority. For a given property name, the `ConfigSources` are searched in order until a value is found.

MicroProfile Config mandates the presence of the following `ConfigSources`:

1. a `ConfigSource` based on System.getProperties() (ordinal = 400)
2. a `ConfigSource` based on System.getenv() (ordinal = 300)
3. a `ConfigSource` for each META-INF/microprofile-config.properties file on the ClassPath, separately configurable via a config_ordinal property inside each file (default ordinal = 100)

Note that a property which is found among the System properties and which is also in the System environment will be assigned the System property value because of the relative priorities of the `ConfigSources`.

The set of `ConfigSources` is extensible. For example, smallrye-config (https://github.com/smallrye/smallrye-smallrye-config), the implementation of the MicroProfile Config specification currently used by RESTEasy, adds the following kinds of `ConfigSources`:

1. `PropertiesConfigSource` creates a `ConfigSource` from a Java `Properties` object or a `Map<String, String>` object or a properties file (referenced by its URL) (default ordinal = 100).
2. `DirConfigSource` creates a `ConfigSource` that will look into a directory where each file corresponds to a property (the file name is the property key and its textual content is the property value). This `ConfigSource` can be used to read configuration from Kubernetes ConfigMap (default ordinal = 100).
3. `ZkMicroProfileConfig` creates a `ConfigSource` that is backed by Apache Zookeeper (ordinal = 150).

These can be registered programatically by using an instance of `ConfigProviderResolver`:

```java
cfg = new PropertiesConfigSource("file:/// ...");
ConfigProviderResolver.instance().registerConfig(cfg, getClass().getClassLoader());
```

where `ConfigProviderResolver` is part of the Eclipse API.

If the application is running in Wildfly, then Wildfly provides another set of `ConfigSource`s, as described in the "MicroProfile Config Subsystem Configuration" section of the WildFly Admin guide (https://docs.wildfly.org/21/Admin_Guide.html#MicroProfile_Config_SmallRye).

Finally, RESTEasy automatically provides three more `ConfigSource`s:

- `org.jboss.resteasy.microprofile.config.ServletConfigSource` represents a servlet's `<init-param>`s from web.xml (ordinal = 60).
- `org.jboss.resteasy.microprofile.config.FilterConfigSource` represents a filter's `<init-param>`s from web.xml (ordinal = 50). (See Section 3.3.4, “Pre-Servlet 3.0 RESTEasy as a Servlet Filter” for more information.)
- `org.jboss.resteasy.microprofile.config.ServletContextConfigSource` represents `<context-param>`s from web.xml (ordinal = 40).

**Note.** As stated by the MicroProfile Config specification, a special property `config_ordinal` can be set within any RESTEasy built-in `ConfigSource`s. The default implementation of `getOrdinal()` will attempt to read this value. If found and a valid integer, the value will be used. Otherwise the respective default value will be used.

### 3.4.2. Using pure MicroProfile Config

The MicroProfile Config API is very simple. A `Config` may be obtained either programatically:

```java
cfg = ConfigProvider.getConfig();
```

or, in the presence of CDI, by way of injection:

```java
@Inject Config cfg;
```
Once a `Config` has been obtained, a property can be queried. For example,

```java
String s = config.getValue("prop_name", String.class);
```

or

```java
String s = config.getOptionalValue("prop_name", String.class).orElse("d'oh");
```

Now, consider a situation in which "prop_name" has been set by `System.setProperty("prop_name", "system")` and also in the application's web.xml in element `<context-param>`.

```xml
<context-param>
    <param-name>prop_name</param-name>
    <param-value>context</param-value>
</context-param>
```

Since the system parameter `ConfigSource (ordinal = 400)` has precedence over `ServletContextConfigSource (ordinal = 40)`, `config.getValue("prop_name", String.class)` will return "system" rather than "context".

### 3.4.3. Using RESTEasy's extension of MicroProfile Config

RESTEasy offers a general purpose parameter retrieval mechanism which incorporates MicroProfile Config if the necessary dependencies are available, and which falls back to an extended version of the classic RESTEasy mechanism (see Section 3.4.5, “RESTEasy's classic configuration mechanism”) otherwise.

Calling

```java
ConfigurationFactory.getInstance().getConfiguration()
```

will return an instance of `org.jboss.resteasy.spi.config.Configuration`:
/**
 * Returns the resolved value for the specified type of the named property.
 * @param name the name of the parameter
 * @param type the type to convert the value to
 * @param <T>  the property type
 * @return the resolved optional value
 * @throws IllegalArgumentException if the type is not supported
 */
<T> Optional<T> getOptionalValue(String name, Class<T> type);

/**
 * Returns the resolved value for the specified type of the named property.
 * @param name the name of the parameter
 * @param type the type to convert the value to
 * @param <T>  the property type
 * @return the resolved value
 * @throws IllegalArgumentException if the type is not supported
 * @throws java.util.NoSuchElementException if there is no property associated with the name
 */
<T> T getValue(String name, Class<T> type);
}

For example,

```java
String value = ConfigurationFactory.getInstance().getConfiguration().getOptionalValue("prop_name", String.class).orElse("d'oh");
```

If MicroProfile Config is available, that would be equivalent to

```java
String value = ConfigProvider.getConfig().getOptionalValue("prop_name", String.class).orElse("d'oh");
```

If MicroProfile Config is not available, then an attempt is made to retrieve the parameter from the following sources in this order:

1. system variables, followed by
2. environment variables, followed by
3. web.xml parameters, as described in Section 3.4.5, “RESTEasy's classic configuration mechanism”

### 3.4.4. Configuring MicroProfile Config

If an application is running inside Wildfly, then all of the dependencies are automatically available. Outside of Wildfly, an application will need the Eclipse MicroProfile API at compile time.

As of RESTEasy 5.0 you will first need to add the RESTEasy MicroProfile Config dependency to the project.

```xml
<dependency>
  <groupId>org.jboss.resteasy.microprofile</groupId>
  <artifactId>microprofile-config</artifactId>
  <scope>compile</scope>
</dependency>
```

You will also need the MicroProfile Config API and an implementation, in our case SmallRye.

```xml
<dependency>
  <groupId>org.eclipse.microprofile.config</groupId>
  <artifactId>microprofile-config-api</artifactId>
  <scope>compile</scope>
</dependency>
```

```xml
<dependency>
  <groupId>io.smallrye</groupId>
  <artifactId>smallrye-config</artifactId>
  <scope>runtime</scope>
</dependency>
```

### 3.4.5. RESTEasy's classic configuration mechanism

Prior to the incorporation of MicroProfile Config, nearly all of RESTEasy's parameters were retrieved from servlet init-params and context-params. Which ones are available depends on how a web application invokes RESTEasy.

If RESTEasy is invoked as a servlet, as in
then the servlet specific init-params and the general context-params are available, with the former taking precedence over the latter. For example, the property "system" would have the value "system-init".

If RESTEasy is invoked by way of a filter (see Section 3.3.4, “Pre-Servlet 3.0 RESTEasy as a Servlet Filter”), as in

```xml
<web-app version="3.0" xmlns="http://java.sun.com/xml/ns/javaee"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    <context-param>
        <param-name>system</param-name>
        <param-value>system-context</param-value>
    </context-param>
    <filter>
        <filter-name>Resteasy</filter-name>
        <filter-class>org.jboss.resteasy.plugins.server.servlet.FilterDispatcher</filter-class>
        <init-param>
            <param-name>system</param-name>
            <param-value>system-filter</param-value>
        </init-param>
    </filter>
</web-app>
```
then the filter specific init-params and the general context-params are available, with the former taking precedence over the latter. For example, the property "system" would have the value "system-filter".

Finally, if RESTEasy is invoked by way of a ServletContextListener (see Section 3.3.3, “Pre-Servlet 3.0 RESTEasy as a ServletContextListener”), as in

```xml
<web-app version="3.0" xmlns="http://java.sun.com/xml/ns/javaee"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  <listener>
    <listener-class>
      org.jboss.resteasy.plugins.server.servlet.ResteasyBootstrap
    </listener-class>
  </listener>
  <context-param>
    <param-name>system</param-name>
    <param-value>system-context</param-value>
  </context-param>
</web-app>
```

where ResteasyBootstrap is a ServletContextListener, then the context-params are available.

### 3.4.6. Overriding RESTEasy's configuration mechanism

Before adopting the default behavior, with or without MicroProfile Config, as described in previous sections, RESTEasy will use service loading to look for one or more implementations of the interface `org.jboss.resteasy.spi.config.ConfigurationFactory`, selecting one with the highest priority as determined by the value returned by `ConfigurationFactory.priority()`. Smaller numbers indicate higher priority. The default `ConfigurationFactory` is `org.jboss.resteasy.core.config.DefaultConfigurationFactory` with a priority of 500.
3.5. Configuration switches

RESTEasy can receive the following configuration options from any `ConfigSource`s that are available at runtime:

<table>
<thead>
<tr>
<th>Option Name</th>
<th>Default Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>resteasy.servlet.mapping.prefix</code></td>
<td>no default</td>
<td>If the url-pattern for the RESTEasy servlet-mapping is not /*</td>
</tr>
<tr>
<td><code>resteasy.providers</code></td>
<td>no default</td>
<td>A comma delimited list of fully qualified @Provider class names to be register</td>
</tr>
<tr>
<td><code>resteasy.use.builtin.providers</code></td>
<td>true</td>
<td>Whether or not to register default, built-in @Provider classes</td>
</tr>
<tr>
<td><code>resteasy.resources</code></td>
<td>no default</td>
<td>A comma delimited list of fully qualified Jakarta RESTful Web Services resource class names to be register</td>
</tr>
<tr>
<td><code>resteasy.jndi.resources</code></td>
<td>no default</td>
<td>A comma delimited list of JNDI names which reference objects to be register as Jakarta RESTful Web Services resources</td>
</tr>
<tr>
<td><code>jakarta.ws.rs.Application</code></td>
<td>no default</td>
<td>Fully qualified name of Application class to bootstrap in a spec portable way</td>
</tr>
<tr>
<td><code>resteasy.media.type.mappings</code></td>
<td>no default</td>
<td>Replaces the need for an Accept header by mapping file name extensions (like .xml or .txt) to a media type. Used when the client is unable to use an Accept header to choose a representation (i.e. a browser). See Chapter 20, <em>Jakarta RESTful Web Services Content Negotiation</em> for more details.</td>
</tr>
<tr>
<td><code>resteasy.language.mappings</code></td>
<td>no default</td>
<td>Replaces the need for an Accept-Language header by mapping file name extensions (like .en or .fr) to a language.</td>
</tr>
<tr>
<td>Option Name</td>
<td>Default Value</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------------------</td>
<td>---------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>resteasy.media.type.param.mapping</td>
<td>no default</td>
<td>Names a query parameter that can be set to an acceptable media type, enabling content negotiation without an Accept header. See Chapter 20,</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Jakarta RESTful Web Services Content Negotiation</em> for more details.</td>
</tr>
<tr>
<td>resteasy.role_based.security</td>
<td>false</td>
<td>Enables role based security. See Chapter 43, <em>Securing Jakarta RESTful Web Services and RESTEasy</em> for more details.</td>
</tr>
<tr>
<td>resteasy.document.expand.entity.references</td>
<td>false</td>
<td>Expand external entities in org.w3c.dom.Document documents and Jakarta XML Binding object representations</td>
</tr>
<tr>
<td>resteasy.document.secure.processing.feature</td>
<td></td>
<td>Impose security constraints in processing org.w3c.dom.Document documents and Jakarta XML Binding object representations</td>
</tr>
<tr>
<td>resteasy.document.secure.disableDTDs</td>
<td>true</td>
<td>Prohibit DTDs in org.w3c.dom.Document documents and Jakarta XML Binding object representations</td>
</tr>
<tr>
<td>resteasy.wider.request.matching</td>
<td>false</td>
<td>Turns off the Jakarta RESTful Web Services spec defined class-level expression filtering and instead tries to match every method's full path.</td>
</tr>
<tr>
<td>resteasy.use.container.form.params</td>
<td>false</td>
<td>Obtain form parameters by using HttpServletRequest.getParameterMap().</td>
</tr>
<tr>
<td><strong>Option Name</strong></td>
<td><strong>Default Value</strong></td>
<td><strong>Description</strong></td>
</tr>
<tr>
<td>-----------------</td>
<td>------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>resteasy.rfc7232preconditions</td>
<td>false</td>
<td>Enables RFC7232 compliant HTTP preconditions handling.</td>
</tr>
<tr>
<td>resteasy.gzip.max.input</td>
<td>10000000</td>
<td>Imposes maximum size on decompressed gzipped.</td>
</tr>
<tr>
<td>resteasy.secure.random.max.ust00</td>
<td>100</td>
<td>The number of times a SecureRandom can be used before reseeding.</td>
</tr>
<tr>
<td>resteasy.buffer.exception.entity</td>
<td>true</td>
<td>Upon receiving an exception, the client side buffers any response entity before closing the connection.</td>
</tr>
<tr>
<td>resteasy.add.charset</td>
<td>true</td>
<td>If a resource method returns a text/* or application/xml* media type without an explicit charset, RESTEasy adds &quot;charset=UTF-8&quot; to the returned Content-Type header. To disable this behavior set this switch to false.</td>
</tr>
<tr>
<td>resteasy.disable.html.sanitizer</td>
<td>false</td>
<td>Normally, a response with media type &quot;text/html&quot; and a status of 400 will be processed so that the characters &quot;/&quot;, &quot;&lt;&quot;, &quot;&gt;&quot;, &quot;&amp;&quot;, &quot;&quot; (double quote), and &quot;,&quot; (single quote) are escaped to prevent an XSS attack. Setting this parameter to &quot;true&quot;, escaping will not occur.</td>
</tr>
<tr>
<td>resteasy.patchfilter.disabled</td>
<td>false</td>
<td>RESTEasy provides class PatchMethodFilter to handle JSON patch and JSON Merge Patch requests. It is active by default. This filter can be disabled by setting this switch to &quot;true&quot; and a customized patch method filter can be provided to serve the JSON patch and</td>
</tr>
<tr>
<td>Option Name</td>
<td>Default Value</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------------------</td>
<td>---------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>resteasy.patchfilter.legacy</td>
<td>true</td>
<td>Setting this value to false, the jsonp provider will be activated to provide PatchFilter for Json patch or Json Merge patch functionalities. The default is true; the Jackson provider will be used.</td>
</tr>
<tr>
<td>resteasy.original.webapplicationexception.behavior</td>
<td>false</td>
<td>Set to &quot;true&quot;, this parameter will restore the original behavior in which a Client running in a resource method will throw a Jakarta RESTful Web Services WebApplicationException instead of a Resteasy version with a sanitized Response. For more information, see section Resteasy WebApplicationExceptions</td>
</tr>
<tr>
<td>dev.resteasy.throw.options.exception</td>
<td>false</td>
<td>Setting this value to true will throw a org.jboss.resteasy.spi.DefaultOptionsMethodException if the HTTP method &quot;OPTIONS&quot; is sent and the matching method is not annotated with @OPTIONS. This is the original behavior of RESTEasy. However, this has been changed to return the response so that it's processed with an ExceptionMapper.</td>
</tr>
</tbody>
</table>

**Note.** The resteasy.servlet.mapping.prefix <context param> variable must be set if the servlet-mapping for the RESTEasy servlet has a url-pattern other than "/". For example, if the url-pattern is

```xml
<servlet-mapping>
  <servlet-name>Resteasy</servlet-name>
  <url-pattern>/restful-services/**</url-pattern>
</servlet-mapping>
```
Then the value of resteasy.servlet.mapping.prefix must be:

```xml
<context-param>
  <param-name>resteasy.servlet.mapping.prefix</param-name>
  <param-value>/restful-services</param-value>
</context-param>
```

Resteasy internally uses a cache to find the resource invoker for the request url. The cache size and enablement can be controlled with these system properties.

**Table 3.3.**

<table>
<thead>
<tr>
<th>System Property Name</th>
<th>Default Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>resteasy.match.cache.enabled</td>
<td>true</td>
<td>If the match cache is enabled or not</td>
</tr>
<tr>
<td>resteasy.match.cache.size</td>
<td>2048</td>
<td>The size of this match cache</td>
</tr>
</tbody>
</table>

### 3.6. jakarta.ws.rs.core.Application

The `jakarta.ws.rs.core.Application` class is a standard Jakarta RESTful Web Services class that may be implemented to provide information about your deployment. It is simply a class that lists all Jakarta RESTful Web Services root resources and providers.

**Note.** If the application's `web.xml` file does not have a `<servlet-mapping>` element, you must provide an `Application` class annotated with `@ApplicationPath`.

### 3.7. Client side

Jakarta RESTful Web Services conforming implementations, such as RESTEasy, support a client side framework which simplifies communicating with restful applications. In RESTEasy, the minimal set of modules needed for the client framework consists of resteasy-core and resteasy-client. You can access them by way of maven:

```xml
<dependency>
  <groupId>org.jboss.resteasy</groupId>
  <artifactId>resteasy-core</artifactId>
  <version>6.2.3.Final</version>
</dependency>
<dependency>
  <groupId>org.jboss.resteasy</groupId>
  <artifactId>resteasy-client</artifactId>
  <version>6.2.3.Final</version>
</dependency>
```
Other modules, such as resteasy-jaxb-provider, may be brought in as needed.
Chapter 4. Using @Path and @GET, @POST, etc.

```java
@Path("/library")
public class Library {

    @GET
    @Path("/books")
    public String getBooks() {...}

    @GET
    @Path("/book/{isbn}")
    public String getBook(@PathParam("isbn") String id) {
        // search my database and get a string representation and return it
    }

    @PUT
    @Path("/book/{isbn}")
    public void addBook(@PathParam("isbn") String id, @QueryParam("name") String name) {...}

    @DELETE
    @Path("/book/{id}")
    public void removeBook(@PathParam("id") String id {...)
}
```

In the class above, the RESTEasy servlet is configured and reachable at a root path of http://myhost.com/services. The requests handled by class, Library, are:

- GET http://myhost.com/services/library/books

The @jakarta.ws.rs.Path annotation must exist on either the class and/or a resource method. If it exists on both the class and method, the relative path to the resource method is a concatenation of the class and method.

In the @jakarta.ws.rs package there are annotations for each HTTP method. @GET, @POST, @PUT, @DELETE, and @HEAD. Place these on public methods that you want to map to that certain kind of HTTP method. As long as there is a @Path annotation on the class, a @Path annotation is not required on the method you are mapping. There can be more than one HTTP method as long as they can be distinguished from other methods.
When a @Path annotation is on a method without an HTTP method, these are called JAXRSResourceLocators.

### 4.1. @Path and regular expression mappings

The @Path annotation is not limited to simple path expressions. Regular expressions can be inserted into a @Path's value. For example:

```java
@Path("/*\{var\}/stuff")
public class MyResource {
    @GET
    public String get() {...}
}
```

The following GETs will route to the `getResource()` method:

- GET /resources/stuff
- GET /resources/foo/stuff
- GET /resources/on/and/on/stuff

The format of the expression is:

`"{" variable-name \[ "\:\" regular-expression \] "\}\"`

The regular-expression part is optional. When the expression is not provided, it defaults to a wildcard matching of one particular segment. In regular-expression terms, the expression defaults to

`"\([\]\)\"`

For example:

```java
@Path("/resources/(\var)/stuff")
```

will match these:
Using @Path and @GET, @POST, etc.

| GET /resources/foo/stuff | GET /resources/bar/stuff |

but will not match:

| GET /resources/a/bunch/of/stuff |
@PathParam is a parameter annotation which allows you to map variable URI path fragments into your method call.

@Path("/library")
public class Library {

    @GET
    @Path("/book/{isbn}")
    public String getBook(@PathParam("isbn") String id) {
        // search my database and get a string representation and return it
    }
}

What this allows you to do is embed variable identification within the URIs of your resources. In the above example, an isbn URI parameter is used to pass information about the book we want to access. The parameter type you inject into can be any primitive type, a String, or any Java object that has a constructor that takes a String parameter, or a static valueOf method that takes a String as a parameter. For example, lets say we wanted isbn to be a real object. We could do:

@GET
@Path("/book/{isbn}")
public String getBook(@PathParam("isbn") ISBN id) {...}

public class ISBN {
    public ISBN(String str) {...}
}

Or instead of a public String constructors, have a valueOf method:

public class ISBN {
    public static ISBN valueOf(String isbn) {...}
}
5.1. Advanced @PathParam and Regular Expressions

There are a few more complicated uses of @PathParams not discussed in the previous section.

It is allowed to specify one or more path params embedded in one URI segment. Here are some examples:

1. @Path("/aaa{param}bbb")
2. @Path("/{name}-{zip}")
3. @Path("/foo{name}-{zip}bar")

So, a URI of "/aaa111bbb" would match #1. "/bill-02115" would match #2. "foobill-02115bar" would match #3.

It was discussed before how to use regular expression patterns within @Path values.

@GET
@Path("/aaa{param:b+}/{many:.*}/stuff")
public String getIt(@PathParam("param") String bs, @PathParam("many") String many) {...}

For the following requests, lets see what the values of the "param" and "many" @PathParams would be:

Table 5.1.

<table>
<thead>
<tr>
<th>Request</th>
<th>param</th>
<th>many</th>
</tr>
</thead>
<tbody>
<tr>
<td>GET /aaabb/some/stuff</td>
<td>bb</td>
<td>some</td>
</tr>
<tr>
<td>GET /aabab/a/lot/of/stuff</td>
<td>b</td>
<td>a/lot/of</td>
</tr>
</tbody>
</table>

5.2. @PathParam and PathSegment

The specification has a very simple abstraction for examining a fragment of the URI path being invoked on jakarta.ws.rs.core.PathSegment:

public interface PathSegment {
    /**
     * Get the path segment.
     * @return the path segment
     */
}
RESTEasy can inject a PathSegment instead of a value with the @PathParam.

```java
@PathParam
String getPath();
/**
 * Get a map of the matrix parameters associated with the path segment
 * @return the map of matrix parameters
 */
MultivaluedMap<String, String> getMatrixParameters();
}
```

This is very useful if you have a bunch of @PathParams that use matrix parameters. The idea of matrix parameters is that they are an arbitrary set of name-value pairs embedded in a uri path segment. The PathSegment object gives you access to these parameters. See also MatrixParam.

A matrix parameter example is:

```
GET http://host.com/library/book;name=EJB 3.0;author=Bill Burke
```

The idea of matrix parameters is that it represents resources that are addressable by their attributes as well as their raw id.
Chapter 6. @QueryParam

Note

RESTEasy supports @QueryParam annotations with no parameter name.

The @QueryParam annotation allows mapping a URI query string parameter or url form encoded parameter to a method invocation.

GET /books?num=5

```java
@GET
public String getBooks(@QueryParam("num") int num) {
...
}
```

Since RESTEasy is built on top of a Servlet, it does not distinguish between URI query strings or url form encoded parameters. Like PathParam, the parameter type can be a String, primitive, or class that has a String constructor or static valueOf() method.
Chapter 7. @HeaderParam

Note

RESTEasy supports @HeaderParam annotations with no parameter name.

The @HeaderParam annotation allows you to map a request HTTP header to a method invocation.

GET /books?num=5

@GET
public String getBooks(@HeaderParam("From") String from) {
  ...
}

Like PathParam, a parameter type can be a String, primitive, or class that has a String constructor or static valueOf() method. For example, MediaType has a valueOf() method and you could do:

@PUT
public void put(@HeaderParam("Content-Type") MediaType contentType, ...) 7.1. HeaderDelegate

In addition to the usual methods for translating parameters to and from strings, parameters annotated with @HeaderParam have another option: implementations of RuntimeDelegate$HeaderDelegate:

/**
 * Defines the contract for a delegate that is responsible for
 * converting between the String form of a HTTP header and
 * the corresponding Jakarta RESTful Web Services type (@code T).
 * 
 * @param <T> a Jakarta RESTful Web Services type that corresponds to the value of a
 * HTTP header.
 */
public static interface HeaderDelegate<T> {

  /**
   * Parse the supplied value and create an instance of (@code T).
   * 
   * @param value the string value.
HeaderDelegate is similar to ParamConverter, but it is not very convenient to register a HeaderDelegate since, unlike, for example, ParamConverterProvider, it is not treated by the Jakarta RESTful Web Services specification as a provider. The class jakarta.ws.rs.core.Configurable, which is subclassed by, for example, org.jboss.resteasy.spi.ResteasyProviderFactory has methods like

```java
/**
 * Register a class of a custom Jakarta RESTful Web Services component (such as an extension provider or
 * a @link jakarta.ws.rs.core.Feature feature) meta-provider) to be instantiated
 * and used in the scope of this configurable context.
 * ...
 * @param componentClass Jakarta RESTful Web Services component class to be configured
 * in the scope of this configurable context.
 * @return the updated configurable context.
 */
public C register(Class<?> componentClass);
```

but it is not clear that they are applicable to HeaderDelegates.

RESTEasy approaches this problem by allowing HeaderDelegateS to be annotated with @Provider. Not only will ResteasyProviderFactory.register() process HeaderDelegateS, but another useful consequence is that HeaderDelegates can be discovered automatically at runtime.
Chapter 8. Linking resources

There are two mechanisms available in RESTEasy to link a resource to another, and to link resources to operations: the Link HTTP header, and Atom links inside the resource representations.

8.1. Link Headers


The main advantage of Link headers over Atom links in the resource is that those links are available without parsing the entity body.

8.2. Atom links in the resource representations

RESTEasy allows the injection of Atom links [http://tools.ietf.org/html/rfc4287#section-4.2.7] directly inside the entity objects that are sending to the client, via auto-discovery.

Warning

This is only available when using the Jackson2 or Jakarta XML Binding providers (for JSON and XML).

The main advantage over Link headers is that there can be any number of Atom links directly over the concerned resources, for any number of resources in the response. For example, you can have Atom links for the root response entity, and also for each of its children entities.

8.2.1. Configuration

There is no configuration required to be able to inject Atom links into a resource representation, you just have to have this maven artifact in the application’s path:

Table 8.1. Maven artifact for Atom link injection

<table>
<thead>
<tr>
<th>Group</th>
<th>Artifact</th>
<th>Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>org.jboss.resteasy</td>
<td>resteasy-links</td>
<td>6.2.3.Final</td>
</tr>
</tbody>
</table>

8.2.2. Your first links injected

Three things are needed in order to tell RESTEasy to inject Atom links into an entity:
• Annotate the Jakarta RESTful Web Services method with @AddLinks to indicate that Atom links are to be injected into the response entity.

• Add RESTServiceDiscovery fields to the resource classes where Atom links are to be injected.

• Annotate the Jakarta RESTful Web Services methods you want Atom links for with @LinkResource, so that RESTEasy knows which links to create for which resources.

The following example illustrates how to declare everything in order to get the Atom links injected in the book store example:

```java
@Path("/")
@Consumes({"application/xml", "application/json"})
@Produces({"application/xml", "application/json"})
public interface BookStore {

    @AddLinks
    @LinkResource(value = Book.class)
    @GET
    @Path("books")
    public Collection<Book> getBooks();

    @LinkResource
    @POST
    @Path("books")
    public void addBook(Book book);

    @AddLinks
    @LinkResource
    @GET
    @Path("book/{id}")
    public Book getBook(@PathParam("id") String id);

    @LinkResource
    @PUT
    @Path("book/{id}")
    public void updateBook(@PathParam("id") String id, Book book);

    @LinkResource(value = Book.class)
    @DELETE
    @Path("book/{id}")
    public void deleteBook(@PathParam("id") String id); 
}
```

And this is the definition of the Book resource:

```java
@Mapped(namespaceMap = @XmlNsMap(jsonName = "atom", namespace = "http://www.w3.org/2005/Atom"))
@XmlRootElement
@XmlAccessorType(XmlAccessType.NONE)
public class Book {
    @XmlAttribute
    private String author;

    @XmlID
```
8.2.3. Customising Atom link serialization

The RESTServiceDiscovery is a Jakarta XML Binding type which inherits from List. You are free to annotate it in order to customise the Jakarta XML Binding serialisation, or just rely on the default with @XmlElementRef.

8.2.4. Specifying which Jakarta RESTful Web Services methods are tied to which resources

This is done by annotating the methods with the @LinkResource annotation. It supports the following optional parameters:

Table 8.2.
### @LinkResource parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Type</th>
<th>Function</th>
<th>Default</th>
</tr>
</thead>
<tbody>
<tr>
<td>value</td>
<td>Class</td>
<td>Declares an Atom link for the given type of resources.</td>
<td>Defaults to the entity body type (non-annotated parameter), or the method's return type. This default does not work with Response or Collection types, they need to be explicitly specified.</td>
</tr>
<tr>
<td>rel</td>
<td>String</td>
<td>The Atom link relation list</td>
<td>For GET methods returning a Collection self For GET methods returning a non-Collection remove For DELETE methods update For PUT methods add For POST methods</td>
</tr>
</tbody>
</table>

Several `@LinkResource` annotations can be added on a single method by enclosing them in a `@LinkResources` annotation. This allows the adding of links to the same method on several resource types. For example the `/order/foo/comments` operation can belong on the `Order` resource with the `comments` relation, and on the `Comment` resource with the `list` relation.

### 8.2.5. Specifying path parameter values for URI templates

When RESTEasy adds links to your resources it needs to insert the right values in the URI template. This is done either automatically by guessing the list of values from the entity, or by specifying the values in the `@LinkResource pathParameters` parameter.
8.2.5.1. Loading URI template values from the entity

URI template values are extracted from the entity from fields or Java Bean properties annotated with @ResourceID, Jakarta XML Binding's @XmlID or Jakarta Persistence's @Id. If there is more than one URI template value to find in a given entity, the entity can be annotated with @ResourceIDs to list the names of fields or properties that make up this entity's Id. If there are other URI template values required from a parent entity, RESTEasy tries to find the parent on a field or Java Bean property annotated with @ParentResource. The list of URI template values extracted up every @ParentResource is then reversed and used as the list of values for the URI template.

For example, consider the previous Book example, and a list of comments:

```java
@XmlRootElement
@XmlAccessorType(XmlAccessType.NONE)
public class Comment {
    @ParentResource
    private Book book;

    @XmlElement
    private String author;

    @XmlID
    @XmlAttribute
    private String id;

    @XmlElementRef
    private RESTServiceDiscovery rest;
}
```

Given the previous book store service augmented with comments:

```java
@Path("/")
@Consumes({"application/xml", "application/json"})
@Produces({"application/xml", "application/json"})
public interface BookStore {

    @AddLinks
    @LinkResources(
        @LinkResource(value = Book.class, rel = "comments"),
        @LinkResource(value = Comment.class)
    )
    @GET
    @Path("book/{id}/comments")
    public Collection<Comment> getComments(@PathParam("id") String bookId);

    @AddLinks
    @LinkResource
    @GET
    @Path("book/{id}/comment/{cid}")
    public Comment getComment(@PathParam("id") String bookId, @PathParam("cid") String commentId);
}
```

 ```
Whenever we need to make links for a Book entity, we look up the ID in the Book's @XmlID property. Whenever we make links for Comment entities, we have a list of values taken from the Comment's @XmlID and its @ParentResource: the Book and its @XmlID.

For a Comment with id "1" on a Book with title "foo" we will therefore get a list of URI template values of {"foo", "1"}, to be replaced in the URI template, thus obtaining either "/book/foo/comments" or "/book/foo/comment/1".

### 8.2.5.2. Specifying path parameters manually

An alternative to annotating entities with resource ID annotations (@ResourceID, @ResourceIDs, @XmlID or @Id) and @ParentResource, you can specify the URI template values inside the @LinkResource annotation, using Unified Expression Language expressions:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Type</th>
<th>Function</th>
<th>Default</th>
</tr>
</thead>
<tbody>
<tr>
<td>pathParameters</td>
<td>String[]</td>
<td>Declares a list of UEL expressions to obtain the URI template values.</td>
<td>Defaults to using @ResourceID, @ResourceIDs, @XmlID or @Id and @ParentResource annotations to extract the values from the model.</td>
</tr>
</tbody>
</table>

The UEL expressions are evaluated in the context of the entity, which means that any unqualified variable will be taken as a property for the entity itself, with the special variable `this` bound to the entity for which links are being generated.

The previous example of Comment service could be declared as such:
@Path("/")
@Consumes( { "application/xml", "application/json" } )
@Produces( { "application/xml", "application/json" } )
public interface BookStore {
  @AddLinks
  @LinkResources({
    @LinkResource(value = Book.class, rel = "comments", pathParameters = "${title}"),
    @LinkResource(value = Comment.class, pathParameters = "${book.title}, ${id}"")
  })
  @GET
  @Path("/book/{id}/comments")
  public Collection<Comment> getComments(@PathParam("id") String bookId);

  @AddLinks
  @LinkResource(pathParameters = "${book.title}, ${id}"")
  @GET
  @Path("/book/{id}/comment/{cid}")
  public Comment getComment(@PathParam("id") String bookId, @PathParam("cid") String commentId);

  @LinkResource(pathParameters = "${book.title}, ${id}"")
  @POST
  @Path("/book/{id}/comments")
  public void addComment(@PathParam("id") String bookId, Comment comment);

  @LinkResource(pathParameters = "${book.title}, ${id}"")
  @PUT
  @Path("/book/{id}/comment/{cid}")
  public void updateComment(@PathParam("id") String bookId, @PathParam("cid") String commentId, Comment comment);

  @LinkResource(Comment.class, pathParameters = "${book.title}, ${id}"")
  @DELETE
  @Path("/book/{id}/comment/{cid}")
  public void deleteComment(@PathParam("id") String bookId, @PathParam("cid") String commentId);
}

8.2.6. Securing entities

The user can restrict which links are injected in the resource based on security restrictions for the client, so that if the current client doesn't have permission to delete a resource he will not be presented with the "delete" link relation.

Security restrictions can either be specified on the @LinkResource annotation, or using RESTEasy and Jakarta Enterprise Beans security annotation @RolesAllowed on the Jakarta RESTful Web Services method.

Table 8.4.
### @LinkResource security restrictions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Type</th>
<th>Function</th>
<th>Default</th>
</tr>
</thead>
<tbody>
<tr>
<td>constraint</td>
<td>String</td>
<td>A UEL expression which must evaluate to true to inject this method's link in the response entity.</td>
<td>Defaults to using @RolesAllowed from the Jakarta RESTful Web Services method.</td>
</tr>
</tbody>
</table>

#### 8.2.7. Extending the UEL context

It has been shown that both the URI template values and the security constraints of @LinkResource use UEL to evaluate expressions. RESTEasy provides a basic UEL context with access only to the entity we are injecting links in, and nothing more.

More variables or functions can be added in this context, by adding a @LinkELProvider annotation on the Jakarta RESTful Web Services method, its class, or its package. This annotation's value should point to a class that implements the ELProvider interface, which wraps the default ELContext in order to add any missing functions.

For example, to support the Seam annotation s:hasPermission(target, permission) in your security constraints, add a package-info.java file like this:

```java
@LinkELProvider(SeamELProvider.class)
package org.jboss.resteasy.links.test;
import org.jboss.resteasy.links. *
```

With the following provider implementation:

```java
package org.jboss.resteasy.links.test;
import jakarta.el.ELContext;
import jakarta.el.ELResolver;
import jakarta.el.FunctionMapper;
import jakarta.el.VariableMapper;
import org.jboss.seam.el.SeamFunctionMapper;
import org.jboss.resteasy.links.ELProvider;

public class SeamELProvider implements ELProvider {

    public ELContext getContext(final ELContext ctx) { return new ELContext() {
        private SeamFunctionMapper functionMapper;

        @Override
        public ELResolver getELResolver() {
```
return ctx.getELResolver();

@Override
public FunctionMapper getFunctionMapper()
{
    if (functionMapper == null)
    {
        functionMapper = new SeamFunctionMapper(ctx
            .getFunctionMapper());
        return functionMapper;
    }
}

@Override
public VariableMapper getVariableMapper()
{
    return ctx.getVariableMapper();
}

And then use it as such:

@Path("/")
@Consumes({"application/xml", "application/json"})
@Produces({"application/xml", "application/json"})
public interface BookStore {

    @AddLinks
    @LinkResources(
            @LinkResource(value = Book.class, rel = "comments", constraint = "${s:hasPermission(this, 'add-comment')}"),
            @LinkResource(value = Comment.class, constraint = "${s:hasPermission(this, 'insert')}"))
    @GET
    @Path("book/{id}/comments")
    public Collection<Comment> getComments(@PathParam("id") String bookId);

    @AddLinks
    @LinkResource(constraint = "${s:hasPermission(this, 'read')}"
    @GET
    @Path("book/{id}/comment/{cid}")
    public Comment getComment(@PathParam("id") String bookId, @PathParam("cid") String commentId);

    @LinkResource(constraint = "${s:hasPermission(this, 'insert')}"
    @POST
    @Path("book/{id}/comments")
    public void addComment(@PathParam("id") String bookId, Comment comment);

    @LinkResource(constraint = "${s:hasPermission(this, 'update')}"
    @PUT
    @Path("book/{id}/comment/{cid}")
    public void updateComment(@PathParam("id") String bookId, @PathParam("cid") String commentId, Comment comment);

    @LinkResource(Comment.class, constraint = "${s:hasPermission(this, 'delete')}"
    @DELETE
    @Path("book/{id}/comment/{cid}")
8.2.8. Resource facades

Sometimes it is useful to add resources which are just containers or layers on other resources, for example to represent a collection of Comment with a start index and a certain number of entries, in order to implement paging. Such a collection is not really an entity in the model, but it should obtain the "add" and "list" link relations for the Comment entity.

This is possibly using resource facades. A resource facade is a resource which implements the ResourceFacade<T> interface for the type T, and as such, should receive all links for that type.

Since in most cases the instance of the T type is not directly available in the resource facade, another way is needed to extract its URI template values. This is done by calling the resource facade's pathParameters() method to obtain a map of URI template values by name. This map will be used to fill in the URI template values for any link generated for T, if there are enough values in the map.

Here is an example of such a resource facade for a collection of Comments:

```java
@XmlElement
@XmlAccessorType(XmlAccessType.NONE)
public class ScrollableCollection implements ResourceFacade<Comment> {
    private String bookId;
    @XmlAttribute
    private int start;
    @XmlAttribute
    private int totalRecords;
    @XmlElement
    private List<Comment> comments = new ArrayList<Comment>();
    @XmlElementRef
    private RESTServiceDiscovery rest;

    public Class<Comment> facadeFor() {
        return Comment.class;
    }

    public Map<String, ? extends Object> pathParameters() {
        HashMap<String, String> map = new HashMap<String, String>();
        map.put("id", bookId);
        return map;
    }
}
```

This will produce such an XML collection:

```xml
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
```
<collection xmlns:atom="http://www.w3.org/2005/Atom" totalRecords="2" start="0">
  <comment xmlid="0">
    <text>great book</text>
  </comment>
  <comment xmlid="1">
    <text>terrible book</text>
    <atom:link href="http://localhost:8081/book/foo/comment/1" rel="remove"/>
  </comment>
</collection>
The idea of matrix parameters is that they are an arbitrary set of name-value pairs embedded in a uri path segment. A matrix parameter example is:

GET http://host.com/library/book;name=EJB 3.0;author=Bill Burke

The idea of matrix parameters is that it represents resources that are addressable by their attributes as well as their raw id. The @MatrixParam annotation allows URI matrix parameters to be injected into a method invocation.

```java
@GET
public String getBook(@MatrixParam("name") String name, @MatrixParam("author") String author) {
    [...]}
```

There is one big problem with @MatrixParam that the current version of the specification does not resolve. What if the same MatrixParam exists twice in different path segments? In this case, it is better to use PathParam combined with PathSegment.
Chapter 10. @CookieParam

The @CookieParam annotation allows the injection of the value of a cookie or an object representation of an HTTP request cookie into a method invocation

GET /books?num=5

```java
@GET
public String getBooks(@CookieParam("sessionid") int id) {
    ...
}

@GET
public String getBooks(@CookieParam("sessionid") jakarta.ws.rs.core.Cookie id) {...}
```

Like PathParam, the parameter type can be a String, primitive, or class that has a String constructor or static valueOf() method. It can also get an object representation of the cookie via the jakarta.ws.rs.core.Cookie class.
When the input request body is of the type "application/x-www-form-urlencoded", a.k.a. an HTML Form, individual form parameters can be injected from the request body into method parameter values.

```html
<form method="POST" action="/resources/service">
First name:
<input type="text" name="firstname">
<br>
Last name:
<input type="text" name="lastname">
</form>
```

If posted through that form, this is what the service might look like:

```java
@Path("/")
public class NameRegistry {

    @Path("/resources/service")
    @POST
    public void addName(@FormParam("firstname") String first, @FormParam("lastname") String last) {
        ...
    }

A @FormParam cannot be combined with the default "application/x-www-form-urlencoded" that unmarshalls to a MultivaluedMap<String, String>. i.e. This is illegal:

```java
@Path("/")
public class NameRegistry {

    @Path("/resources/service")
    @POST
    @Consumes("application/x-www-form-urlencoded")
    public void addName(@FormParam("firstname") String first, MultivaluedMap<String, String> form) {
        ...
    }
```
Chapter 12. @Form

@Form is a RESTEasy specific annotation that allows the re-use of any @*Param annotation within an injected class. RESTEasy will instantiate the class and inject values into any annotated @*Param or @Context property. This is useful when there are a lot of parameters on a method and it is wanted to condense them into a value object.

```java
public class MyForm {
    @FormParam("stuff")
    private int stuff;

    @HeaderParam("myHeader")
    private String header;

    @PathParam("foo")
    public void setFoo(String foo) {...}
}

@POST
@Path("/myservice")
public void post(@Form MyForm form) {...}
```

When somebody posts to /myservice, RESTEasy will instantiate an instance of MyForm and inject the form parameter "stuff" into the "stuff" field, the header "myheader" into the header field, and call the setFoo method with the path param variable of "foo".

@Form has some expanded @FormParam features. If a prefix is specified within the Form param, this will prepend a prefix to any form parameter lookup. For example, say you have one Address class, but want to reference invoice and shipping addresses from the same set of form parameters:

```java
public static class Person {
    @FormParam("name")
    private String name;

    @Form(prefix = "invoice")
    private Address invoice;

    @Form(prefix = "shipping")
    private Address shipping;
}

public static class Address {
    @FormParam("street")
    private String street;
}
```
In this example, the client could send the following form parameters:

```plaintext
name=bill
invoice.street=xxx
shipping.street=yyy
```

The `Person.invoice` and `Person.shipping` fields would be populated appropriately. Note, prefix mappings also support lists and maps:

```java
public static class Person {
    @Form(prefix="telephoneNumbers") List<TelephoneNumber> telephoneNumbers;
    @Form(prefix="address") Map<String, Address> addresses;
}
```

```java
public static class TelephoneNumber {
    @FormParam("countryCode") private String countryCode;
    @FormParam("number") private String number;
}
```

```java
public static class Address {
    @FormParam("street") private String street;
    @FormParam("houseNumber") private String houseNumber;
}
```

In this example, the client could send the following form parameters:

```plaintext
public void post (@Form Person p) {}
```

The following form params could be submitted and the `Person.telephoneNumbers` and `Person.addresses` fields would be populated appropriately.
request.addFormHeader("telephoneNumbers[0].countryCode", "31");
request.addFormHeader("telephoneNumbers[0].number", "0612345678");
request.addFormHeader("telephoneNumbers[1].countryCode", "91");
request.addFormHeader("telephoneNumbers[1].number", "9717738723");
request.addFormHeader("address[INVOICE].street", "Main Street");
request.addFormHeader("address[INVOICE].houseNumber", "2");
request.addFormHeader("address[SHIPPING].street", "Square One");
request.addFormHeader("address[SHIPPING].houseNumber", "13");
Chapter 13. Improved @_Param annotations

The Jakarta RESTful Web Services specification defines annotations @PathParam, @QueryParam, @FormParam, @CookieParam, @HeaderParam and @MatrixParam. Each annotation requires a parameter name. RESTEasy provides a parallel set of annotations, @PathParam, @QueryParam, @FormParam, @CookieParam, @HeaderParam and @MatrixParam which do not require a parameter name. To use this RESTEasy feature, replace the annotation's package name, jakarta.ws.rs with, org.jboss.resteasy.annotations.jaxrs.

Note that you can omit the annotation name for annotated method parameters as well as annotated fields or JavaBean properties.

Usage:

```java
import org.jboss.resteasy.annotations.jaxrs.*;

@Path("/library")
public class Library {
    @GET
    @Path("/book/{isbn}")
    public String getBook(@PathParam String isbn) {
        // search my database and get a string representation and return it
    }
}
```

If an annotated variable does not have the same name as the path parameter, the name can still be specified:

```java
import org.jboss.resteasy.annotations.jaxrs.*;

@Path("/library")
public class Library {
    @GET
    @Path("/book/{isbn}")
    public String getBook(@PathParam("isbn") String id) {
        // search my database and get a string representation and return it
    }
}
```
Chapter 14. Optional parameter types

RESTEasy offers a mechanism to support a series of java.util.Optional types as a wrapper object types. This will give users the ability to use optional typed parameters, and eliminate all null checks by using methods like Optional.orElse().

Here is the sample:

```java
@Path("/double")
@GET
public String optDouble(@QueryParam("value") OptionalDouble value) {
    return Double.toString(value.orElse(4242.0));
}
```

From the above sample code we can see that the OptionalDouble can be used as parameter type, and when users don’t provide a value in @QueryParam, then the default value will be returned.

Here is the list of supported optional parameter types:

- @QueryParam
- @FormParam
- @MatrixParam
- @HeaderParam
- @CookieParam

As the list shown above, those parameter types support the Java-provided Optional types. Please note that the @PathParam is an exception for which Optional is not available. The reason is that Optional for the @PathParam use case would just be a NO-OP, since an element of the path cannot be omitted.

The Optional types can also be used as type of the fields of a @BeanParam’s class.

Here is an example of endpoint with a @BeanParam:

```java
@Path("/double")
@GET
public String optDouble(@BeanParam Bean bean) {
    return Double.toString(bean.value.orElse(4242.0));
}
```
Optional parameter types

```java
Double.toString(bean.value.orElse(4242.0));
```

The corresponding class `Bean`:

```java
public class Bean {
    @QueryParam("value")
    OptionalDouble value;
}
```

Finally, the `Optional` types can be used directly as type of the fields of a Jakarta RESTful Web Services resource class.

Here is an example of a Jakarta RESTful Web Services resource class with an `Optional` type:

```java
@RequestScoped
public class OptionalResource {
    @QueryParam("value")
    Optional<String> value;
    ...
}
```
Chapter 15. @DefaultValue

@DefaultValue is a parameter annotation that can be combined with any of the other @*Param annotations to define a default value when the HTTP request item does not exist.

@GET
public String getBooks(@QueryParam("num") @DefaultValue("10") int num) {...}
Chapter 16. @Encoded and
encoding
Jakarta RESTful Web Services allows encoded or decoded @*Params, the specification of path
definitions and parameter names using encoded or decoded strings.

The @jakarta.ws.rs.Encoded annotation can be used on a class, method, or param. By default,
inject @PathParam and @QueryParams are decoded. By additionally adding the @Encoded annotation, the value of these params will be provided in encoded form.

@Path("/")
public class MyResource {
@Path("/{param}")
@GET
public String get(@PathParam("param") @Encoded String param) {...}
}

In the above example, the value of the @PathParam injected into the param of the get() method
will be URL encoded. Adding the @Encoded annotation as a paramater annotation triggers this
affect.
The @Encoded annotation may also be used on the entire method and any combination of
@QueryParam or @PathParam's values will be encoded.

@Path("/")
public class MyResource {
@Path("/{param}")
@GET
@Encoded
public String get(@QueryParam("foo") String foo, @PathParam("param") String param) {}
}

In the above example, the values of the "foo" query param and "param" path param will be injected
as encoded values.
The default can also be encoded for the entire class.

@Path("/")
@Encoded

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The `@Path` annotation has an attribute called `encode`. It controls whether the literal part of the supplied value (those characters that are not part of a template variable) are URL encoded. If true, any characters in the URI template that are not valid URI character will automatically be encoded. If false, all characters must be valid URI characters. By default, this is set to true. If you want to encode the characters yourself, you may.

```java
@Path(value="hello%20world", encode=false)
```

Much like `@Path.encode()`, this controls whether the specified query param name should be encoded by the container before it tries to find the query param in the request.

```java
@QueryParam(value="hello%20world", encode=false)
```
Chapter 17. @Context

The @Context annotation allows the injection of instances of

- jakarta.ws.rs.core.HttpHeaders
- jakarta.ws.rs.core.UriInfo
- jakarta.ws.rs.core.Request
- jakarta.servlet.http.HttpServletRequest
- jakarta.servlet.http.HttpServletResponse
- jakarta.servlet.ServletConfig
- jakarta.servlet.ServletContext
- jakarta.ws.rs.core.SecurityContext

objects.
Chapter 18. Jakarta RESTful Web Services Resource Locators and Sub Resources

Resource classes are able to partially process a request and provide another "sub" resource object that can process the remainder of the request. For example:

```java
@Path("/")
public class ShoppingStore {

    @Path("/customers/{id}")
    public Customer getCustomer(@PathParam("id") int id) {
        Customer cust = ...; // Find a customer object
        return cust;
    }
}

public class Customer {

    @GET
    public String get() {...}

    @Path("/address")
    public String getAddress() {...}
}
```

Resource methods that have a @Path annotation, but no HTTP method are considered sub-resource locators. Their job is to provide an object that can process the request. In the above example ShoppingStore is a root resource because its class is annotated with @Path. The getCustomer() method is a sub-resource locator method.

If the client invoked:

```
GET /customer/123
```

The ShoppingStore.getCustomer() method would be invoked first. This method provides a Customer object that can service the request. The http request will be dispatched to the Customer.get() method. Another example is:

```
GET /customer/123/address
```
In this request, again, first the ShoppingStore.getCustomer() method is invoked. A customer object is returned, and the rest of the request is dispatched to the Customer.getAddress() method.

Another interesting feature of Sub-resource locators is that the locator method result is dynamically processed at runtime to figure out how to dispatch the request. So, the ShoppingStore.getCustomer() method does not have to declare any specific type.

```java
@Path("/")
public class ShoppingStore {

    @Path("/customers/{id}"),
    public java.lang.Object getCustomer(@PathParam("id") int id) {
        Customer cust = ...; // Find a customer object
        return cust;
    }
}

public class Customer {

    @GET
    public String get() {...}

    @Path("/address")
    public String getAddress() {...}
}
```

In the above example, getCustomer() returns a java.lang.Object. Per request, at runtime, the Jakarta RESTful Web Services server will determine how to dispatch the request based on the object returned by getCustomer(). Possible uses of this are:

- There maybe a class hierarchy for your customers. Customer is the abstract base class, CorporateCustomer and IndividualCustomer are subclasses.

- The getCustomer() method might be doing a Hibernate polymorphic query and doesn't know, or care, what concrete class is it querying for, or what it returns.

```java
@Path("/")
public class ShoppingStore {

    @Path("/customers/{id}"),
    public java.lang.Object getCustomer(@PathParam("id") int id) {
        Customer cust = entityManager.find(Customer.class, id);
        return cust;
    }
}

public class Customer {

    @GET
```
public String get() {...}

@Path("/address")
public String getAddress() {...}
}

public class CorporateCustomer extends Customer {

@Path("/businessAddress")
public String getAddress() {...}
}
Chapter 19. Resources metadata configuration

When processing Jakarta RESTful Web Services deployments, RESTEasy relies on ResourceBuilder to create metadata for each Jakarta RESTful Web Services resource. Such metadata is defined using the metadata SPI in package org.jboss.resteasy.spi.metadata, in particular the ResourceClass interface:

```java
package org.jboss.resteasy.spi.metadata;

public interface ResourceClass {
    String getPath();
    Class<?> getClazz();
    ResourceConstructor getConstructor();
    FieldParameter[] getFields();
    SetterParameter[] getSetters();
    ResourceMethod[] getResourceMethods();
    ResourceLocator[] getResourceLocators();
}
```

Among the other classes and interfaces defining metadata SPI, the following interfaces are worth a mention here:

```java
public interface ResourceConstructor {
    ResourceClass getResourceClass();
    Constructor getConstructor();
    ConstructorParameter[] getParams();
}

public interface ResourceMethod extends ResourceLocator {
    Set<String> getHttpMethods();
    MediaType[] getProduces();
    MediaType[] getConsumes();
}
```
Resources metadata configuration

```java
boolean isAsynchronous();

void markAsynchronous();
}

public interface ResourceLocator {
    ResourceClass getResourceClass();
    Class<?> getReturnType();
    Type getGenericReturnType();
    Method getMethod();
    Method getAnnotatedMethod();
    MethodParameter[] getParams();
    String getFullpath();
    String getPath();
}
```

The interesting point is that RESTEasy allows tuning the metadata generation by providing implementations of the `ResourceClassProcessor` interface:

```java
package org.jboss.resteasy.spi.metadata;

public interface ResourceClassProcessor {

    /**
     * Allows the implementation of this method to modify the resource metadata represented by
     * the supplied ResourceClass instance. Implementation will typically create
     * wrappers which modify only certain aspects of the metadata.
     * @param clazz The original metadata
     * @return the (potentially modified) metadata (never null)
     */
    ResourceClass process(ResourceClass clazz);
}
```

The processors are meant to be, and are resolved as, regular Jakarta RESTful Web Services annotated providers. They allow for wrapping resource metadata classes with custom versions that can be used for various advanced scenarios like:

- adding additional resource method/locators to the resource
- altering the http methods
Resources meta-data configuration

- altering the @Produce / @Consume media types
Chapter 20. Jakarta RESTful Web Services Content Negotiation

The HTTP protocol has built in content negotiation headers that allow the client and server to specify what content they are transferring and what content they would prefer to get. The server declares content preferences via the @Produces and @Consumes headers.

@Consumes is an array of media types that a particular resource or resource method consumes. For example:

```java
@Consumes("text/*")
@Path("/library")
public class Library {

    @POST
    public String stringBook(String book) {...}

    @Consumes("text/xml")
    @POST
    public String jaxbBook(Book book) {...}
}
```

When a client makes a request, Jakarta RESTful Web Services first finds all methods that match the path, then, it those matches based on the content-type header sent by the client. So, if a client sent:

```
POST /library
Content-Type: text/plain

This is a nice book
```

The stringBook() method would be invoked because it matches to the default "text/*" media type. Now, if the client instead sends XML:

```
POST /library
Content-Type: text/xml

<book name="EJB 3.0" author="Bill Burke"/>
```

The jaxbBook() method would be invoked.
Jakarta RESTful Web Services Content Negotiation

The @Produces is used to map a client request and match it up to the client's Accept header. The Accept HTTP header is sent by the client and defines the media types the client prefers to receive from the server.

```java
@Produces("text/*")
@Path("/library")
public class Library {

    @GET
    @Produces("application/json")
    public String getJSON() {...}

    @GET
    public String get() {...}
}
```

So, if the client sends:

```
GET /library
Accept: application/json
```

The getJSON() method would be invoked.

@Consumes and @Produces can list multiple media types that they support. The client's Accept header can also send multiple types it might like to receive. More specific media types are chosen first. The client Accept header or @Produces @Consumes can also specify weighted preferences that are used to match requests with resource methods. This is best explained by RFC 2616 section 14.1. RESTEasy supports this complex way of doing content negotiation.

A variant in Jakarta RESTful Web Services is a combination of media type, content-language, and content encoding as well as etags, last modified headers, and other preconditions. This is a more complex form of content negotiation that is done programmatically by the application developer using the jakarta.ws.rs.core.Variant, VarianListBuilder, and Request objects. Request is injected via @Context. Read the javadoc for more info on these.

### 20.1. URL-based negotiation

Some clients, like browsers, cannot use the Accept and Accept-Language headers to negotiate the representation's media type or language. RESTEasy allows the mapping of file name suffixes like (.xml, .txt, .en, .fr) to media types and languages. These file name suffixes take the place and override any Accept header sent by the client. They are configured using the resteasy.media.type.mappings and resteasy.language.mappings parameters. If configured within the application's web.xml, it would look like:
See Section 3.4, “Configuration” for more information about application configuration.

Mappings are a comma delimited list of suffix/mediatype or suffix/language mappings. Each mapping is delimited by a ‘:’. If GET /foo/bar.xml.en is invoked, this would be equivalent to invoking the following request:

GET /foo/bar
Accept: application/xml
Accept-Language: en-US

The mapped file suffixes are stripped from the target URL path before the request is dispatched to a corresponding Jakarta RESTful Web Services resource.

20.2. Query String Parameter-based negotiation

RESTEasy can do content negotiation based in a parameter in the query string. To enable this, the parameter resteasy.media.type.param.mapping should be configured in the web.xml file. It would look like the following:

See Section 3.4, “Configuration” for more information about application configuration.
The param-value is the name of the query string parameter that RESTEasy will use in the place of the Accept header.

Invoking http://service.foo.com/resource?someName=application/xml, will give the application/xml media type the highest priority in the content negotiation.

In cases where the request contains both the parameter and the Accept header, the parameter will be more relevant.

It is possible to leave the param-value empty, that will cause the processor to look for a parameter named 'accept'.
Chapter 21. Content Marshalling/Providers

21.1. Default Providers and default Jakarta RESTful Web Services Content Marshalling

RESTEasy can automatically marshal and unmarshal a few different message bodies.

Table 21.1.

<table>
<thead>
<tr>
<th>Media Types</th>
<th>Java Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>application/<em>+xml, text/</em>+xml, application/<em>+json, application/</em>+fastinfoset, application/atom+*</td>
<td>Jakarta XML Binding annotated classes</td>
</tr>
<tr>
<td>application/<em>+xml, text/</em>+xml</td>
<td>org.w3c.dom.Document</td>
</tr>
<tr>
<td>/*</td>
<td>java.lang.String</td>
</tr>
<tr>
<td>*/</td>
<td>java.io.InputStream</td>
</tr>
<tr>
<td>text/plain</td>
<td>primitives, java.lang.String, or any type that has a String constructor, or static valueOf(String) method for input, toString() for output</td>
</tr>
<tr>
<td>/*</td>
<td>jakarta.activation.DataSource</td>
</tr>
<tr>
<td>/*</td>
<td>java.io.File</td>
</tr>
<tr>
<td>/*</td>
<td>byte[]</td>
</tr>
<tr>
<td>application/x-www-form-urlencoded</td>
<td>jakarta.ws.rs.core.MultivaluedMap</td>
</tr>
</tbody>
</table>

Note. When a java.io.File is created, as in

```java
@Path("/test")
public class TempFileDeletionResource {
    @POST
    @Path("post")
    public Response post(File file) throws Exception {
        return Response.ok(file.getPath()).build();
    }
}
```
a temporary file is created in the file system. On the server side, that temporary file will be deleted at the end of the invocation. On the client side, however, it is the responsibility of the user to delete the temporary file.

21.2. Content Marshalling with @Provider classes

The Jakarta RESTful Web Services specification allows the user to plug in their own request/response body reader and writers. To do this, the user annotates a class with @Provider and specify the @Produce types for a writer and @Consumes types for a reader. The user must also implement a MessageBodyReader/Writer interface respectively. Here is an example:

```java
@Provider
@Produces("text/plain")
@Consumes("text/plain")
public class DefaultTextPlain implements MessageBodyReader, MessageBodyWriter {
    public boolean isReadable(Class type, Type genericType, Annotation[] annotations,
        MediaType mediaType) {
        // StringTextStar should pick up strings
        return !String.class.equals(type) && TypeConverter.isConvertible(type);
    }

    public Object readFrom(Class type, Type genericType, Annotation[] annotations,
        MediaType mediaType, MultivaluedMap httpHeaders, InputStream entityStream)
        throws IOException, WebApplicationException {
        InputStream delegate = NoContent.noContentCheck(httpHeaders, entityStream);
        String value = ProviderHelper.readString(delegate, mediaType);
        return TypeConverter.getType(type, value);
    }

    public boolean isWriteable(Class type, Type genericType, Annotation[] annotations,
        MediaType mediaType) {
        // StringTextStar should pick up strings
        return !String.class.equals(type) && !type.isArray();
    }

    public long getSize(Object o, Class type, Type genericType, Annotation[] annotations,
        MediaType mediaType) {
        String charset = mediaType.getParameters().get("charset");
        if (charset != null)
            try {
                return o.toString().getBytes(charset).length;
            } catch (UnsupportedEncodingException e) {
                // Use default encoding.
            }
        return o.toString().getBytes(StandardCharsets.UTF_8).length;
    }

    public void writeTo(Object o, Class type, Type genericType, Annotation[] annotations,
        MediaType mediaType, MultivaluedMap httpHeaders, OutputStream entityStream)
        throws IOException, WebApplicationException {
        String charset = mediaType.getParameters().get("charset");
    }
}
if (charset == null)
    entityStream.write(o.toString().getBytes(StandardCharsets.UTF_8));
else entityStream.write(o.toString().getBytes(charset));
}
}

Note that in order to support Async IO, the user must implement the AsyncMessageBodyWriter interface, which requires the implementation of this extra method:

@Provider
@Produces("text/plain")
@Consumes("text/plain")
public class DefaultTextPlain implements MessageBodyReader, AsyncMessageBodyWriter {
    // ...
    public CompletionStage<Void> asyncWriteTo(Object o, Class type, Type genericType,
        Annotation[] annotations, MediaType mediaType, MultivaluedMap httpHeaders, AsyncOutputStream
        entityStream) {
        String charset = mediaType.getParameters().get("charset");
        if (charset == null)
            return entityStream.asyncWrite(o.toString().getBytes(StandardCharsets.UTF_8));
        else
            return entityStream.asyncWrite(o.toString().getBytes(charset));
    }
}

The RESTEasy ServletContextLoader will automatically scan the application's WEB-INF/lib and
classes directories for classes annotated with @Provider or the user can manually configure them
in web.xml. See Installation/Configuration.

21.3. Providers Utility Class

jakarta.ws.rs.ext.Providers is a simple injectable interface that allows you to look up Message-
BodyReaders, Writers, ContextResolvers, and ExceptionMappers. It is very useful, for instance,
for implementing multipart providers. Content types that embed other random content types.

public interface Providers {

    /**
     * Get a message body reader that matches a set of criteria. The set of
     * readers is first filtered by comparing the supplied value of
     * @code mediaType) with the value of each reader's
     * @link jakarta.ws.rs.Consumes), ensuring the supplied value of
     * @code type) is assignable to the generic type of the reader, and
     * eliminating those that do not match.
     * The list of matching readers is then ordered with those with the best
### Content Marshalling/Providers

```java
* matching values of (@link jakarta.ws.rs.Consumes) (x/y > x/* > */*)
* sorted first. Finally, the
* (@link MessageBodyReader#isReadable)
* method is called on each reader in order using the supplied criteria and
* the first reader that returns (@code true) is selected and returned.
* 
* @param type the class of object that is to be written.
* @param mediaType the media type of the data that will be read.
* @param genericType the type of object to be produced. E.g. if the
* message body is to be converted into a method parameter, this will be
* the formal type of the method parameter as returned by
* <code>Class.getGenericParameterTypes</code>.
* @param annotations an array of the annotations on the declaration of the
* artifact that will be initialized with the produced instance. E.g. if the
* message body is to be converted into a method parameter, this will be
* the annotations on that parameter returned by
* <code>Class.getParameterAnnotations</code>.
* @return a MessageBodyReader that matches the supplied criteria or null
* if none is found.
*/
<T> MessageBodyReader<T> getMessageBodyReader(Class<T> type,
                                              Type genericType, Annotation
                                              annotations[], MediaType mediaType);
```

```java
/**
* Get a message body writer that matches a set of criteria. The set of
* writers is first filtered by comparing the supplied value of
* (@code mediaType) with the value of each writer's
* (@link jakarta.ws.rs.Produces), ensuring the supplied value of
* (@code type) is assignable to the generic type of the reader, and
* eliminating those that do not match.
* The list of matching writers is then ordered with those with the best
* matching values of (@link jakarta.ws.rs.Produces) (x/y > x/* > */*)
* sorted first. Finally, the
* (@link MessageBodyWriter#isWriteable)
* method is called on each writer in order using the supplied criteria and
* the first writer that returns (@code true) is selected and returned.
* 
* @param mediaType the media type of the data that will be written.
* @param type the class of object that is to be written.
* @param genericType the type of object to be written. E.g. if the
* message body is to be produced from a field, this will be
* the declared type of the field as returned by
* <code>Field.getGenericType</code>.
* @param annotations an array of the annotations on the declaration of the
* artifact that will be written. E.g. if the
* message body is to be produced from a field, this will be
* the annotations on that field returned by
* <code>Field.getDeclaredAnnotations</code>.
* @return a MessageBodyWriter that matches the supplied criteria or null
* if none is found.
*/
<T> MessageBodyWriter<T> getMessageBodyWriter(Class<T> type,
                                              Type genericType, Annotation
                                              annotations[], MediaType mediaType);
```

/**
* Get an exception mapping provider for a particular class of exception.
* Returns the provider whose generic type is the nearest superclass of
A Providers instance is injectable into MessageBodyReader or Writers:

```java
@Provider
@Consumes("multipart/fixed")
public class MultipartProvider implements MessageBodyReader {
    private @Context Providers providers;
    ...
}
```

## 21.4. Configuring Document Marshalling

XML document parsers are subject to a form of attack known as the XXE (Xml eXternal Entity) Attack (https://owasp.org/www-community/vulnerabilities/XML_External_Entity_(XXE)_Processing), in which expanding an external entity causes an unsafe file to be loaded. For example, the document
could cause the passwd file to be loaded.

By default, RESTEasy's built-in unmarshaller for org.w3c.dom.Document documents will not expand external entities, replacing them by the empty string instead. It can be configured to replace external entities by values defined in the DTD by setting the parameter to "true". If configured in the web.xml file, it would be:

```
<context-param>
  <param-name>resteasy.document.expand.entity.references</param-name>
  <param-value>true</param-value>
</context-param>
```

See Section 3.4, "Configuration" for more information about application configuration.

Another way of dealing with the problem is by prohibiting DTDs, which RESTEasy does by default. This behavior can be changed by setting the parameter to "false".

Documents are also subject to Denial of Service Attacks when buffers are overrun by large entities or too many attributes. For example, if a DTD defined the following entities

```
<!ENTITY foo 'foo '>
<!ENTITY foo1 '&foo;&foo;&foo;&foo;&foo;&foo;&foo;&foo;&foo;&foo;'>
<!ENTITY foo2 '&foo1;&foo1;&foo1;&foo1;&foo1;&foo1;&foo1;&foo1;&foo1;&foo1;'>
<!ENTITY foo3 '&foo2;&foo2;&foo2;&foo2;&foo2;&foo2;&foo2;&foo2;&foo2;&foo2;'>
<!ENTITY foo4 '&foo3;&foo3;&foo3;&foo3;&foo3;&foo3;&foo3;&foo3;&foo3;&foo3;'>
<!ENTITY foo5 '&foo4;&foo4;&foo4;&foo4;&foo4;&foo4;&foo4;&foo4;&foo4;&foo4;'>
<!ENTITY foo6 '&foo5;&foo5;&foo5;&foo5;&foo5;&foo5;&foo5;&foo5;&foo5;&foo5;'>
```

then the expansion of &foo6; would result in 1,000,000 foos. By default, RESTEasy will limit the number of expansions and the number of attributes per entity. The exact behavior depends on the underlying parser. The limits can be turned off by setting the parameter to "false".
21.5. Text media types and character sets

The Jakarta RESTful Web Services specification says

> 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.

On the other hand, the HTTP specification says

> When no explicit charset parameter is provided by the sender, media subtypes of the "text" type are defined to have a default charset value of "ISO-8859-1" when received via HTTP. Data in character sets other than "ISO-8859-1" or its subsets MUST be labeled with an appropriate charset value.

It follows that, in the absence of a character set specified by a resource or resource method, RESTEasy SHOULD use UTF-8 as the character set for text media types, and, if it does, it MUST add an explicit charset parameter to the Content-Type response header. RESTEasy started adding the explicit charset parameter in releases 3.1.2.Final and 3.0.22.Final, and that new behavior could cause some compatibility problems. To specify the previous behavior, in which UTF-8 was used for text media types, but the explicit charset was not appended, the parameter "resteasy.add.charset" may be set to "false". It defaults to "true".

**Note.** By "text" media types, we mean

- a media type with type "text" and any subtype;
- a media type with type "application" and subtype beginning with "xml".

The latter set includes "application/xml-external-parsed-entity" and "application/xml-dtd".
Chapter 22. Jakarta XML Binding providers

As required by the specification, RESTEasy includes support for (un)marshalling Jakarta XML Binding annotated classes. RESTEasy provides multiple providers to address some subtle differences between classes generated by XJC and classes which are simply annotated with @XmlRootElement, or working with JAXBElement classes directly.

For the most part, developers using the Jakarta RESTful Web Services API, the selection of which provider is invoked will be completely transparent. For developers wishing to access the providers directly (which most folks won’t need to do), this document describes which provider is best suited for different configurations.

A Jakarta XML Binding Provider is selected by RESTEasy when a parameter or return type is an object that is annotated with Jakarta XML Binding annotations (such as @XmlRootElement or @XmlType) or if the type is a JAXBElement. Additionally, the resource class or resource method will be annotated with either a @Consumes or @Produces annotation and contain one or more of the following values:

- text/*+xml
- application/*+xml
- application/*+fastinfoset
- application/*+json

RESTEasy will select a different provider based on the return type or parameter type used in the resource. This section describes how the selection process works.

@XmlRootElement When a class is annotated with a @XmlRootElement annotation, RESTEasy will select the JAXBXmlRootElementProvider. This provider handles basic marshaling and unmarshalling of custom Jakarta XML Binding entities.

@XmlType Classes which have been generated by XJC will most likely not contain an @XmlRootElement annotation. In order for these classes to marshalled, they must be wrapped within a JAXBElement instance. This is typically accomplished by invoking a method on the class which serves as the XmlRegistry and is named ObjectFactory.

The JAXBXmlTypeProvider provider is selected when the class is annotated with an XmlType annotation and not an XmlRootElement annotation.

This provider simplifies this task by attempting to locate the XmlRegistry for the target class. By default, a Jakarta XML Binding implementation will create a class called ObjectFactory and is located in the same package as the target class. When this class is located, it will contain a "create"
method that takes the object instance as a parameter. For example, if the target type is called "Contact", then the ObjectFactory class will have a method:

```java
public JAXBElement createContact(Contact value) {
```

JAXBElement<?>:: If your resource works with the JAXBElement class directly, the RESTEasy runtime will select the JAXBElementProvider. This provider examines the ParameterizedType value of the JAXBElement in order to select the appropriate JAXBContext.

### 22.1. Jakarta XML Binding Decorators

Resteasy’s Jakarta XML Binding providers have a pluggable way to decorate Marshaller and Unmarshaller instances. The way it works is that you can write an annotation that can trigger the decoration of a Marshaller or Unmarshaller. Your decorators can do things like set Marshaller or Unmarshaller properties, set up validation, and the like. Here’s an example. Say we want to have an annotation that will trigger pretty-printing, nice formatting, of an XML document. If we were using raw Jakarta XML Binding, we would set a property on the Marshaller of Marshaller.JAXB_FORMATTED_OUTPUT. Let’s write a Marshaller decorator.

First define an annotation:

```java
import org.jboss.resteasy.annotations.Decorator;

@Target({ElementType.TYPE, ElementType.METHOD, ElementType.PARAMETER, ElementType.FIELD})
@Retention(RetentionPolicy.RUNTIME)
@Decorator(processor = PrettyProcessor.class, target = Marshaller.class)
public @interface Pretty {}
```

For this to work, we must annotate the @Pretty annotation with a meta-annotation called @Decorator. The target() attribute must be the Jakarta XML Binding Marshaller class. The processor() attribute is a class we will write next.

```java
import org.jboss.resteasy.core.interception.DecoratorProcessor;
import org.jboss.resteasy.annotations.DecorateTypes;

import jakarta.xml.bind.Marshaller;
import jakarta.xml.bind.PropertyException;
import jakarta.ws.rs.core.MediaType;
import jakarta.ws.rs.Produces;
import java.lang.annotation.Annotation;

/**
 * @author <a href="mailto:bill@burkecentral.com">Bill Burke</a>
 * @version $Revision: 1 $
 */
@DecorateTypes("text/*+xml", "application/*+xml")
public class PrettyProcessor implements DecoratorProcessor<Marshaller, Pretty>
```
The processor implementation must implement the DecoratorProcessor interface and should also be annotated with @DecorateTypes. This annotation specifies what media types the processor can be used with. Now that we've defined our annotation and our Processor, we can use it on our Jakarta RESTful Web Services resource methods or Jakarta XML Binding types as follows:

```java
@GET
@Pretty
@Produces("application/xml")
public SomeJAXBObject get() {...}
```

Check the RESTEasy source code for the implementation of @XmlHeader for more detailed information.

### 22.2. Pluggable JAXBContext's with ContextResolvers

Do not use this feature unless you are knowledgeable about using it.

Based on the class being marshalling/unmarshalling, RESTEasy will, by default create and cache JAXBContext instances per class type. If you do not want RESTEasy to create JAXBContexts, plug in your own by implementing an instance of jakarta.ws.rs.ext.ContextResolver.

```java
public interface ContextResolver<T> {
    T getContext(Class<?> type);
}

@Provider
@Produces("application/xml")
public class MyJAXBContextResolver implements ContextResolver<JAXBContext> {
    JAXBContext getContext(Class<?> type) {
        if (type.equals(WhateverClassIsOverridedFor.class)) return JAXBContext.newInstance()...;
    }
}
```

A @Produces annotation must be provided to specify the media type the context is meant for. An implementation of ContextResolver<JAXBContext> must be provided and that class must have the @Provider annotation. This helps the runtime match to the correct context resolver.
There are multiple ways to make this ContextResolver available.

1. Return it as a class or instance from a jakarta.ws.rs.core.Application implementation
2. List it as a provider with resteasy.providers
3. Let RESTEasy automatically scan for it within the WAR file. See Configuration Guide
4. Manually add it via ResteasyProviderFactory.getInstance().registerProvider(Class) or registerProviderInstance(Object)

22.3. Jakarta XML Binding + XML provider

RESTEasy is required to provide Jakarta XML Binding provider support for XML. It has a few extra annotations that can help code the application.

22.3.1. @XmlHeader and @Stylesheet

Sometimes when outputting XML documents you may want to set an XML header. RESTEasy provides the @org.jboss.resteasy.annotations.providers.jaxb.XmlHeader annotation for this. For example:

```java
@XmlElement
public static class Thing
{
    private String name;

    public String getName()
    {
        return name;
    }

    public void setName(String name)
    {
        this.name = name;
    }
}

@Path("/test")
public static class TestService
{
    @GET
    @Path("/header")
    @Produces("application/xml")
    @XmlHeader("<?xml-stylesheet type='text/xsl' href='${baseuri}foo.xsl' ?>")
    public Thing get()
    {
        Thing thing = new Thing();
        thing.setName("bill");
        return thing;
    }
}
```
Jakarta XML Binding providers

The @XmlHeader forces the XML output to have a xml-stylesheet header. This header could also have been put on the Thing class to get the same result. See the javadocs for more details on how to use substitution values provided by resteasy.

RESTEasy also has a convenience annotation for stylesheet headers. For example:

```java
@XmlRootElement
public static class Thing
{
    private String name;

    public String getName()
    {
        return name;
    }

    public void setName(String name)
    {
        this.name = name;
    }
}

@Path("/test")
public static class TestService
{
    @GET
    @Path("/stylesheet")
    @Produces("application/xml")
    @Stylesheet(type="text/css", href="${basepath}foo.xsl")
    @Junk
    public Thing getStyle()
    {
        Thing thing = new Thing();
        thing.setName("bill");
        return thing;
    }
}
```

**22.4. Jakarta XML Binding + JSON provider**

RESTEasy supports the marshalling of Jakarta XML Binding annotated POJOs to and from JSON. This provider wraps the Jackson2 library to accomplish this.

To use this integration with Jackson import the resteasy-jackson2-provider Maven module.

For example, consider this Jakarta XML Binding class:

```java
@XmlElement(name = "book")
public class Book
{
    private String author;
```
private String ISBN;
private String title;

public Book()
{
}

public Book(String author, String ISBN, String title)
{
    this.author = author;
    this.ISBN = ISBN;
    this.title = title;
}

@XmlElement
public String getAuthor()
{
    return author;
}

public void setAuthor(String author)
{
    this.author = author;
}

@XmlElement
public String getISBN()
{
    return ISBN;
}

public void setISBN(String ISBN)
{
    this.ISBN = ISBN;
}

@XmlAttribute
public String getTitle()
{
    return title;
}

public void setTitle(String title)
{
    this.title = title;
}

And we can write a method to use the above entity:

@Path("/test_json")
@GET
@Produces(MediaType.APPLICATION_JSON)
public Book test_json()
{
    Book book = new Book();
When making a request of the above method, the default Jackson2 marshaller would return JSON output that looked like this:

```
$ http localhost:8080/dummy/test_json
HTTP/1.1 200
...
Content-Type: application/json
{
  "ISBN": "596529260",
  "author": "Bill Burke",
  "title": "EJB 3.0"
}
```

### 22.5. Jakarta XML Binding + FastinfoSet provider

RESTEasy supports the FastinfoSet mime type with Jakarta XML Binding annotated classes. Fast infoSet documents are faster to serialize and parse, and smaller in size, than logically equivalent XML documents. Thus, fast infoSet documents may be used whenever the size and processing time of XML documents is an issue. It is configured the same way the provider is.

To use this integration with FastinfoSet import the resteasy-fastinfoSet-provider Maven module.

### 22.6. Arrays and Collections of Jakarta XML Binding Objects

RESTEasy will automatically marshal arrays, java.util.Set's, and java.util.List's of Jakarta XML Binding objects to and from XML, JSON, FastinfoSet.

```java
@XmlElement(name = "customer")
@XmlAccessorType(XmlAccessType.FIELD)
public class Customer
{
  @XmlElement
  private String name;

  public Customer()
  {
  }
}```
public Customer(String name)
{
    this.name = name;
}

public String getName()
{
    return name;
}
}

@Path("/")
public class MyResource
{
    @PUT
    @Path("array")
    @Consumes("application/xml")
    public void putCustomers(Customer[] customers)
    {
        Assert.assertEquals("bill", customers[0].getName());
        Assert.assertEquals("monica", customers[1].getName());
    }

    @GET
    @Path("set")
    @Produces("application/xml")
    public Set<Customer> getCustomerSet()
    {
        HashSet<Customer> set = new HashSet<Customer>();
        set.add(new Customer("bill"));
        set.add(new Customer("monica"));

        return set;
    }

    @PUT
    @Path("list")
    @Consumes("application/xml")
    public void putCustomers(List<Customer> customers)
    {
        Assert.assertEquals("bill", customers.get(0).getName());
        Assert.assertEquals("monica", customers.get(1).getName());
    }
}

The above resource can publish and receive Jakarta XML Binding objects. It is assumed they are wrapped in a collection element

<collection>
    <customer><name>bill</name></customer>
    <customer><name>monica</name></customer>
<collection>
The namespace URI, namespace tag, and collection element name can be changed by using the `@org.jboss.resteasy.annotations.providers.jaxb.Wrapped` annotation on a parameter or method:

```java
@Target({ElementType.PARAMETER, ElementType.METHOD})
@Retention(RetentionPolicy.RUNTIME)
public @interface Wrapped {
    String element() default "collection";
    String namespace() default "http://jboss.org/resteasy";
    String prefix() default "resteasy";
}
```

To output this XML:

```xml
<foo:list xmlns:foo="http://foo.org">
    <customer><name>bill</name></customer>
    <customer><name>monica</name></customer>
</foo:list>
```

The `@Wrapped` annotation would be used as follows:

```java
@GET
@Path("list")
@Produces("application/xml")
@Wrapped(element="list", namespace="http://foo.org", prefix="foo")
public List<Customer> getCustomerSet() {
    List<Customer> list = new ArrayList<Customer>();
    list.add(new Customer("bill"));
    list.add(new Customer("monica"));
    return list;
}
```

### 22.6.1. Retrieving Collections on the client side

To retrieve a `List` or `Set` of Jakarta XML Binding objects on the client side, the element type returned in the `List` or `Set` must be identified. Below the call to `readEntity()` will fail because the class type, `Customer` has not been properly identified:

```java
Response response = request.get();
```
Use jakarta.ws.rs.core.GenericType to declare the data type, Customer, returned within the List.

`List<Customer> list = response.readEntity(List.class);`

For more information about `GenericType`, please see its javadoc.

The same strategy applies to retrieving a Set:

```java
Response response = request.get();
GenericType<Set<Customer>> genericType = new GenericType<Set<Customer>>() {};
Set<Customer> set = response.readEntity(genericType);
```

`GenericType` is not necessary to retrieve an array of Jakarta XML Binding objects:

```java
Response response = request.get();
Customer[] array = response.readEntity(Customer[].class);
```

### 22.6.2. JSON and Jakarta XML Binding Collections/arrays

RESTEasy supports using collections with JSON. It encloses List, Set, or arrays of returned XML objects within a simple JSON array. For example:

```java
@XmlRootElement
@XmlAccessorType(XmlAccessType.FIELD)
public static class Foo
{
    @XmlAttribute
    private String test;

    public Foo()
    {
    }

    public Foo(String test)
    {
        this.test = test;
    }
}
```
public String getTest()
{
    return test;
}

public void setTest(String test)
{
    this.test = test;
}

A List or array of Foo class would be represented in JSON like this:


It also expects this format for input

### 22.7. Maps of XML Objects

RESTEasy automatically marshals maps of Jakarta XML Binding objects to and from XML, JSON, Fastinfoset (or any other new Jakarta XML Binding mapper). The parameter or method return type must be a generic with a String as the key and the Jakarta XML Binding object's type.

```java
@XmlRootElement(namespace = "http://foo.com")
public static class Foo
{
    @XmlAttribute
    private String name;

    public Foo()
    {
    }

    public Foo(String name)
    {
        this.name = name;
    }

    public String getName()
    {
        return name;
    }
}

@Path("/map")
public static class MyResource
{
    @POST
    @Produces("application/xml")
    @Consumes("application/xml")
```
public Map<String, Foo> post(Map<String, Foo> map) {
    Assert.assertEquals(2, map.size());
    Assert.assertNotNull(map.get("bill"));
    Assert.assertNotNull(map.get("monica"));
    Assert.assertEquals(map.get("bill").getName(), "bill");
    Assert.assertEquals(map.get("monica").getName(), "monica");
    return map;
}

The above resource can publish and receive XML objects within a map. By default, they are wrapped in a "map" element in the default namespace. Also, each "map" element has zero or more "entry" elements with a "key" attribute.

<map>
  <entry key="bill" xmlns="http://foo.com">
    <foo name="bill"/>
  </entry>
  <entry key="monica" xmlns="http://foo.com">
    <foo name="monica"/>
  </entry>
</map>

The namespace URI, namespace prefix and map, entry, and key element and attribute names can be changed by using the @org.jboss.resteasy.annotations.providers.jaxb.WrappedMap annotation on a parameter or method:

@Target({ElementType.PARAMETER, ElementType.METHOD})
@Retention(RetentionPolicy.RUNTIME)
public @interface WrappedMap {

/**
 * map element name
 */
String map() default "map";

/**
 * entry element name
 */
String entry() default "entry";

/**
 * entry's key attribute name
 */
String key() default "key";

String namespace() default "";

String prefix() default "";
To output this XML

```xml
<hashmap>
  <hashentry hashkey="bill" xmlns:foo="http://foo.com">
    <foo:foo name="bill"/>
  </hashentry>
</map>
```

Use the `@WrappedMap` annotation as follows:

```java
@Path("/map")
public static class MyResource {
  @GET
  @Produces("application/xml")
  @WrappedMap(map="hashmap", entry="hashentry", key="hashkey")
  public Map<String, Foo> get() {
    ...
    return map;
  }
}
```

### 22.7.1. Retrieving Maps on the client side

To retrieve a `Map` of XML objects on the client side, the element types returned in the Map must be identified. Below the call to `readEntity()` will fail because the class types, `String` and `Customer` have not been properly identified:

```java
Response response = request.get();
Map<String, Customer> map = response.readEntity(Map.class);
```

Use `jakarta.ws.rs.core.GenericType` to declare the data types, `String` and `Customer`, returned within the Map.

```java
Response response = request.get();
GenericType<Map<String, Customer>> genericType = new GenericType<Map<String, Customer>>() {}; 
Map<String, Customer> map = response.readEntity(genericType);
```
For more information about `GenericType`, please see its javadoc.

### 22.7.2. JSON and XML maps

RESTEasy supports using maps with JSON. It encloses maps returned XML objects within a simple JSON map. For example:

```java
@XmlElement
@XmlAccessorType(XmlAccessType.FIELD)
public static class Foo {
    @XmlAttribute
    private String test;

    public Foo() {
    }

    public Foo(String test) {
        this.test = test;
    }

    public String getTest() {
        return test;
    }

    public void setTest(String test) {
        this.test = test;
    }
}
```

A List or array of this Foo class would be represented in JSON like this:

```json
{ "entry1" : {"foo":{"@test":"bill"}}, "entry2" : {"foo":{"@test":"monica"}}} 
```

It also expects this format for input

### 22.8. Interfaces, Abstract Classes, and Jakarta XML Binding

Some objects models use abstract classes and interfaces heavily. Unfortunately, Jakarta XML Binding doesn't work with interfaces that are root elements and RESTEasy can't unmarshal parameters that are interfaces or raw abstract classes because it doesn't have enough information to create a JAXBContext. For example:
In this example, RESTEasy will report error, "Cannot find a MessageBodyReader for...". This is because RESTEasy does not know that implementations of IFoo are Jakarta XML Binding classes and doesn't know how to create a JAXBContext for it. As a workaround, RESTEasy allows the use of Jakarta XML Binding annotation @XmlSeeAlso on the interface to correct the problem. (NOTE, this will not work with manual, hand-coded Jakarta XML Binding).

The extra @XmlSeeAlso on IFoo allows RESTEasy to create a JAXBContext that knows how to unmarshal RealFoo instances.

### 22.9. Configuring Jakarta XML Binding Marshalling

As a consumer of XML datasets, Jakarta XML Binding is subject to a form of attack known as the XXE (Xml eXternal Entity) Attack (https://owasp.org/www-community/vulnerabilities/XML_External_Entity_(XXE)_Processing), in which expanding an external entity causes an unsafe file to be loaded. Preventing the expansion of external entities is discussed in Section 21.4, “Configuring Document Marshalling”. The same parameter, applies to Jakarta XML Binding unmarshallers.

Section 21.4, “Configuring Document Marshalling” also discusses the prohibition of DTDs and the imposition of limits on entity expansion and the number of attributes per element. The parameters and discussed there, and their default values, also apply to the representation of Jakarta XML Binding objects.
Chapter 23. RESTEasy Atom Support


"Atom is an XML-based document format that describes lists of related information known as "feeds". Feeds are composed of a number of items, known as "entries", each with an extensible set of attached metadata. For example, each entry has a title. The primary use case that Atom addresses is the syndication of Web content such as weblogs and news headlines to Websites as well as directly to user agents."

23.1. RESTEasy Atom API and Provider

RESTEasy has defined a simple object model in Java to represent Atom and uses Jakarta XML Binding to marshal and unmarshal it. The main classes are in the org.jboss.resteasy.plugins.providers.atom package and are Feed, Entry, Content, and Link. If you look at the source, you will see that these are annotated with Jakarta XML Binding annotations. The distribution contains the javadocs for this project and are a must to learn the model. Here is a simple example of sending an atom feed using the RESTEasy API.

```java
import org.jboss.resteasy.plugins.providers.atom.Content;
import org.jboss.resteasy.plugins.providers.atom.Entry;
import org.jboss.resteasy.plugins.providers.atom.Feed;
import org.jboss.resteasy.plugins.providers.atom.Link;
import org.jboss.resteasy.plugins.providers.atom.Person;

@Path("atom")
public class MyAtomService {

    @GET
    @Path("feed")
    @Produces("application/atom+xml")
    public Feed getFeed() throws URISyntaxException {
        Feed feed = new Feed();
        feed.setId(new URI("http://example.com/42"));
        feed.setTitle("My Feed");
        feed.setUpdated(new Date());
        Link link = new Link();
        link.setHref(new URI("http://localhost"));
        link.setRel("edit");
        feed.getLinks().add(link);
        feed.getAuthors().add(new Person("Bill Burke"));
        Entry entry = new Entry();
        entry.setTitle("Hello World");
        Content content = new Content();
        content.setType(MediaType.TEXT_HTML_TYPE);
        content.setText("Nothing much");
```
RESTEasy's atom provider is Jakarta XML Binding based, there are no limits to sending atom objects using XML. All the other Jakarta XML Binding providers that RESTEasy has like JSON and fastinfoset can automatically be re-use. Just add "atom+" in front of the main subtype. i.e. @Produces("application/atom+json") or @Consumes("application/atom+fastinfoset")

### 23.2. Using Jakarta XML Binding with the Atom Provider

The org.jboss.resteasy.plugins.providers.atom.Content class is used to unmarshal and marshal Jakarta XML Binding annotated objects that are the body of the content. Here's an example of sending an Entry with a Customer object attached as the body of the entry's content.

```java
@XmlRootElement(namespace = "http://jboss.org/Customer")
@XmlAccessorType(XmlAccessType.FIELD)
public class Customer
{
    @XmlElement
    private String name;

    public Customer()
    {
    }

    public Customer(String name)
    {
        this.name = name;
    }

    public String getName()
    {
        return name;
    }
}

@Path("atom")
public static class AtomServer
{
    @GET
    @Path("entry")
    @Produces("application/atom+xml")
    public Entry getEntry()
    {
        Entry entry = new Entry();
        entry.setTitle("Hello World");
        Content content = new Content();
        content.setJAXBObject(new Customer("bill"));
    }
```
The `Content.setJAXBObject()` method is used to tell the content object, an object is being sent back and it is to be marshalled appropriately. If using a different base format than XML, i.e. "application/atom+json", this attached object will be marshalled into that same format.

If the input is an atom document, Jakarta XML Binding objects can be extracted from `Content` using the `Content.getJAXBObject(Class clazz)` method. Here is an example of an input atom document and extracting a `Customer` object from the content.

```java
@Path("atom")
public static class AtomServer
{
    @PUT
   @Path("entry")
    @Produces("application/atom+xml")
    public void putCustomer(Entry entry)
    {
        Content content = entry.getContent();
        Customer cust = content.getJAXBObject(Customer.class);
    }
}
```
Chapter 24. JSON Support via Jackson

RESTEasy supports integration with the Jackson project. For more on Jackson 2, see https://github.com/FasterXML/jackson-databind/wiki. Besides having Jakarta XML Binding like APIs, it has a JavaBean based model, described at https://github.com/FasterXML/jackson-databind/wiki/Databind-annotations, which allows the marshalling of Java objects to and from JSON. RESTEasy integrates with the JavaBean model. While Jackson does come with its own Jakarta RESTful Web Services integration, RESTEasy expanded it a little, as described below.

24.1. Using Jackson 2 Outside of WildFly

If deploying RESTEasy outside WildFly, add the RESTEasy Jackson provider to the pom.xml:

```xml
<dependency>
    <groupId>org.jboss.resteasy</groupId>
    <artifactId>resteasy-jackson2-provider</artifactId>
    <version>${version.resteasy}</version>
</dependency>
```

24.2. Jakarta XML Binding Annotations

In Jackson 2.13+, com.fasterxml.jackson.module.jakarta.xmlbind.JakartaXmlBindAnnotationModule must be registered in order to use XML binding annotations for Jackson to marshall/unmarshall them in JSON. To do this, com.fasterxml.jackson.databind.ObjectMapper must be provided via an implementation of jakarta.ws.rs.ext.ContextResolver.

An example jakarta.ws.rs.ext.ContextResolver:

```java
@Provider
public class ObjectMapperProvider implements ContextResolver<ObjectMapper> {
    static final JsonMapper MAPPER = JsonMapper.builder()
        .addModule(new JakartaXmlBindAnnotationModule())
        .build();

    @Override
    public ObjectMapper getContext(final Class<?> type) {
        return MAPPER;
    }
}
```
24.3. Additional RESTEasy Specifics

RESTEasy added support for "application/*+json". Jackson supports "application/json" and "text/json" as valid media types. This allows the creation of json-based media types and still lets Jackson perform the marshalling. For example:

```java
@Path("/customers")
public class MyService {

    @GET
    @Produces("application/vnd.customer+json")
    public Customer[] getCustomers() {}
}
```

24.4. JSONP Support

RESTEasy supports JSONP [http://en.wikipedia.org/wiki/JSONP]. It can be enabled by adding provider `org.jboss.resteasy.plugins.providers.jackson.Jackson2JsonpInterceptor` to the deployment. Jackson and JSONP can be used together. If the media type of the response is json and a callback query parameter is given, the response will be a javascript snippet with a method call of the method defined by the callback parameter. For example:

```
GET /resources/stuff?callback=processStuffResponse
```

will produce this response:

```
processStuffResponse(<nomal JSON body>)
```

This supports the default behavior of jQuery [http://api.jquery.com/jQuery.ajax/]. To enable Jackson2JsonpInterceptor in WildFly, annotations must be imported from the `org.jboss.resteasy.resteasy-jackson2-provider` module. To do that a `jboss-deployment-structure.xml` file must be added to the application's WAR:

```xml
<jboss-deployment-structure>
    <deployment>
        <dependencies>
            <module name="org.jboss.resteasy.resteasy-jackson2-provider" annotations="true"/>
        </dependencies>
    </deployment>
</jboss-deployment-structure>
```
The name of the callback parameter can be changed by setting the callbackQueryParameter property.

Jackson2JsonpInterceptor can wrap the response into a try-catch block:

```java
try{processStuffResponse(<normal JSON body>)}catch(e){}
```

This feature can be enabled by setting the resteasy.jsonp.silent property to true

**Note.** Because JSONP can be used in **Cross Site Scripting Inclusion (XSSI) attacks**, Jackson2JsonpInterceptor is disabled by default. Two steps are necessary to enable it:

1. As noted above, Jackson2JsonpInterceptor must be included in the deployment. For example, a service file META-INF/services/jakarta.ws.rs.ext.Providers with the line

   ```none
   org.jboss.resteasy.plugins.providers.jackson.Jackson2JsonpInterceptor
   ```

   may be included on the classpath

2. Parameter "resteasy.jsonp.enable" must be set to "true". [See Section 3.4, “Configuration” for more information about application configuration.]

### 24.5. Jackson JSON Decorator

If using the Jackson 2 provider, RESTEasy has provided a pretty-printing annotation similar with the one in Jakarta XML Binding provider:

```java
org.jboss.resteasy.annotations.providers.jackson.Formatted
```

Here is an example:

```java
@GET
@Produces("application/json")
@Path("/formatted/{id}")
@Formatted
public Product getFormattedProduct()
{
    return new Product(333, "robot");
}
```
As the example shown above, the @Formatted annotation will enable the underlying Jackson option "SerializationFeature.INDENT_OUTPUT".

### 24.6. JSON Filter Support

Jackson2 provides annotation, `JsonFilter` [http://fasterxml.github.io/jackson-annotations/javadoc/2.13/com/fasterxml/jackson/annotation/JsonFilter.html]. `@JsonFilter` is used to apply filtering during serialization/de-serialization for example which properties are to be used or not.

Here is an example which defines mapping from "nameFilter" to filter instances and filter bean properties when serialized to json format:

```java
@JsonFilter(value="nameFilter")
public class Jackson2Product {
    protected String name;
    protected int id;
    public Jackson2Product() {
    }
    public Jackson2Product(final int id, final String name) {
        this.id = id;
        this.name = name;
    }
    public String getName() {
        return name;
    }
    public void setName(String name) {
        this.name = name;
    }
    public int getId() {
        return id;
    }
    public void setId(int id) {
        this.id = id;
    }
}
```

`@JsonFilter` annotates a resource class to filter out some property not to be serialized in the json response. To map the filter id and instance we need to create another jackson class to add the id and filter instance map:

```java
public class ObjectFilterModifier extends ObjectWriterModifier {
    public ObjectFilterModifier() {
    }
    @Override
    public ObjectWriter modify(EndpointConfigBase<?> endpoint,
            MultivaluedMap<String, Object> httpHeaders, Object valueToWrite,
            ObjectWriter w, JsonGenerator jg) throws IOException {
        FilterProvider filterProvider = new SimpleFilterProvider().addFilter("nameFilter",
```
Here the method `modify()` takes care of filtering all properties except "name" property before a write. To make this work, the mapping information must be accessible to RESTEasy. This can be made available through a WriterInterceptor that uses Jackson's `ObjectWriterInjector`:

```java
@Provider
public class JsonFilterWriteInterceptor implements WriterInterceptor{

    private ObjectFilterModifier modifier = new ObjectFilterModifier();

    @Override
    public void aroundWriteTo(WriterInterceptorContext context)
        throws IOException, WebApplicationException {
        //set a threadlocal modifier
        ObjectWriterInjector.set(modifier);
        context.proceed();
    }
}
```

Alternatively, Jackson’s documentation suggest doing the same in a servlet filter; that however potentially leads to issues in RESTEasy. The ObjectFilterModifier is stored using a ThreadLocal object and there’s no guarantee the same thread serving the servlet filter will be running the resource endpoint execution. For the servlet filter scenario, RESTEasy offers its own injector that relies on the current thread context classloader for carrying the specified modifier:

```java
public class ObjectWriterModifierFilter implements Filter {

    private static ObjectFilterModifier modifier = new ObjectFilterModifier();

    @Override
    public void init(FilterConfig filterConfig) throws ServletException {
    }

    @Override
    public void doFilter(ServletRequest request, ServletResponse response,
        FilterChain chain) throws IOException, ServletException {
        ResteasyObjectWriterInjector.set(Thread.currentThread().getContextClassLoader(), modifier);
        chain.doFilter(request, response);
    }

    @Override
    public void destroy() {
    }
}
```
24.7. Polymorphic Typing deserialization

Due to numerous CVEs for a specific kind of Polymorphic Deserialization (see details in FasterXML Jackson documentation), starting from Jackson 2.10 users have a means to allow only specified classes to be deserialized. RESTEasy enables this feature by default. It allows controlling the content of the whitelist of allowed classes/packages.

Table 24.1.

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>resteasy.jackson.deserialization.whitelist.allowIfBaseType.prefix</td>
<td>Matcher that will allow all subtypes in cases where nominal base type’s class name starts with specific prefix. &quot;***&quot; can be used for allowing any class.</td>
</tr>
<tr>
<td>resteasy.jackson.deserialization.whitelist allowIfSubType.prefix</td>
<td>Matcher that will allow specific subtype (regardless of declared base type) in cases where subclass name starts with specified prefix. &quot;***&quot; can be used for allowing any class.</td>
</tr>
</tbody>
</table>
Chapter 25. JSON Support via Jakarta EE JSON-P API

JSON-P is a Jakarta EE parsing API. RESTEasy provides an archive for it. It has support for JsonObject, JsonArray, and JsonStructure as request or response entities. It should not conflict with Jackson if it is on the classpath too. RESTEasy's provider is provided by default in WildFly. If using another server, use this maven dependency.

```xml
<dependency>
  <groupId>org.jboss.resteasy</groupId>
  <artifactId>resteasy-json-p-provider</artifactId>
  <version>6.2.3.Final</version>
</dependency>
```
Chapter 26. Multipart Providers

RESTEasy has rich support for the "multipart/*" and "multipart/form-data" mime types. The multipart mime format is used to pass lists of content bodies. Multiple content bodies are embedded in one message. "multipart/form-data" is often found in web application HTML Form documents and is generally used to upload files. The form-data format is the same as other multipart formats, except that each inlined piece of content has a name associated with it.

RESTEasy provides a custom API for reading and writing multipart types as well as marshalling arbitrary List (for any multipart type) and Map (multipart/form-data only) objects.

Classes MultipartInput and MultipartOutput provide read and write support for mime type "multipart/mixed" messages respectively. They provide for multiple part messages, in which one or more different sets of data are combined in a single body.

MultipartRelatedInput and MultipartRelatedOutput classes provide read and write support for mime type "multipart/related" messages. These are messages that contain multiple body parts that are inter-related.

MultipartFormDataInput and MultipartFormDataOutput classes provide read and write support for mime type "multipart/form-data". This type is used when returning a set of values as the result of a user filling out a form or for uploading files.

26.1. Multipart/mixed

26.1.1. Writing multipart/mixed messages

MultipartOutput provides a set of addPart methods for registering message content and specifying special marshalling requirements. In all cases the addPart methods require an input parameter, Object and a MediaType that declares the mime type of the object. Sometimes there may be an object in which marshalling is sensitive to generic type metadata. In such cases, use an addPart method in which you declare the GenericType of the entity Object. Perhaps a file will be passed as content and it will require UTF-8 encoding. Setting input parameter, utf8Encode to true will indicate to RESTEasy to process the filename according to the character set and language encoding rules of rfc5987. This flag is only processed when mime type "multipart/form-data" is specified.

MultipartOutput automatically generates a unique message boundary identifier when it is created. Method setBoundary is provided to declare a different identifier.

```java
class MultipartOutput {
    public OutputPart addPart(Object entity, MediaType mediaType);
    public OutputPart addPart(Object entity, MediaType mediaType,
                               String filename);
```
Each message part registered with `MultipartOutput` is represented by an `OutputPart` object. Class `MultipartOutput` generates an `OutputPart` object for each `addPart` method call.

```java
public class MultipartOutput {
    public MultipartOutput {
        public OutputPart addPart(final Object entity, final Class<?> type, final MediaType mediaType, final String filename, final boolean utf8Encode);
    }
}
```

### 26.1.2. Reading multipart/mixed messages

`MultipartInput` and `InputPart` are interface classes that provide access to multipart/mixed message data. RESTEasy provides an implementation of these classes. They perform the work to retrieve message data.
public interface MultipartInput {
    List<InputPart> getParts();
    String getPreamble();

    /**
     * Call this method to delete any temporary files created from unmarshalling
     * this multipart message
     * Otherwise they will be deleted on Garbage Collection or JVM exit.
     */
    void close();
}

package org.jboss.resteasy.plugins.providers.multipart;

import jakarta.ws.rs.core.GenericType;
import jakarta.ws.rs.core.MediaType;
import jakarta.ws.rs.core.MultivaluedMap;
import java.io.IOException;
import java.lang.reflect.Type;

/**
 * Represents one part of a multipart message.
 */
public interface InputPart {

    /**
     * If no content-type header is sent in a multipart message part
     * "text/plain; charset=ISO-8859-1" is assumed.
     * This can be overwritten by setting a different String value in
     * (\%link org.jboss.resteasy.spi.HttpRequest\%setAttribute(String, Object))
     * with this (\%text\%restate\%provider\%multipart\%inputpart\%defaultContentType\%)
     * String as key. It should be done in a
     * (\%link jakarta.ws.rs.container.ContainerRequestFilter\%)
     */
    String DEFAULT_CONTENT_TYPE_PROPERTY =
        *restate\%provider\%multipart\%inputpart\%defaultContentType*;

    /**
     * If there is a content-type header without a charset parameter,
     * charset=US-ASCII is assumed.
     * This can be overwritten by setting a different String value in
     * (\%link org.jboss.resteasy.spi.HttpRequest\%setAttribute(String, Object))
     * with this (\%restate\%provider\%multipart\%inputpart\%defaultCharset\%)
     * String as key. It should be done in a
     * (\%link jakarta.ws.rs.container.ContainerRequestFilter\%)
     */
    String DEFAULT_CHARSET_PROPERTY =
        *restate\%provider\%multipart\%inputpart\%defaultCharset*;

    /**
     * @return headers of this part
     */
    MultivaluedMap<String, String> getHeaders();
    String getBodyAsString() throws IOException;
26.1.3. Simple multipart/mixed message example

The following example shows how to read and write a simple multipart/mixed message.

The data to be transferred is a very simple class, Soup.

```java
package org.jboss.resteasy.test.providers.multipart.resource;

import jakarta.xml.bind.annotation.XmlAccessType;
import jakarta.xml.bind.annotation.XmlAccessorType;
import jakarta.xml.bind.annotation.XmlRootElement;
import jakarta.xml.bind.annotation.XmlElement;

@XmlRootElement(name = "soup")
@XmlAccessorType(XmlAccessType.FIELD)
public class Soup {
    @XmlElement
    private String id;

    public Soup(){}
    public Soup(final String id){this.id = id;}
    public String getId(){return id;}
}
```

This code fragment creates a multipart/mixed message passing Soup information using class, MultipartOutput.
This code fragment uses class `MultipartInput` to extract the Soup information provided by `multipartOutput` above.

```
// MultipartInput multipartInput, the entity returned in the client in a
// Response object or the input value of an endpoint method parameter.
for (InputPart inputPart : multipartInput.getParts()) {
    if (MediaType.APPLICATION_XML_TYPE.equals(inputPart.getMediaType())) {
        Soup c = inputPart.getBody(Soup.class, null);
        String name = c.getId();
    } else {
        String s = inputPart.getBody(String.class, null);
    }
}
```

Returning a multipart/mixed message from an endpoint can be done in two ways. `MultipartOutput` can be returned as the method's return object or as an entity in a `Response` object.

```
@GET
@Path("soups/obj")
@Produces("multipart/mixed")
public MultipartOutput soupsObj() {
    return multipartOutput;
}

@GET
@Path("soups/resp")
@Produces("multipart/mixed")
public Response soupsResp() {
    return Response.ok(multipartOutput, MediaType.valueOf("multipart/mixed"))
        .build();
}
```

There is no difference in the way a client retrieves the message from the endpoint. It is done as follows.
A client sends the message, multipartOutput, to an endpoint as an entity object in an HTTP method call in this code fragment.

```java
ResteasyClient client = (ResteasyClient)ClientBuilder.newClient();
ResteasyWebTarget target = client.target(SOME_URL + "/register/soups");
Entity<MultipartOutput> entity = Entity.entity(multipartOutput,
    new MediaType("multipart", "mixed"));
Response response = target.request().post(entity);
```

Here is the endpoint receiving the message and extracting the contents.

```java
@POST
@Consumes("multipart/mixed")
@Path("register/soups")
public void registerSoups(MultipartInput multipartInput) throws IOException {
    for (InputPart inputPart : multipartInput.getParts()) {
        if (MediaType.APPLICATION_XML_TYPE.equals(inputPart.getMediaType())) {
            Soup c = inputPart.getBody(Soup.class, null);
            String name = c.getId();
        } else {
            String s = inputPart.getBody(String.class, null);
        }
    }
}
```
26.1.4. Multipart/mixed message with GenericType example

This example shows how to read and write a multipart/mixed message whose content consists of a generic type, in this case a \texttt{List<Soup>}. The \texttt{MultipartOutput} and \texttt{MultipartInput} methods that use \texttt{GenericType} parameters are used.

The multipart/mixed message is created using \texttt{MultipartOutput} as follows.

```java
MultipartOutput multipartOutput = new MultipartOutput();
List<Soup> soupList = new ArrayList<Soup>();
soupList.add(new Soup("Chicken Noodle"));
soupList.add(new Soup("Vegetable"));
multipartOutput.addPart(soupList, new GenericType<List<Soup>>{}, MediaType.APPLICATION_XML_TYPE);
multipartOutput.addPart("Granny's Soups", MediaType.TEXT_PLAIN_TYPE);
```

The message data is extracted with \texttt{MultipartInput}. Note there are two \texttt{MultipartInput} \texttt{getBody} methods that can be used to retrieve data specifying \texttt{GenericType}. This code fragment uses the second one but shows the first one in comments.

```java
<T> T getBody(Class<T> type, Type genericType) throws IOException;
<T> T getBody(GenericType<T> type) throws IOException;
```

```java
// MultipartInput multipartInput, the entity returned in the client in a Response object or the input value of an endpoint method parameter.
GenericType<List<Soup>> gType = new GenericType<List<Soup>>(){};

for (InputPart inputPart : multipartInput.getParts()) { 
    if (MediaType.APPLICATION_XML_TYPE.equals(inputPart.getMediaType())) { 
        List<Soup> c = inputPart.getBody(gType);
        // List<Soup> c = inputPart.getBody(gType.getRawType(), gType.getType());
    } else {
        String s = inputPart.getBody(String.class, null);
    }
}
```
26.1.5. java.util.List with multipart/mixed data example

When a set of message parts are uniform they do not need to be written using MultipartOutput or read with MultipartInput. They can be sent and received as a List. RESTEasy performs the necessary work to read and write the message data.

For this example the data to be transmitted is class, ContextProvidersCustomer

```java
package org.jboss.resteasy.test.providers.multipart.resource;

import jakarta.xml.bind.annotation.XmlAccessType;
import jakarta.xml.bind.annotation.XmlAccessorType;
import jakarta.xml.bind.annotation.XmlElement;
import jakarta.xml.bind.annotation.XmlRootElement;

@XmlRootElement(name = "customer")
@XmlAccessorType(XmlAccessType.FIELD)
public class ContextProvidersCustomer {

    @XmlElement
    private String name;

    public ContextProvidersCustomer() {
    }

    public ContextProvidersCustomer(final String name) {
        this.name = name;
    }

    public String getName() { return name; }
}
```

In this code fragment the client creates and sends a list of ContextProvidersCustomers.

```java
List<ContextProvidersCustomer> customers =
        new ArrayList<ContextProvidersCustomer>();
customers.add(new ContextProvidersCustomer("Bill"));
customers.add(new ContextProvidersCustomer("Bob"));

Entity<ContextProvidersCustomer> entity = Entity.entity(customers,
        new MediaType("multipart", "mixed"));

Client client = ClientBuilder.newClient();
WebTarget target = client.target(SOME_URL);
Response response = target.request().post(entity);
```

The endpoint receives the list, alters the contents and returns a new list.
@POST
@Consumes("multipart/mixed")
@Produces(MediaType.APPLICATION_XML)
@Path("post/list")
public List<ContextProvidersName> postList(
    List<ContextProvidersCustomer> customers) throws IOException {
    List<ContextProvidersName> names = new ArrayList<ContextProvidersName>();
    for (ContextProvidersCustomer customer : customers) {
        names.add(new ContextProvidersName("Hello " + customer.getName()));
    }
    return names;
}

The client receives the altered message data and processes it.

Response response = target.request().post(entity);
List<ContextProvidersCustomer> rtnList =
    response.readEntity(new GenericType<List<ContextProvidersCustomer>>(){});

26.2. Multipart/related

The Multipart/Related mime type is intended for compound objects consisting of several inter-related body parts, (RFC2387). There is a root or start part. All other parts are referenced from the root part. Each part has a unique id. The type and the id of the start part is presented in parameters in the message content-type header.

26.2.1. Writing multipart/related messages

RESTEasy provides class MultipartRelatedOutput to assist the user in specifying the required information and generating a properly formatted message. MultipartRelatedOutput is a subclass of MultipartOutput.
### 26.2.2. Reading multipart/related messages

`MultipartRelatedInput` is an interface class that provides access to multipart/related message data. It is a subclass of `MultipartInput`. RESTEasy provides an implementation of this class. It performs the work to retrieve message data.

```java
package org.jboss.resteasy.plugins.providers.multipart;

import jakarta.ws.rs.core.MediaType;

public class MultipartRelatedOutput extends MultipartOutput {
    private String startInfo;

    /**
     * The part used as the root.
     */
    public OutputPart getRootPart();

    /**
     * entity  object representing the part's body
     * mediaType Content-Type of the part
     * contentId  Content-ID to be used as identification for the current
     *            part, optional, if null one will be generated
     * contentTransferEncoding
     *            value used for the Content-Transfer-Encoding header
     *            field of the part. It's optional, if you don't want to set
     *            this pass null. Example values are: "7bit",
     *            "quoted-printable", "base64", "8bit", "binary"
     */
    public OutputPart addPart(Object entity, MediaType mediaType,
                               String contentId, String contentTransferEncoding);

    /**
     * start-info parameter of the Content-Type. An optional parameter.
     * As described in RFC2387, section 3.3. The Start-Info Parameter
     */
    public String getStartInfo();
}
```
26.2.3. Multipart/related message example

The client in this example creates a multipart/related message, POSTs it to the endpoint and processes the multipart/related message returned by the endpoint.

```java
MultipartRelatedOutput mRelatedOutput = new MultipartRelatedOutput();
mRelatedOutput.setStartInfo("text/html");
mRelatedOutput.addPart("Bill", new MediaType("image", "png"), "bill", "binary");
mRelatedOutput.addPart("Bob", new MediaType("image", "png"), "bob", "binary");

Entity<MultipartRelatedOutput> entity = Entity.entity(mRelatedOutput,
new MediaType("multipart", "related");

Client client = ClientBuilder.newClient();
WebTarget target = client.target(SOME_URL);
Response response = target.request().post(entity);
MultipartRelatedInput result = response.readEntity(
  MultipartRelatedInput.class);
Map<String, InputPart> map = result.getRelatedMap();
Set<String> keys = map.keySet();
boolean a = keys.contains("Bill");
boolean b = keys.contains("Bob");
for (InputPart inputPart : map.values()) {
  String alterName = inputPart.getBody(String.class, null);
}
```

Here is the endpoint the client above is calling.

```java
@POST
@Consumes("multipart/related")
@Produces("multipart/related")
@Path("post/related")
public MultipartRelatedOutput postRelated(MultipartRelatedInput input)
  throws IOException {
```
MultipartProviders

```java
MultipartRelatedOutput rtnMRelatedOutput = new MultipartRelatedOutput();
    rtnMRelatedOutput.setStartInfo("text/html");
    for (Iterator<InputPart> it = input.getParts().iterator(); it.hasNext(); ) {
        InputPart part = it.next();
        String name = part.getBody(String.class, null);
        rtnMRelatedOutput.addPart("Hello " + name,
                                new MediaType("image", "png"), name, null);
    }
    return rtnMRelatedOutput;
```

26.2.4. XML-binary Optimized Packaging (XOP)

RESTEasy supports XOP messages packaged as multipart/related messages (http://www.w3.org/TR/xop10/). A Jakarta XML Binding annotated POJO that also holds binary content can be transmitted using XOP. XOP allows the binary data to skip going through the XML serializer because binary data can be serialized differently from text and this can result in faster transport time.

RESTEasy requires annotation @XopWithMultipartRelated to be placed on any endpoint method that returns an object that is to be processed with XOP and on any endpoint input parameter that is to be processed by XOP.

RESTEasy highly recommends, if you know the exact mime type of the POJO's binary data, tag the field with annotation @XmlMimeType. This annotation tells Jakarta XML Binding the mime type of the binary content, however this is not required in order to do XOP packaging.

26.2.5. @XopWithMultipartRelated return object example

The data to be transmitted is class, `ContextProvidersXop`. Note that field, `bytes`, is identified as an application/octet-stream mime type using annotation @XmlMimeType

```java
package org.jboss.resteasy.test.providers.multipart.resource;

import jakarta.ws.rs.core.MediaType;
import jakarta.xml.bind.annotation.XmlAccessType;
import jakarta.xml.bind.annotation.XmlAccessorType;
import jakarta.xml.bind.annotation.XmlMimeType;
import jakarta.xml.bind.annotation.XmlRootElement;

@XmlRootElement
@XmlAccessorType(XmlAccessType.FIELD)
public class ContextProvidersXop {

    @XmlMimeType(MediaType.APPLICATION_OCTET_STREAM)
    private byte[] bytes;
```
The endpoint returns an instance of `ContextProvidersXop`. Note annotation `@XopWithMultipartRelated` is declared on the method because we want the return object to use XOP packaging.

```java
public ContextProvidersXop(final byte[] bytes) {
    this.bytes = bytes;
}

public ContextProvidersXop() {}  
public byte[] getBytes() {return bytes;}
public void setBytes(byte[] bytes) {this.bytes = bytes;}
}
```

The client retrieves the data as follows:

```java
Client client = ClientBuilder.newClient();  
WebTarget target = client.target(SOME_URL);  
Response response = target.request().get();  
ContextProvidersXo entity = response.readEntity(ContextProvidersXop.class);  
client.close();
```

### 26.2.6. `@XopWithMultipartRelated` input parameter example

Here is an endpoint that has an input parameter that is transmitted as an XOP package. Note the `@XopWithMultipartRelated` annotation on input parameter `xop`.

```java
@POST
@Path("post/xop")  
@Consumes("multipart/related")  
public String postXop(@XopWithMultipartRelated ContextProvidersXop xop) {
    return new String(xop.getBytes());
}
```
Multipart Providers

This client is sending the data to the endpoint above.

```java
ContextProvidersXop xop = new ContextProvidersXop("hello world").getBytes();
Entity<ContextProvidersXop> entity = Entity.entity(xop,
        new MediaType("multipart", "related"));

Client client = ClientBuilder.newClient();
WebTarget target = client.target(SOME_URL);
Response response = target.request().post(entity);
```

26.3. Multipart/form-data

The MultiPart/Form-Data mime type is used in sending form data (rfc2388). It can include data generated by user input, information that is typed, or included from files that the user has selected. "multipart/form-data" is often found in web application HTML Form documents and is generally used to upload files. The form-data format is the same as other multi-part formats, except that each inlined piece of content has a name associated with it.

26.3.1. Multipart/form-data with EntityPart's

In Jakarta RESTful Web Services 3.1 the `jakarta.ws.rs.core.EntityPart` API was introduced. This can be used to read and write `multipart/form-data` with a standardized API.

The content of the `EntityPart` has two definable size limits. These can be set as system properties, servlet context properties or a MicroProfile Config compatible value.

Table 26.1.

<table>
<thead>
<tr>
<th>Property Name</th>
<th>Description</th>
<th>Default Value</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>dev.resteasy.entity.memory.threshold</td>
<td>The threshold to use for the amount of data to store in memory for entities.</td>
<td>5MB</td>
<td>&quot;512MB&quot; is equivalent to 512 Megabytes</td>
</tr>
<tr>
<td>dev.resteasy.entity.file.threshold</td>
<td>The threshold to use for the amount of data that can be stored in a file for entities. If the threshold is reached an <code>IllegalStateException</code> will be thrown. A value of -1 means no limit.</td>
<td>50MB</td>
<td>&quot;1GB&quot; is equivalent to 1 Gigabyte</td>
</tr>
</tbody>
</table>

You can read, write and inject (with `@FormParam`) an `EntityPart` in the following forms;
Multipart Providers

- EntityPart
- List<EntityPart>
- InputStream

Example reading data:

```java
try (Client client = ClientBuilder.newClient()) {
    final List<EntityPart> multipart = new ArrayList<>();
    multipart.add(
        EntityPart.withName("content")
            .content("Example Content")
            .mediaType(MediaType.TEXT_PLAIN_TYPE)
            .build()
    );
    try {
        Response response = client.target(INSTANCE.configuration().baseUriBuilder().path("test/injected"))
            .request(MediaType.MULTIPART_FORM_DATA_TYPE)
            .post(Entity.entity(new GenericEntity<>(multipart) {}, MediaType.MULTIPART_FORM_DATA))
        ) {
            Assert.assertEquals(Response.Status.OK, response.getStatusInfo());
            final List<EntityPart> entityParts = response.readEntity(new GenericType<>() {
                });
        }
    }
}
```

Example receiving and writing data.

```java
@POST
@Consumes(MediaType.MULTIPART_FORM_DATA)
@Produces(MediaType.MULTIPART_FORM_DATA)
@Path("/injected")
public List<EntityPart> injected(@FormParam("content") final String string,
    @FormParam("content") final EntityPart entityPart,
    @FormParam("content") final InputStream in) throws IOException {
    final List<EntityPart> multipart = new ArrayList<>();
    multipart.add(
        EntityPart.withName("received-entity-part")
            .content(entityPart.getContent(String.class))
            .mediaType(entityPart.getMediaType())
            .fileName(entityPart.getFileName().orElse(null))
            .build()
    );
    multipart.add(
        EntityPart.withName("received-input-stream")
            .content(MultipartEntityPartProviderTest.toString(in).getBytes(StandardCharsets.UTF_8))
            .mediaType(MediaType.APPLICATION_OCTET_STREAM_TYPE)
            .build()
    );
```
Currently multipart/form-data requests only work in the provided servlet containers. The servlet’s multipart-config must be configured as well. If using one of the RESTEasy Undertow embedded servers or the resteasy-servlet-initializer, then annotate the application with @MultipartConfig. For other servers specify the configuration. Below is an example web.xml configuration.

```xml
<?xml version="1.0" encoding="UTF-8"?>
<web-app xmlns="https://jakarta.ee/xml/ns/jakartaee"
   xmlns:xsi="https://www.w3.org/2001/XMLSchema-instance"
   xsi:schemaLocation="https://jakarta.ee/xml/ns/jakartaee https://jakarta.ee/xml/ns/jakartaee/web-app_5_0.xsd"
   version="5.0">
   <servlet>
      <servlet-name>RESTEasy</servlet-name>
      <servlet-class>org.jboss.resteasy.plugins.server.servlet.HttpServlet30Dispatcher</servlet-class>
      <init-param>
         <param-name>jakarta.ws.rs.core.Application</param-name>
         <param-value>dev.resteasy.resource.EntityApplication</param-value>
      </init-param>
      <async-supported>true</async-supported>
      <multipart-config>
         <max-file-size>-1</max-file-size>
         <max-request-size>-1</max-request-size>
         <file-size-threshold>0</file-size-threshold>
         <location></location>
      </multipart-config>
   </servlet>
   <servlet-mapping>
      <servlet-name>RESTEasy</servlet-name>
      <url-pattern>/*</url-pattern>
   </servlet-mapping>
</web-app>
```

### 26.3.2. Writing multipart/form-data messages

Form data consists of key/value pairs. RESTEasy provides class `MultipartFormDataOutput` to assist the user in specifying the required information and generating a properly formatted mes-
Multipart Providers

It is a subclass of MultipartOutput. And as with multipart/mixed data sometimes there may be marshalling which is sensitive to generic type metadata, in those cases use the methods containing input parameter GenericType.

```java
package org.jboss.resteasy.plugins.providers.multipart;

public class MultipartFormDataOutput extends MultipartOutput {
    public OutputPart addFormData(String key, Object entity, MediaType mediaType)
    public OutputPart addFormData(String key, Object entity, GenericType type, MediaType mediaType)
    public OutputPart addFormData(String key, Object entity, Class type, Type genericType, MediaType mediaType)
    public Map<String, OutputPart> getFormData()
    public Map<String, List<OutputPart>> getFormDataMap()
}
```

26.3.3. Reading multipart/form-data messages

MultipartFormDataInput is an interface class that provides access to multipart/form-data message data. It is a subclass of MultipartInput. RESTEasy provides an implementation of this class. It performs the work to retrieve message data.

```java
package org.jboss.resteasy.plugins.providers.multipart;

import java.io.IOException;
import java.lang.reflect.Type;
import java.util.List;
import java.util.Map;
import jakarta.ws.rs.core.GenericType;

public interface MultipartFormDataInput extends MultipartInput {
    /**
     * @return A parameter map containing a list of values per name.
     */
    Map<String, List<InputPart>> getFormDataMap();
    <T> T getFormDataPart(String key, Class<T> rawType, Type genericType) throws IOException;
    <T> T getFormDataPart(String key, GenericType<T> type) throws IOException;
}
```

26.3.4. Simple multipart/form-data message example

The following example show how to read and write a simple multipart/form-data message.
The multipart/mixed message is created on the clientside using the `MultipartFormDataOutput` object. One piece of form data to be transferred is a very simple class, `ContextProvidersName`.

```java
package org.jboss.resteasy.test.providers.multipart.resource;

import jakarta.xml.bind.annotation.XmlAccessType;
import jakarta.xml.bind.annotation.XmlAccessorType;
import jakarta.xml.bind.annotation.XmlElement;
import jakarta.xml.bind.annotation.XmlRootElement;

@XmlRootElement(name = "name")
@XmlAccessorType(XmlAccessType.FIELD)
public class ContextProvidersName {
    @XmlElement
    private String name;

    public ContextProvidersName() {}  
    public ContextProvidersName(final String name) {this.name = name;}
    public String getName() {return name;}
}
```

The client creates and sends the message as follows:

```java
MultipartFormDataOutput output = new MultipartFormDataOutput();
output.addFormData("bill", new ContextProvidersCustomer("Bill"),
    MediaType.APPLICATION_XML_TYPE);
output.addFormData("bob", "Bob", MediaType.TEXT_PLAIN_TYPE);
Entity<MultipartFormDataOutput> entity = Entity.entity(output,
    new MediaType("multipart", "related"));

Client client = ClientBuilder.newClient();
WebTarget target = client.target(SOME_URL);
Response response = target.request().post(entity);
```

The endpoint receives the message and processes it.

```java
@POST
@Consumes("multipart/form-data")
@Produces(MediaType.APPLICATION_XML)
@Path("post/form")
public Response postForm(MultipartFormDataInput input)
    throws IOException {
```
26.3.5. java.util.Map with multipart/form-data

When the data of a multipart/form-data message is uniform it does not need to be written in a MultipartFormDataOutput object. It can be sent and received as a java.util.Map object. RESTEasy performs the necessary work to read and write the message data, however the Map object must declare the type it is unmarshalling via the generic parameters in the Map type declaration.

Here is an example of a client creating and sending a multipart/form-data message.

```java
Map<String, ContextProvidersCustomer> customers =
    new HashMap<String, ContextProvidersCustomer>();
customers.put("bill", new ContextProvidersCustomer("Bill"));
customers.put("bob", new ContextProvidersCustomer("Bob"));

Entity<Map<String, ContextProvidersCustomer>> entity =
    Entity.entity(customers, new MediaType("multipart", "form-data"));

Client client = ClientBuilder.newClient();
WebTarget target = client.target(SOME_URL);
Response response = target.request().post(entity)
```

This is the endpoint the client above is calling. It receives the message and processes it.

```java
@POST
@Consumes("multipart/form-data")
@Produces(MediaType.APPLICATION_XML)
@Path("post/map")
public Response postMap(Map<String, ContextProvidersCustomer> customers)
Multipart Providers

```java
throws IOException {
    List<ContextProvidersName> names = new ArrayList<ContextProvidersName>();
    for (Iterator<String> it = customers.keySet().iterator(); it.hasNext(); ) {
        String key = it.next();
        ContextProvidersCustomer customer = customers.get(key);
        names.add(new ContextProvidersName(key + ":" + customer.getName()));
    }
    return Response.ok().build();
}
```

### 26.3.6. Multipart/form-data java.util.Map as method return type

A `java.util.Map` object representing a multipart/form-data message can be returned from an endpoint as long as the message data is uniform, however the endpoint method MUST be annotated with `@PartType` which declares the media type of the Map entries and the Map object must declare the type it is unmarshalling via the generic parameters in the Map type declaration. RESTEasy requires this information so it can generate the message properly.

Here is an example of an endpoint returning a Map of `ContextProvidersCustomer` to the client.

```java
@GET
@Produces("multipart/form-data")
@PartType("application/xml")
@Path("get/map")
public Map<String, ContextProvidersCustomer> getMap() {
    Map<String, ContextProvidersCustomer> map =
        new HashMap<String, ContextProvidersCustomer>();
    map.put("bill", new ContextProvidersCustomer("Bill"));
    map.put("bob", new ContextProvidersCustomer("Bob"));
    return map;
}
```

The client would retrieve the data as follows.

```java
Client client = ClientBuilder.newClient();
WebTarget target = client.target(SOME_URL);
Response response = target.request().get();
MultipartFormDataInput entity = response.readEntity(MultipartFormDataInput.class);
client.close();

ContextProvidersCustomer bill = entity.getFormDataPart("bill",
    ContextProvidersCustomer.class, null);
ContextProvidersCustomer bob = entity.getFormDataPart("bob",
    ContextProvidersCustomer.class, null);
```
26.3.7. `@MultipartForm` and POJOs

If you have exact knowledge of the multipart/form-data packets, they can be mapped to and from a POJO class using the annotation `@org.jboss.resteasy.annotations.providers.multipart.MultipartForm` and the Jakarta RESTful Web Services `@FormParam` annotation. Simply define a POJO with at least a default constructor and annotate its fields and/or properties with `@FormParams`. These `@FormParams` must also be annotated with `@org.jboss.resteasy.annotations.providers.multipart.PartType` if doing output. For example:

```java
public class CustomerProblemForm {
    @FormParam("customer")
    @PartType("application/xml")
    private Customer customer;

    @FormParam("problem")
    @PartType("text/plain")
    private String problem;

    public Customer getCustomer() { return customer; }
    public void setCustomer(Customer cust) { this.customer = cust; }
    public String getProblem() { return problem; }
    public void setProblem(String problem) { this.problem = problem; }
}
```

After defining the POJO class it can be used to represent multipart/form-data. Here's an example of sending a `CustomerProblemForm` using the RESTEasy client framework:

```java
@Path("portal")
public interface CustomerPortal {

    @Path("issues/{id}")
    @Consumes("multipart/form-data")
    @PUT
    public void putProblem(@MultipartForm CustomerProblemForm,
                            @PathParam("id") int id) {
        CustomerPortal portal = ProxyFactory.create(  
            CustomerPortal.class, "http://example.com");
        CustomerProblemForm form = new CustomerProblemForm();
        form.setCustomer(...);
        form.setProblem(...);

        portal.putProblem(form, 333);
    }
```
Note that the @MultipartForm annotation was used to tell RESTEasy that the object has a @Form-Param and that it should be marshalled from that. The same object can be used to receive multipart data. Here is an example of the server side counterpart of our customer portal.

```java
@Path("portal")
public class CustomerPortalServer {

@Path("issues/{id})
@Consumes("multipart/form-data")
@PUT
public void putIssue(@MultipartForm CustomerProblemForm,
    @PathParam("id") int id) {
    ... write to database...
}
}
```

In addition to the XML data format, JSON formatted data can be used to represent POJO classes. To achieve this, plug in a JSON provider into your project. For example, add the RESTEasy Jackson2 Provider into the project's dependency scope:

```xml
dependency
    <groupId>org.jboss.resteasy</groupId>
    <artifactId>resteasy-jackson2-provider</artifactId>
    <version>${resteasy.ver}</version>
</dependency>
```

Now an ordinary POJO class can be written, which Jackson2 will automatically serialize/deserialize into JSON format:

```java
public class JsonUser {
    private String name;

    public JsonUser() {} // Empty constructor
    public JsonUser(final String name) { this.name = name; }
    public String getName() { return name; }
    public void setName(String name) { this.name = name; }
}
```

The resource class can be written like this:
In the code shown above, it can be seen the PartType of JsonUser is marked as "application/json", and it's included in the "@MultipartForm Form" class instance.

To send the request to the resource method, send the JSON formatted data that corresponds with the JsonUser class. The easiest way to do this is to use a proxy class that has the same definition of the resource class. Here is the sample code of the proxy class that is corresponding with the JsonFormResource class:
import jakarta.ws.rs.Consumes;
import jakarta.ws.rs.PUT;
import jakarta.ws.rs.Path;

@Path("/")
public interface JsonForm {

@PUT
@Path("form/class")
@Consumes("multipart/form-data")
    String putMultipartForm(@MultipartForm JsonFormResource.Form form);
}

And then use the proxy class above to send the request to the resource method correctly. Here is the sample code:

ResteasyClient client = (ResteasyClient)ClientBuilder.newClient();
...
JsonForm proxy = client.target("your_request_url_address")
    .proxy(JsonForm.class);
String name = proxy.putMultipartForm(new JsonFormResource.Form(new JsonUser("bill")));
...

If the client side has the Jackson2 provider included, the request will be marshaled correctly. The JsonUser data will be converted into JSON format and sent to the server side. Hand-crafted JSON data can be use in the request and sent to the server side. It must be made sure the request data is in the correct form.

### 26.4. Note about multipart parsing and working with other frameworks

There are many frameworks doing multipart parsing automatically with the help of filters and interceptors, like org.jboss.seam.web.MultipartFilter in Seam and org.springframework.web.multipart.MultipartResolver in Spring, however these incoming multipart request stream can be parsed only once. RESTEasy users working with multipart should make sure that nothing parses the stream before RESTEasy gets it.

### 26.5. Overwriting the default fallback content type for multipart messages

By default if no Content-Type header is present in a part "text/plain; charset=us-ascii" is used as the fallback. This is the value defined by the MIME RFC, however some web clients, and web browsers do not send Content-Type headers for all fields in a multipart/form-data request. They send them only for the file parts. This can cause character encoding and unmarshalling
errors on the server side. To correct this there is an option to define another, non-rfc compliant fallback value. This can be done dynamically per request with the filter facility of Jakarta RESTful Web Services 3.0. In the following example we will set "]*/*; charset=UTF-8" as the new default fallback:

```java
import org.jboss.resteasy.plugins.providers.multipart.InputPart;

@Provider
public class InputPartDefaultCharsetOverwriteContentTypeCharsetUTF8
    implements ContainerRequestFilter {

    @Override
    public void filter(ContainerRequestContext requestContext) throws IOException {
        requestContext.setProperty(InputPart.DEFAULT_CONTENT_TYPE_PROPERTY, "]*/*; charset=UTF-8");
    }
}
```

### 26.6. Overwriting the content type for multipart messages

Using attribute, `InputPart.DEFAULT_CONTENT_TYPE_PROPERTY` and a filter enables the setting of a default Content-Type. It is also possible to override the Content-Type by setting a different media type with method `InputPart.setMediaType()`. Here is an example:

```java
@POST
@Path("query")
@Consumes(MediaType.MULTIPART_FORM_DATA)
@Produces(MediaType.TEXT_PLAIN)
public Response setMediaType(MultipartInput input) throws IOException {
    List<InputPart> parts = input.getParts();
    InputPart part = parts.get(0);
    part.setMediaType(MediaType.valueOf("application/foo+xml"));
    String s = part.getBody(String.class, null);
    ...
}
```

### 26.7. Overwriting the default fallback charset for multipart messages

Sometimes, a part may have a Content-Type header with no charset parameter. If the `InputPart.DEFAULT_CONTENT_TYPE_PROPERTY` property is set and the val-
Multipart Providers

If both `InputPart.DEFAULT_CONTENT_TYPE_PROPERTY` and `InputPart.DEFAULT_CHARSET_PROPERTY` are set, then the value of `InputPart.DEFAULT_CHARSET_PROPERTY` will override any charset in the value of `InputPart.DEFAULT_CONTENT_TYPE_PROPERTY`.
Chapter 27. Jakarta RESTful Web Services 2.1 Additions

Jakarta RESTful Web Services 2.1 adds more asynchronous processing support in both the Client and the Server API. The specification adds a Reactive programming style to the Client side and Server-Sent Events (SSE) protocol support to both client and server.

27.1. CompletionStage support

The specification adds support for declaring asynchronous resource methods by returning a CompletionStage instead of using the @Suspended annotation.

![Note]

RESTEasy supports more reactive types than the specification.

27.2. Reactive Clients API

The specification defines a new type of invoker named RxInvoker, and a default implementation of this type named CompletionStageRxInvoker. CompletionStageRxInvoker implements Java 8's interface CompletionStage. This interface declares a large number of methods dedicated to managing asynchronous computations.

There is also a new rx method which is used in a similar manner to async.

27.3. Server-Sent Events (SSE)

SSE is part of HTML standard, currently supported by many browsers. It is a server push technology, which provides a way to establish a one-way channel to continuously send data to clients. SSE events are pushed to the client via a long-running HTTP connection. In case of lost connection, clients can retrieve missed events by setting a "Last-Event-ID" HTTP header in a new request.

SSE stream has text/event-stream media type and contains multiple SSE events. SSE event is a data structure encoded with UTF-8 and contains fields and comment. The field can be event, data, id, retry and other kinds of field will be ignored.

From Jakarta RESTful Web Services 2.1, Server-sent Events APIs are introduced to support sending, receiving and broadcasting SSE events.

27.3.1. SSE Server

As shown in the following example, a SSE resource method has the text/event-stream produce media type and an injected context parameter SseEventSink. The injected SseEventSink is the
connected SSE stream where events can be sent. Another injected context Sse is an entry point for creating and broadcasting SSE events. Here is an example to demonstrate how to send SSE events every 200ms and close the stream after a "done" event.

**Example 27.1.**

```java
@GET
@Path("domains/{id}")
@Produces(MediaType.SERVER_SENT_EVENTS)
public void startDomain(@PathParam("id") final String id, @Context SseEventSink sink @Context Sse sse)
{
    ExecutorService service = (ExecutorService) servletContext
        .getAttribute(ExecutorServletContextListener.TEST_EXECUTOR);
    service.execute(new Thread()
    {
        public void run()
        {
            try
            {
                sink.send(sse.newEventBuilder().name("domain-progress")
                    .data(String.class, "starting domain "+ id + "...").build());
                Thread.sleep(200);
                sink.send(sse.newEvent("domain-progress", "50%"));
                Thread.sleep(200);
                sink.send(sse.newEvent("domain-progress", "60%"));
                Thread.sleep(200);
                sink.send(sse.newEvent("domain-progress", "70%"));
                Thread.sleep(200);
                sink.send(sse.newEvent("domain-progress", "99%"));
                Thread.sleep(200);
                sink.send(sse.newEvent("domain-progress", "Done.")).thenAccept((Object obj) -> {
                    sink.close();
                });
            }
            catch (final InterruptedException e)
            {
                logger.error(e.getMessage(), e);
            }
        }
    });
}
```

**Note**

RESTEasy supports sending SSE events via reactive types.
27.3.2. SSE Broadcasting

With SseBroadcaster, SSE events can be broadcasted to multiple clients simultaneously. It will iterate over all registered SseEventSinks and send events to all requested SSE Stream. An application can create a SseBroadcaster from an injected context Sse. The broadcast method on a SseBroadcaster is used to send SSE events to all registered clients. The following code snippet is an example on how to create SseBroadcaster, subscribe and broadcast events to all subscribed consumers.

Example 27.2.

```java
@GET
@Path("/subscribe")
@Produces(MediaType.SERVER_SENT_EVENTS)
public void subscribe(@Context SseEventSink sink) throws IOException {
    if (sink == null) {
        throw new IllegalStateException("No client connected.");
    }
    if (sseBroadcaster == null) {
        sseBroadcaster = sse.newBroadcaster();
    }
    sseBroadcaster.register(sink);
}

@POST
@Path("/broadcast")
public void broadcast(String message) throws IOException {
    if (sseBroadcaster == null) {
        sseBroadcaster = sse.newBroadcaster();
    }
    sseBroadcaster.broadcast(sse.newEvent(message));
}
```

27.3.3. SSE Client

SseEventSource is the entry point to read and process incoming SSE events. A SseEventSource instance can be initialized with a WebTarget. Once SseEventSource is created and connected to a server, registered event consumer will be invoked when an inbound event arrives. In case of errors, an exception will be passed to a registered consumer so that it can be processed. SseEventSource can automatically reconnect the server and continuously receive pushed events after the connection has been lost. SseEventSource can send lastEventId to the server by default when it is reconnected, and server may use this id to replay all missed events. But reply event
is really upon on SSE resource method implementation. If the server responds HTTP 503 with a RETRY_AFTER header, SseEventSource will automatically schedule a reconnect task with this RETRY_AFTER value. The following code snippet is to create a SseEventSource and print the inbound event data value and error if it happens.

**Example 27.3.**

```java
public void printEvent() throws Exception {
    WebTarget target = client.target("http://localhost:8080/service/server-sent-events");
    SseEventSource msgEventSource = SseEventSource.target(target).build();
    try (SseEventSource eventSource = msgEventSource) {
        eventSource.register(event -> {
            System.out.println(event.readData(String.class));
        }, ex -> {
            ex.printStackTrace();
        });
        eventSource.open();
    }
}
```

### 27.4. Java API for JSON Binding

RESTEasy supports both JSON-B and JSON-P. In accordance with the specification, entity providers for JSON-B take precedence over those for JSON-P for all types except JsonValue and its sub-types.

The support for JSON-B is provided by the `JsonBindingProvider` from `resteasy-json-binding-provider` module. To satisfy Jakarta RESTful Web Services 2.1 requirements, JsonBindingProvider takes precedence over the other providers for dealing with JSON payloads, in particular the Jackson one. The JSON outputs (for the same input) from Jackson and JSON-B reference implementation can be slightly different. As a consequence, in order to allow retaining backward compatibility, RESTEasy offers a `resteasy.preferJacksonOverJsonB` context property that can be set to `true` to disable JsonBindingProvider for the current deployment.

WildFly 14 supports specifying the default value for the `resteasy.preferJacksonOverJsonB` context property by setting a system property with the same name. Moreover, if no value is set for the context and system properties, it scans Jakarta RESTful Web Services deployments for Jackson annotations and sets the property to `true` if any of those annotations is found.

### 27.5. JSON Patch and JSON Merge Patch

RESTEasy supports applying partial modifications to target resources with JSON Patch/JSON Merge Patch. Instead of sending a json request which represents the whole modified resource
with an HTTP PUT method, the json request only contains the modified part with an HTTP PATCH method to do the same job.

JSON Patch request has an array of json objects and each JSON object gives the operation to execute against the target resource. Here is an example to modify the target Student resource which has these fields and values: {
  "firstName": "Alice",
  "id": 1,
  "school": "MiddleWood School"
}:

```
PATCH /StudentPatchTest/students/1 HTTP/1.1
Content-Type: application/json-patch+json
Content-Length: 184
Host: localhost:8090
Connection: Keep-Alive

[{
  "op": "copy",
  "from": "/firstName",
  "path": "/lastName"
},
{
  "op": "replace",
  "path": "/firstName",
  "value": "John"
},
{
  "op": "remove",
  "path": "/school"
},
{
  "op": "add",
  "path": "/gender",
  "value": "male"
}]
```

This JSON Patch request will copy the firstName to lastName field, then change the firstName value to "John". The next operation will remove the school value and add male gender to this "id=1" student resource. After this JSON Path is applied. The target resource will be modified to: {
  "firstName": "John",
  "gender": "male",
  "id": 1,
  "lastName": "Taylor"
}. The operation keyword here can be "add", "remove", "replace", "move", "copy", or "test". The "path" value must be a JSON Pointer value that points to the part to apply this JSON Patch.

Unlike using the operation keyword to patch the target resource, JSON Merge Patch request directly sends the expected json change. RestEasy merges this change into the target resource which is identified by the request URI. Like the JSON Merge Patch request below, it removes the "school" value and changes the "firstName" to "Green".

```
PATCH /StudentPatchTest/students/1 HTTP/1.1
Content-Type: application/merge-patch+json
Content-Length: 34
Host: localhost:8090
Connection: Keep-Alive

{"firstName": "Green", "school": null}
```

Enabling JSON Patch or JSON Merge Patch only requires correctly annotating the resource method with these mediaTypes. 
@Consumes(MediaType.APPLICATION_JSON_PATCH_JSON) enables JSON Patch. 
@Consumes("application/merge-patch+json") enables JSON Merge Patch:
@GET
@Path("/{id}")
@Consumes(MediaType.APPLICATION_JSON)
@Produces(MediaType.APPLICATION_JSON)
public Student getStudent(@PathParam("id") long id)
{
    Student student = studentsMap.get(id);
    if (student == null)
    {
        throw new NotFoundException();
    }
    return student;
}

@PATCH
@Path("/{id}")
@Consumes(MediaType.APPLICATION_JSON_PATCH_JSON)
@Produces(MediaType.APPLICATION_JSON)
public Student patchStudent(@PathParam("id") long id, Student student)
{
    if (studentsMap.get(id) == null)
    {
        throw new NotFoundException();
    }
    studentsMap.put(id, student);
    return student;
}

@PATCH
@Path("/{id}")
@Consumes("application/merge-patch+json")
@Produces(MediaType.APPLICATION_JSON)
public Student mergePatchStudent(@PathParam("id") long id, Student student)
{
    if (studentsMap.get(id) == null)
    {
        throw new NotFoundException();
    }
    studentsMap.put(id, student);
    return student;
}

---

**Note**

Before creating a JSON Patch or JSON Merge Patch resource method, there must be a GET method to get the target resource. In the above code example, the first resource method is responsible for getting the target resource to apply the patch.

It requires the patch filter to enable JSON Patch or JSON Merge Patch. The RESTEasy PatchMethodFilter is enabled by default. This filter can be disabled by
setting "resteasy.patchfilter.disabled" to true as described in Section 3.5, "Configuration switches".

The client side needs to create these json objects and send them with a http PATCH method.

```java
//send JSON Patch request
WebTarget patchTarget = client.target("http://localhost:8090/StudentPatchTest/students/1");
JsonArray patchRequest = Json.createArrayBuilder()
    .add(Json.createObjectBuilder().add("op", "copy").add("from", "/firstName").add("path", "/lastName").build())
    .build();
patchTarget.request().build(HttpMethod.PATCH, Entity.entity(patchRequest, MediaType.APPLICATION_JSON_PATCH_JSON)).invoke();

//send JSON Merge Patch request
WebTarget patchTarget = client.target("http://localhost:8090/StudentPatchTest/students/1");
JsonObject object = Json.createObjectBuilder().add("lastName", "Green").addNull("school").build();
Response result = patchTarget.request().build(HttpMethod.PATCH, Entity.entity(object, "application/merge-patch+json")).invoke();
```
Parameters and properties annotated with @CookieParam, @HeaderParam, @MatrixParam, @PathParam, or @QueryParam are represented as strings in a raw HTTP request. The specification says that any of these injected parameters can be converted to an object if the object's class has a `valueOf(String)` static method or a constructor that takes one `String` parameter. In the following, for example,

```java
public static class Customer {
    private String name;

    public Customer(String name) {
        this.name = name;
    }

    public String getName() {
        return name;
    }
}

@Path("test")
public static class TestResource {
    @GET
    @Path(""")
    public Response test(@QueryParam("cust") Customer cust) {
        return Response.ok(cust.getName()).build();
    }
}

@Test
public void testQuery() throws Exception {
    Response response = request.get();
    ...
}
```

the query "?cust=Bill" will be transformed automatically to an instance of `Customer` with name `"Bill"`. 

28.2. ParamConverter

What if you have a class where `valueOf()` or this string constructor don't exist or is inappropriate for an HTTP request? Jakarta RESTful Web Services has the `jakarta.ws.rs.ext.ParamConverterProvider` to help in this situation.

A `ParamConverterProvider` is a provider defined as follows:

```java
public interface ParamConverterProvider {
    public <T> ParamConverter<T> getConverter(Class<T> rawType, Type genericType, Annotation... annotations);
}
```

where a `ParamConverter` is defined:

```java
public interface ParamConverter<T> {
    ...
    public T fromString(String value);
    public String toString(T value);
}
```

For example, consider `DateParamConverterProvider` and `DateParamConverter`:

```java
@Provider
public class DateParamConverterProvider implements ParamConverterProvider {
    @SuppressWarnings("unchecked")
    @Override
    public <T> ParamConverter<T> getConverter(Class<T> rawType, Type genericType, Annotation[] annotations) {
        if (rawType.isAssignableFrom(Date.class)) {
            return (ParamConverter<T>) new DateParamConverter();
        }
        return null;
    }
}
```

```java
public class DateParamConverter implements ParamConverter<Date> {
    public static final String DATE_PATTERN = "yyyyMMdd";
    @Override
    public Date fromString(String param) {
        try {
            return new SimpleDateFormat(DATE_PATTERN).parse(param.trim());
        } catch (ParseException e) {
            throw new IllegalArgumentException(e);
        }
    }
    @Override
    public String toString(Date value) {
        return value.format(new SimpleDateFormat(DATE_PATTERN));
    }
}
```
String marshalling for
String based @*Param

```java
} catch (ParseException e) {
    throw new BadRequestException(e);
}

@Override
public String toString(Date date) {
    return new SimpleDateFormat(DATE_PATTERN).format(date);
}
```

Sending a `Date` in the form of a query, e.g., "?date=20161217" will cause the string "20161217" to be converted to a `Date` on the server.

### 28.3. StringParameterUnmarshaller

In addition to the Jakarta RESTful Web Services `jakarta.ws.rs.ext.ParamConverterProvider`, RESTEasy also has its own `org.jboss.resteasy.StringParameterUnmarshaller`, defined

```java
public interface StringParameterUnmarshaller<T> {
    void setAnnotations(Annotation[] annotations);

    T fromString(String str);
}
```

It is similar to `jakarta.ws.rs.ext.ParamConverter` except that

- it converts only from `Strings`;
- it is configured with the annotations on the injected parameter, which allows for fine-grained control over the injection; and
- it is bound to a given parameter by an annotation that is annotated with the meta-annotation `org.jboss.resteasy.annotations.StringParameterUnmarshallerBinder`:

```java
@Target(ElementType.ANNOTATION_TYPE)
@Retention(RetentionPolicy.RUNTIME)
public @interface StringParameterUnmarshallerBinder {
    Class<? extends StringParameterUnmarshaller> value();
}
```
String marshalling for
String based @*Param

For example,

```java
@Retention(RetentionPolicy.RUNTIME)
@StringParameterUnmarshallerBinder(TestDateFormatter.class)
public @interface TestDateFormat {
    String value();
}

public static class TestDateFormatter implements StringParameterUnmarshaller<Date> {
    private SimpleDateFormat formatter;

    public void setAnnotations(Annotation[] annotations) {
        TestDateFormat format = FindAnnotation.findAnnotation(annotations, TestDateFormat.class);
        formatter = new SimpleDateFormat(format.value());
    }

    public Date fromString(String str) {
        try {
            return formatter.parse(str);
        } catch (ParseException e) {
            throw new RuntimeException(e);
        }
    }
}

@Path("/")
public static class TestResource {
    @GET
    @Produces("text/plain")
    @Path("/datetest/{date}")
    public String get(@PathParam("date") @TestDateFormat("MM-dd-yyyy") Date date) {
        Calendar c = Calendar.getInstance();
        c.setTime(date);
        return date.toString();
    }
}
```

Note that the annotation @StringParameterUnmarshallerBinder on the annotation @TestDateFormat binds the formatter TestDateFormatter to a parameter annotated with @TestDateFormat. In this example, TestDateFormatter is used to format the Date parameter. Note also that the parameter “MM-dd-yyyy” to @TestDateFormat is accessible from TestDateFormatter.setAnnotations().

28.4. Collections

For parameters and properties annotated with @CookieParam, @HeaderParam, @MatrixParam, @PathParam, or @QueryParam, the Jakarta RESTful Web Services specification [https://jcp.org/aboutJava/communityprocess/final/jsr339/index.html] allows conversion as defined in the Javadoc of the corresponding annotation. In general, the following types are supported:
1. Types for which a ParamConverter is available via a registered ParamConverterProvider. See Javadoc for these classes for more information.

2. Primitive types.

3. Types that have a constructor that accepts a single String argument.

4. 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 used.

5. List<T>, Set<T>, or SortedSet<T>, where T satisfies 3 or 4 above.

Items 1, 3, and 4 have been discussed above, and item 2 is obvious. Note that item 5 allows for collections of parameters. How these collections are expressed in HTTP messages depends, by default, on the particular kind of parameter. In most cases, the notation for collections is based on convention rather than a specification.

28.4.1. @QueryParam

For example, a multivalued query parameter is conventionally expressed like this:

```
http://bluemonkeydiamond.com?q=1&q=2&q=3
```

In this case, there is a query with name "q" and value {1, 2, 3}. This notation is further supported in Jakarta RESTful Web Services by the method

```
public MultivaluedMap<String, String> getQueryParameters();
```

in `jakarta.ws.rs.core.UriInfo`

28.4.2. @MatrixParam

There is no specified syntax for collections derived from matrix parameters, but

1. matrix parameters in a URL segment are conventionally separated by ";", and

2. the method

```
MultivaluedMap<String, String> getMatrixParameters();
```
String marshalling for 
String based @*Param

in jakarta.ws.rs.core.PathSegment supports extraction of collections from matrix parameters.

RESTEasy adopts the convention that multiple instances of a matrix parameter with the same name are treated as a collection. For example,

http://bluemonkeydiamond.com/sippycup;m=1;m=2;m=3

is interpreted as a matrix parameter on path segment "sippycup" with name "m" and value {1, 2, 3}.

28.4.3. @HeaderParam

The HTTP 1.1 specification doesn't exactly specify that multiple components of a header value should be separated by commas, but commas are used in those headers that naturally use lists, e.g. Accept and Allow. Also, note that the method

public MultivaluedMap<String, String> getHeaders();

in jakarta.ws.rs.core.HttpHeaders returns a MultivaluedMap. It is natural, then, for RESTEasy to treat

x-header: a, b, c

as mapping name "x-header" to set {a, b, c}.

28.4.4. @CookieParam

The syntax for cookies is specified, but, unfortunately, it is specified in multiple competing specifications. Typically, multiple name=value cookie pairs are separated by ";". However, unlike the case with query and matrix parameters, there is no specified Jakarta RESTful Web Services method that returns a collection of cookie values. Consequently, if two cookies with the same name are received on the server and directed to a collection typed parameter, RESTEasy will inject only the second one. Note, in fact, that the method

public Map<String, Cookie> getCookies();
String marshalling for String based @*Param

in jakarta.ws.rs.core.HttpHeaders returns a Map rather than a MultivaluedMap.

28.4.5. @PathParam

Deriving a collection from path segments is somewhat less natural than it is for other parameters, but Jakarta RESTful Web Services supports the injection of multiple jakarta.ws.rs.core.PathSegment. There are a couple of ways of obtaining multiple PathSegments. One is through the use of multiple path variables with the same name. For example, the result of calling testTwoSegmentsArray() and testTwoSegmentsList() in

```java
@Path("*")
public static class TestResource {

    @GET
    @Path("{segment}/{other}/{segment}/array")
    public Response getTwoSegmentsArray(@PathParam("segment") PathSegment[] segments) {
        System.out.println("array segments: " + segments.length);
        return Response.ok().build();
    }

    @GET
    @Path("{segment}/{other}/{segment}/list")
    public Response getTwoSegmentsList(@PathParam("segment") List<PathSegment> segments) {
        System.out.println("list segments: " + segments.size());
        return Response.ok().build();
    }
}
...

@Test
public void testTwoSegmentsArray() throws Exception {
    Response response = request.get();
    Assert.assertEquals(200, response.getStatus());
    response.close();
}

@Test
public void testTwoSegmentsList() throws Exception {
    Invocation.Builder request = client.target("http://localhost:8081/a/b/c/list").request();
    Response response = request.get();
    Assert.assertEquals(200, response.getStatus());
    response.close();
}
```

is

array segments: 2
list segments: 2
An alternative is to use a wildcard template parameter. For example, the output of calling `test-WildcardArray()` and `testWildcardList()` in

```java
@Path(""**")
public static class TestResource {

    @GET
    @Path("{segments:.*}/array")
    public Response getWildcardArray(@PathParam("segments") PathSegment[] segments) {
        System.out.println("array segments: "+ segments.length);
        return Response.ok().build();
    }

    @GET
    @Path("{segments:.*}/list")
    public Response getWildcardList(@PathParam("segments") List<PathSegment> segments) {
        System.out.println("list segments: "+ segments.size());
        return Response.ok().build();
    }

    ...

    @Test
    public void testWildcardArray() throws Exception {
        Response response = request.get();
        response.close();
    }

    @Test
    public void testWildcardList() throws Exception {
        Invocation.Builder request = client.target("http://localhost:8081/a/b/c/list").request();
        Response response = request.get();
        response.close();
    }

    is

    array segments: 3
    list segments: 3
```

28.5. Extension to `ParamConverter` Semantics

In the Jakarta RESTful Web Services semantics, a `ParamConverter` is supposed to convert a single `String` that represents an individual object. RESTEasy extends the semantics to allow a
String marshalling for string based `ParamConverter` to parse the string representation of multiple objects and generate a `List<T>`, `Set<T>`, `SortedSet<T>`, array, or, indeed, any multivalued data structure whatever. First, consider the resource

```java
@Path("queryParam")
public static class TestResource {

    @GET
    @Path(""")
    public Response conversion(@QueryParam("q") List<String> list) {
        return Response.ok(stringify(list)).build();
    }
}
```

```java
private static <T> String stringify(List<T> list) {
    StringBuffer sb = new StringBuffer();
    for (T s : list) {
        sb.append(s).append(',');
    }
    return sb.toString();
}
```

Calling `TestResource` as follows, using the standard notation,

```java
@Test
public void testQueryParamStandard() throws Exception {
    Client client = ClientBuilder.newClient();
    Response response = request.get();
    System.out.println("response: "+ response.readEntity(String.class));
}
```

results in

```java
response: 20161217,20161218,20161219,
```

Suppose, instead, that we want to use a comma separated notation. We can add

```java
public static class MultiValuedParamConverterProvider implements ParamConverterProvider

    @SuppressWarnings("unchecked")
```
String marshalling for
String based @*Param

public <T> ParamConverter<T> getConverter(Class<T> rawType, Type genericType, Annotation[] annotations) {
    if (List.class.isAssignableFrom(rawType)) {
        return (ParamConverter<T>) new MultiValuedParamConverter();
    }
    return null;
}

public static class MultiValuedParamConverter implements ParamConverter<List<?>> {
    @Override
    public List<?> fromString(String param) {
        if (param == null || param.trim().isEmpty()) {
            return null;
        }
        return parse(param.split(","));
    }

    @Override
    public String toString(List<?> list) {
        if (list == null || list.isEmpty()) {
            return null;
        }
        return stringify(list);
    }

    private static List<String> parse(String[] params) {
        List<String> list = new ArrayList<String>;
        for (String param : params) {
            list.add(param);
        }
        return list;
    }
}

Now we can call

@Test
public void testQueryParamCustom() throws Exception {
    Client client = ClientBuilder.newClient();
    Response response = request.get();
    System.out.println("response: " + response.readEntity(String.class));
}

and get
String marshalling for
String based @*Param

response: 20161217,20161218,20161219,

Note that in this case, MultiValuedParamConverter.fromString() creates and returns an ArrayList, so TestResource.conversion() could be rewritten

@Path("queryParam")
public static class TestResource {

    @GET
    @Path("")
    public Response conversion(@QueryParam("q") ArrayList<String> list) {
        return Response.ok(stringify(list)).build();
    }
}

On the other hand, MultiValuedParamConverter could be rewritten to return a LinkList and the parameter list in TestResource.conversion() could be either a List or a LinkedList.

Finally, note that this extension works for arrays as well. For example,

public static class Foo {
    private String foo;
    public Foo(String foo) {this.foo = foo;}
    public String getFoo() {return foo;}
}

test Resource : FooArrayParamConverter implements ParamConverter<Foo[]> {

    @Override
    public Foo[] fromString(String value) {
        String[] ss = value.split(",");
        Foo[] fs = new Foo[ss.length];
        int i = 0;
        for (String s : ss) {
            fs[i++] = new Foo(s);
        }
        return fs;
    }

    @Override
    public String toString(Foo[] values) {
        StringBuffer sb = new StringBuffer();
        for (int i = 0; i < values.length; i++) {
            sb.append(values[i].getFoo()).append(",");
        }
        if (sb.length() > 0) {
            sb.deleteCharAt(sb.length() - 1);
        }
    }
}
28.6. Default multiple valued `ParamConverter`

RESTEasy includes two built-in `ParamConverter`s in the resteasy-core module, one for `Collection`s:

```
org.jboss.resteasy.plugins.providers.MultiValuedCollectionParamConverter,
```

and one for arrays:

```
org.jboss.resteasy.plugins.providers.MultiValuedArrayParamConverter,
```

which implement the concepts in the previous section.

In particular, `MultiValued*ParamConverter.fromString()` can transform a string representation coming over the network into a `Collection` or array, and `MultiValued*ParamConverter.toString()` can be used by a client side proxy to transform `Collection`s or arrays into a string representation.
String marshalling for
String based @*Param

String representations are determined by org.jboss.resteasy.annotations.Separator, a parameter annotation in the resteasy-core module:

```java
@Target({ElementType.PARAMETER})
@Retention(RetentionPolicy.RUNTIME)
public @interface Separator
{
    public String value() default "";
}
```

The value of Separator.value() is used to separate individual elements of a Collection or array. For example, a proxy implementing

```java
@Path("/path/separator/multi/{p}")
@GET
public String pathMultiSeparator(@PathParam("p") @Separator("-") List<String> ss);```

will turn

```java
List<String> list = new ArrayList<String>();
list.add("abc");
list.add("xyz");
proxy.pathMultiSeparator(list);
```

and "/path/separator/multi/{p}" into ".../path/separator/multi/abc-xyz". On the server side, the RESTEasy runtime will turn "abc-xyz" back into a list consisting of elements "abc" and "xyz" for

```java
@Path("/path/separator/multi/{p}")
@GET
public String pathMultiSeparator(@PathParam("p") @Separator("-") List<String> ss) {
    StringBuffer sb = new StringBuffer();
    for (String s : ss) {
        sb.append(s);
        sb.append("|");
    }
    return sb.toString();
}
```

which will return "abc|xyz".
String marshalling for
String based @*Param

In fact, the value of the Separator annotations may be a more general regular expression, which is passed to String.split(). For example, "[-,;]" tells the server side to break up a string using either ",", ",", or ";". On the client side, a string will be created using the first element, "," in this case.

If a parameter is annotated with @Separator with no value, then the default value is

- ",," for a @HeaderParam, @MatrixParam, @PathParam, or @QueryParam, and
- ",-" for a @CookieParam.

The MultiValued*ParamConverter$ depend on existing facilities for handling the individual elements. On the server side, once it has parsed the incoming string into substrings, MultiValued*ParamConverter turns each substring into an Java object according to Section 3.2 "Fields and Bean Properties" of the Jakarta RESTful Web Services specification. On the client side, MultiValued*ParamConverter turns a Java object into a string as follows:

1. look for a ParamConverter;
2. if there is no suitable ParamConverter and the parameter is labeled @HeaderParam, look for a HeaderDelegate; or
3. call toString().

These ParamConverter$ are meant to be fairly general, but there are a number of restrictions:

1. They don't handle nested Collections or arrays. That is, List<String> and String[] are OK, but List<List<String>> and String[][] are not.
2. The regular expression used in Separator must match the regular expression

```
"\p{Punct}|\\\p{Punct}\""
```

That is, it must be either a single instance of a punctuation symbol, i.e., a symbol in the set

```
!*#$%&'()*+,-./;<=?>@[^{}\_`{|}~
```

or a class of punctuation symbols like "[\-;:]."

3. For either of these ParamConverter$ to be available for use with a given parameter, that parameter must be annotated with @Separator.

There are also some logical restrictions:
1. Cookie syntax, as specified in https://tools.ietf.org/html/rfc6265#section-4.1.1, assigns a meaning to ";", so it cannot be used as a separator.

2. If a separator character appears in the content of an element, then there will be problems. For example, if ",," is used as a separator, then, if a proxy sends the array ["a", "b, c", "d"], it will turn into the string "a,b,c,d" on the wire and be reconstituted on the server as four elements.

These built-in ParamConverters have the lowest priority, so any user supplied ParamConverters will be tried first.
Chapter 29. Responses using jakarta.ws.rs.core.Response

Custom responses can be built using the jakarta.ws.rs.core.Response and ResponseBuilder classes. To do your own streaming, your entity response must be an implementation of jakarta.ws.rs.core.StreamingOutput. See the java doc for more information.
Chapter 30. Exception Handling

30.1. Exception Mappers

ExceptionMappers are custom, application provided, components that can catch thrown application exceptions and write specific HTTP responses. They are classes annotated with @Provider and implement this interface:

```java
package jakarta.ws.rs.ext;

import jakarta.ws.rs.core.Response;

/**
 * Contract for a provider that maps Java exceptions to
 * {@link jakarta.ws.rs.core.Response}. An implementation of this interface must
 * be annotated with {@link Provider}.
 * @see Provider
 * @see jakarta.ws.rs.core.Response
 */
public interface ExceptionMapper<E> {
    /**
     * Map an exception to a {@link jakarta.ws.rs.core.Response}.
     * @param exception the exception to map to a response
     * @return a response mapped from the supplied exception
     */
    Response toResponse(E exception);
}
```

When an application exception is thrown it will be caught by the Jakarta RESTful Web Services runtime. Jakarta RESTful Web Services will then scan registered ExceptionMappers to see which one support marshalling the exception type thrown. Here is an example of ExceptionMapper:

```java
@Provider
class EJBExceptionMapper implements ExceptionMapper<jakarta.ejb.EJBException> {
    public Response toResponse(EJBException exception) {
        return Response.status(500).build();
    }
}
```
Exception Mappers are registered the same way as MessageBodyReader/Writers. By scanning for @Provider annotated classes, or programmatically through the ResteasyProviderFactory class.

As of RESTEasy 6.1 if a default ExceptionMapper is registered. It handles all uncaught exceptions and returns a response with the exception's message and a status of 500. If the exception is a WebApplicationException the response from the exception is returned. This can be turned off by setting the dev.resteasy.exception.mapper to false.

The default ExceptionMapper will also log the exception at a error level. The logger name is org.jboss.resteasy.core.providerfactory.DefaultExceptionMapper which can be used to disable these log messages.

### 30.2. RESTEasy Built-in Internally-Thrown Exceptions

RESTEasy has a set of built-in exceptions that are thrown when it encounters errors during dispatching or marshalling. They all revolve around specific HTTP error codes. They can be found in RESTEasy's javadoc under the package org.jboss.resteasy.spi. Here's a list of them:

#### Table 30.1.

<table>
<thead>
<tr>
<th>Exception</th>
<th>HTTP Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ReaderException</td>
<td>400</td>
<td>All exceptions thrown from MessageBodyReaders are wrapped within this exception. If there is no ExceptionMapper for the wrapped exception or if the exception isn't a WebApplicationException, then resteasy will return a 400 code by default.</td>
</tr>
<tr>
<td>WriterException</td>
<td>500</td>
<td>All exceptions thrown from MessageBodyWriters are wrapped within this exception. If there is no ExceptionMapper for the wrapped exception or if the exception isn't a WebApplicationException, then resteasy will return a 400 code by default.</td>
</tr>
<tr>
<td>o.j.r.plugins.providersjaxb.JAXBUnmarshalException</td>
<td>400</td>
<td>The Jakarta XML Binding providers throw this exception on reads. They may be wrapping JAXBExceptions. This class extends ReaderException</td>
</tr>
</tbody>
</table>
### Exception Handling

<table>
<thead>
<tr>
<th>Exception</th>
<th>HTTP Code</th>
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</thead>
<tbody>
<tr>
<td>o.j.r.plugins.providers.jaxb.JAXBMarshalException</td>
<td>500</td>
<td>The Jakarta XML Binding providers throw this exception on writes. They may be wrapping JAXBExceptions. This class extends WriterException.</td>
</tr>
<tr>
<td>ApplicationException</td>
<td>N/A</td>
<td>This exception wraps all exceptions thrown from application code. It functions much in the same way as InvocationTargetException. If there is an ExceptionMapper for wrapped exception, then that is used to handle the request.</td>
</tr>
<tr>
<td>Failure</td>
<td>N/A</td>
<td>Internal RESTEasy. Not logged</td>
</tr>
<tr>
<td>LoggableFailure</td>
<td>N/A</td>
<td>Internal RESTEasy error. Logged</td>
</tr>
<tr>
<td>DefaultOptionsMethodException</td>
<td>N/A</td>
<td>If the user invokes HTTP OPTIONS and no Jakarta RESTful Web Services method for it, RESTEasy provides a default behavior by throwing this exception. This is only done if the property dev.resteasy.throw.options.exception is set to true.</td>
</tr>
<tr>
<td>UnrecognizedPropertyExceptionHandler</td>
<td>400</td>
<td>A Jackson provider throws this exception when JSON data is determine to be invalid.</td>
</tr>
</tbody>
</table>

### 30.3. Resteasy WebApplicationExceptions

Suppose a client at local.com calls the following resource method:

```java
@GET
@Path("remote")
public String remote() throws Exception {
    Client client = ClientBuilder.newClient();
    return client.target("http://third.party.com/exception").request().get(String.class);
}
```
If the call to http://third.party.com returns a status code 3xx, 4xx, or 5xx, then the Client is obliged by the Jakarta RESTful Web Services specification to throw a WebApplicationException. Moreover, if the WebApplicationException contains a Response, which it normally would in RESTEasy, the server runtime is obliged by the Jakarta RESTful Web Services specification to return that Response. As a result, information from the server at third.party.com, e.g., headers and body, will get sent back to local.com. The problem is that that information could be, at best, meaningless to the client and, at worst, a security breach.

RESTEasy has a solution that works around the problem and still conforms to the Jakarta RESTful Web Services specification. In particular, for each WebApplicationException it defines a new subclass:

```
WebApplicationException
 ++-ResteasyWebApplicationException
   +-ClientErrorException
    +-ResteasyClientErrorException
     +-BadRequestException
     +-ResteasyBadRequestException
    +-ForbiddenException
     +-ResteasyForbiddenException
    +-NotAcceptableException
     +-ResteasyNotAcceptableException
    +-NotAllowedException
     +-ResteasyNotAllowedException
    +-NotAuthorizedException
     +-ResteasyNotAuthorizedException
    +-NotFoundException
     +-ResteasyNotFoundException
    +-NotSupportedException
     +-ResteasyNotSupportedException
    +-RedirectionException
     +-ResteasyRedirectionException
    +-ServerErrorException
     +-ResteasyServerErrorException
    +-InternalServerErrorException
     +-ResteasyInternalServerErrorException
    +-ServiceUnavailableException
     +-ResteasyServiceUnavailableException
```

The new Exceptions play the same role as the original ones, but RESTEasy treats them slightly differently. When a Client detects that it is running in the context of a resource method, it will throw one of the new Exceptions. However, instead of storing the original Response, it stores a "sanitized" version of the Response, in which only the status and the Allow and Content-Type headers are preserved. The original WebApplicationException, and therefore the original Response, can be accessed in one of two ways:

```
// Create a NotAcceptableException.
NotAcceptableException nae = new NotAcceptableException(Response.status(406).entity("ooops").build());
```
Exception Handling

// Wrap the NotAcceptableException in a ResteasyNotAcceptableException.
ResteasyNotAcceptableException rnae = (ResteasyNotAcceptableException)
WebApplicationExceptionWrapper.wrap(nae);

// Extract the original NotAcceptableException using instance method.
NotAcceptableException nae2 = rnae.unwrap();
Assert.assertEquals(nae, nae2);

// Extract the original NotAcceptableException using class method.
NotAcceptableException nae3 = (NotAcceptableException)
WebApplicationExceptionWrapper.unwrap(nae); // second way
Assert.assertEquals(nae, nae3);

Note that this change is intended to introduce a safe default behavior in the case that the Exception
generated by the remote call is allowed to make its way up to the server runtime. It is considered a good practice, though, to catch the Exception and treat it in some appropriate manner:

@GET
@Path("remote/{i}")
public String remote(@PathParam("i") String i) throws Exception {
    Client client = ClientBuilder.newClient();
    try {
        return client.target("http://remote.com/exception/" + i).request().get(String.class);
    } catch (WebApplicationException wae) {
        ...
    }
}

Note. While RESTEasy will default to the new, safer behavior, the original behavior can be restored by setting the configuration parameter "resteasy.original.webapplicationexception.behavior" to "true".

30.4. Overriding RESTEasy Builtin Exceptions

RESTEasy built-in exceptions can be overridden by writing an ExceptionMapper for the exception. You can write an ExceptionMapper for any thrown exception including WebApplicationException
Chapter 31. Content encoding

31.1. GZIP Compression/Decompression

RESTEasy supports (though not by default - see below) GZIP decompression. If properly configured, the client framework or a Jakarta RESTful Web Services service, upon receiving a message body with a Content-Encoding of "gzip", will automatically decompress it. The client framework can (though not by default - see below) automatically set the Accept-Encoding header to be "gzip, deflate" so you do not have to set this header yourself.

RESTEasy also supports (though not by default - see below) automatic compression. If the client framework is sending a request or the server is sending a response with the Content-Encoding header set to "gzip", RESTEasy will (if properly configured) do the compression. So that you do not have to set the Content-Encoding header directly, you can use the @org.jboss.resteasy.annotation.GZIP annotation.

```java
@Path("/")
public interface MyProxy {

    @Consumes("application/xml")
    @PUT
    public void put(@GZIP Order order);
}
```

In the above example, we tag the outgoing message body, order, to be gzip compressed. The same annotation can be used to tag server responses

```java
@Path("/")
public class MyService {

    @GET
    @Produces("application/xml")
    @GZIP
    public String getData() {
        ...
    }
}
```

31.1.1. Configuring GZIP compression / decompression

Note. Decompression carries a risk of attack from a bad actor that can package an entity that will expand greatly. Consequently, RESTEasy disables GZIP compression / decompression by default.

There are three interceptors that are relevant to GZIP compression / decompression:
1. org.jboss.resteasy.plugins.interceptors.GZIPDecodingInterceptor: If the Content-Encoding header is present and has the value "gzip", GZIPDecodingInterceptor will install an InputStream that decompresses the message body.

2. org.jboss.resteasy.plugins.interceptors.GZIPEncodingInterceptor: If the Content-Encoding header is present and has the value "gzip", GZIPEncodingInterceptor will install an OutputStream that compresses the message body.

3. org.jboss.resteasy.plugins.interceptors.AcceptEncodingGZIPFilter: If the Accept-Encoding header does not exist, AcceptEncodingGZIPFilter will add Accept-Encoding with the value "gzip, deflate". If the Accept-Encoding header exists but does not contain "gzip", AcceptEncodingGZIPFilter will append ", gzip". Note that enabling GZIP compression/decompression does not depend on the presence of this interceptor.

If GZIP decompression is enabled, an upper limit is imposed on the number of bytes GZIPDecodingInterceptor will extract from a compressed message body. The default limit is 10,000,000, but a different value can be configured. See below.

### 31.1.1.1. Server side configuration

The interceptors may be enabled by including their classnames in a META-INF/services/jakarta.ws.rs.ext.Providers file on the classpath. The upper limit on deflated files may be configured by setting the parameter "resteasy.gzip.max.input". [See Section 3.4, “Configuration” for more information about application configuration.] If the limit is exceeded on the server side, GZIPDecodingInterceptor will return a Response with status 413 ("Request Entity Too Large") and a message specifying the upper limit.

**Note.** As of release 3.1.0.Final, the GZIP interceptors have moved from package org.jboss.resteasy.plugins.interceptors.encoding to org.jboss.resteasy.plugins.interceptors. and they should be named accordingly in jakarta.ws.rs.ext.Providers.

### 31.1.1.2. Client side configuration

The interceptors may be enabled by registering them with a Client or WebTarget. For example,

```java
Client client = ClientBuilder.newBuilder() // Activate gzip compression on client:
    .register(AcceptEncodingGZIPFilter.class)
    .register(GZIPDecodingInterceptor.class)
    .register(GZIPEncodingInterceptor.class)
    .build();
```

The upper limit on deflated files may be configured by creating an instance of GZIPDecodingInterceptor with a specific value:
If the limit is exceeded on the client side, GZIPDecodingInterceptor will throw a `ProcessingException` with a message specifying the upper limit.

### 31.2. General content encoding

The designation of a compressible entity by the use of the `@GZIP` annotation is a built-in, specific instance of a more general facility supported by RESTEasy. There are three components to this facility.

1. The annotation `org.jboss.resteasy.annotations.ContentEncoding` is a "meta-annotation" used on other annotations to indicate that they represent a Content-Encoding. For example, `@GZIP` is defined

   ```java
   @Target({ElementType.TYPE, ElementType.METHOD, ElementType.PARAMETER})
   @Retention(RetentionPolicy.RUNTIME)
   @ContentEncoding("gzip")
   public @interface GZIP {
   }
   
   The value of `@ContentEncoding` indicates the represented Content-Encoding. For `@GZIP` it is "gzip".

2. `ClientContentEncodingAnnotationFeature` and `ServerContentEncodingAnnotationFeature`, two DynamicFeatures in package `org.jboss.resteasy.plugins.interceptors`, examine resource methods for annotations decorated with `@ContentEncoding`.

3. For each value found in a `@ContentEncoding` decorated annotation on a resource method, an instance of `ClientContentEncodingAnnotationFilter` or `ServerContentEncodingAnnotationFilter`, `jakarta.ws.rs.ext.WriterInterceptor` in package `org.jboss.resteasy.plugins.interceptors`, is registered. They are responsible for adding an appropriate Content-Encoding header. For example, `ClientContentEncodingAnnotationFilter` is defined

   ```java
   @ConstrainedTo(RuntimeType.CLIENT)
   @Priority(Priorities.HEADER_DECORATOR)
   public class ClientContentEncodingAnnotationFilter implements WriterInterceptor {
   ```
protected String encoding;

    public ClientContentEncodingAnnotationFilter(String encoding)
    {
        this.encoding = encoding;
    }

    @Override
    public void aroundWriteTo(WriterInterceptorContext context) throws IOException,
    WebApplicationException
    {
        context.getHeaders().putSingle(HttpHeaders.CONTENT_ENCODING, encoding);
        context.proceed();
    }
}

When it is created, ClientContentEncodingAnnotationFeature passes in the value to be used for Content-Encoding headers.

The annotation @GZIP is built into RESTEasy, but ClientContentEncodingAnnotationFeature and ServerContentEncodingAnnotationFeature will also recognize application defined annotations. For example,

    @Target({ElementType.TYPE, ElementType.METHOD, ElementType.PARAMETER})
    @Retention(RetentionPolicy.RUNTIME)
    @ContentEncoding("compress")
    public @interface Compress
    {
    }

    @Path(""
    public static class TestResource {

        @GET
        @Path("a")
        @Compress
        public String a() {
            return "a";
        }
    }

    If TestResource.a() is invoked as follows

    @Test
    public void testCompress() throws Exception
    {
        Client client = ClientBuilder.newClient();
        Invocation.Builder request = client.target("http://localhost:8081/a").request();
        request.acceptEncoding("gzip,compress");
    }
Response response = request.get();
System.out.println("content-encoding: " + response.getHeaderString("Content-Encoding"));
client.close();
}

the output will be

ccontent-encoding: compress
Chapter 32. CORS

RESTEasy has a ContainerRequestFilter that can be used to handle CORS preflight and actual requests. org.jboss.resteasy.plugins.interceptors.CorsFilter. You must allocate this and register it as a singleton provider from your Application class. See the javadoc or its various settings.

```java
CorsFilter filter = new CorsFilter();
filter.getAllowedOrigins().add("http://localhost");
```
Chapter 33. Content-Range Support

RESTEasy supports Range requests for java.io.File response entities.

```java
@Path("/")
public class Resource {
    @GET
    @Path("file")
    @Produces("text/plain")
    public File getFile()
    {
        return file;
    }
}

Response response = client.target(generateURL("/file")).request()
    .header("Range", "1-4").get();
Assert.assertEquals(response.getStatus(), 206);
Assert.assertEquals(4, response.getLength());
System.out.println("Content-Range: " + response.getHeaderString("Content-Range"));
```
Chapter 34. RESTEasy Caching

Features

RESTEasy provides numerous annotations and facilities to support HTTP caching semantics. Annotations to make setting Cache-Control headers easier and both server-side and client-side in-memory caches are available.

34.1. @Cache and @NoCache Annotations

RESTEasy provides an extension to Jakarta RESTful Web Services that allows you to automatically set Cache-Control headers on a successful GET request. It can only be used on @GET annotated methods. A successful @GET request is any request that returns 200 OK response.

```java
package org.jboss.resteasy.annotations.cache;

public @interface Cache {
    int maxAge() default -1;
    int sMaxAge() default -1;
    boolean noStore() default false;
    boolean noTransform() default false;
    boolean mustRevalidate() default false;
    boolean proxyRevalidate() default false;
    boolean isPrivate() default false;
}

public @interface NoCache {
    String[] fields() default {};
}
```

While @Cache builds a complex Cache-Control header, @NoCache is a simplified notation to indicate no caching is wanted; i.e. Cache-Control: nocache.

These annotations can be put on the resource class or interface and specifies a default cache value for each @GET resource method, or they can be put individually on each @GET resource method.

34.2. Client "Browser" Cache

RESTEasy has the ability to set up a client-side, browser-like, cache. It can be used with the Client Proxy Framework, or with ordinary requests. This cache looks for Cache-Control headers sent back with a server response. If the Cache-Control headers specify that the client is allowed
to cache the response, Resteasy caches it within local memory. The cache obeys max-age requirements and will also automatically do HTTP 1.1 cache revalidation if either or both the Last-Modified and/or ETag headers are sent back with the original response. See the HTTP 1.1 specification for details on how Cache-Control or cache revalidation works.

It is very simple to enable caching. Here's an example of using the client cache with the Client Proxy Framework

```java
@Path("/orders")
public interface OrderServiceClient {

    @Path("/{id}")
    @GET
    @Produces("application/xml")
    public Order getOrder(@PathParam("id") String id);
}
```

To create a proxy for this interface and enable caching for that proxy requires only a few simple steps in which the `BrowserCacheFeature` is registered:

```java
ResteasyWebTarget target = (ResteasyWebTarget) ClientBuilder.newClient().target("http://localhost:8081");
BrowserCacheFeature cacheFeature = new BrowserCacheFeature();
OrderServiceClient orderService = target.register(cacheFeature).proxy(OrderServiceClient.class);
```

`BrowserCacheFeature` will create a Resteasy LightweightBrowserCache by default. It is also possible to configure the cache, or install a completely different cache implementation:

```java
ResteasyWebTarget target = (ResteasyWebTarget) ClientBuilder.newClient().target("http://localhost:8081");
LightweightBrowserCache cache = new LightweightBrowserCache();
cache.setMaxBytes(20);
BrowserCacheFeature cacheFeature = new BrowserCacheFeature();
cacheFeature.setCache(cache);
OrderServiceClient orderService = target.register(cacheFeature).proxy(OrderServiceClient.class);
```

If using the standard Jakarta RESTful Web Services client framework to make invocations rather than the proxy framework, it is just as easy:

```java
ResteasyWebTarget target = (ResteasyWebTarget) ClientBuilder.newClient().target("http://localhost:8081/orders/{id}");
```
RESTEasy Caching Features

```java
BrowserCacheFeature cacheFeature = new BrowserCacheFeature();
target.register(cacheFeature);
String rtn = target.resolveTemplate("id", "1").request().get(String.class);
```

The LightweightBrowserCache, by default, has a maximum 2 megabytes of caching space. This can be changed programmatically by calling its setMaxBytes() method. If the cache gets full, the cache completely wipes itself of all cached data. This may seem a bit draconian, but the cache was written to avoid unnecessary synchronizations in a concurrent environment where the cache is shared between multiple threads. If a more complex caching solution is desired or a third party cache is to be plugged in please contact our resteasy-developers list and discuss it with the community.

### 34.3. Local Server-Side Response Cache

RESTEasy has a server-side cache that can sit in front of Jakarta RESTful Web Services services. It automatically caches marshalled responses from HTTP GET Jakarta RESTful Web Services invocations if, and only if the Jakarta RESTful Web Services resource method sets a Cache-Control header. When a GET comes in, the RESTEasy Server Cache checks to see if the URI is stored in the cache. If found, it returns the already marshalled response without invoking the Jakarta RESTful Web Services method. Each cache entry has a max age to whatever is specified in the Cache-Control header of the initial request. The cache also will automatically generate an ETag using an MD5 hash on the response body. This allows the client to do HTTP 1.1 cache revalidation with the IF-NONE-MATCH header. The cache is also smart enough to perform revalidation if there is no initial cache hit, but the Jakarta RESTful Web Services method still returns a body that has the same ETag.

The cache is also automatically invalidated for a particular URI that has PUT, POST, or DELETE invoked on it. A reference to the cache can be obtained by injecting an org.jboss.resteasy.plugins.cache.ServerCache via the @Context annotation

```java
@Context
ServerCache cache;

@GET
public String get(@Context ServerCache cache) {...}
```

To set up the server-side cache an instance of org.jboss.resteasy.plugins.cache.server.ServerCacheFeature must be registered via the Application's getSingletons() or getClasses() methods. The underlying cache is Infinispan. By default, RESTEasy will create an Infinispan cache for you. Alternatively, you can create and pass in an instance of your cache to the ServerCacheFeature constructor. Infinispan can also be configured by specifying various parameters. If using Maven, add RESTEasy's cache-core artifact to the project:
<dependency>
  <groupId>org.jboss.resteasy.cache</groupId>
  <artifactId>cache-core</artifactId>
  <version>${version.org.jboss.resteasy.cache}</version>
</dependency>

Next set up the Infinispan configuration in the application's web.xml, it would look like

<web-app>
  <context-param>
    <param-name>server.request.cache.infinispan.config.file</param-name>
    <param-value>infinispan.xml</param-value>
  </context-param>
  <context-param>
    <param-name>server.request.cache.infinispan.cache.name</param-name>
    <param-value>MyCache</param-value>
  </context-param>
</web-app>

server.request.cache.infinispan.config.file can either be a classpath or a file path. server.request.cache.infinispan.cache.name is the name of the cache to reference that is declared in the config file.

See Section 3.4, “Configuration” for more information about application configuration.

34.4. HTTP preconditions

Jakarta RESTful Web Services provides an API for evaluating HTTP preconditions based on "If-Match", "If-None-Match", "If-Modified-Since" and "If-Unmodified-Since" headers.

```java
Response.ResponseBuilder rb = request.evaluatePreconditions(lastModified, etag);
```

By default RESTEasy will return status code 304 (Not modified) or 412 (Precondition failed) if any of conditions fails, however it is not compliant with RFC 7232 which states that headers "If-Match", "If-None-Match" MUST have higher precedence. RFC 7232 compatible mode can be enabled by setting the parameter resteasy.rfc7232preconditions to true. See Section 3.4, “Configuration” for more information about application configuration.
Chapter 35. Filters and Interceptors

Jakarta RESTful Web Services has two different concepts for interceptions: Filters and Interceptors. Filters are mainly used to modify or process incoming and outgoing request headers or response headers. They execute before and after request and response processing.

35.1. Server Side Filters

On the server-side there are two different types of filters. ContainerRequestFilters run before a Jakarta RESTful Web Services resource method is invoked. ContainerResponseFilters run after a Jakarta RESTful Web Services resource method is invoked. As an added caveat, ContainerRequestFilters come in two flavors: pre-match and post-matching. Pre-matching ContainerRequestFilters are designated with the @PreMatching annotation and will execute before the Jakarta RESTful Web Services resource method is matched with the incoming HTTP request. Pre-matching filters often are used to modify request attributes to change how it matches to a specific resource method (i.e. strip .xml and add an Accept header). ContainerRequestFilters can abort the request by calling ContainerRequestContext.abortWith(Response). A filter might want to abort if it implements a custom authentication protocol.

After the resource class method is executed, Jakarta RESTful Web Services will run all ContainerResponseFilters. These filters allow the outgoing response to be modified before it is marshalling and sent to the client. Here is some pseudocode to give some understanding of how it works.

```java
// execute pre match filters
for (ContainerRequestFilter filter : preMatchFilters) {
    filter.filter(requestContext);
    if (isAborted(requestContext)) {
        sendAbortionToClient(requestContext);
        return;
    }
}

// match the HTTP request to a resource class and method
JaxrsMethod method = matchMethod(requestContext);

// Execute post match filters
for (ContainerRequestFilter filter : postMatchFilters) {
    filter.filter(requestContext);
    if (isAborted(requestContext)) {
        sendAbortionToClient(requestContext);
        return;
    }
}

// execute resource class method
method.execute(request);

// execute response filters
for (ContainerResponseFilter filter : responseFilters) {
    filter.filter(requestContext, responseContext);
}
```
35.1.1. Asynchronous filters

It is possible to turn filters into asynchronous filters, if it is needed to suspend execution of the filter until a certain resource has become available. This makes the request asynchronous, but requires no change to the resource method declaration. In particular, synchronous and asynchronous resource methods continue to work as specified, regardless of whether a filter has made the request asynchronous. Similarly, one filter making the request asynchronous requires no change in the declaration of other filters.

In order to make a filter's execution asynchronous, ContainerRequestContext must be cast to a SuspendableContainerRequestContext (for pre/post request filters), or cast the ContainerResponseContext to a SuspendableContainerResponseContext (for response filters).

These context objects can make the current filter's execution asynchronous by calling the suspend() method. Once asynchronous, the filter chain is suspended, and will only resume after one of the following methods is called on the context object:

- **abortWith(Response)**
  Terminate the filter chain, return the given Response to the client (only for ContainerRequestFilter).

- **resume()**
  Resume execution of the filter chain by calling the next filter.

- **resume(Throwable)**
  Abort execution of the filter chain by throwing the given exception. This behaves as if the filter were synchronous and threw the given exception.

Async processing can be done inside an AsyncWriterInterceptor (if using Async IO), which is the asynchronous-supporting equivalent to WriterInterceptor. In this case, there is no need to manually suspend or resume the request.

### 35.2. Client Side Filters

The client side also has two types of filters: ClientRequestFilter and ClientResponseFilter. ClientRequestFilters run before an HTTP request is sent over the wire to the server. ClientResponseFilters run after a response is received from the server, but before the response body is unmarshalled. ClientRequestFilters are allowed to abort the execution of the request and provide a canned response without going over the wire to the server. ClientResponseFilters can modify the Response object before it is handed back to application code. Here's pseudocode to illustrate this.
for (ClientRequestFilter filter : requestFilters) {
    filter.filter(requestContext);
    if (isAborted(requestContext)) {
        return requestContext.getAbortedResponseObject();
    }
}

// send request over the wire
response = sendRequest(request);

// execute response filters
for (ClientResponseFilter filter : responseFilters) {
    filter.filter(requestContext, responseContext);
}

35.3. Reader and Writer Interceptors

While filters modify request or response headers, interceptors deal with message bodies. Interceptors are executed in the same call stack as their corresponding reader or writer. ReaderInterceptors wrap around the execution of MessageBodyReaders. WriterInterceptors wrap around the execution of MessageBodyWriters. They can be used to implement a specific content-encoding. They can be used to generate digital signatures or to post or pre-process a Java object model before or after it is marshalled.

Note that in order to support Async IO, AsyncWriterInterceptor can be implemented, which is a subtype of WriterInterceptor.

35.4. Per Resource Method Filters and Interceptors

Sometimes it is desired to have a filter or interceptor only run for a specific resource method. This can be done in two different ways: register an implementation of DynamicFeature or use the @NameBinding annotation. The DynamicFeature interface is executed at deployment time for each resource method. Use the Configurable interface to register the filters and interceptors wanted for the specific resource method. @NameBinding works a lot like CDI interceptors. Annotate a custom annotation with @NameBinding and then apply that custom annotation to the filter and resource method. The custom annotation must use @Retention(RetentionPolicy.RUNTIME) in order for the attribute to be picked up by the RESTEasy runtime when it is deployed.

```java
@NameBinding
@Retention(RetentionPolicy.RUNTIME)
public @interface DoIt {}

@DoIt
public class MyFilter implements ContainerRequestFilter {...}

@Path("/root")
public class MyResource {
```
35.5. Ordering

Ordering is accomplished by using the @BindingPriority annotation on the filter or interceptor classes.
Chapter 36. Asynchronous HTTP Request Processing

Asynchronous HTTP Request Processing is a relatively new technique that allows the processing of a single HTTP request using non-blocking I/O and, if desired in separate threads. Some refer to it as COMET capabilities. The primary use case for Asynchronous HTTP is in the case where the client is polling the server for a delayed response. The usual example is an AJAX chat client where you want to push/pull from both the client and the server. These scenarios have the client blocking a long time on the server’s socket waiting for a new message. In synchronous HTTP where the server is blocking on incoming and outgoing I/O is that you have a thread consumed per client connection. This eats up memory and valuable thread resources. Not such a big deal in 90% of applications (in fact using asynchronous processing may actually hurt performance in most common scenarios), but when there are a lot of concurrent clients that are blocking like this, there is a lot of wasted resources and the server does not scale that well.

36.1. Using the @Suspended annotation

The Jakarta RESTful Web Services specification includes asynchronous HTTP support via two classes. The @Suspended annotation, and AsyncResponse interface.

Injecting an AsyncResponse as a parameter to a Jakarta RESTful Web Services methods tells RESTEasy that the HTTP request/response should be detached from the currently executing thread and that the current thread should not try to automatically process the response.

The AsyncResponse is the callback object. The act of calling one of the resume() methods will cause a response to be sent back to the client and will also terminate the HTTP request. Here is an example of asynchronous processing:

```java
import jakarta.ws.rs.Suspend;
import jakarta.ws.rs.container.AsyncResponse;

@Path("/")
public class SimpleResource {

    @GET
    @Path("basic")
    @Produces("text/plain")
    public void getBasic(@Suspended final AsyncResponse response) throws Exception {
        Thread t = new Thread()
        {
            @Override
            public void run()
            {
                try
```
Asynchronous HTTP
Request Processing

```java
{
    Response jaxrs = Response.ok("basic").type(MediaType.TEXT_PLAIN).build();
    response.resume(jaxrs);
}
```
catch (Exception e)
{
    response.resume(e);
}
};
t.start();
}
}

AsyncResponse also has other methods to cancel the execution. See javadoc for more details.

**NOTE:** In RESTEasy version 4.0.0.Final proprietary annotation
org.jboss.resteasy.annotations.Suspend was removed and replaced by
jakarta.ws.rs.container.Suspended and class
org.jboss.resteasy.spi.AsynchronousResponse was removed and replaced by
jakarta.ws.rs.container.AsyncResponse.

jakarta.ws.rs.container.Suspended replaces javax.ws.rs.container.Suspended. Note
that @Suspended does not have a value field, which represented a timeout limit. Instead,
AsyncResponse.setTimeout() may be called.

### 36.2. Using Reactive return types

The Jakarta RESTful Web Services 2.1 specification adds support for declaring asynchronous
resource methods by returning a `CompletionStage` instead of using the `@Suspended` annotation.

Whenever a resource method returns a `CompletionStage`, it will be subscribed to, the request
will be suspended, and only resumed when the `CompletionStage` is resolved either to a value
(which is then treated as the return value for the method), or as an error case, in which case the
exception will be processed as if it were thrown by the resource method.

Here is an example of asynchronous processing using `CompletionStage`:

```java
import jakarta.ws.rs.Suspend;
import jakarta.ws.rs.container.AsyncResponse;

@Path("/")
public class SimpleResource
{
    @GET
    @Path("basic")
    @Produces("text/plain")
    public CompletionStage<Response> getBasic() throws Exception
Asynchronous HTTP Request Processing

```java
    final CompletableFuture<Response> response = new CompletableFuture<>();
    Thread t = new Thread()
    {
        @Override
        public void run()
        {
            try
            {
                Response jaxrs = Response.ok("basic").type(MediaType.TEXT_PLAIN).build();
                response.complete(jaxrs);
            }
            catch (Exception e)
            {
                response.completeExceptionally(e);
            }
        }
    }
    t.start();
    return response;
```

Note
RESTEasy supports more reactive types for asynchronous programming.

36.3. Asynchronous filters

It is possible to write filters that also make the request asynchronous. Whether filters make the request asynchronous before execution of a method makes absolutely no difference to a method: it does not need to be declared asynchronous in order to function as specified. Synchronous methods and asynchronous methods will work as specified by the spec.

36.4. Asynchronous IO

Some backends support asynchronous IO operations (Servlet, Undertow, Vert.x, Quarkus, Netty), which are exposed using the AsyncOutputStream subtype of OutputStream. It includes async variants for writing and flushing the stream.

Some backends have what is called an "Event Loop Thread", which is a thread responsible for doing all IO operations. Those backends require the Event Loop Thread to never be blocked, because it does IO for every other thread. Those backends typically require Jakarta RESTful Web Services endpoints to be invoked on worker threads, to make sure they never block the Event Loop Thread.

Sometimes, with Async programming, it is possible for asynchronous Jakarta RESTful Web Services requests to be resumed from the Event Loop Thread. As a result, Jakarta RESTful Web Ser-
Asynchronous HTTP
Request Processing

Services will attempt to serialise the response and send it to the client. But Jakarta RESTful Web Services is written using “Blocking IO” mechanics, such as OutputStream (used by MessageBodyWriter and WriterInterceptor), which means that sending the response will block the current thread until the response is received. This would work on a worker thread, but if it happens on the Event Loop Thread it will block it and prevent it from sending the response, resulting in a deadlock.

As a result, we’ve decided to support and expose Async IO interfaces in the form of AsyncOutputStream, AsyncMessageBodyWriter and AsyncWriterInterceptor, to allow users to write Async IO applications in RESTEasy.

Most built-in MessageBodyWriter and WriterInterceptor support Async IO, with the notable exceptions of:

- HtmlRenderableWriter, which is tied to servlet APIs
- ReaderProvider
- StreamingOutputProvider: use AsyncStreamingOutput instead

Async IO will be preferred if the following conditions are met:

- The backend supports it
- The writer supports it
- All writer interceptors support it

If those conditions are not met, and you attempt to use Blocking IO on an Event Loop Thread (as determined by the backend), then an exception will be thrown.
Chapter 37. Asynchronous Job Service

The RESTEasy Asynchronous Job Service is an implementation of the Asynchronous Job pattern defined in O'Reilly's "Restful Web Services" book. The idea of it is to bring asynchronicity to a synchronous protocol.

37.1. Using Async Jobs

While HTTP is a synchronous protocol it does have a faint idea of asynchronous invocations. The HTTP 1.1 response code 202, "Accepted" means that the server has received and accepted the response for processing, but the processing has not yet been completed. The RESTEasy Asynchronous Job Service builds around this idea.

POST http://example.com/myservice?asynch=true

For example, if making the above post with the asynch query parameter set to true, RESTEasy will return a 202, "Accepted" response code and run the invocation in the background. It also sends back a Location header with a URL pointing to where the response of the background method is located.

HTTP/1.1 202 Accepted
Location: http://example.com/async/jobs/3332334

The URI will have the form of:

/asynch/jobs/{job-id}?wait={milliseconds}|nowait=true

You can perform the GET, POST, and DELETE operations on this job URL. GET returns whatever the Jakarta RESTful Web Services resource method invoked returns as a response if the job was completed. If the job has not completed, this GET will return a response code of 202, Accepted. Invoking GET does not remove the job, so it can be called multiple times. When RESTEasy's job queue gets full, it will evict the least recently used job from memory. Manual clean up can be performed by calling DELETE on the URI. POST does a read of the JOB response and will remove the JOB it has completed.
Both GET and POST allow the specification of a maximum wait time in milliseconds, a "wait" query parameter. Here's an example:

```
POST http://example.com/asynch/jobs/122?wait=3000
```

If a "wait" parameter is not specified, the GET or POST will not wait if the job is not complete.

NOTE!! While GET, DELETE, and PUT methods can be invoked asynchronously, this breaks the HTTP 1.1 contract of these methods. While these invocations may not change the state of the resource if invoked more than once, they do change the state of the server as new Job entries with each invocation. To be a purist, stick with only invoking POST methods asynchronously.

Security NOTE! RESTEasy's role-based security (annotations) does not work with the Asynchronous Job Service. XML declarative security must be used within the web.xml file, because it is impossible to implement role-based security in a portable way.

NOTE. A `java.security.SecureRandom` object is used to generate unique job ids. For security purposes, the `SecureRandom` is periodically reseeded. By default, it is reseeded after 100 uses. This value may be configured with the servlet init parameter "resteasy.secure.random.max.use".

### 37.2. Oneway: Fire and Forget

RESTEasy also supports the notion of fire and forget. This will also return a 202, Accepted response, but no Job will be created. This is as simple as using the oneway query parameter instead of asynch. For example:

```
POST http://example.com/myservice?oneway=true
```

Security NOTE! RESTEasy role-based security (annotations) does not work with the Asynchronous Job Service. XML declaritive security must be use within the web.xml file, because it is impossible to implement role-based security in a portable way.

### 37.3. Setup and Configuration

The Asynchronous Job Service must be enabled, as it is not turned on by default. If the relevant configuration properties are configured in web.xml, it would look like the following:

```
<web-app>
    <!-- enable the Asynchronous Job Service -->
    <context-param>
        <param-name>resteasy.async.job.service.enabled</param-name>
    </context-param>
</web-app>
```
Asynchronous Job Service

See Section 3.4, “Configuration” for more information about application configuration.
Chapter 38. Asynchronous Injection

Pluggable Asynchronous Injection, also referred to as Asynch Injection, is a feature that allows users to create custom injectable asynchronous types. For example, it is possible to declare an injector for `Single<Foo>` and inject it into an endpoint as a class variable or as a method parameter using `@Context Foo`. The response will be made asynchronous automatically and the resource method will only be invoked once the `Single<Foo>` object is resolved to `Foo`. Resolution is done in a non-blocking manner.

**Note.** Asynch injection is only attempted at points where asynchronous injection is permitted, such as on resource creation and resource method invocation. It is not enabled at points where the API does not allow for suspending the request, for example on `ResourceContext.getResource(Foo.class)`.

38.1. org.jboss.resteasy.spi.ContextInjector Interface

The `org.jboss.resteasy.spi.ContextInjector` interface must be implemented on any custom asynch injector object. The implementation class must be tagged with the `@Provider` annotation.

```java
/**
 * @param <WrappedType> A class that wraps a data type or data object
 *                       (e.g. Single<Foo>)
 * @param <UnwrappedType> The data type or data object declared in the
 *                        WrappedType (e.g. Foo)
 */
public interface ContextInjector<WrappedType, UnwrappedType> {

/**
 * This interface allows users to create custom injectable asynchronous types.
 * Asynch injection is only attempted at points where asynchronous injection is
 * permitted, such as on resource creation and resource method invocation. It
 * is not enabled at points where the API does not allow for suspending the
 * request
 * @param rawType
 * @param genericType
 * @param annotations The annotation list is useful to parametrize the injection.
 * @return
 */
public WrappedType resolve(
    Class<? extends WrappedType> rawType,
    Type genericType,
    Annotation[] annotations);
}
```
38.2. Single<Foo> Example

```java
package my.test;

public class Foo {
    private String value = "PRE-SET-VALUE";

    public void setValue(String s) {
        this.value = s;
    }

    public String getValue() {
        return this.value;
    }
}
```

```java
package my.test.asyc.resources;

import io.reactivex.Single;
import jakarta.ws.rs.ext.Provider;
import org.jboss.resteasy.spi.ContextInjector;
import my.test.Foo;

@Provider
public class FooAsychInjectorProvider implements ContextInjector<Single<Foo>, Foo> {
    public Single<Foo> resolve(Class<? extends Single<Foo>> rawType, Type genericType, Annotation[] annotations) {
        Foo value = new Foo();
        return Single.just(value.setValue("made it"));
    }
}
```

38.3. Async Injector With Annotations Example

A convenience interface to provide annotation parameter designators

```java
@Retention(RUNTIME)
@Target({ FIELD, METHOD, PARAMETER })
public @interface AsyncInjectionPrimitiveInjectorSpecifier {
    public enum Type {
        VALUE, NULL, NO_RESULT;
    }
```

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@Provider
public class AsyncInjectionFloatInjector implements ContextInjector<CompletionStage<Float>, Float> {

    @Override
    public CompletionStage<Float> resolve(Class<? extends CompletionStage<Float>> rawType, Type genericType, Annotation[] annotations) {
        for (Annotation annotation : annotations) {
            if (annotation.annotationType() == AsyncInjectionPrimitiveInjectorSpecifier.class) {
                AsyncInjectionPrimitiveInjectorSpecifier.Type value = ((AsyncInjectionPrimitiveInjectorSpecifier) annotation).value();
                switch (value) {
                    case NO_RESULT:
                        return null;
                    case NULL:
                        return CompletableFuture.completedFuture(null);
                    case VALUE:
                        return CompletableFuture.completedFuture(4.2f);
                }
            }
            break;
        }
        return CompletableFuture.completedFuture(4.2f);
    }
}

Type value() default Type.VALUE;
Chapter 39. Reactive programming support

With version 2.1, the Jakarta RESTful Web Services specification (https://jcp.org/en/jsr/detail?id=370) takes its first steps into the world of Reactive Programming. There are many discussions of reactive programming on the internet, and a general introduction is beyond the scope of this document, but there are a few things worth discussing. Some primary aspects of reactive programming are the following:

- Reactive programming supports the declarative creation of rich computational structures. The representations of these structures can be passed around as first class objects such as method parameters and return values.

- Reactive programming supports both synchronous and asynchronous computation, but it is particularly helpful in facilitating, at a relatively high level of expression, asynchronous computation. Conceptually, asynchronous computation in reactive program typically involves pushing data from one entity to another, rather than polling for data.

39.1. CompletionStage

In Java 1.8 and Jakarta RESTful Web Services, the support for reactive programming is fairly limited. Java 1.8 introduces the interface java.util.concurrent.CompletionStage, and Jakarta RESTful Web Services mandates support for the jakarta.ws.rs.client.CompletionStageRxInvoker, which allows a client to obtain a response in the form of a CompletionStage.

One implementation of CompletionStage is the java.util.concurrent.CompletableFuture. For example:

```java
@Test
public void testCompletionStage() throws Exception {
    CompletionStage<String> stage = getCompletionStage();
    log.info("result: " + stage.toCompletableFuture().get());
}

private CompletionStage<String> getCompletionStage() {
    CompletableFuture<String> future = new CompletableFuture<String>();
    future.complete("foo");
    return future;
}
```

Here, a CompletableFuture is created with the value "foo", and its value is extracted by the method CompletableFuture.get(). That's fine, but consider the altered version:
Reactive programming support

```java
import java.util.concurrent.CompletableFuture;

public class TestCompletionStageAsync {
    @Test
    public void testCompletionStageAsync() throws Exception {
        log.info("start");
        CompletionStage<String> stage = getCompletionStageAsync();
        String result = stage.toCompletableFuture().get();
        log.info("do some work");
        log.info("result: " + result);
    }

    private CompletionStage<String> getCompletionStageAsync() {
        CompletableFuture<String> future = new CompletableFuture<String>();
        Executors.newCachedThreadPool().submit(() -> {sleep(2000); future.complete("foo");});
        return future;
    }

    private void sleep(long l) {
        try {
            Thread.sleep(l);
        } catch (InterruptedException e) {
            e.printStackTrace();
        }
    }
}
```

with output something like:

```
3:10:51 PM INFO: start
3:10:53 PM INFO: do some work
3:10:53 PM INFO: result: foo
```

It also works, but it illustrates the fact that `CompletableFuture.get()` is a blocking call. The `CompletionStage` is constructed and returned immediately, but the value isn't returned for two seconds. A version that is more in the spirit of the reactive style is:

```java
import java.util.concurrent.CompletableFuture;

public class TestCompletionStageAsyncAccept {
    @Test
    public void testCompletionStageAsyncAccept() throws Exception {
        log.info("start");
        CompletionStage<String> stage = getCompletionStageAsync();
        stage.thenAccept((String s) -> log.info("s: " + s));
        log.info("do some work");
        ...
    }

    private CompletionStage<String> getCompletionStageAsync() {
        CompletableFuture<String> future = new CompletableFuture<String>();
        Executors.newCachedThreadPool().submit(() -> {sleep(2000); future.complete("foo");});
        return future;
    }

    private void sleep(long l) {
        try {
            Thread.sleep(l);
        } catch (InterruptedException e) {
            e.printStackTrace();
        }
    }
}
```

In this case, the lambda `(String s) -> log.info("s: " + s)` is registered with the `CompletionStage` as a "subscriber", and, when the `CompletionStage` eventually has a value, that value is passed to the lambda. Note that the output is something like
Executing `CompletionStage`s asynchronously is so common that there are several supporting convenience methods. For example:

```java
public void testCompletionStageSupplyAsync() throws Exception {
    CompletionStage<String> stage = getCompletionStageSupplyAsync();
    stage.thenAccept((String s) -> log.info("s: " + s));
}
```

```java
private CompletionStage<String> getCompletionStageSupplyAsync() {
    return CompletableFuture.supplyAsync(() -> "foo");
}
```

The static method `ComputableFuture.supplyAsync()` creates a `ComputableFuture`, the value of which is supplied asynchronously by the lambda `() -> "foo"`, running, by default, in the default pool of `java.util.concurrent.ForkJoinPool`.

One final example illustrates a more complex computational structure:

```java
public void testCompletionStageComplex() throws Exception {
    ExecutorService executor = Executors.newCachedThreadPool();
    CompletionStage<String> stage1 = getCompletionStageSupplyAsync1("foo", executor);
    CompletionStage<String> stage2 = getCompletionStageSupplyAsync1("bar", executor);
    CompletionStage<String> stage3 = stage1.thenCombineAsync(stage2, (String s, String t) -> s + t, executor);
    stage3.thenAccept((String s) -> log.info("s: " + s));
}
```

```java
private CompletionStage<String> getCompletionStageSupplyAsync1(String s, ExecutorService executor) {
    return CompletableFuture.supplyAsync(() -> s, executor);
}
```

Stage 1 returns "foo", stage 2 returns "bar", and stage 3, which runs when both stage 1 and stage 2 have completed, returns the concatenation of "foo" and "bar". Note that, in this example, an explicit `ExecutorService` is provided for asynchronous processing.
39.2. CompletionStage in Jakarta RESTful Web Services

On the client side, the Jakarta RESTful Web Services specification mandates an implementation of the interface `jakarta.ws.rs.client.CompletionStageRxInvoker`:

```java
public interface CompletionStageRxInvoker extends RxInvoker<CompletionStage> {
    @Override
    public CompletionStage<Response> get();
    @Override
    public <T> CompletionStage<T> get(Class<T> responseType);
    @Override
    public <T> CompletionStage<T> get(GenericType<T> responseType);
    ...
}
```

That is, there are invocation methods for the standard HTTP verbs, just as in the standard `jakarta.ws.rs.client.SyncInvoker`. A `CompletionStageRxInvoker` is obtained by calling `rx()` on a `jakarta.ws.rs.client.Invocation.Builder`, which extends `SyncInvoker`. For example,

```java
Invocation.Builder builder = client.target(generateURL("/get/string")).request();
CompletionStageRxInvoker invoker = builder.rx(CompletionStageRxInvoker.class);
CompletionStage<Response> stage = invoker.get();
Response response = stage.toCompletableFuture().get();
log.info("result: " + response.readEntity(String.class));
```

or

```java
CompletionStageRxInvoker invoker = client.target(generateURL("/get/string")).request().rx(CompletionStageRxInvoker.class);
CompletionStage<String> stage = invoker.get(String.class);
String s = stage.toCompletableFuture().get();
log.info("result: " + s);
```

On the server side, the Jakarta RESTful Web Services specification requires support for resource methods with return type `CompletionStage<T>`. For example,

```java
@GET
@Path("get/async")
```
Reactive programming support

```java
public CompletionStage<String> longRunningOpAsync() {
    CompletableFuture<String> cs = new CompletableFuture<>();
    executor.submit(
        new Runnable() {
            public void run() {
                executeLongRunningOp();
                cs.complete("Hello async world!");
            }
        });
    return cs;
}
```

The way to think about `longRunningOpAsync()` is that it is asynchronously creating and returning a `String`. After `cs.complete()` is called, the server will return the `String "Hello async world!"` to the client.

An important thing to understand is that the decision to produce a result asynchronously on the server and the decision to retrieve the result asynchronously on the client are independent. Suppose that there is also a resource method

```java
@GET
@Path("get-sync")
public String longRunningOpSync() {
    return "Hello async world!!"
}
```

Then all three of the following invocations are valid:

```java
public void testGetStringAsyncAsync() throws Exception {
    CompletionStageRxInvoker invoker = client.target(generateURL("/get/async")).request().rx();
    CompletionStage<String> stage = invoker.get(String.class);
    log.info("s: " + stage.toCompletableFuture().get());
}
```

```java
public void testGetStringSyncAsync() throws Exception {
    Builder request = client.target(generateURL("/get/async")).request();
    String s = request.get(String.class);
    log.info("s: " + s);
}
```

and

```java
public void testGetStringAsyncSync() throws Exception {
    // Code...
}
```
Reactive programming support

```java
CompletionStageRxInvoker invoker = client.target(generateURL("/get/sync")).request().rx();
CompletionStage<String> stage = invoker.get(String.class);
log.info("s: " + stage.toCompletableFuture().get());
}
```

**Note**
CompletionStage in Jakarta RESTful Web Services is also discussed in the chapter Asynchronous HTTP Request Processing.

**Note**
Since running code asynchronously is so common in this context, it is worth pointing out that objects obtained by way of the annotation `@Context` or by way of calling `ResteasyContext.getContextData()` are sensitive to the executing thread. For example, given resource method

```java
@GET
@Path("test")
@Produces("text/plain")
public CompletionStage<String> text(@Context HttpRequest request) {
    System.out.println("request (inline): " + request);
    System.out.println("application (inline): " + ResteasyContext.getContextData(Application.class));
    CompletableFuture<String> cs = new CompletableFuture<>();
    ExecutorService executor = Executors.newSingleThreadExecutor();
    executor.submit(
        new Runnable() {
            public void run() {
                try {
                    System.out.println("request (async): " + request);
                    System.out.println("application (async): " + ResteasyContext.getContextData(Application.class));
                    cs.complete("hello");
                } catch (Exception e) {
                    e.printStackTrace();
                }
            }
        });
    return cs;
}
```

the output will look something like

```
application (inline): org.jboss.resteasy.experiment.Test1798CompletionStage$TestApp@23c57474
```
Reactive programming support

The point is that it is the developer's responsibility to extract information from these context objects in advance. For example:

```java
@GET
@Path("test")
@Produces("text/plain")
public CompletionStage<String> text(@Context HttpRequest request) {
    System.out.println("request (inline): "+ request);
    System.out.println("application (inline): " + ResteasyContext.getContextData(Application.class));
    CompletableFuture<String> cs = new CompletableFuture<>();
    ExecutorService executor = Executors.newSingleThreadExecutor();
    final String httpMethodFinal = request.getHttpMethod();
    final Map<String, Object> mapFinal =
        ResteasyContext.getContextData(Application.class).getProperties();
    executor.submit( new Runnable() {
        public void run() {
            System.out.println("httpMethod (async): " + httpMethodFinal);
            System.out.println("map (async): " + mapFinal);
            cs.complete("hello");
        }
    });
    return cs;
}
```

Alternatively, RESTEasy's support of MicroProfile Context Propagation [https://github.com/eclipse/microprofile-context-propagation] can be used by using `ThreadContext.contextualRunnable` around a `Runnable`, which will take care of capturing and restoring all registered contexts (the `org.jboss.resteasy.microprofile:microprofile-context-propagation` module will need to be imported):

```java
@GET
@Path("test")
@Produces("text/plain")
public CompletionStage<String> text(@Context HttpRequest request) {
    System.out.println("request (inline): "+ request);
    System.out.println("application (inline): " + ResteasyContext.getContextData(Application.class));
    CompletableFuture<String> cs = new CompletableFuture<>();
    ThreadContext threadContext = ThreadContext.builder()
        .propagated(ThreadContext.ALL_REMAINING)
        .unchanged()
```
As another alternative the RESTEasy SPI's `ContextualExecutor` can be used if the MicroProfile Context Propagation is not available. This requires a dependency on `org.jboss.resteasy:resteasy-core`.

```java
@GET
@Path("test")
@Produces(MediaType.TEXT_PLAIN)
public CompletionStage<String> text(@Context UriInfo uriInfo) {
  CompletableFuture<String> cs = new CompletableFuture<>();
  ExecutorService executor = ContextualExecutors.threadPool();
  executor.submit(() -> {
    try {
      cs.complete("hello from: " + uriInfo.getAbsolutePath());
    } catch (Exception e) {
      e.printStackTrace();
    }
  });
  return cs;
}
```

### 39.3. Beyond CompletionStage

The picture becomes more complex and interesting when sequences are added. A `CompletionStage` holds no more than one potential value, but other reactive objects can hold multiple, even unlimited, values. Currently, most Java implementations of reactive programming are based on the project Reactive Streams (http://www.reactive-streams.org/), which defines a set of four interfaces and a specification, in the form of a set of rules, describing how they interact:

```java
public interface Publisher<T> {
```
A **Producer** pushes objects to a **Subscriber**, a **Subscription** mediates the relationship between the two, and a **Processor** which is derived from both, helps to construct pipelines through which objects pass.

One important aspect of the specification is flow control, the ability of a **Subscriber** to control the load it receives from a **Producer** by calling `Subscription.request()`. The general term in this context for flow control is **backpressure**.

There are a number of implementations of Reactive Streams, including:

1. **RxJava**: [https://github.com/ReactiveX/RxJava/tree/1.x](https://github.com/ReactiveX/RxJava/tree/1.x) (end of life, superseded by RxJava 2)
2. **RxJava 2**: [https://github.com/ReactiveX/RxJava/tree/2.x](https://github.com/ReactiveX/RxJava/tree/2.x) (superseded by RxJava 3)
3. **RxJava 3**: [https://github.com/ReactiveX/RxJava](https://github.com/ReactiveX/RxJava) (Currently the newest branch)
5. **Flow**: [https://community.oracle.com/docs/DOC-1006738](https://community.oracle.com/docs/DOC-1006738): (Java JDK 9+)

RESTEasy currently supports RxJava (deprecated), RxJava2 and Reactor.

### 39.4. Pluggable reactive types: RxJava 2 in RESTEasy

Jakarta RESTful Web Services doesn't currently require support for any Reactive Streams implementations, but it does allow for extensibility to support various reactive libraries. RESTEasy's optional module `resteasy-rxjava2` adds support for RxJava 2 [https://github.com/ReactiveX/RxJava](https://github.com/ReactiveX/RxJava).

**More in details**, `resteasy-rxjava2` contributes support for reactive types `io.reactivex.Single`, `io.reactivex.Flowable`, and `io.reactivex.Observable`. Of these, `Single` is similar to
CompletionStage in that it holds at most one potential value. Flowable implements io.reactivex.Publisher, and Observable is very similar to Flowable except that it doesn’t support backpressure. If importing resteasy-rxjava2, you can start returning these reactive types from your resource methods on the server side and receiving them on the client side.

**Note**

When using RESTEasy’s modules for RxJava, the reactive contexts are automatically propagated to all supported RxJava types, which means there is no need to worry about @Context injection not working within RxJava lambdas, contrary to CompletionStage (as previously noted).

### 1. Server side

**Given the class** `Thing`, which can be represented in JSON:

```java
public class Thing {
    private String name;

    public Thing() {
    }

    public Thing(String name) {
        this.name = name;
    }
    ...
}
```

**the method** `postThingList()` in the following is a valid resource method:

```java
@POST
@Path("post/thing/list")
@Produces(MediaType.APPLICATION_JSON)
@Stream
public Flowable<List<Thing>> postThingList(String s) {
    return buildFlowableThingList(s, 2, 3);
}

static Flowable<List<Thing>> buildFlowableThingList(String s, int listSize, int elementSize) {
    return Flowable.create(
        new FlowableOnSubscribe<List<Thing>>() {
            @Override
            public void subscribe(FlowableEmitter<List<Thing>> emitter) throws Exception {
                for (int i = 0; i < listSize; i++) {
                    emitter.onNext(new Thing(s, i));
                }
            }
        });
    }
```
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List<Thing> list = new ArrayList<Thing>();
for (int j = 0; j < elementSize; j++) {
    list.add(new Thing(s));
    emitter.onNext(list);
}
emitter.onComplete();

The method `buildFlowableThingList()` deserves some explanation. First,

```java
Flowable<List<Thing>> Flowable.create(FlowableOnSubscribe<List<Thing>> source,
                                      BackpressureStrategy mode);
```

creates a `Flowable<List<Thing>>` by describing what should happen when the `Flowable<List<Thing>>` is subscribed to. `FlowableEmitter<List<Thing>>` extends `io.reactivex.Emitter<List<Thing>>`:

```java
/**
 * Base interface for emitting signals in a push-fashion in various generator-like source
 * operators (create, generate).
 *
 * @param <T> the value type emitted
 */
public interface Emitter<T> {

    /**
     * Signal a normal value.
     * @param value the value to signal, not null
     */
    void onNext(@NonNull T value);

    /**
     * Signal a Throwable exception.
     * @param error the Throwable to signal, not null
     */
    void onError(@NonNull Throwable error);

    /**
     * Signal a completion.
     */
    void onComplete();
}
```

and `FlowableOnSubscribe` uses a `FlowableEmitter` to send out values from the `Flowable<List<Thing>>`:
/**
 * A functional interface that has a `subscribe()` method that receives
 * an instance of a `FlowableEmitter` instance that allows pushing
 * events in a backpressure-safe and cancellation-safe manner.
 * @param <T> the value type pushed
 */
public interface FlowableOnSubscribe<T> {

/**
 * Called for each Subscriber that subscribes.
 * @param e the safe emitter instance, never null
 * @throws Exception on error
 */
void subscribe(@NonNull FlowableEmitter<T> e) throws Exception;
}

So, what will happen when a subscription to the `Flowable<List<Thing>>` is created is, the `FlowableEmitter.onNext()` will be called, once for each `List<Thing>` created, followed by a call to `FlowableEmitter.onComplete()` to indicate that the sequence has ended. Under the covers, RESTEasy subscribes to the `Flowable<List<Thing>>` and handles each element passed in by way of `onNext()`.

## 2. Client side

On the client side, Jakarta RESTful Web Services supports extensions for reactive classes by adding the method

```java
/**
 * Access a reactive invoker based on a `RxInvoker` subclass provider. Note
 * that corresponding `RxInvokerProvider` must be registered in the client runtime.
 * This method is an extension point for Jakarta RESTful Web Services implementations to support
 * other types
 * representing asynchronous computations.
 * @param clazz `RxInvoker` subclass.
 * @return reactive invoker instance.
 * @throws IllegalStateException when provider for given class is not registered.
 * @see jakarta.ws.rs.client.Client#register(Class)
 * @since 2.1
 */
public <T extends RxInvoker> T rx(Class<T> clazz);
```

to interface `jakarta.ws.rs.client.Invocation.Builder`. Resteasy module `resteasy-rxjava2` adds support for classes:

1. `org.jboss.resteasy.rxjava2.SingleRxInvoker`,

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2. org.jboss.resteasy.rxjava2.FlowableRxInvoker

3. org.jboss.resteasy.rxjava2.ObservableRxInvoker

which allows accessing Singles, Observables, and Flowables on the client side.

For example, given the resource method `postThingList()` above, a `Flowable<List<Thing>>` can be retrieved from the server by calling

```java
@Test
public void testPostThingList() throws Exception {
    CountDownLatch latch = new CountDownLatch(1);
    FlowableRxInvoker invoker = client.target(generateURL("/post/thing/list")).request().rx(FlowableRxInvoker.class);
    Flowable<List<Thing>> flowable = (Flowable<List<Thing>>) invoker.post(Entity.entity("a", MediaType.TEXT_PLAIN_TYPE), new GenericType<List<Thing>>() {});
    flowable.subscribe(
        (List<?> l) -> thingListList.add(l),
        (Throwable t) -> latch.countDown(),
        () -> latch.countDown());
    latch.await();
    Assert.assertEquals(aThingListList, thingListList);
}
```

where `aThingListList` is

```java
[[Thing[a], Thing[a], Thing[a]], [Thing[a], Thing[a], Thing[a]]]
```

Note the call to `Flowable.subscribe()`. On the server side, RESTEasy subscribes to a returning `Flowable` in order to receive its elements and send them over the wire. On the client side, the user subscribes to the `Flowable` in order to receive its elements and do whatever it wants to with them. In this case, three lambdas determine what should happen 1) for each element, 2) if a `Throwable` is thrown, and 3) when the `Flowable` is done passing elements.

3. Representation on the wire

Neither Reactive Streams nor Jakarta REStful Web Services have anything to say about representing reactive types on the network. RESTEasy offers a number of representations, each suitable for different circumstances. The wire protocol is determined by 1) the presence or absence of the `@Stream` annotation on the resource method, and 2) the value of the `value` field in the `@Stream` annotation:

```java
@Target({ElementType.TYPE, ElementType.METHOD})
```
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```java
@Retention(RetentionPolicy.RUNTIME)
public @interface Stream {
    public enum MODE {RAW, GENERAL};
    public String INCLUDE_STREAMING_PARAMETER = "streaming";
    public MODE value() default MODE.GENERAL;
    public boolean includeStreaming() default false;
}
```

Note that `MODE.GENERAL` is the default value, so `@Stream` is equivalent to `@Stream(Stream.MODE.GENERAL)`.

No `@Stream` annotation on the resource method

Resteasy will collect every value until the stream is complete, then wrap them into a `java.util.List` entity and send to the client.

`@Stream(Stream.MODE.GENERAL)`

This case uses a variant of the SSE format, modified to eliminate some restrictions inherent in SSE. (See the specification at [https://html.spec.whatwg.org/multipage/server-sent-events.html](https://html.spec.whatwg.org/multipage/server-sent-events.html) for details.) In particular, 1) SSE events are meant to hold text data, represented in character set UTF-8. In the general streaming mode, certain delimiting characters in the data ('\r', '\n', and ') are escaped so that arbitrary binary data can be transmitted. Also, 2) the SSE specification requires the client to reconnect if it gets disconnected. If the stream is finite, reconnecting will induce a repeat of the stream, so SSE is really meant for unlimited streams. In general streaming mode, the client will close, rather than automatically reconnect, at the end of the stream. It follows that this mode is suitable for finite streams.

Note. The Content-Type header in general streaming mode is set to

```
application/x-stream-general;"element-type=<element-type>"
```

where `<element-type>` is the media type of the data elements in the stream. The element media type is derived from the `@Produces` annotation. For example,

```java
@GET
@Path("flowable/thing")
@Stream
@Produces("application/json")
public Flowable<Thing> getFlowable() { ... }
```

induces the media type

```
application/x-stream-general;"element-type=application/json"
```
Reactive programming support

which describes a stream of JSON elements.

@Stream(Stream.MODE.RAW)

In this case each value is written directly to the wire, without any formatting, as it becomes available. This is most useful for values that can be cut in pieces, such as strings, bytes, buffers, etc., and then re-concatenated on the client side. Note that without delimiters as in general mode, it isn't possible to reconstruct something like `List<List<String>>`.

Note. The Content-Type header in raw streaming mode is derived from the `@Produces` annotation. The `@Stream` annotation offers the possibility of an optional `MediaType` parameter called "streaming". The point is to be able to suggest that the stream of data emanating from the server is unbounded, i.e., that the client shouldn't try to read it all as a single byte array, for example. The parameter is set by explicitly setting the `@Stream` parameter `includeStreaming()` to true. For example,

```java
@GET
@Path("byte/default")
@Produces("application/octet-stream;x=y")
@Stream(Stream.MODE.RAW)
public Flowable<Byte> aByteDefault() {
    return Flowable.fromArray((byte) 0, (byte) 1, (byte) 2);
}
```

induces the `MediaType "application/octet-stream;x=y"`, and

```java
@GET
@Path("byte/true")
@Produces("application/octet-stream;x=y")
@Stream(value=Stream.MODE.RAW, includeStreaming=true)
public Flowable<Byte> aByteTrue() {
    return Flowable.fromArray((byte) 0, (byte) 1, (byte) 2);
}
```

induces the `MediaType "application/octet-stream;x=y;streaming=true"`.

Note that browsers such as Firefox and Chrome seem to be comfortable with reading unlimited streams without any additional hints.

4. Examples.

Example 1.
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```java
@POST
@Path("post/thing/list")
@Produces(MediaType.APPLICATION_JSON)
@Stream(Stream.MODE.GENERAL)
public Flowable<List<Thing>> postThingList(String s) {
    return buildFlowableThingList(s, 2, 3);
}
...

@SuppressWarnings("unchecked")
@Test
public void testPostThingList() throws Exception {
    CountDownLatch latch = new CountDownLatch(1);
    FlowableRxInvoker invoker = client.target(generateURL("/post/thing/list")).request().rx(FlowableRxInvoker.class);
    Flowable<List<Thing>> flowable = (Flowable<List<Thing>>) invoker.post(Entity.entity("a", MediaType.TEXT_PLAIN_TYPE), new GenericType<List<Thing>>() {});
    flowable.subscribe(
            (List<?> l) -> thingListList.add(l),
            (Throwable t) -> latch.countDown(),
            () -> latch.countDown());
    latch.await();
    Assert.assertEquals(aThingListList, thingListList);
}
```

This is the example given previously, except that the mode in the `@Stream` annotation (which defaults to MODE.GENERAL) is given explicitly. In this scenario, the `Flowable` emits `<List<Thing>>` elements on the server, they are transmitted over the wire as SSE events:

```json
data: [{"name":"a"},{"name":"a"},{"name":"a"}]
data: [{"name":"a"},{"name":"a"},{"name":"a"}]
```

and the `FlowableRxInvoker` reconstitutes a `Flowable` on the client side.

**Example 2.**

```java
@POST
@Path("post/thing/list")
@Produces(MediaType.APPLICATION_JSON)
public Flowable<List<Thing>> postThingList(String s) {
    return buildFlowableThingList(s, 2, 3);
}
...

@Test
public void testPostThingList() throws Exception {
    Builder request = client.target(generateURL("/post/thing/list")).request();
    List<List<Thing>> list = request.post(Entity.entity("a", MediaType.TEXT_PLAIN_TYPE), new GenericType<List<List<Thing>>>() {});
    Assert.assertEquals(aThingListList, list);
}
```
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In this scenario, in which the resource method has no `@Stream` annotation, the `Flowable` emits stream elements which are accumulated by the server until the `Flowable` is done, at which point the entire JSON list is transmitted over the wire:

```
[{
    "name": "a"
},
{
    "name": "a"
},
{
    "name": "a"
}]
```

and the list is reconstituted on the client side by an ordinary invoker.

**Example 3.**

```java
@GET
@Path("get/bytes")
@Produces(MediaType.APPLICATION_OCTET_STREAM)
@Stream(Stream.MODE.RAW)
public Flowable<byte[]> getBytes() {
    return Flowable.create(
        new FlowableOnSubscribe<byte[]>() {
            @Override
            public void subscribe(FlowableEmitter<byte[]> emitter) throws Exception {
                for (int i = 0; i < 3; i++) {
                    byte[] b = new byte[10];
                    for (int j = 0; j < 10; j++) {
                        b[j] = (byte) (i + j);
                    }
                    emitter.onNext(b);
                }
                emitter.onComplete();
            }
        },
        BackpressureStrategy.BUFFER);
}
```

```java
@Test
public void testGetBytes() throws Exception {
    Builder request = client.target(generateURL("/get/bytes")).request();
    InputStream is = request.get(InputStream.class);
    int n = is.read();
    while (n > -1) {
        System.out.print(n);
        n = is.read();
    }
}
```

Here, the byte arrays are written to the network as they are created by the `Flowable`. On the network, they are concatenated, so the client sees one stream of bytes.
Note

Given that asynchronous code is common in this context, it is worth looking at the earlier Note.

5. Rx and SSE

Since general streaming mode and SSE share minor variants of the same wire protocol, they are, modulo the SSE restriction to character data, interchangeable. That is, an SSE client can connect to a resource method that returns a `Flowable` or an `Observable`, and a `FlowableRxInvoker`, for example, can connect to an SSE resource method.

**Note.** SSE requires a `@Produces("text/event-stream")` annotation, so, unlike the cases of raw and general streaming, the element media type cannot be derived from the `@Produces` annotation. To solve this problem, Resteasy introduces the

```java
@Target({ElementType.TYPE, ElementType.METHOD})
@Retention(RetentionPolicy.RUNTIME)
public @interface SseElementType {
    public String value();
}
```

annotation, from which the element media type is derived.

**Example 1.**

```java
@GET
@Path("eventStream/thing")
@Produces("text/event-stream")
%SseElementType("application/json")
public void eventStreamThing(@Context SseEventSink eventSink, @Context Sse sse) {
    new ScheduledThreadPoolExecutor(5).execute(() -> {
        try (SseEventSink sink = eventSink) {
            OutboundSseEvent.Builder builder = sse.newEventBuilder();
            eventSink.send(builder.data(new Thing("e1")).build());
            eventSink.send(builder.data(new Thing("e2")).build());
            eventSink.send(builder.data(new Thing("e3")).build());
        }
    });
}
```

@ suppressWarnings("unchecked")
@Test
public void testFlowableToSse() throws Exception {
    CountDownLatch latch = new CountDownLatch(1);
    final AtomicInteger errors = new AtomicInteger(0);
Here, a `FlowableRxInvoker` is connecting to an SSE resource method. On the network, the data looks like

```plaintext
data: {"name":"e1"}
data: {"name":"e2"}
data: {"name":"e3"}
```

Note that the character data is suitable for an SSE resource method.

Also, note that the `eventStreamThing()` method in this example induces the media type

```plaintext
text/event-stream;element-type="application/json"
```

**Example 2.**

```java
@GET
@Path("flowable/thing")
@Produces("text/event-stream")
@SseElementType("application/json")
public Flowable<Thing> flowableSSE() {
    return Flowable.create(
        new FlowableOnSubscribe<Thing>() {
            @Override
            public void subscribe(FlowableEmitter<Thing> emitter) throws Exception {
                emitter.onNext(new Thing("e1"));
                emitter.onNext(new Thing("e2"));
                emitter.onNext(new Thing("e3"));
                emitter.onComplete();
            }
        },
        BackpressureStrategy.BUFFER);
    }
    ...
    @Test
```
Here, an SSE client is connecting to a resource method that returns a `Flowable`. Again, the server is sending character data, which is suitable for the SSE client, and the data looks the same on the network.

### 6. To stream or not to stream

Whether or not it is appropriate to stream a list of values is a judgment call. Certainly, if the list is unbounded, then it isn’t practical, or even possible, perhaps, to collect the entire list and send it at once. In other cases, the decision is less obvious.

**Case 1.** Suppose that all of the elements are producible quickly. Then the overhead of sending them independently is probably not worth it.

**Case 2.** Suppose that the list is bounded but the elements will be produced over an extended period of time. Then returning the initial elements when they become available might lead to a better user experience.

**Case 3.** Suppose that the list is bounded and the elements can be produced in a relatively short span of time but only after some delay. Here is a situation that illustrates the fact that asynchronous reactive processing and streaming over the network are independent concepts. In this case it’s worth considering having the resource method return something like `CompletionStage<List<Thing>>` *rather than* `Flowable<List<Thing>>`. This has the benefit of creating the list asynchronously but, once it is available, sending it to the client in one piece.

### 39.5. Proxies

Proxies, discussed in RESTEasy Proxy Framework, are a RESTEasy extension that supports a natural programming style in which generic Jakarta RESTful Web Services invoker calls are replaced by application specific interface calls. The proxy framework is extended to include both `CompletionStage` and the RxJava2 types `Single`, `Observable`, and `Flowable`. 
Example 1.

```java
@Path("*")
public interface RxCompletionStageResource {

    @GET
    @Path("get/string")
    @Produces(MediaType.TEXT_PLAIN)
    public CompletionStage<String> getString();
}

@Path("*")
public class RxCompletionStageResourceImpl {

    @GET
    @Path("get/string")
    @Produces(MediaType.TEXT_PLAIN)
    public CompletionStage<String> getString() {

    }
}

public class RxCompletionStageProxyTest {

    private static ResteasyClient client;
    private static RxCompletionStageResource proxy;

    static {
        client = (ResteasyClient)ClientBuilder.newClient();
        proxy = client.target(generateURL("/")).proxy(RxCompletionStageResource.class);
    }

    @Test
    public void testGet() throws Exception {
        CompletionStage<String> completionStage = proxy.getString();
        Assert.assertEquals("x", completionStage.toCompletableFuture().get());
    }
}
```

Example 2.

```java
public interface Rx2FlowableResource {

    @GET
    @Path("get/string")
    @Produces(MediaType.TEXT_PLAIN)
    @Stream
    public Flowable<String> getFlowable();
}

@Path("*")
public class Rx2FlowableResourceImpl {

    @GET
    @Path("get/string")
```
@Produces(MediaType.TEXT_PLAIN)
@Stream
public Flowable<String> getFlowable() { ... }

public class Rx2FlowableProxyTest {

    private static ResteasyClient client;
    private static Rx2FlowableResource proxy;

    static {
        client = (ResteasyClient)ClientBuilder.newClient();
        proxy = client.target(generateURL("/")).proxy(Rx2FlowableResource.class);
    }

    @Test
    public void testGet() throws Exception {
        Flowable<String> flowable = proxy.getFlowable();
        flowable.subscribe(
            (String o) -> stringList.add(o),
            (Throwable t) -> errors.incrementAndGet(),
            () -> latch.countDown());
        boolean waitResult = latch.await(30, TimeUnit.SECONDS);
        Assert.assertTrue("Waiting for event to be delivered has timed out.", waitResult);
        Assert.assertEquals(0, errors.get());
        Assert.assertEquals(xStringList, stringList);
    }

39.6. Adding extensions

RESTEasy implements a framework that supports extensions for additional reactive classes. To understand the framework, it is necessary to understand the existing support for CompletionStage and other reactive classes.

Server side. When a resource method returns a CompletionStage, RESTEasy subscribes to it using the class org.jboss.resteasy.core.AsyncResponseConsumer.CompletionStageResponseConsumer. When the CompletionStage completes, it calls CompletionStageResponseConsumer.accept(), which sends the result back to the client.

Support for CompletionStage is built in to RESTEasy, but it’s not hard to extend that support to a class like Single by providing a mechanism for transforming a Single into a CompletionStage. In module resteasy-rxjava2, that mechanism is supplied by org.jboss.resteasy.rxjava2.SingleProvider, that implements interface org.jboss.resteasy.spi.AsyncResponseProvider.<T>:

```java
public interface AsyncResponseProvider<T> {
    public CompletionStage toCompletionStage(T asyncResponse);
}
```
Reactive programming support

Given `SingleProvider`, RESTEasy can take a `Single`, transform it into a `CompletionStage`, and then use `CompletionStageResponseConsumer` to handle the eventual value of the `Single`.

Similarly, when a resource method returns a streaming reactive class like `Flowable`, RESTEasy subscribes to it, receives a stream of data elements, and sends them to the client. `AsyncResponseConsumer` has several supporting classes, each of which implements a different mode of streaming. For example, `AsyncResponseConsumer.AsyncGeneralStreamingSseResponseConsumer` handles general streaming and SSE streaming. Subscribing is done by calling `org.reactivestreams.Publisher.subscribe()`, so a mechanism is needed for turning, say, a `Flowable` into a `Publisher`. That is, an implementation of `org.jboss.resteasy.spi.AsyncStreamProvider<Flowable>` is called for, where `AsyncStreamProvider` is defined:

```java
public interface AsyncStreamProvider<T> {
    public Publisher toAsyncStream(T asyncResponse);
}
```

In module `resteasy-rxjava2`, `org.jboss.resteasy.FlowableProvider` provides that mechanism for `Flowable`. [Actually, that's not too hard since, in rxjava2, a `Flowable` is a `Provider`.]

So, on the server side, adding support for other reactive types can be done by declaring a `@Provider` for the interface `AsyncStreamProvider` (for streams) or `AsyncResponseProvider` (for single values), which both have a single method to convert the new reactive type into (respectively) a `Publisher` (for streams) or a `CompletionStage` (for single values).

**Client side.** The Jakarta RESTful Web Services specification imposes two requirements for support of reactive classes on the client side:

1. support for `CompletionStage` in the form of an implementation of the interface `jakarta.ws.rs.client.CompletionStageRxInvoker`, and
2. extensibility in the form of support for registering providers that implement

```java
public interface RxInvokerProvider<T extends RxInvoker> {
    public boolean isProviderFor(Class<T> clazz);
    public T getRxInvoker(SyncInvoker syncInvoker, ExecutorService executorService);
}
```

Once an `RxInvokerProvider` is registered, an `RxInvoker` can be requested by calling the `jakarta.ws.rs.client.Invocation.Builder` method

```java
public <T extends RxInvoker> T rx(Class<T> clazz);
```
That `RxInvoker` can then be used for making an invocation that returns the appropriate reactive class. For example,

```java
FlowableRxInvoker invoker = client.target(generateURL("/get/string")).request().rx(FlowableRxInvoker.class);
Flowable<String> flowable = (Flowable<String>) invoker.get();
```

RESTEasy provides partial support for implementing `RxInvoker`s. For example, `SingleProvider`, mentioned above, also implements `org.jboss.resteasy.spi.AsyncClientResponseProvider<Single<?>>`, where `AsyncClientResponseProvider` is defined:

```java
public interface AsyncClientResponseProvider<T> {
    public T fromCompletionStage(CompletionStage<?> completionStage);
}
```

`SingleProvider`'s ability to turn a `CompletionStage` into a `Single` is used in the implementation of `org.jboss.resteasy.rxjava2.SingleRxInvokerImpl`.

The same concept might be useful in implementing other `RxInvokers`. Note, though, that `ObservableRxInvokerImpl` and `FlowableRxInvokerImpl` in module `resteasy-rxjava2` are each derived directly from the SSE implementation.
Chapter 40. Jakarta RESTful Web Services SeBootstrap

In Jakarta RESTful Web Services 3.1 the new jakarta.ws.rs.SeBootstrap API was introduced to run Jakarta RESTful Web Services applications in a Java SE environment. As an implementation of the specification RESTEasy includes an implementation for this API.

40.1. Overview

It's suggested by default that the org.jboss.resteasy:resteasy-undertow-cdi implementation be used. However, the other org.jboss.resteasy.plugins.server.embedded.EmbeddedServer will work excluding the org.jboss.resteasy:resteasy-jdk-http.

The org.jboss.resteasy:resteasy-undertow-cdi implementation also uses Weld to create a CDI container. This allows the CDI in the SE environment to be used. If CDI is not required or desired the org.jboss.resteasy:resteasy-undertow implementation could be used instead.

Example POM Dependencies:

<dependencies>
    <dependency>
        <groupId>jakarta.ws.rs</groupId>
        <artifactId>jakarta.ws.rs-api</artifactId>
    </dependency>
    <dependency>
        <groupId>org.jboss.resteasy</groupId>
        <artifactId>resteasy-core</artifactId>
    </dependency>
    <dependency>
        <groupId>org.jboss.resteasy</groupId>
        <artifactId>resteasy-client</artifactId>
    </dependency>
    <dependency>
        <groupId>org.jboss.resteasy</groupId>
        <artifactId>resteasy-undertow-cdi</artifactId>
    </dependency>
</dependencies>

It's also suggested that if the resources to be used in the application are not explicitly define, then use the org.jboss.jandex:jandex-maven-plugin to create a Jandex Index. Without this the class path will be scanned for resources which could have significant performance impacts.
<plugin>
  <groupId>org.jboss.jandex</groupId>
  <artifactId>jandex-maven-plugin</artifactId>
  <executions>
    <execution>
      <id>make-index</id>
      <goals>
        <goal>jandex</goal>
      </goals>
    </execution>
  </executions>
</plugin>

40.2. Usage

Example of using the jakarta.ws.rs.SeBootstrap API:

SeBootstrap.start(ExampleApplication.class, SeBootstrap.Configuration.builder()
    .build());
    .thenApply((instance) -> {
        try (Client client = ClientBuilder.newClient()) {
            final WebTarget target = client.target(instance.configuration().baseUriBuilder());
            final Response response = client.target(instance.configuration()  
                .baseUriBuilder()  
                .path("/api/product/widget")  
                .request()  
                .get();  
            System.out.printf("Response: %d - %s\n", response.getStatus(),  
                response.readEntity(String.class));
            }  
    return instance;
    })
    .whenComplete((instance, t) -> instance.stop());

40.3. Configuration Options

Configuration options are represented by the org.jboss.resteasy.core.se.ConfigurationOption enum. This enum includes all the supported configuration options.

final SeBootstrap.Configuration configuration = SeBootstrap.Configuration.builder()
    .port(8443)
    .protocol("HTTPS")
    .property(ConfigurationOption.JANDEX_CLASS_PATH_FILTER.key(),  
        Index.of(ItemResource.class, OrderResource.class));
Chapter 41. Embedded Containers

**NOTE:** The `org.jboss.resteasy.plugins.server.embedded.EmbeddedJaxrsServer` is deprecated and replaced by `org.jboss.resteasy.plugins.server.embedded.EmbeddedServer` and `jakarta.ws.rs.SeBootstrap.Instance`. The preference should be to use the `SeBootstrap` API.

RESTEasy has a few different plugins for different embeddable HTTP and/or Servlet containers, if using RESTEasy in a test environment or within an environment where you do not want a Servlet engine dependency.

### 41.1. Undertow

Undertow is a new Servlet Container that is used by WildFly (JBoss Community Server). It can be embedded if desired. Here’s a test that shows it in action.

```java
import io.undertow.servlet.api.DeploymentInfo;
import org.jboss.resteasy.plugins.server.undertow.UndertowJaxrsServer;
import org.jboss.resteasy.test.TestPortProvider;
import org.junit.AfterClass;
import org.junit.Assert;
import org.junit.BeforeClass;
import org.junit.Test;
import jakarta.ws.rs.ApplicationPath;
import jakarta.ws.rs.GET;
import jakarta.ws.rs.Path;
import jakarta.ws.rs.Produces;
import jakarta.ws.rs.client.Client;
import jakarta.ws.rs.client.ClientBuilder;
import jakarta.ws.rs.core.Application;
import java.util.HashSet;
import java.util.Set;

/**
 * @author <a href="mailto:bill@burkecentral.com">Bill Burke</a>
 * @version $Revision: 1 $
 */
public class UndertowTest{
    private static UndertowJaxrsServer server;

    @Path("/test")
    public static class Resource{
        @GET
        @Produces("text/plain")
        public String get()
        {
            return "hello world";
        }
    }
}
```
@ApplicationPath("/base")
public static class MyApp extends Application
{
    @Override
    public Set<Class<?>> getClasses()
    {
        HashSet<Class<?>> classes = new HashSet<Class<?>>();
        classes.add(Resource.class);
        return classes;
    }
}

@BeforeClass
public static void init() throws Exception
{
    server = new UndertowJaxrsServer().start();
}

@AfterClass
public static void stop() throws Exception
{
    server.stop();
}

@Test
public void testApplicationPath() throws Exception
{
    server.deployOldStyle(MyApp.class);
    Client client = ClientBuilder.newClient();
    String val = client.target(TestPortProvider.generateURL("/base/test"))
        .request().get(String.class);
    Assert.assertEquals("hello world", val);
    client.close();
}

@Test
public void testApplicationContext() throws Exception
{
    server.deployOldStyle(MyApp.class, "/root" bât
    Client client = ClientBuilder.newClient();
    String val = client.target(TestPortProvider.generateURL("/root/test"))
        .request().get(String.class);
    Assert.assertEquals("hello world", val);
    client.close();
}

@Test
public void testDeploymentInfo() throws Exception
{
    DeploymentInfo di = server.undertowDeployment(MyApp.class);
    di.setContextPath("/di";
    di.setDeploymentName("DI");
    server.deploy(di);
    Client client = ClientBuilder.newClient();
    String val = client.target(TestPortProvider.generateURL("/di/base/test"))
        .request().get(String.class);
    Assert.assertEquals("hello world", val);
    client.close();
}
41.2. Sun JDK HTTP Server

**NOTE:** This module is deprecated and should not be used.

> The Sun JDK comes with a simple HTTP server implementation (com.sun.net.httpserver.HttpServer) on which RESTEasy can be run on top of.

```java
HttpServer httpServer = HttpServer.create(new InetSocketAddress(port), 10);
contextBuilder = new HttpContextBuilder();
contextBuilder.getDeployment().getActualResourceClasses().add(SimpleResource.class);
HttpContext context = contextBuilder.bind(httpServer);
context.getAttributes().put("some.config.info", "42");
httpServer.start();

contextBuilder.cleanup();
httpServer.stop(0);
```

Create the HttpServer as desired, then use the org.jboss.resteasy.plugins.server.sun.http.HttpContextBuilder to initialize Resteasy and bind it to an HttpContext. The HttpContext attributes are available by injecting an org.jboss.resteasy.spi.ResteasyConfiguration interface using @Context within the provider and resource classes.

Maven project you must include is:

```xml
<dependency>
    <groupId>org.jboss.resteasy</groupId>
    <artifactId>resteasy-jdk-http</artifactId>
    <version>6.2.3.Final</version>
</dependency>
```

41.3. Netty

RESTEasy has integration with the popular Netty project.

```java
public static void start(ResteasyDeployment deployment) throws Exception {
    netty = new NettyJaxrsServer();
    netty.setDeployment(deployment);
    netty.setPort(TestPortProvider.getPort());
```
Include this archive to use netty4

```xml
<dependency>
  <groupId>org.jboss.resteasy</groupId>
  <artifactId>resteasy-netty4</artifactId>
  <version>6.2.3.Final</version>
</dependency>
```

41.4. Reactor-Netty

RESTEasy integrates with the reactor-netty project. This server adapter was created to pair with RESTEasy's reactor-netty based Jakarta RESTful Web Services client integration. Ultimately, if using reactor-netty for both the server and server-contained clients it will be possible to do things like share the same event loop for both server and client calls.

```java
public static void start(ResteasyDeployment deployment) throws Exception {
    ReactorNettyJaxrsServer server = new ReactorNettyJaxrsServer();
    server.setDeployment(new ResteasyDeploymentImpl());
    server.setDeployment(deployment);
    server.setPort(TestPortProvider.getPort());
    server.setRootResourcePath('"');
    server.setSecurityDomain(null);
    server.start();
}
```

Include this archive to use the reactor netty feature

```xml
<dependency>
  <groupId>org.jboss.resteasy</groupId>
  <artifactId>resteasy-reactor-netty</artifactId>
  <version>6.2.3.Final</version>
</dependency>
```

41.5. Vert.x

RESTEasy has integration with the popular Vert.x project.
public static void start(VertxResteasyDeployment deployment) throws Exception {
    VertxJaxrsServer server = new VertxJaxrsServer();
    server.setDeployment(deployment);
    server.setPort(TestPortProvider.getPort());
    server.setRootResourcePath("");
    server.setSecurityDomain(null);
    server.start();
}

Include this archive to use the Vertx feature

<dependency>
    <groupId>org.jboss.resteasy</groupId>
    <artifactId>resteasy-vertx</artifactId>
    <version>6.2.3.Final</version>
</dependency>

The server will bootstrap its own Vert.x instance and Http server.

When a resource is called, it is done with the Vert.x Event Loop thread, keep in mind not block
this thread and respect the Vert.x programming model, see the related Vert.x manual page [http://
vertx.io/docs/vertx-core/java/#_don_t_block_me].

Vert.x extends the RESTEasy registry to provide a new binding scope that creates resources per
Event Loop:

VertxResteasyDeployment deployment = new VertxResteasyDeployment();
// Create an instance of resource per Event Loop
deployment.getRegistry().addPerInstanceResource(Resource.class);

The per instance binding scope caches the same resource instance for each event loop providing
the same concurrency model than a verticle deployed multiple times.

Vert.x can also embed a RESTEasy deployment, making it easy to use Jakarta RESTful Web
Services annotated controller in Vert.x applications:

Vertx vertx = Vertx.vertx();
HttpServer server = vertx.createHttpServer();
// Set an handler calling Resteasy
server.requestHandler(new VertxRequestHandler(vertx, deployment));

// Start the server
server.listen(8080, "localhost");

Vert.x objects can be injected in annotated resources:

```java
@GET
@Path("/somepath")
@Produces("text/plain")
public String context(
    @Context io.vertx.core.Context context,
    @Context io.vertx.core.Vertx vertx,
    @Context io.vertx.core.http.HttpServerRequest req,
    @Context io.vertx.core.http.HttpServerResponse resp) {
    return "the-response";
}
```

## 41.6. EmbeddedJaxrsServer

EmbeddedJaxrsServer is an interface provided to enable each embedded container wrapper class to configure, start and stop its container in a standard fashion. Each server UndertowJaxrsServer, SunHttpJaxrsServer, NettyJaxrsServer, and VertxJaxrsServer implements EmbeddedJaxrsServer.

```java
public interface EmbeddedJaxrsServer<T> {
    T deploy();
    T start();
    void stop();
    ResteasyDeployment getDeployment();
    T setDeployment(ResteasyDeployment deployment);
    T setPort(int port);
    T setHostname(String hostname);
    T setRootResourcePath(String rootResourcePath);
    T setSecurityDomain(SecurityDomain sd);
}
```
Chapter 42. Server-side Mock Framework

Although RESTEasy has an Embeddable Container, you may not be comfortable with the idea of starting and stopping a web server within unit tests. In reality, the embedded container starts in milliseconds. You might not like the idea of using Apache HTTP Client or java.net.URL to test your code. RESTEasy provides a mock framework so that you can invoke on your resource directly.

```java
import org.jboss.resteasy.mock.*;
...

Dispatcher dispatcher = MockDispatcherFactory.createDispatcher();

POJOResourceFactory noDefaults = new POJOResourceFactory(LocatingResource.class);
dispatcher.getRegistry().addResourceFactory(noDefaults);

MockHttpRequest request = MockHttpRequest.get("/locating/basic");
MockHttpResponse response = new MockHttpResponse();
dispatcher.invoke(request, response);

Assert.assertEquals(HttpServletResponse.SC_OK, response.getStatus());
Assert.assertEquals("basic", response.getContentAsString());
}
```

See the RESTEasy Javadoc for all the ease-of-use methods associated with MockHttpRequest, and MockHttpResponse.
Chapter 43. Securing Jakarta RESTful Web Services and RESTEasy

Because RESTEasy is deployed as a servlet, standard web.xml constraints must be used to enable authentication and authorization.

Unfortunately, web.xml constraints do not mesh very well with Jakarta RESTful Web Services in some situations. The problem is that web.xml URL pattern matching is limited. URL patterns in web.xml only support simple wildcards, so Jakarta RESTful Web Services resources such as the following:

```
/{pathparam1}/foo/bar/{pathparam2}
```

Cannot be mapped as a web.xml URL pattern like:

```
/*/foo/bar/*
```

To resolve this issue, use the security annotations defined below on your Jakarta RESTful Web Services methods. Some general security constraint elements will still need to be declared in web.xml to turn on authentication.

RESTEasy supports the @RolesAllowed, @PermitAll and @DenyAll annotations on Jakarta RESTful Web Services methods. By default, RESTEasy does not recognize these annotations. RESTEasy must be configured to turn on role-based security by setting the appropriate parameter. The code fragment below show how to enable security.

```
<web-app>
  ...
  <context-param>
    <param-name>resteasy.role.based.security</param-name>
    <param-value>true</param-value>
  </context-param>
</web-app>
```

NOTE!!! Do not turn on this switch if using Jakarta Enterprise Beans. The Jakarta Enterprise Beans container will provide this functionality instead of RESTEasy.
Securing Jakarta RESTful Web Services and RESTEasy

See Section 3.4, “Configuration” for more information about application configuration.

RESTEasy requires that all roles used within the application be declared in the war’s web.xml file. A security constraint that permits all of those roles access to every URL handled by the Jakarta RESTful Web Services runtime must also be declared in the web.xml.

RESTEasy performs authorization by checking the method annotations. If a method is annotated with @RolesAllowed, it calls HttpServletRequest.isUserInRole. If one of the @RolesAllowed passes, the request is processed, otherwise, a response is returned with a 401 (Unauthorized) response code.

Here is an example of a modified RESTEasy WAR file. Notice that every role declared is allowed access to every URL controlled by the RESTEasy servlet.

```xml
<web-app>
  ...
  <context-param>
    <param-name>resteasy.role.based.security</param-name>
    <param-value>true</param-value>
  </context-param>
  <security-constraint>
    <web-resource-collection>
      <web-resource-name>Resteasy</web-resource-name>
      <url-pattern>/security</url-pattern>
    </web-resource-collection>
    <auth-constraint>
      <role-name>admin</role-name>
      <role-name>user</role-name>
    </auth-constraint>
  </security-constraint>
  <login-config>
    <auth-method>BASIC</auth-method>
    <realm-name>Test</realm-name>
  </login-config>
  <security-role>
    <role-name>admin</role-name>
  </security-role>
  <security-role>
    <role-name>user</role-name>
  </security-role>
  ...
</web-app>
```
Chapter 44. JSON Web Signature and Encryption (JOSE-JWT)

JSON Web Signature and Encryption (JOSE JWT) specification, rfc7517 [https://datatracker.ietf.org/doc/html/rfc7517], defines how to encode content as a string and either digitally sign or encrypt it.

44.1. JSON Web Signature (JWS)

To digitally sign content using JWS, use the org.jboss.resteasy.jose.jws.JWSBuilder class. To unpack and verify a JWS, use the org.jboss.resteasy.jose.jws.JWSInput class. Here’s an example:

```java
@Test
public void testRSAWithContentType() throws Exception {
    KeyPair keyPair = KeyPairGenerator.getInstance("RSA").generateKeyPair();

    String encoded = new JWSBuilder()
        .contentType(MediaType.TEXT_PLAIN_TYPE)
        .content("Hello World", MediaType.TEXT_PLAIN_TYPE)
        .rsa256(keyPair.getPrivate());

    System.out.println(encoded);

    JWSInput input = new JWSInput(encoded, ResteasyProviderFactory.getInstance());
    System.out.println(input.getHeader());
    String msg = (String)input.readContent(String.class);
    Assert.assertEquals("Hello World", msg);
    Assert.assertTrue(RSAProvider.verify(input, keyPair.getPublic()));
}
```

44.2. JSON Web Encryption (JWE)

To encrypt content using JWE, use the org.jboss.resteasy.jose.jwe.JWEBuilder class. To decrypt content using JWE, use the org.jboss.resteasy.jose.jwe.JWEInput class. Here’s an example:

```java
@Test
public void testRSA() throws Exception {
}
```
```java
KeyPair keyPair = KeyPairGenerator.getInstance("RSA").generateKeyPair();

String content = "Live long and prosper.";

String encoded = new JWEBuilder().contentBytes(content.getBytes()).RSA1_5((RSAPublicKey)keyPair.getPublic());
System.out.println("encoded: " + encoded);
byte[] raw = new JWEInput(encoded).decrypt((RSAPrivateKey)keyPair.getPrivate()).getRawContent();
String from = new String(raw);
Assert.assertEquals(content, from);

encoded = new JWEBuilder().contentBytes(content.getBytes()).RSA_OAEP((RSAPublicKey)keyPair.getPublic());
System.out.println("encoded: " + encoded);
raw = new JWEInput(encoded).decrypt((RSAPrivateKey)keyPair.getPrivate()).getRawContent();
from = new String(raw);
Assert.assertEquals(content, from);

encoded = new JWEBuilder().contentBytes(content.getBytes()).A128CBC_HS256().RSA1_5((RSAPublicKey)keyPair.getPublic());
System.out.println("encoded: " + encoded);
raw = new JWEInput(encoded).decrypt((RSAPrivateKey)keyPair.getPrivate()).getRawContent();
from = new String(raw);
Assert.assertEquals(content, from);

encoded = new JWEBuilder().contentBytes(content.getBytes()).A128CBC_HS256().RSA_OAEP((RSAPublicKey)keyPair.getPublic());
System.out.println("encoded: " + encoded);
raw = new JWEInput(encoded).decrypt((RSAPrivateKey)keyPair.getPrivate()).getRawContent();
from = new String(raw);
Assert.assertEquals(content, from);

@Test
public void testDirect() throws Exception
{
    String content = "Live long and prosper.";
    String encoded = new JWEBuilder().contentBytes(content.getBytes()).dir("geheim");
    System.out.println("encoded: " + encoded);
    byte[] raw = new JWEInput(encoded).decrypt("geheim").getRawContent();
    String from = new String(raw);
    Assert.assertEquals(content, from);
}
```
Chapter 45. Doseta Digital Signature Framework

Digital signatures allow the protection of the integrity of a message. They are used to verify that a transmitted message was sent by the actual user and the sent message was not modified in transit. Most web applications handle message integrity by using TLS, like HTTPS, to secure the connection between the client and server. Sometimes there will be representations that are going to be forwarded to more than one recipient. Some representations may hop around from server to server. In this case, TLS is not enough. There needs to be a mechanism to verify who sent the original representation and that they actually sent that message. This is where digital signatures come in.

While the mime type multiple/signed exists, it does have drawbacks. Most importantly it requires the receiver of the message body to understand how to unpack it. A receiver may not understand this mime type. A better approach would be to put signatures in an HTTP header so that receivers that don’t need to worry about the digital signature, don’t have to.

The email world has a protocol called Domain Keys Identified Mail [http://dkim.org] (DKIM). Work is underway to apply this header to protocols other than email (i.e. HTTP) through the DOSETA specifications [https://tools.ietf.org/html/draft-crocker-doseta-base-02]. It allows the user to sign a message body and attach the signature via a DKIM-Signature header. Signatures are calculated by first hashing the message body then combining this hash with an arbitrary set of metadata included within the DKIM-Signature header. Other request or response headers can be added to the calculation of the signature. Adding metadata to the signature calculation gives a lot of flexibility to piggyback various features like expiration and authorization. Here’s what an example DKIM-Signature header might look like.

```
DKIM-Signature: v=1; a=rsa-sha256; d=example.com; s=burke; c=simple/simple; h=Content-Type; x=0023423111111; bh=2342322111; b=M232234=
```

You can see it is a set of name value pairs delimited by a ';'. While it is not THAT important to know the structure of the header, here’s an explanation of each parameter:
Doseta Digital Signature Framework

v


a

Algorithm used to hash and sign the message. RSA signing and SHA256 hashing is the only supported algorithm at the moment by RESTEasy.

d

Domain of the signer. This is used to identify the signer as well as discover the public key to use to verify the signature.

s

Selector of the domain. Also used to identify the signer and discover the public key.

c

Canonical algorithm. Only simple/simple is supported at the moment. This allows the transform of the message body before calculating the hash

h

Semi-colon delimited list of headers that are included in the signature calculation.

x

Signature expiration. This is a numeric long value of the time in seconds since epoch. Allows signer to control when a signed message's signature expires

t

Signature timestamp. Numeric long value of the time in seconds since epoch. Allows the verifier to control when a signature expires.

bh

Base 64 encoded hash of the message body.

b

Base 64 encoded signature.

To verify a signature a public key is needed. DKIM uses DNS text records to discover a public key. To find a public key, the verifier concatenates the Selector (s parameter) with the domain (d parameter)

<selector>._domainKey.<domain>

It then takes that string and does a DNS request to retrieve a TXT record under that entry. In the above example burke._domainKey.example.com would be used as a string. This is an interesting way to publish public keys. For one, it becomes very easy for verifiers to find public keys. There's no real central store that is needed. DNS is an infrastructure IT knows how to deploy. Verifiers can
choose which domains they allow requests from. RESTEasy supports discovering public keys via DNS. It also allows the discovery of public keys within a local Java KeyStore if you do not want to use DNS. It also allows the user to plug in their own mechanism to discover keys.

If interested in learning the possible use cases for digital signatures, here's an informative blog [http://bill.burkecentral.com/2011/02/21/multiple-uses-for-content-signature/].

### 45.1. Maven settings

Archive, resteasy-crypto must include the project to use the digital signature framework.

```xml
<dependency>
    <groupId>org.jboss.resteasy</groupId>
    <artifactId>resteasy-crypto</artifactId>
    <version>6.2.3.Final</version>
</dependency>
```

### 45.2. Signing API

To sign a request or response using the RESTEasy client or server framework create an instance of org.jboss.resteasy.security.doseta.DKIMSignature. This class represents the DKIM-Signature header. Instantiate the DKIMSignature object and then set the "DKIM-Signature" header of the request or response. Here's an example of using it on the server-side:

```java
import org.jboss.resteasy.security.doseta.DKIMSignature;
import java.security.PrivateKey;

@Path("/signed")
public static class SignedResource {
    @GET
    @Path("manual")
    @Produces("text/plain")
    public Response getManual() {
        PrivateKey privateKey = ...; // get the private key to sign message
        DKIMSignature signature = new DKIMSignature();
        signature.setSelector("test");
        signature.setDomain("samplezone.org");
        signature.setPrivateKey(privateKey);
        Response response = Response.ok("hello world");
        response.header(DKIMSignature.DKIM_SIGNATURE, signature);
        return response.build();
    }
}
```

Client example:

```java
import java.security.PrivateKey;
import org.jboss.resteasy.security.doseta.DKIMSignature;

@Path("/signed")
public static class SignedResource {
    @GET
    @Path("manual")
    @Produces("text/plain")
    public Response getManual() {
        PrivateKey privateKey = ...; // get the private key to sign message
        DKIMSignature signature = new DKIMSignature();
        signature.setSelector("test");
        signature.setDomain("samplezone.org");
        signature.setPrivateKey(privateKey);
        ClientRequest request = new ClientRequest("http://...");
        request.header("DKIM-Signature", signature);
        request.body("text/plain", "some body to sign");
        ClientResponse response = request.put();
    }
}
```
To sign a message a PrivateKey is needed. This can be generated by KeyTool or manually using regular, standard JDK Signature APIs. RESTEasy currently only supports RSA key pairs. The DKIMSignature class allows the user to add and control how various pieces of metadata are added to the DKIM-Signature header and the signature calculation. See the javadoc for more details.

If including more than one signature, then add additional DKIMSignature instances to the headers of the request or response.

### 45.2.1. @Signed annotation

Instead of using the API, RESTEasy provides an annotation alternative to the manual way of signing using a DKIMSignature instances. RESTEasy provides annotation @org.jboss.resteasy.annotations.security.doseta.Signed. It is required that a KeyRepository be configured as described later in this chapter. Here’s an example:

```java
@GET
@Produces("text/plain")
@Path("signedresource")
@Signed(selector="burke", domain="sample.com", timestamped=true, expires=@After(hours=24))
public String getSigned()
{
    return "hello world";
}
```

The above example uses optional annotation attributes of @Signed to create the following Content-Signature header:
DKIM-Signature: v=1; a=rsa-sha256; c=simple/simple; domain=sample.com; s=burke; t=02342342341; x=02342342322; bh=m0234fsefasf==; b=mababaddbb==

This annotation also works with the client proxy framework.

### 45.3. Signature Verification API

RESTEasy supports fine grain control over verification with an API to verify signatures manually. To verify the signature the raw bytes of the HTTP message body are needed. Using org.jboss.resteasy.spi.MarshalledEntity injection will provide access to the unmarshalled message body and the underlying raw bytes. Here is an example of doing this on the server side:

```java
import org.jboss.resteasy.spi.MarshalledEntity; @POST@Consumes("text/plain")@Path("verify-manual")public void verifyManual(@HeaderParam("Content-Signature") DKIMSignature signature, @Context KeyRepository repository, @Context HttpHeaders headers, MarshalledEntity<String> input) throws Exception {      Verifier verifier = new Verifier();      Verification verification = verifier.addNew();      verification.setRepository(repository);      verification.setStaleCheck(true);      verification.setStaleSeconds(100);      try {          verifier.verifySignature(headers.getRequestHeaders(), input.getMarshalledBytes, signature);      } catch (SignatureException ex) {          }      System.out.println("The text message posted is: " + input.getEntity());}
```

org.jboss.resteasy.spi.MarshalledEntity; @POST@Consumes("text/plain")@Path("verify-manual")public void verifyManual(@HeaderParam("Content-Signature") DKIMSignature signature, @Context KeyRepository repository, @Context HttpHeaders headers, MarshalledEntity<String> input) throws Exception {      Verifier verifier = new Verifier();      Verification verification = verifier.addNew();      verification.setRepository(repository);      verification.setStaleCheck(true);      verification.setStaleSeconds(100);      try {          verifier.verifySignature(headers.getRequestHeaders(), input.getMarshalledBytes, signature);      } catch (SignatureException ex) {      }      System.out.println("The text message posted is: " +
```
MarshalledEntity is a generic interface. The template parameter should be the Java type of the message body to be converted into. A KeyRepository will have to be configured. This is described later in this chapter.

The client side is a little different:

```java
ClientRequest request = new ClientRequest("http://localhost:9095/signed");
ClientResponse<String> response = request.get(String.class);
Verifier verifier = new Verifier();
Verification verification = verifier.addNew();
verification.setRepository(repository);
response.getProperties().put(Verifier.class.getName(), verifier);
// signature verification happens when you get the entity
String entity = response.getEntity();
```

On the client side, create a verifier and add it as a property to the ClientResponse. This will trigger the verification interceptors.

### 45.3.1. Annotation-based verification

The easiest way to verify a signature sent in an HTTP request on the server side is to use the `@org.jboss.resteasy.annotations.security.doseta.Verify` (or `@Verifications` which is used to verify multiple signatures). Here's an example:

```java
@POST
@Consumes("text/plain")
@Verify
public void post(String input)
{
}
```

In the above example, any DKIM-Signature headers attached to the posted message body will be verified. The public key to verify is discovered using the configured KeyRepository (discussed later in this chapter). The user can specify which specific signatures to be verified as well as define multiple verifications want via the `@Verifications` annotation. Here's a complex example:
@POST
@Consumes("text/plain")
@Verifications{
   @Verify(identifierName="d", identifierValue="inventory.com", stale=@After{days=2}),
   @Verify(identifierName="d", identifierValue="bill.com")
}
public void post(String input) {...}

The above is expecting 2 different signature to be included within the DKIM-Signature header.

Failed verifications will throw an org.jboss.resteasy.security.doseta.UnauthorizedSignatureException. This causes a 401 error code to be sent back to the client. Catching this exception using an ExceptionHandler allows the user to browse the failure results.

45.4. Managing Keys via a KeyRepository

RESTEasy manages keys through an org.jboss.resteasy.security.doseta.KeyRepository. By default, the KeyRepository is backed by a Java KeyStore. Private keys are always discovered by looking into this KeyStore. Public keys may also be discovered via a DNS text (TXT) record lookup if configured to do so. The user can also implement and plug in their own implementation of KeyRepository.

45.4.1. Create a KeyStore

Use the Java keytool to generate RSA key pairs. Key aliases MUST HAVE the form of:

<selector>._domainKey.<domain>

For example:

$ keytool -genkeypair -alias burke._domainKey.example.com -keyalg RSA -keysize 1024 -keystore my-apps.jks

You can always import your own official certificates too. See the JDK documentation for more details.

45.4.2. Configure RESTEasy to use the KeyRepository

Three context-param elements must be declared in the application's web.xml in order for RESTEasy to properly be configured to use the KeyRepository. This information enables the KeyRepository to be created and made available to RESTEasy, which will use it to discover private and public keys.

- (1) The Java key store to be referenced by the Resteasy signature framework must be identified using either resteasy.keystore.classpath or resteasy.keystore.filename context parameters.
Doseta Digital Signature Framework

- (2) The password must be specified using the `resteasy.keystore.password` context parameter. Unfortunately the password must be in clear text.

- (3) The `resteasy.context.objects` parameter is used to identify the classes used in creating the repository.

For example:

```
(1) <context-param>  
   <param-name>resteasy.doseta.keystore.classpath</param-name>  
   <param-value>test.jks</param-value>  
</context-param>  
(2)    <context-param>  
       <param-name>resteasy.doseta.keystore.password</param-name>  
       <param-value>geheim</param-value>  
    </context-param>  
(3)    <context-param>  
       <param-name>resteasy.context.objects</param-name>  
       <param-value>org.jboss.resteasy.security.doseta.KeyRepository :  
       org.jboss.resteasy.security.doseta.ConfiguredDosetaKeyRepository</param-value>  
    </context-param>
```

The user can manually register their own instance of a KeyRepository within an Application class.

For example:

```java
import org.jboss.resteasy.core.Dispatcher;import  
jakarta.ws.rs.core.Application;import  
jakarta.ws.rs.core.Context;public     class  
SignatureApplication extends Application{    private HashSet<Class<?>> classes = new  
HashMap<Class<?>>(){};    private KeyRepository repository;    public SignatureApplication(@Context  
Dispatcher dispatcher) {        classes.add(SignedResource.class);        repository = new DosetaKeyRepository();        repository.setKeyStorePath("test.jks");        repository.setKeyStorePassword("password");        repository.setUseDns(false);        repository.start();        dispatcher.getDefaultContextObjects().put(KeyRepository.class,  
repository);    }    @Override    public Set<Class<?>> getClasses() {        return classes;    }
}
```
On the client side, a KeyStore can be loaded manually, by instantiating an instance of `org.jboss.resteasy.security.doseta.DosetaKeyRepository`. Then set a request attribute, "org.jboss.resteasy.security.doseta.KeyRepository", with the value of the created instance. Use the `ClientRequest.getAttributes()` method to do this. For example:

```java
DosetaKeyRepository keyRepository = new DosetaKeyRepository();
keyRepository.setKeyStorePath("test.jks");
keyRepository.setKeyStorePassword("password");
keyRepository.setUseDns(false);

keyRepository.start();
dispatcher.getDefaultContextObjects().put(KeyRepository.class, keyRepository);

@Override
public Set<Class<?>> getClasses() {
    return classes;
}
```

### 45.4.3. Using DNS to Discover Public Keys

Public keys can be discovered by a DNS text record lookup. The web.xml must be configured to enable this feature:

```xml
<context-param>
    <param-name>resteasy.doseta.use.dns</param-name>
    <param-value>true</param-value>
</context-param>
<context-param>
    <param-name>resteasy.doseta.dns.uri</param-name>
    <param-value>dns://localhost:9095</param-value>
</context-param>
```
The resteasy.doseta.dns.uri context-param is optional and allows pointing to a specific DNS server to locate text records.

### 45.4.3.1. Configuring DNS TXT Records

DNS TXT Records are stored via a format described by the DOSETA specification. The public key is defined via a base 64 encoding. Text encoding can be obtained by exporting the public keys from your keystore and then using a tool like openssl to get the text-based format. For example:

```bash
$ keytool -export -alias bill._domainKey.client.com -keystore client.jks -file bill.der $ openssl x509 -noout -pubkey -in bill.der -inform der > bill.pem
```

The output will look something like:

```
-----BEGIN PUBLIC KEY-----MIGfMA0GCSqGSIb3DQEBAQUAA4GNADCBiQKBgQCKxct5GHz8dFw0mzAMfjvNju2b3oeAv/EOPfVb9mD73Wn+CJYXvnyrhqc99Y/q47urWY/WAF/bqH9AMyMfjizP611P8m09pNYf/Zsqup/7oJxrvzU7T01GdGN1hHcC+qRnwkKddNMD8UEQ4Eix4xFxTBjNvKWLZVKGQMyg6EFVQ1DAQAB-----END PUBLIC KEY-----
```

The DNS text record entry would look like this:

```
test2._domainKey        IN      TXT
"v=DKIM1; p=MIGfMA0GCSqGSIb3DQEBAUA4GNADCBIK8gQC1KFLFWuQfDf8ug688BZ0dazeQ/x+GEh443KpnBX8sgpJX3gFAPhlRvf0yhgHeuI+J5onsSoa9N4fKqAqQNhCQpQHSM2pBC3X0G58c1Hwq1A1tBl621rbyFen4CMGYOyRzDBUGW6n8QK47f3hvoSxkpY1pHdgyoWVOYdIF+wIDAQAB; t=s"
```

Notice that the newlines are taken out. Also, notice that the text record is a name value `;` delimited list of parameters. The p field contains the public key.
Chapter 46. Body Encryption and Signing via SMIME

S/MIME (Secure/Multipurpose Internet Mail Extensions) is a standard for public key encryption and signing of MIME data. MIME data being a set of headers and a message body. Its most often seen in the email world when somebody wants to encrypt and/or sign an email message they are sending across the internet. It can also be used for HTTP requests as well which is what the RESTEasy integration with S/MIME is all about. RESTEasy allows you to easily encrypt and/or sign an email message using the S/MIME standard.

46.1. Maven settings

Reference the resteasy-crypto archive to use the smime framework.

```xml
<dependency>
  <groupId>org.jboss.resteasy</groupId>
  <artifactId>resteasy-crypto</artifactId>
  <version>6.2.3.Final</version>
</dependency>
```

46.2. Message Body Encryption

While HTTPS is used to encrypt the entire HTTP message, S/MIME encryption is used solely for the message body of the HTTP request or response. This is very useful if there is a representation that may be forwarded by multiple parties (for example, HornetQ's REST Messaging integration!) and the message needed to be protected from prying eyes as it travels across the network. RESTEasy has two different interfaces for encrypting message bodies. One for output, one for input. If the client or server wants to send an HTTP request or response with an encrypted body, it uses the `org.jboss.resteasy.security.smime.EnvelopedOutput` type. Encrypting a body also requires an X509 certificate which can be generated by the Java keytool command-line interface, or the openssl tool that comes installed on many OS's. Here's an example of using the `EnvelopedOutput` interface:

```java
// server side   @Path("encrypted")@GETpublic EnvelopedOutput getEncrypted(){
  Customer cust = new Customer();
  cust.setName("Bill");
  X509Certificate certificate = ...;
  EnvelopedOutput output = new EnvelopedOutput(cust, MediaType.APPLICATION_XML_TYPE);
  output.setCertificate(certificate);
  return output; // client side

X509Certificate cert = ...; Customer cust = new Customer();cust.setName("Bill");EnvelopedOutput output = new EnvelopedOutput(cust, "application/xml");output.setCertificate(cert);Response res = target.request().post(Entity.entity(output, "application/pkcs7-mime").post());
```
A Body Encryption and Signing via SMIME

An EnvelopedOutput instance is created passing in the entity to be marshaled and the media type to marshal into. In this example, a Customer class is being marshaled into XML before it is encrypted. RESTEasy will then encrypt the EnvelopedOutput using the BouncyCastle framework's SMIME integration. The output is a Base64 encoding and would look something like this:

```
Content-Type: application/pkcs?7-mime; smime-type=enveloped-data; name="smime.p7m"
Transfer-Encoding: attachment;

O34DF12p2zm+x2Q6R+94BqZHdtEWNQ2evrcgtAng+f2ltILxr/P1K+8bE8w0DGuCg
+k92uYp2rLk1Z58xCGb8tRM4kYCY9sNh2fDaqzUKhMxjgWdMCX6Q7E130u9MdGeCF74Ogwj8fN131D4sx/0k02/
Qwgauke7uNhzCBgqkhiG9w8BBwKwFAY1koZihvcNAwcECDRozFJsPSgolAEQ8qmgjSAW1qBuqlQ1w4nRw41
+44Wg7Y1xf7mOWzyYV8tOcCdmhdxRSM1ly682imrLT2f0LXXuFGTscGUUq742NhAAAABAAAAA
```

Decrypting an S/MIME encrypted message requires using the org.jboss.resteasy.security.smime.EnvelopedInput interface. Both the private key and X509Certificate used to encrypt the message are also needed. Here's an example:

```
// server @Path("encrypted")@POSTpublic void postEncrypted(EnvelopedInput<Customer> input){   PrivateKey privateKey = ...;   X509Certificate certificate = ...;   Customer cust = input.getEntity(privateKey, certificate);}
```
Both examples simply call the getEntity() method passing in the PrivateKey and X509Certificate instances requires to decrypt the message. On the server side, a generic is used with EnvelopedInput to specify the type to marshal to. On the server side this information is passed as a parameter to getEntity(). The message is in MIME format: a Content-Type header and body, so the EnvelopedInput class has everything it needs to both decrypt and unmarshall the entity.

### 46.3. Message Body Signing

S/MIME allows the user to digitally sign a message. It is different than the Doseta Digital Signing Framework. Doseta is an HTTP header that contains the signature. S/MIME uses the multipart/signed data format which is a multipart message that contains the entity and the digital signature. Doseta is a header, S/MIME is its own media type. S/MIME signatures require the client to know how to parse a multipart message and Doseta doesn't. It is left to the user to select the method to use.

RESTEasy has two different interfaces for creating a multipart/signed message. One for input, one for output. If the client or server is to send an HTTP request or response with a multipart/signed body, it uses the `org.jboss.resteasy.security.smime.SignedOutput` type. This type requires both the PrivateKey and X509Certificate to create the signature. Here's an example of signing an entity and sending a multipart/signed entity.
An SignedOutput instance is created passing in the entity wanted to be marshaled and the media type to marshal into. In this example, a Customer class is marshaled into XML before it is sign. RESTEasy will then sign the SignedOutput using the BouncyCastle framework's SMIME integration. The output would look like this:
To unmarshal and verify a signed message requires using the org.jboss.resteasy.security.smime.SignedInput interface. Only the X509Certificate is needed to verify the message. Here’s an example of unmarshalling and verifying a multipart/signed entity.

```java
// server side   @Path("signed")   @POST   @Consumes("multipart/signed")   public void
postSigned(SignedInput<Customer> input) throws Exception {   Customer cust =
input.getEntity();   if (!input.verify(certificate))   {      throw
new WebApplicationException(500);   }   }

// client side      Client client =
ClientBuilder.newClient();      WebTarget target = client.target("http://localhost:9095/smime/
signed");      SignedInput input = target.request().get(SignedInput.class);      Customer cust =
(Customer)input.getEntity(Customer.class)      input.verify(cert);
```

46.4. application/pkcs7-signature

application/pkcs7-signature is a data format that includes both the data and the signature in one ASN.1 binary encoding.

SignedOutput and SignedInput can be used to return application/pkcs7-signature format in binary form. Just change the @Produces or @Consumes to that media type to send back that format.

Also, if the @Produces or @Consumes is text/plain instead, SignedOutput will be base64 encoded and sent as a string.
Chapter 47. Jakarta Enterprise Beans Integration

RESTEasy currently only has simple integration with Jakarta Enterprise Beans. To make a bean a Jakarta RESTful Web Services resource, an SLSB's @Remote or @Local interface must be annotated with Jakarta RESTful Web Services annotations. Also the application's beans must be configured in web.xml.

```java
@Local
@Path("/Library")
public interface Library {

    @GET
    @Path("/books/{isbn}")
    public String getBook(@PathParam("isbn") String isbn);
}

@Stateless
public class LibraryBean implements Library {
    ...
}
```

Next, in RESTEasy's web.xml file manually register the bean with RESTEasy using the resteasy.jndi.resources <context-param>.

```xml
<web-app>
    <display-name>Archetype Created Web Application</display-name>
    <context-param>
        <param-name>resteasy.jndi.resources</param-name>
        <param-value>LibraryBean/local</param-value>
    </context-param>
    ...
</web-app>
```

This is the only portable way RESTEasy offers Jakarta Enterprise Beans integration. Future versions of RESTEasy will have tighter integration with Wildfly, thus eliminating manual registrations or modifications to web.xml.

If you're using RESTEasy with an EAR and Jakarta Enterprise Beans, a good structure to have is:
From the distribution, remove all libraries from WEB-INF/lib and place them in a common EAR lib or place the RESTEasy jar dependencies in the application server's system classpath.
Chapter 48. Spring Integration

48.1. Overview

There are three RESTEasy GitHub projects that provide components for RESTEasy's Spring Framework support.

- RESTEasy [https://github.com/resteasy/resteasy.git]: provides core components for Spring Framework integration.

- resteasy-spring [https://github.com/resteasy/resteasy-spring.git]: This project has been created to separate RESTEasy’s Spring integration extensions from RESTEasy’s core code. It contains RESTEasy’s modules resteasy-spring-web, resteasy-spring, resteasy-under-tow-spring and related tests. These modules were moved out of the RESTEasy project as of version 5.0.0. In maven the GAV groupId is now org.jboss.resteasy.spring. The artifactids remain the same.

```
<dependency>
  <groupId>org.jboss.resteasy.spring</groupId>
  <artifactId>resteasy-spring</artifactId>
  <version>${version.org.jboss.resteasy.spring}</version>
</dependency>
```

- resteasy-spring-boot [https://github.com/resteasy/resteasy-spring-boot.git]: provides two Spring Boot starters.

```
<dependency>
  <groupId>org.jboss.resteasy</groupId>
  <artifactId>resteasy-spring-boot-starter</artifactId>
  <version>${latest_version_of_restesy_spring_boot}</version>
</dependency>
```

RESTEasy currently supports Spring version 6.0

RESTEasy provides integrated support for Spring Framework. It supplies a default org.springframework.web.context.ContextLoaderListener and org.springframework.beans.factory.config.BeanPostProcessor implementation that is used to run Spring applications. Alternatively RESTEasy provides support for registering a custom org.springframework.beans.factory.config.BeanFactoryPostProcessor thus enabling the user to create their own bean factories.
Spring MVC Framework support is provided in RESTEasy. A default implementation of Spring’s
org.springframework.web.servlet.DispatcherServlet is supplied.

RESTEasy furnishes an Undertow based embedded Spring container in which Spring applications can run. It supplies class
org.jboss.resteasy.plugins.server.undertow.spring.UndertowJaxrsSpringServer which accepts a Spring context configuration file and performs the appropriate wiring of Spring to RESTEasy.

Two types of Spring Boot starters are provided by resteasy-spring-boot. These can be used by any regular Spring Boot application that wants to have REST endpoints and prefers RESTEasy as the JAX-RS implementation. The starters integrate with Spring, thus Spring beans will be automatically auto-scanned, integrated, and available. Two types of starters are available, one Servlet based for Tomcat and one for Reactor Netty.

RESTEasy supports Spring’s singleton and prototype scopes and Spring Web REST annotations.

The following subsections discuss ways of configuring these features for use in RESTEasy. Code examples can be found in project resteasy-examples [https://github.com/resteasy/resteasy-examples.git]

### 48.2. Basic Integration

Basic integration makes use of RESTEasy’s default implementations of interface jakarta.servlet.ServletContextListener, and classes
org.springframework.web.context.ContextLoaderListener
org.springframework.beans.factory.config.BeanPostProcessor
org.jboss.resteasy.plugins.server.servlet.ResteasyBootstrap,
org.jboss.resteasy.plugins.spring.SpringContextLoaderListener and
org.jboss.resteasy.plugins.spring.ResteasyBeanPostProcessor.

To use this feature the user must add the maven resteasy-spring dependency to their project.

```xml
<dependency>
  <groupId>org.jboss.resteasy.spring</groupId>
  <artifactId>resteasy-spring</artifactId>
  <version>${version.org.jboss.resteasy.spring}</version>
</dependency>
```

RESTEasy’s SpringContextLoaderListener registers its ResteasyBeanPostProcessor. It processes Jakarta RESTful Web Services annotations when a bean is created by a BeanFactory. It automatically scans for @Provider and Jakarta RESTful Web Services resource annotations on bean classes and registers them as Jakarta RESTful Web Services resources.
A user's application must be configured via a web.xml and optionally a bean.xml file to use these classes. The configuration files discussed below can be found in example, Basic Example [https://github.com/resteasy/resteasy-examples/tree/master/resteasy-spring-basic]

Optionally Spring Framework can be configured to scan for the Jakarta RESTful Web Services resources and beans with a Spring configuration file. Here is an example bean.xml that declares component scanning. In the example code this file is named, resteasy-spring-basic.xml.

```xml
<beans xmlns="http://www.springframework.org/schema/beans"
       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
       xmlns:p="http://www.springframework.org/schema/p"
       xmlns:context="http://www.springframework.org/schema/context"
    <context:component-scan base-package="org.jboss.resteasy.examples.springbasic">
        <context:include-filter type="annotation" expression="jakarta.ws.rs.Path"/>
    </context:component-scan>
    <context:annotation-config/>
</beans>
```

Two or three elements will need to be added to the application's web.xml. Two listener classes must be declared. The RESTEasy servlet must be identified. If the user provided an optional bean.xml file, that needs to be referenced also.

Here is the content that should add into the web.xml file:

```xml
...  
  <listener>
    (1) <listener-class>org.jboss.resteasy.plugins.server.servlet.ResteasyBootstrap</listener-class>
  </listener>

  <listener>
    (1) <listener-class>org.jboss.resteasy.plugins.spring.SpringContextLoaderListener</listener-class>
  </listener>

  <servlet>
    <servlet-name>resteasy-dispatcher</servlet-name>
    <servlet-class>org.jboss.resteasy.plugins.server.servlet.HttpServletDispatcher</servlet-class>
  </servlet>

  <context-param>
    <param-name>contextConfigLocation</param-name>
    <param-value>resteasy-spring-basic.xml</param-value>
  </context-param>
```
• (1) Two listener classes must be declared, **ResteasyBootstrap** and **SpringContextLoaderListener**. The declaration order is critical. **ResteasyBootstrap** must be declared first because **SpringContextLoaderListener** relies on ServletContext attributes initialized by it.

• (2) The RESTEasy servlet is declared.

• (3) A reference to the bean.xml file must be added if the application provides one.

An alternative for using **HttpServletDispatcher** for deployment, a **FilterDispatcher** can be declared instead:

```
<filter>
  <filter-name>resteasy-filter</filter-name>
  <filter-class>
    org.jboss.resteasy.plugins.server.servlet.FilterDispatcher
  </filter-class>
</filter>
```

### 48.3. Customized Configuration

The user is not limited to using RESTEasy's **ContextLoaderListener** implementation. The user may provide their own implementation, however such a customization will require the creation of two additional custom classes, to facilitate the wiring of needed RESTEasy classes into the Spring configuration. An implementation of **org.springframework.web.WebApplicationInitializer** and a class that provides an instance of **org.jboss.resteasy.plugins.spring.SpringBeanProcessorServletAware** will be needed. Spring and Resteasy Customized Example [https://github.com/resteasy/resteasy-examples/tree/master/resteasy-spring-customized] provides an example of the wiring that is required.

There are four RESTEasy classes that must be registered with Spring in the implementation of **WebApplicationInitializer**, **ResteasyBootstrap**, **HttpServletDispatcher**, **ResteasyDeployment**, and **SpringBeanProcessorServletAware**.

```java
@Override
public void onStartup(ServletContext servletContext) throws ServletException {
    (1)   servletContext.addListener(ResteasyBootstrap.class);
    AnnotationConfigWebApplicationContext context = new AnnotationConfigWebApplicationContext();
    context.register(MyConfig.class);
    (2)   context.register(MyConfig.class);
    (3)   servletContext.addListener(new MyContextLoaderListener(context));
```
Spring Integration

```java
ServletRegistration.Dynamic dispatcher = servletContext.addServlet("resteasy-dispatcher",
        new HttpServletDispatcher());
dispenser.setLoadOnStartup(1);
dispenser.addMapping("/rest/*");
```

• (1) ResteasyBootstrap needs to be registered in the servletContext so that the RESTEasy container can gain access to it.

• (2) The user's MyConfig class provides RESTEasy's implementation of BeanProcessorServletAware as a @Bean to the Spring container.

• (3) The user's implementation of ContextLoaderListener is registered in servletContext so that the RESTEasy container can gain access to it.

• (4) RESTEasy's servlet, HttpServletDispatcher is registered in servletContext so that the RESTEasy container can gain access to it.

The user's implementation of ContextLoaderListener performs two important actions.

```java
@override
protected void customizeContext(ServletContext servletContext,
                   ConfigurableWebApplicationContext configurableWebApplicationContext) {
    super.customizeContext(servletContext, configurableWebApplicationContext);

    (1)     ResteasyDeployment deployment = (ResteasyDeployment)
            servletContext.getAttribute(ResteasyDeployment.class.getName());
    if (deployment == null) {
        throw new RuntimeException(Messages.MESSAGES.deploymentIsNull());
    }
    (2)     SpringBeanProcessor processor = new SpringBeanProcessor(deployment);
    configurableWebApplicationContext.addBeanFactoryPostProcessor(processor);
    configurableWebApplicationContext.addApplicationListener(processor);
}
```

• (1) an instance of RESTEasy's ResteasyDeployment must be retrieved from the servletContext.

• (2) and register with Spring

RESTEasy's Spring integration supports both singleton and prototype scope. It handles injecting @Context references. Constructor injection is not supported. With the prototype scope RESTEasy will inject any @*Param annotated fields or setters before the request is dispatched.

Note: Only auto-proxied beans can be used with RESTEasy's Spring integration. There will be undesirable affects if you use handcoded proxying with Spring, i.e., with ProxyFactoryBean.
48.4. Spring MVC Integration

RESTEasy can be integrated with the Spring MVC Framework. Generally speaking, Jakarta RESTful Web Services can be combined with a Spring org.springframework.web.servlet.DispatcherServlet and used in the same web application. An application combined in this way allows the application to dispatch to either the Spring controller or the Jakarta RESTful Web Services resource using the same base URL. In addition Spring ModelAndView objects can be returned as arguments from @GET resource methods.

The Spring MVC Integration Example [https://github.com/resteasy/resteasy-examples/tree/master/resteasy-spring-mvc] demonstrates how to configure an application using Spring MVC.

resteasy-spring provides bean xml file, springmvc-resteasy.xml. It resides in the org.jboss.resteasy.spring:resteasy-spring archive. The file defines the beans for the Spring MVC/RESTEasy integration. The file is required to be imported into the user's MVC application. This bean file can be used as a template to define more advanced functionality, such as configuring multiple RESTEasy factories, dispatchers and registries.

In the example, the reference to springmvc-resteasy.xml is declared in an application provided bean xml named, resteasy-spring-mvc-servlet.xml. This file imports springmvc-resteasy.xml.

```
<beans xmlns="http://www.springframework.org/schema/beans"
       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
       xmlns:context="http://www.springframework.org/schema/context"
       xsi:schemaLocation="
           context/spring-context-2.5.xsd
           spring-beans.xsd">

    <context:component-scan base-package="org.jboss.resteasy.examples.springmvc"/>
    <context:annotation-config/>

    (1) <import resource="classpath:springmvc-resteasy.xml"/>
    (2) ....
</beans>
```

- (1) The application must tell Spring the package to scan for its Jakarta RESTful Web Services resource classes
- (2) A reference to resteasy-spring project's springmvc-resteasy.xml

The setup requires the application to provide a web.xml file in which a Spring DispatcherServlet implementation is declared. Project resteasy-spring provides a default Spring DispatcherServlet implementation, org.jboss.resteasy.springmvc.ResteasySpringDispatcherServlet. This is the DispatcherServlet used in the example code.
The DispatcherServlet takes as an input parameter a reference to the application’s bean file. This reference is declared as an init-param to the servlet.

The application’s web.xml should define the servlet as follows:

```xml
<web-app version="3.0" xmlns="http://java.sun.com/xml/ns/javaee"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://java.sun.com/xml/ns/javaee
http://java.sun.com/xml/ns/javaee/web-app_3_0.xsd">
    <display-name>resteasy-spring-mvc</display-name>
    <servlet>
        <servlet-name>resteasy-spring-mvc</servlet-name>
        <servlet-class>org.jboss.resteasy.springmvc.ResteasySpringDispatcherServlet</servlet-class>
        <init-param>
            <param-name>contextConfigLocation</param-name>
            <param-value>classpath:resteasy-spring-mvc-servlet.xml</param-value>
        </init-param>
    </servlet>
    ....
</web-app>
```

- (1) An implementation of Spring’s DispatcherServlet
- (2) The application’s bean xml file that imports org.jboss.resteasy.spring:resteasy-spring archive’s springmvc-resteasy.xml file.

A jakarta.ws.rs.core.Application subclass can be combined with a Spring DispatcherServlet and used in the same web application. In this scenario a servlet declaration is required for the Spring DispatcherServlet and the jakarta.ws.rs.core.Application subclass. A RESTEasy Configuration Switch, resteasy.scan.resources must be declared as a context-param in the web.xml. Here is an example of the minimum configuration information needed in the web.xml.

```xml
<web-app>
    <servlet>
        <servlet-name>mySpring</servlet-name>
        <servlet-class>org.springframework.web.servlet.DispatcherServlet</servlet-class>
    </servlet>
    <servlet-mapping>
        <servlet-name>mySpring</servlet-name>
        <url-pattern>/*</url-pattern>
    </servlet-mapping>
    <servlet>
        <servlet-name>myAppSubclass</servlet-name>
        <servlet-class>org.my.app.EntryApplicationSubclass</servlet-class>
    </servlet>
</web-app>
```
<servlet-mapping>
  <servlet-name>myAppSubclass</servlet-name>
  <url-pattern>/*</url-pattern>
</servlet-mapping>

<!-- required RESTEasy Configuration Switch directs auto scanning of the archive for Jakarta RESTful Web Services resource files -->
<context-param>
  <param-name>resteasy.scan.resources</param-name>
  <param-value>true</param-value>
</context-param>
</web-app>

- (1) DispatcherServlet declaration
- (2) Application declaration
- (3) scanning configuration switch

**Note:** RESTEasy parameters like `resteasy.scan.resources` may be set in a variety of ways. See Section 3.4, “Configuration” for more information about application configuration.

If the web application contains Jakarta RESTful Web Services provider classes the RESTEasy Configuration Switch, `resteasy.scan.providers`, will also be needed. If the url-pattern for the Jakarta RESTful Web Services Application subclass is other than `/*` a declaration of RESTEasy Configuration Switch, `resteasy.servlet.mapping.prefix` will be required. This switch can be declared either as a `context-param` or as a servlet `init-param`. It’s value must be the text that precedes the `/*`. Here is an example of such a `web.xml`:

<web-app>
  ....
  <servlet>
    <servlet-name>myAppSubclass</servlet-name>
    <servlet-class>org.my.app.EntryApplicationSubclass</servlet-class>
    <init-param>
      <param-name>resteasy.servlet.mapping.prefix</param-name>
      <param-value>/resources</param-value>
    </init-param>
  </servlet>
  <servlet-mapping>
    <servlet-name>myAppSubclass</servlet-name>
    <url-pattern>/resources/*</url-pattern>
  </servlet-mapping>
  <context-param>
    <param-name>resteasy.scan.resources</param-name>
    <param-value>true</param-value>
  </context-param>
</web-app>
(3)  <param-name>resteasy.scan.providers</param-name>
     <param-value>true</param-value>
  </context-param>
</web-app>

- (1) Configuration switch, resteasy.servlet.mapping.prefix, specified in an init-param
- (2) The url-pattern /* is preceeded by /resources.
- (3) Configuration switches specified as context-params

48.5. Undertow Embedded Spring Container

Project resteasy-spring provides an Undertow based embedded Spring container module, resteasy-undertow-spring. It provides class, org.jboss.resteasy.plugins.server.undertow.spring.UndertowJaxrsSpringServer. This class has a single method, undertowDeployment which requires an input parameter that references a Spring context configuration file. The Spring context configuration data is used to wire Spring into Undertow.

An example of setting up the Undertow embedded Spring container can be found in example, resteasy-spring-undertow [https://github.com/resteasy/resteasy-examples/tree/master/resteasy-spring-undertow]

To use this container the user must add the following two archives to their maven project.

```xml
<dependency>
  <groupId>org.jboss.resteasy</groupId>
  <artifactId>resteasy-undertow</artifactId>
  <version>${SOME_VERSION}</version>
</dependency>
<dependency>
  <groupId>org.jboss.resteasy</groupId>
  <artifactId>resteasy-undertow-spring</artifactId>
  <version>${SOME_VERSION}</version>
</dependency>
```

The user's application must provide a bean xml file that imports a reference to the org.jboss.resteasy.spring:resteasy-spring archive's bean file, spring-mvc-resteasy.xml. In the example code the user's provided file is named, spring-servlet.xml. Here is the information needed in this file.

```xml
<beans xmlns="http://www.springframework.org/schema/beans"
       xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
```
Below is a code snippet that shows the creation and configuration of the Undertow embedded Spring container.

(1) UndertowJaxrsSpringServer server = new UndertowJaxrsSpringServer();
    server.start();

(2) DeploymentInfo deployment = server.undertowDeployment("classpath:spring-servlet.xml", null);
    deployment.setDeploymentName(BasicSpringTest.class.getName());
    deployment.setContextPath(“/”);
    deployment.setClassLoader(BasicSpringTest.class.getClassLoader());
    server.deploy(deployment);

• (1) Create an instance of the Undertow Spring server
• (2) Provide the server a reference to the user's application bean.xml

48.6. Processing Spring Web REST annotations in RESTEasy

RESTEasy also provides the ability to process Spring Web REST annotations (i.e. Spring classes annotated with @RestController) and handle related REST requests without delegating to Spring MVC. This functionality is currently experimental.

In order for RESTEasy to be able to process Spring @RestController, the user must include the following maven dependency.
RESTEasy does not auto-scan for `@RestController` annotated classes, so all `@RestController` annotated classes need to be declared in the application's `web.xml` file as shown below.

```
<web-app>
  <display-name>RESTEasy application using Spring REST annotations</display-name>
  <context-param>
    <param-name>resteasy.scanned.resource.classes.with.builder</param-name>
  </context-param>
  ...
</web-app>
```

In the example above, `Controller1` and `Controller2` are registered and expected to be annotated with `@RestController`.

Currently supported annotations:

**Table 48.1.**

<table>
<thead>
<tr>
<th>Annotation</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>@RestController</td>
<td></td>
</tr>
<tr>
<td>@RequestMapping</td>
<td></td>
</tr>
<tr>
<td>@GetMapping</td>
<td></td>
</tr>
<tr>
<td>@PostMapping</td>
<td></td>
</tr>
<tr>
<td>@PutMapping</td>
<td></td>
</tr>
<tr>
<td>@DeleteMapping</td>
<td></td>
</tr>
<tr>
<td>@PatchMapping</td>
<td></td>
</tr>
<tr>
<td>@RequestParam</td>
<td></td>
</tr>
<tr>
<td>@RequestHeader</td>
<td></td>
</tr>
<tr>
<td>@PathVariable</td>
<td></td>
</tr>
<tr>
<td>@CookieValue</td>
<td></td>
</tr>
<tr>
<td>@RequestBody</td>
<td></td>
</tr>
<tr>
<td>@ResponseStatus</td>
<td>Only supported as a method annotation</td>
</tr>
<tr>
<td>@RequestParam</td>
<td></td>
</tr>
</tbody>
</table>

A usage example can be found in sample project resteasy-spring-rest [https://github.com/resteasy/resteasy-examples/tree/master/resteasy-spring-rest]

### 48.7. Spring Boot starter

RESTEasy supports Spring Boot integration. The code was developed by PayPal and donated to the RESTEasy community. The project is maintained in the RESTEasy Spring Boot Starter Project [https://github.com/resteasy/resteasy-spring-boot].

Here is the usage in brief:

Add this maven dependency to the Spring Boot application:

```xml
<dependency>
  <groupId>org.jboss.resteasy</groupId>
  <artifactId>resteasy-spring-boot-starter</artifactId>
  <version>${latest_version_of_resteasy_spring_boot}</version>
  <scope>runtime</scope>
</dependency>
```

Use Spring annotation `@Component` to register a Jakarta RESTful Web Services Application class:

```java
package com.sample.app;

import org.springframework.stereotype.Component;
import jakarta.ws.rs.ApplicationPath;
import jakarta.ws.rs.core.Application;

@Component
@ApplicationPath("/sample-app/")
public class JaxrsApplication extends Application {
}
```

To register Jakarta RESTful Web Services resources and providers, define them as Spring beans. They will be automatically registered. Notice that Jakarta RESTful Web Services resources can be singleton or request scoped, while Jakarta RESTful Web Services providers must be singletons.

To see an example, please check the sample-app [https://github.com/resteasy/resteasy-spring-boot/tree/master/sample-app].
48.8. Upgrading in Wildfly

As noted in Section 3.1.2, “Upgrading RESTEasy within WildFly”, Galleon is used in updating RESTEasy distributions in Wildfly. RESTEasy Spring also uses Galleon for the same task. Follow the directions in that section to install Galleon, then run command:

```
galleon.sh install org.jboss.resteasy.spring:galleon-feature-pack:{CURRENT-VERSION} --dir=\n${WILDFLY-HOME}
```

Note Installing resteasy-spring feature pack, also installs the corresponding RESTEasy archives do to transitive dependencies.
Chapter 49. CDI Integration

This module provides integration with (Contexts and Dependency Injection for the Jakarta EE platform) [https://jakarta.ee/specifications/cdi/3.0/jakarta-cdi-spec-3.0.html]

49.1. Using CDI beans as Jakarta RESTful Web Services components

Both the Jakarta RESTful Web Services and CDI specifications introduce their own component model. On the one hand, every class placed in a CDI archive that fulfills a set of basic constraints is implicitly a CDI bean. On the other hand, explicit decoration of a Java class with @Path or @Provider is required for it to become a Jakarta RESTful Web Services component. Without the integration code, annotating a class suitable for being a CDI bean with Jakarta RESTful Web Services annotations leads into a faulty result (Jakarta RESTful Web Services component not managed by CDI). The resteasy-cdi module is a bridge that allows RESTEasy to work with class instances obtained from the CDI container.

During a web service invocation, resteasy-cdi asks the CDI container for the managed instance of a Jakarta RESTful Web Services component. Then, this instance is passed to RESTEasy. If a managed instance is not available for some reason (the class is placed in a jar which is not a bean deployment archive), RESTEasy falls back to instantiating the class itself.

As a result, CDI services like injection, lifecycle management, events, decoration and interceptor bindings can be used in Jakarta RESTful Web Services components.

49.2. Default scopes

A CDI bean that does not explicitly define a scope is @Dependent scoped by default. This pseudo scope means that the bean adapts to the lifecycle of the bean it is injected into. Normal scopes (request, session, application) are more suitable for Jakarta RESTful Web Services components as they designate component’s lifecycle boundaries explicitly. Therefore, the resteasy-cdi module alters the default scoping in the following way:

- If a Jakarta RESTful Web Services root resource does not define a scope explicitly, it is bound to the Request scope.
- If a Jakarta RESTful Web Services Provider or jakarta.ws.rs.Application subclass does not define a scope explicitly, it is bound to the Application scope.

Warning

Since the scope of all beans that do not declare a scope is modified by resteasy-cdi, this affects session beans as well. As a result, a conflict occurs if the scope of a
stateless session bean or singleton is changed automatically as the spec prohibits these components to be @RequestScoped. Therefore, you need to explicitly define a scope when using stateless session beans or singletons. This requirement is likely to be removed in future releases.

49.3. Configuration within WildFly

CDI integration is provided with no additional configuration with WildFly.

49.4. Configuration with different distributions

Provided there is an existing RESTEasy application, all that needs to be done is to add the resteasy-cdi jar into the project's WEB-INF/lib directory. When using maven, this can be achieved by defining the following dependency.

```xml
<dependency>
  <groupId>org.jboss.resteasy</groupId>
  <artifactId>resteasy-cdi</artifactId>
  <version>${project.version}</version>
</dependency>
```

Furthermore, when running a pre-Servlet 3 container, the following context parameter needs to be specified in web.xml. (This is done automatically via web-fragment in a Servlet 3 environment)

```xml
<context-param>
  <param-name>resteasy.injector.factory</param-name>
  <param-value>org.jboss.resteasy.cdi.CdiInjectorFactory</param-value>
</context-param>
```

When deploying an application to a Servlet container that does not support CDI out of the box (Tomcat, Jetty, Google App Engine), a CDI implementation needs to be added first. Weld-servlet module [http://docs.jboss.org/weld/reference/latest/en-US/html/environments.html] can be used for this purpose.
Chapter 50. RESTEasy Client API

50.1. Jakarta RESTful Web Services Client API

The Jakarta RESTful Web Services includes a client API so the user can make http requests to remote RESTful web services. It is a 'fluent' request building API with really 3 main classes: Client, WebTarget, and Response. The Client interface is a builder of WebTarget instances. WebTarget represents a distinct URL or URL template from which the user can build more sub-resource WebTargets or invoke requests on.

There are really two ways to create a Client. Standard way, or to use the ResteasyClientBuilder class. The advantage of the latter is that it provides a few more helper methods to configure the client.

```java
Client client = ClientBuilder.newClient();
... or...
Client client = ClientBuilder.newBuilder().build();
WebTarget target = client.target("http://foo.com/resource");
Response response = target.request().get();
String value = response.readEntity(String.class);
response.close(); // You should close connections!
```

RESTEasy will automatically load a set of default providers. (Basically all classes listed in all META-INF/services/jakarta.ws.rs.ext.Providers files). Additionally, other providers, filters, and interceptors can be manually registered through the Configuration object provided by the method call Client.configuration(). Configuration also lets the user set various configuration properties that may be needed.

Each WebTarget has its own Configuration instance which inherits the components and properties registered with its parent. This allows the user to set specific configuration options per target resource. For example, username and password.

One RESTEasy extension to the client API is the ability to specify that requests should be sent in "chunked" transfer mode. There are two ways of doing that. One is to configure an org.jboss.resteasy.client.jaxrs.ResteasyWebTarget so that all requests to that target are sent in chunked mode:

```java
ResteasyClient client = (ResteasyClient)ClientBuilder.newClient();
ResteasyWebTarget target = client.target("http://localhost:8081/test");
target.setChunked(b.booleanValue());
Invocation.Builder request = target.request();
```
Alternatively, it is possible to configure a particular request to be sent in chunked mode:

```java
ResteasyClient client = (ResteasyClient)ClientBuilder.newClient();
ResteasyWebTarget target = client.target("http://localhost:8081/test");
ClientInvocationBuilder request = (ClientInvocationBuilder) target.request();
request.setChunked(b);
```

**Note** that `org.jboss.resteasy.client.jaxrs.internal.ClientInvocationBuilder`, unlike `jakarta.ws.rs.client.Invocation.Builder`, is a RESTEasy class.

**Note.** The ability to send in chunked mode depends on the underlying transport layer; in particular, it depends on which implementation of `org.jboss.resteasy.client.jaxrs.ClientHttpEngine` is being used. Currently, only the default implementation, `ApacheHttpClient43Engine`, supports chunked mode. See Section Apache HTTP Client 4.x and other backends for more information.

**Note** To follow REST principles and avoid introducing state management in applications, `jakarta.ws.rs.client.Client` instances do not provide support for cookie management by default. However, the user can enable it if necessary using `ResteasyClientBuilder`:

```java
Client client = ((ResteasyClientBuilder)
ClientBuilder.newBuilder()).enableCookieManagement().build();
```

## 50.2. RESTEasy Proxy Framework

The RESTEasy Proxy Framework is the mirror opposite of the Jakarta RESTful Web Services server-side specification. Instead of using Jakarta RESTful Web Services annotations to map an incoming request to RESTful Web Service methods, the client framework builds an HTTP request that it uses to invoke a remote RESTful Web Service. This remote service does not have to be a Jakarta RESTful Web Services service and can be any web resource that accepts HTTP requests.

RESTEasy has a client proxy framework that allows the use of Jakarta RESTful Web Services annotations to invoke a remote HTTP resource. Write a Java interface and use Jakarta RESTful Web Services annotations on methods and the interface. For example:
public interface SimpleClient
{
    @GET
    @Path("basic")
    @Produces("text/plain")
    String getBasic();

    @PUT
    @Path("basic")
    @Consumes("text/plain")
    void putBasic(String body);

    @GET
    @Path("QueryParam")
    @Produces("text/plain")
    String getQueryParam(@QueryParam("param")String param);

    @GET
    @Path("matrixParam")
    @Produces("text/plain")
    String getMatrixParam(@MatrixParam("param")String param);

    @GET
    @Path("uriParam/{param}")
    @Produces("text/plain")
    int getUriParam(@PathParam("param")int param);
}

RESTEasy has a simple API based on Apache HttpClient. Generate a proxy, then invoke methods on the proxy. The invoked method gets translated to an HTTP request based on how the method was annotated and posted to the server. Here’s how to set this up:

```java
Client client = ClientBuilder.newClient();
WebTarget target = client.target("http://example.com/base/uri");
ResteasyWebTarget rtarget = (ResteasyWebTarget)target;
SimpleClient simple = rtarget.proxy(SimpleClient.class);
simple.putBasic("hello world");
```

Alternatively use the RESTEasy client extension interfaces directly:

```java
ResteasyClient client = (ResteasyClient)ClientBuilder.newClient();
ResteasyWebTarget target = client.target("http://example.com/base/uri");

SimpleClient simple = target.proxy(SimpleClient.class);
simple.putBasic("hello world");
```
@CookieParam works the mirror opposite of its server-side counterpart and creates a cookie header to send to the server. It is not needed to use @CookieParam if you allocate your own jakarta.ws.rs.core.Cookie object and pass it as a parameter to a client proxy method. The client framework understands the cookie is being passed to the server so no extra metadata is needed.

The framework supports the Jakarta RESTful Web Services locator pattern, but on the client side. So, if there is a method annotated only with @Path, that proxy method will return a new proxy of the interface returned by that method.

### 50.2.1. Abstract Responses

Sometimes there is interest in viewing the response status code and/or the response headers in addition to the response body of the client request. The Client-Proxy framework has two ways to get at this information.

A jakarta.ws.rs.core.Response.Status enumeration can be returned from the method.

```java
@Path("/")
public interface MyProxy {
    @POST
    Response.Status updateSite(MyPojo pojo);
}
```

Internally, after invoking the server, the client proxy internals will convert the HTTP response code into a Response.Status enum.

The jakarta.ws.rs.core.Response class provides all accessible information:

```java
@Path("/")
public interface LibraryService {

    @GET
    @Produces("application/xml")
    Response getAllBooks();
}
```

### 50.2.2. Response proxies

A further extension implemented by the RESTEasy client proxy framework is the "response proxy facility", where a client proxy method returns an interface that represents the information contained in a jakarta.ws.rs.core.Response. Such an interface must be annotated with @ResponseObject from package org.jboss.resteasy.annotations, and its methods may be further
annotated with @Body, @LinkHeaderParam, and @Status from the same package, as well as jakarta.ws.rs.HeaderParam. Consider the following example.

```java
@ResponseObject
public interface TestResponseObject {
    @Status
    int status();
    @Body
    String body();
    @HeaderParam("Content-Type")
    String contentType();
    ClientResponse response();
}

@Path("test")
public interface TestClient {
    @GET
    TestResponseObject get();
}

@Path("test")
public static class TestResource {
    @GET
    @Produces("text/plain")
    public String get() {
        return "ABC";
    }
}
```

Here, TestClient will define the client side proxy for TestResource. Note that TestResource.get() returns a String but the proxy based on TestClient will return a TestResponseObject on a call to get():

```java
Client client = ClientBuilder.newClient();
TestClient ClientInterface = ProxyBuilder.builder(TestClient.class, client.target("http://localhost:8081")).build();
TestResponseObject tro = ClientInterface.get();
```

The methods of TestResponseObject provide access to various pieces of information about the response received from TestResponse.get(). This is where the annotations on those methods come into play. status() is annotated with @Status, and a call to status() returns the HTTP
status. Similarly, `body()` returns the returned entity, and `contentType()` returns the value of the response header Content-Type:

```java
System.out.println("status: " + tro.status());
System.out.println("entity: " + tro.body());
System.out.println("Content-Type: " + tro.contentType());
```

will yield

```
status: 200
entity: ABC
Content-Type: text/plain;charset=UTF-8
```

Note that there is one other method in `TestResponseObject`, `response()`, that has no annotation. When RESTEasy sees a method in an interface annotated with `@ResponseObject` that returns a `jakarta.ws.rs.core.Response` (or a subclass thereof), it will return a `org.jboss.resteasy.client.jaxrs.internal.ClientResponse`. For example,

```java
ClientResponse clientResponse = tro.response();
System.out.println("Content-Length: " + clientResponse.getLength());
```

Perhaps the most interesting piece of the response proxy facility is the treatment of methods annotated with `@LinkHeaderParam`. Its simplest use is to assist in accessing a `jakarta.ws.rs.core.Link` returned by a resource method. For example, let's add

```java
@GET
@Path("/link-header")
public Response getWithHeader(@Context UriInfo uri) {
    URI subUri = uri.getAbsolutePathBuilder().path("next-link").build();
    Link link = new LinkBuilderImpl().uri(subUri).rel("nextLink").build();
    return Response.noContent().header("Link", link.toString()).build();
}
```

```java`@GET` to TestResource, add
```
@Path("link-header")
ResponseObjectInterface performGetBasedOnHeader();

to ClientInterface, and add

@LinkHeaderParam(rel = "nextLink")
URI nextLink();

to ResponseObjectInterface. Then calling

ResponseObjectInterface obj = ClientInterface.performGetBasedOnHeader();
System.out.println("nextLink(): " + obj.nextLink());

will access the LinkHeader returned by TestResource.getWithHeader():

nextlink: http://localhost:8081/test/link-header/next-link

Last but not least, let's add

@GET
@Produces("text/plain")
@Path("/link-header/next-link")
public String getHeaderForward() {
    return "forwarded";
}

to TestResource and

@GET
@LinkHeaderParam(rel = "nextLink")
String followNextLink();
to ResponseObjectInterface. **Note that, unlike** ResponseObjectInterface.nextLink(), followNextLink() **is annotated with** @GET; **that is, it qualifies as** (the client proxy to) a resource method. When executing followNextLink(), RESTEasy will retrieve the value of the Link returned by TestResource.getWithHeader() and then will make a GET invocation on the URL in that Link. Calling

```java
System.out.println("followNextLink(): " + obj.followNextLink());
```

causes RESTEasy to retrieve the URL `http://localhost:8081/test/link-header/next-link` from the call to TestResource.getWithHeader() and then perform a GET on it, invoking TestResource.getHeaderForward()::

```java
followNextLink(): forwarded
```

**Note.** This facility for extracting a URL and following it is a step toward supporting the Representation State Transfer principle of HATEOAS. For more information, see RESTful Java with JAX-RS 2.0, 2nd Edition [http://shop.oreilly.com/product/0636920028925.do] by Bill Burke.

### 50.2.3. Giving client proxy an ad hoc URI

Client proxies figure out appropriate URIs for targeting resource methods by looking at @Path annotations in the client side interface, but it is also possible to pass URIs explicitly to the proxy through the use of the org.jboss.resteasy.annotations.ClientURI annotation. For example, let TestResource be a client side interface and TestResourceImpl a server resource:

```java
@Path(""")
public interface TestResource {

    @GET
    @Path("dispatch")
    public String dispatch(@ClientURI String uri);
}

@Path(""")
public static class TestResourceImpl {

    @GET
    @Path("a")
    public String a() {
        return "a";
    }

    @GET
```
Calling `TestResource.dispatch()` allows specifying a specific URI for accessing a resource method. In the following, let BASE_URL be the address of the `TestResourceImpl` resource.

```java
private static String BASE_URL = "http://localhost:8081/";
...
public void test() throws Exception {
    ResteasyClient client = (ResteasyClient)ClientBuilder.newClient();
    TestResource proxy = client.target(BASE_URL).proxy(TestResource.class);
    String name = proxy.dispatch(BASE_URL + "a");
    System.out.println("name: " + name);
    name = proxy.dispatch(BASE_URL + "b");
    System.out.println("name: " + name);
    client.close();
}
```

Then passing "http://localhost:8081/a" and "http://localhost/b" to `dispatch()` invokes `TestResourceImp.a()` and `TestResourceImp.b()` respectively, yielding the output

```
name: a
name: b
```

### 50.2.4. Sharing an interface between client and server

It is generally possible to share an interface between the client and server. In this scenario, just have the Jakarta RESTful Web Services services implement an annotated interface and then reuse that same interface to create client proxies to invoke on the client-side.

### 50.3. Apache HTTP Client 4.x and other backends

Network communication between the client and server is handled by default in RESTEasy. The interface between the RESTEasy Client Framework and the network is defined by RESTEasy’s `ClientHttpEngine` interface. RESTEasy ships with multiple implementations of this interface.

The default implementation is `ApacheHttpClient43Engine`, which uses version 4.3 of the `HttpClient` from the Apache HttpComponents project.
ApacheHttpAsyncClient4Engine, instead, is built on top of HttpAsyncClient (still from the Apache HttpComponents project) with internally dispatches requests using a non-blocking IO model.

JettyClientEngine is built on top of Eclipse Jetty HTTP engine, which is possibly an interesting option for those already running on the Jetty server.

VertxClientHttpEngine is built on top of Eclipse Vert.x, which provides a non-blocking HTTP client based on Vert.x framework.

ReactorNettyClientHttpEngine is built on top of Reactor Netty, which provides a non-blocking HTTP client based on Netty framework.

Finally, InMemoryClientEngine is an implementation that dispatches requests to a server in the same JVM and URLConnectionEngine is an implementation that uses java.net.HttpURLConnection.

### Table 50.1.

<table>
<thead>
<tr>
<th>RESTEasy ClientHttpEngine implementations</th>
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</tbody>
</table>

The RESTEasy Client Framework can also be customized. The user can provide their own implementations of ClientHttpEngine to the ResteasyClient.

```java
ClientHttpEngine myEngine = new ClientHttpEngine() {
    protected SSLContext sslContext;
    protected HostnameVerifier hostnameVerifier;

    @Override
    public ClientResponse invoke(ClientInvocation request) {
        // implement your processing code and return a
        // org.jboss.resteasy.client.jaxrs.internal.ClientResponse
        // object.
    }

    @Override
    public SSLContext getSslContext() {
        return sslContext;
    }
};
```
@Override
public HostnameVerifier getHostnameVerifier() {
    return hostnameVerifier;
}

@Override
public void close() {
    // do nothing
}
);
ResteasyClient client =
((ResteasyClientBuilder)ClientBuilder.newBuilder()).httpEngine(myEngine).build();

RESTEasy and HttpClient make reasonable default decisions so that it is possible to use
the client framework without ever referencing HttpClient. For some applications it may
be necessary to drill down into the HttpClient details. ApacheHttpClient43Engine can
be supplied with an instance of org.apache.http.client.HttpClient and an instance of
org.apache.http.protocol.HttpContext, which can carry additional configuration details into
the HttpClient layer.
HttpContextProvider is a RESTEasy provided interface through which a custom HttpContext
is supplied to ApacheHttpClient43Engine.

package org.jboss.resteasy.client.jaxrs.engines;
public interface HttpContextProvider {
    HttpContext getContext();
}

Here is an example of providing a custom HttpContext

DefaultHttpClient httpClient = new DefaultHttpClient();
ApacheHttpClient43Engine engine = new ApacheHttpClient43Engine(httpClient,
    new HttpContextProvider() {
        @Override
        public HttpContext getContext() {
            // Configure HttpClient to authenticate preemptively
            // by prepopulating the authentication data cache.
            // 1. Create AuthCache instance
            AuthCache authCache = new BasicAuthCache();
            // 2. Generate BASIC scheme object and add it to the local auth cache
            BasicScheme basicAuth = new BasicScheme();
            authCache.put(getHttpHost(url), basicAuth);
            // 3. Add AuthCache to the execution context
50.3.1. HTTP redirect

The `ClientHttpEngine` implementations based on Apache `HttpClient` support HTTP redirection. The feature is disabled by default and has to be enabled by users explicitly:

```java
ApacheHttpClient43Engine engine = new ApacheHttpClient43Engine();
engine.setFollowRedirects(true);
Client client = ((ResteasyClientBuilder)ClientBuilder.newBuilder()).httpEngine(engine).build();
```

50.3.2. Configuring SSL

To enable SSL on client, a `ClientHttpEngine` containing a SSLContext can be created to build client as in the following example:

```java
ClientHttpEngine myEngine = new ClientHttpEngine() {
    ... 
    @Override
    public HostnameVerifier getHostnameVerifier() {
        return hostnameVerifier;
    }
};
myEngine.setSslContext(mySslContext)
ResteasyClient client =
    ((ResteasyClientBuilder)ClientBuilder.newBuilder()).httpEngine(myEngine).build();
```

An alternative is to set up a keystore and truststore and pass a custom SslContext to `ClientBuilder`:

```java
Client sslClient = ClientBuilder.newBuilder().sslContext(mySslContext).build();
```
If you don’t want to create a SSLContext, you can build client with a keystore and truststore. Note if both SSLContext and keystore/truststore are configured, the later will be ignored by Resteasy ClientBuilder.

```java
Client sslClient = ClientBuilder.newBuilder().keystore(keystore, mypassword).
    trustKeystore(trustStore).build();
```

During handshaking, a custom HostNameVerifier can be called to allow the connection if URL’s hostname and the server’s identification hostname match.

```java
Client sslClient = ((ResteasyClientBuilder)ClientBuilder.newBuilder()).sslContext(mysslContext).
    hostnameVerifier(myhostnameVerifier).build();
```

Resteasy provides another simple way to set up a HostnameVerifier. It allows configuring ResteasyClientBuilder with a HostnameVerificationPolicy without creating a custom HostNameVerifier:

```java
Client sslClient = ((ResteasyClientBuilder)ClientBuilder.newBuilder()).sslContext(mysslContext).
    hostnameVerification(ResteasyClientBuilder.HostnameVerificationPolicy.ANY).build();
```

- Setting HostnameVerificationPolicy.ANY will allow all connections without a check.
- HostnameVerificationPolicy.WILDCARD only allows wildcards in subdomain names i.e. ".foo.com.
- HostnameVerificationPolicy.STRICT checks if DNS names match the content of the Public Suffix List (https://publicsuffix.org/list/public_suffix_list.dat). Please note if this public suffix list isn’t the check wanted, create your own HostNameVerifier instead of this policy setting.

### 50.3.3. HTTP proxy

The ClientHttpEngine implementations based on Apache HttpClient support HTTP proxy. This feature can be enabled by setting specific properties on the builder:

- org.jboss.resteasy.jaxrs.client.proxy.host
- org.jboss.resteasy.jaxrs.client.proxy.port
• org.jboss.resteasy.jaxrs.client.proxy.scheme


50.3.4. Apache HTTP Client 4.3 APIs

The RESTEasy Client framework automatically creates and properly configures the underlying Apache HTTP Client engine. When the ApacheHttpClient43Engine is manually created, though, the user can either let it build and use a default HttpClient instance or provide a custom one:

```java
public ApacheHttpClient43Engine() {
...
}

public ApacheHttpClient43Engine(HttpClient httpClient) {
...
}

public ApacheHttpClient43Engine(HttpClient httpClient, boolean closeHttpClient) {
...
}
```

The closeHttpClient parameter on the last constructor above allows controlling whether the Apache HttpClient is to be closed upon engine finalization. The default value is true. When a custom HttpClient instance is not provided, the default instance will always be closed together with the engine.

For more information about HttpClient (4.x), see the documentation at https://hc.apache.org/index.html/ [https://hc.apache.org/index.html].

Note. It is important to understand the difference between "releasing" a connection and "closing" a connection. Releasing a connection makes it available for reuse. Closing a connection frees its resources and makes it unusable.

If an execution of a request or a call on a proxy returns a class other than Response, then RESTEasy will take care of releasing the connection. For example, in the fragments

```java
WebTarget target = client.target("http://localhost:8081/customer/123");
String answer = target.request().get(String.class);
```
or

```java
ResteasyWebTarget target = client.target("http://localhost:8081/customer/123");
RegistryStats stats = target.proxy(RegistryStats.class);
RegistryData data = stats.get();
```

RESTEasy will release the connection under the covers. The only counterexample is the case in which the response is an instance of `InputStream`, which must be closed explicitly.

On the other hand, if the result of an invocation is an instance of `Response`, then the `Response.close()` method must be used to release the connection.

```java
WebTarget target = client.target("http://localhost:8081/customer/123");
Response response = target.request().get();
System.out.println(response.getStatus());
response.close();
```

It is advisable to execute this in a `try/finally` block. Again, releasing a connection only makes it available for another use. **It does not normally close the socket.**

On the other hand, `ApacheHttpClient43Engine.finalize()` will close any open sockets, unless the user set `closeHttpClient as false` when building the engine, in which case he is responsible for closing the connections.

Note that if `ApacheHttpClient43Engine` has created its own instance of `HttpClient`, it is not necessary to wait for `finalize()` to close open sockets. The `ClientHttpEngine` interface has a `close()` method for this purpose.

If the user's `jakarta.ws.rs.client.Client` class has created the engine automatically, the user should call `Client.close()` and this will clean up any socket connections.

Finally, having explicit `finalize()` methods can badly affect performances, the `org.jboss.resteasy.client.jaxrs.engines.ManualClosingApacheHttpClient43Engine` flavour of `org.jboss.resteasy.client.jaxrs.engines.ApacheHttpClient43Engine` can be used. With that the user is always responsible for calling `close()` as no `finalize()` is there to do that before object garbage collection.

### 50.3.5. Asynchronous HTTP Request Processing

RESTEasy’s default async engine implementation class is `ApacheHttpAsyncClient4Engine`. It can be set as the active engine by calling method `useAsyncHttpEngine` in `ResteasyClientBuilder`. 

RESTEasy Client API

```java
Client asyncClient = ((ResteasyClientBuilder)ClientBuilder.newBuilder()).useAsyncHttpEngine()
.build();
Future<Response> future = asyncClient
.target("http://localhost:8080/test").request()
.async().get();
Response res = future.get();
Assert.assertEquals(HttpResponseCodes.SC_OK, res.getStatus());
String entity = res.readEntity(String.class);
```

### 50.3.5.1. InvocationCallbacks

InvocationCallbacks are called from within the io-threads and thus must not block or else the application may slow down to a halt. Reading the response is safe because the response is buffered in memory, as are other async and in-memory client-invocations that submit-calls returning a future not containing Response, InputStream or Reader.

```java
final CountDownLatch latch = new CountDownLatch(1);
Future<String> future = nioClient.target(generateURL("/test")).request()
.async().get(new InvocationCallback<String>()
{
    @Override
    public void completed(String s)
    {
        Assert.assertEquals("get", s);
        latch.countDown();
        throw new RuntimeException("for the test of it");
    }

    @Override
    public void failed(Throwable error)
    {
    }
});
String entity = future.get();
Assert.assertEquals("get", entity);
```

InvocationCallbacks may be called seemingly "after" the future-object returns. Thus, responses should be handled solely in the InvocationCallback.

InvocationCallbacks will see the same result as the future-object and vice versa. Thus, if the invocationcallback throws an exception, the future-object will not see it. This is the reason to handle responses only in the InvocationCallback.

### 50.3.5.2. Async Engine Usage Considerations

Asynchronous IO means non-blocking IO utilizing few threads, typically at most as many threads as number of cores. As such, performance may profit from fewer thread switches and less memory
usage due to fewer thread-stacks. But doing synchronous, blocking IO (the invoke-methods not returning a future) may suffer, because the data has to be transferred piecewise to/from the io-threads.

Request-Entities are fully buffered in memory, thus HttpAsyncClient is unsuitable for very large uploads. Response-Entities are buffered in memory, except if requesting a Response, InputStream or Reader as Result. For large downloads or COMET, one of these three return types must be requested, but there may be a performance penalty because the response-body is transferred piecewise from the io-threads. When using InvocationCallbacks, the response is always fully buffered in memory.

### 50.3.6. Jetty Client Engine

As a drop in replacement, RESTEasy allows selecting a Jetty 9.4+ based HTTP engine. The Jetty implementation is newer and less tested, but it may end up being a good choice when relying on Jetty as server side already. The Jetty Server can even share execution resources with Client libraries if configured to use e.g. the same QueuedThreadPool.

The Jetty engine is enabled by adding a dependency to the `org.jboss.resteasy:resteasy-client-jetty` artifact to the Maven project; then the client can be built as follows:

```java
ResteasyClient client = ((ResteasyClientBuilder)ClientBuilder.newBuilder()).clientEngine(     new JettyClientEngine(new HttpClient())).build();
```

### 50.3.7. Vertx Client Engine

Still as a drop in replacement, RESTEasy allows selecting a Vert.x-based HTTP engine. The Vert.x implementation can perform asynchronous client invocations. It provides the following features:

- HTTP/1.1
- HTTP/2
- SSL/TLS (including native SSL engine)
- Efficient client connection pooling
- Optional native IO on Linux and BSD for greater performance
- Domain sockets
- HTTP Metrics with Dropwizard or Micrometer

The Vert.x engine is enabled by adding a dependency to the `org.jboss.resteasy:resteasy-client-vertx` artifact to the Maven project; then the client can be built as follows:
VertxClientHttpEngine engine = new VertxClientHttpEngine();
ResteasyClient client = ((ResteasyClientBuilder)ClientBuilder.newBuilder())
   .clientEngine(engine).build();

A Vert.x instance can also be provided when creating the client engine, as well as options configuration:

HttpClientOptions options = new HttpClientOptions()
   .setSsl(true)
   .setTrustStoreOptions(new JksOptions()
      .setPath("/path/to/your/truststore.jks")
      .setPassword("password-of-your-truststore")
   );
VertxClientHttpEngine engine = new VertxClientHttpEngine(vertx, options);

You can read more about HttpClient configuration here [https://vertx.io/docs/vertx-core/ja-va/#_making_requests].

50.3.8. Reactor Netty Client Engine

Still as a drop in replacement, RESTEasy allows selecting a Reactor Netty based HTTP engine. The Reactor Netty implementation is newer and less tested, but can be a good choice if the user application is already depending on Netty and performs asynchronous client invocations.

The Reactor Netty engine is enabled by adding a dependency to the org.jboss.resteasy:resteasy-client-reactor-netty artifact to the Maven project; then the client can be built as follows:

ReactorNettyClientHttpEngine engine = new ReactorNettyClientHttpEngine(
   HttpClient.create(),
   new DefaultChannelGroup(new DefaultEventExecutor()),
   HttpResources.get());
ResteasyClient client = ((ResteasyClientBuilder)ClientBuilder.newBuilder())
   .clientEngine(engine).build();

When coupled with the MonoRxInvoker, this has several benefits. It supports things like this:

webTarget.path("/foo").get().rx(MonoRxInvoker.class).map(...).subscribe()

in order to achieve non-blocking HTTP client calls. This allows leveraging some reactor features:
• the ability for a Mono#timeout set on the response to aggressively terminate the HTTP request;
• the ability to pass a (reactor) context from client calls into ReactorNettyClientHttpEngine.

For some sample code, see org.jboss.resteasy.reactor.ReactorTest in the RESTEasy module resteasy-reactor.

50.4. Client Utilities

The client utilities contain various client side helpers that can be registered on a client. These utilities do not require RESTEasy and can be used with any Jakarta RESTful Web Services implementation.

50.4.1. Client Authentication

The client authentication utilities can be used on a client when an endpoint requires authentication. Currently, BASIC and DIGEST authentication are supported.

```java
try {
  Client client = ClientBuilder.newBuilder()
      .register(HttpAuthenticators.basic(UserCredentials.clear("user", new char[] {'p', 'a', 's', 's', 'w', 'o', 'r', 'd'})))
    .build();

  final Response response = client.target("https://example.com/api/info")
    .request(MediaType.APPLICATION_JSON_TYPE)
    .get();
}
```

```java
final Response response = client.target("https://example.com/api/info")
    .register(HttpAuthenticators.digest(UserCredentials.clear("user", new char[] {'p', 'a', 's', 's', 'w', 'o', 'r', 'd'})))
    .request(MediaType.APPLICATION_JSON_TYPE)
    .get();
```
As the microservices style of system architecture (see, for example, Microservices [https://martinfowler.com/articles/microservices.html] by Martin Fowler) gains increasing traction, new API standards are coming along to support it. One set of such standards comes from the Microprofile Project [https://microprofile.io/] supported by the Eclipse Foundation, and among those is one, MicroProfile Rest Client [https://microprofile.io/project/eclipse/microprofile-rest-client], of particular interest to RESTEasy and Jakarta RESTful Web Services. In fact, it is intended to be based on, and consistent with, Jakarta RESTful Web Services, and it includes ideas already implemented in RESTEasy. For a more detailed description of MicroProfile Rest Client, see https://github.com/eclipse/microprofile-rest-client. In particular, the API code is in https://github.com/eclipse/microprofile-rest-client/tree/master/api and the specification is in https://github.com/eclipse/microprofile-rest-client/tree/master/spec.

**IMPORTANT:** As of RESTEasy 5.0.0 the MicroProfile integration has moved to a new project, group id, artifact id and version. The new group id is org.jboss.resteasy.microprofile. The artifact id for the client is now microprofile-client. To use the MicroProfile Config sources the artifact id is microprofile-config. Finally for context propagation the new artifact is is microprofile-context-propagation.

You could also use the RESTEasy MicroProfile BOM:

```xml
<dependency>
  <groupId>org.jboss.resteasy.microprofile</groupId>
  <artifactId>resteasy-microprofile-bom</artifactId>
  <version>${version.org.jboss.resteasy.microprofile}</version>
</dependency>
```

51.1. Client proxies

One of the central ideas in MicroProfile Rest Client is a version of *distributed object communication*, a concept implemented in, among other places, CORBA [http://www.corba.org/orb_basics.htm], Java RMI, the JBoss Remoting project, and RESTEasy. Consider the resource

```java
@Path("resource")
public class TestResource {

    @Path("test")
    @GET
    String test() {
        return "test";
    }
}
```
The Jakarta RESTful Web Services native way of accessing `TestResource` looks like

```java
Client client = ClientBuilder.newClient();
String response = client.target("http://localhost:8081/test").request().get(String.class);
```

The call to `TestResource.test()` is not particularly onerous, but calling `test()` directly allows a more natural syntax. That is exactly what Microprofile Rest Client supports:

```java
@Path("resource")
public interface TestResourceIntf {
    
    @Path("test")
    @GET
    public String test();
}

TestResourceIntf service = RestClientBuilder.newBuilder()
    .baseUrl("http://localhost:8081/")
    .build(TestResourceIntf.class);
String s = service.test();
```

The first four lines of executable code are spent creating a proxy, `service`, that implements `TestResourceIntf`, but once that is done, calls on `TestResource` can be made very naturally in terms of `TestResourceIntf`, as illustrated by the call `service.test()`.

Beyond the natural syntax, another advantage of proxies is the way the proxy construction process quietly gathers useful information from the implemented interface and makes it available for remote invocations. Consider a more elaborate version of `TestResourceIntf`:

```java
@Path("resource")
public interface TestResourceIntf2 {

    @Path("test/{path}")
    @Produces("text/html")
    @Consumes("text/plain")
    @POST
    public String test(@PathParam("path") String path, @QueryParam("query") String query, String entity);
}
```

Calling `service.test("p", "q", "e")` results in an HTTP message that looks like
The HTTP verb is derived from the `@POST` annotation, the request URI is derived from the two instances of the `@Path` annotation (one on the class, one on the method) plus the first and second parameters of `test()`, the Accept header is derived from the `@Produces` annotation, and the Content-Type header is derived from the `@Consumes` annotation.

Using the Jakarta RESTful Web Services API, `service.test("p", "q", "e")` would look like the more verbose

```java
Client client = ClientBuilder.newClient();
    .queryParam("query", "q")
    .request()
    .accept("text/html")
    .post(Entity.entity("e", "text/plain"), String.class);
```

One other basic facility offered by MicroProfile Rest Client is the ability to configure the client environment by registering providers:

```java
TestResourceIntf service = RestClientBuilder.newBuilder()
    .baseUrl("http://localhost:8081/")
    .register(MyClientResponseFilter.class)
    .register(MyMessageBodyReader.class)
    .build(TestResourceIntf.class);
```

Naturally, the registered providers should be relevant to the client environment, rather than, say, a `ContainerResponseFilter`.

**Note**

So far, the MicroProfile Rest Client should look familiar to anyone who has used the RESTEasy client proxy facility (Section "RESTEasy Proxy Framework"). The construction in the previous listing would look like

```java
ResteasyClient client = (ResteasyClient) ResteasyClientBuilder.newClient();
```
TestResourceIntf service = client.target("http://localhost:8081/")
    .register(MyClientResponseFilter.class)
    .register(MyMessageBodyReader.class)
    .proxy(TestResourceIntf.class);

in RESTEasy.

51.2. Concepts imported from Jakarta RESTful Web Services

Beyond the central concept of the client proxy, some basic concepts in MicroProfile Client originate in Jakarta RESTful Web Services. Some of these have already been introduced in the previous section, since the interface implemented by a client proxy represents the facilities provided by a Jakarta RESTful Web Services server. For example, the HTTP verb annotations and the @Consumes and @Produces annotations originate on the Jakarta RESTful Web Services server side. Injectable parameters annotated with @PathParameter, @QueryParameter, etc., also come from Jakarta RESTful Web Services.

Nearly all of the provider concepts supported by MicroProfile Client also originate in Jakarta RESTful Web Services. These are:

- jakarta.ws.rs.client.ClientRequestFilter
- jakarta.ws.rs.client.ClientResponseFilter
- jakarta.ws.rs.ext.MessageBodyReader
- jakarta.ws.rs.ext.MessageBodyWriter
- jakarta.ws.rs.ext.ParamConverter
- jakarta.ws.rs.ext.ReaderInterceptor
- jakarta.ws.rs.ext.WriterInterceptor

Like Jakarta RESTful Web Services, MicroProfile Client also has the concept of mandated providers. These are:

- JSON-P MessageBodyReader and MessageBodyWriter must be provided.
- JSON-B MessageBodyReader and MessageBodyWriter must be provided if the implementation supports JSON-B.
- MessageBodyReader and MessageBodyWriter must be provided for the following types:
  - byte[]
  - String
Some concepts in MicroProfile Rest Client do not appear in either Jakarta RESTful Web Services or RESTEasy.

1. Default media type

Whenever no media type is specified by, for example, @Consumes or @Produces annotations, the media type of a request entity or response entity is "application/json". This is different than Jakarta RESTful Web Services, where the media type defaults to "application/octet-stream".

2. Declarative registration of providers

In addition to programmatic registration of providers as illustrated above, it is also possible to register providers declaratively with annotations introduced in MicroProfile Rest Client. In particular, providers can be registered by adding the org.eclipse.microprofile.rest.client.annotation.RegisterProvider annotation to the target interface:

```java
@Path("resource")
@RegisterProvider(MyClientResponseFilter.class)
@RegisterProvider(MyMessageBodyReader.class)
public interface TestResourceIntf2 {

@Path("test/{path}")
@Consumes("text/plain")
@Produces("text/html")
@POST
public String test(@PathParam("path") String path, @QueryParam("query") String query, String entity);
}
```

Declaring MyClientResponseFilter and MyMessageBodyReader with annotations eliminates the need to call RestClientBuilder.register().

3. Global registration of providers

One more way to register providers is by implementing one or both of the listeners in package org.eclipse.microprofile.rest.client.spi:
which can access a `RestClientBuilder` upon creation of a new `RestClientBuilder` or upon the execution of `RestClientBuilder.build()`, respectively. Implementations must be declared in

```
META-INF/services/org.eclipse.microprofile.rest.client.spi.RestClientBuilderListener
```

or

```
META-INF/services/org.eclipse.microprofile.rest.client.spi.RestClientListener
```

### 4. Declarative specification of headers

One way of declaring a header to be included in a request is by annotating one of the resource method parameters with `@HeaderValue`:

```
@POST
@Produces(MediaType.TEXT_PLAIN)
@Consumes(MediaType.TEXT_PLAIN)
String contentLang(@HeaderParam(HttpHeaders.CONTENT_LANGUAGE) String contentLanguage, String subject);
```

That option is available with RESTEasy client proxies as well, but in case it is inconvenient or otherwise inappropriate to include the necessary parameter, MicroProfile Client makes a declarative alternative available through the use of the `org.eclipse.microprofile.rest.client.annotation.ClientHeaderParam` annotation:

```
@POST
@Produces(MediaType.TEXT_PLAIN)
@Consumes(MediaType.TEXT_PLAIN)
@ClientHeaderParam(name=HttpHeaders.CONTENT_LANGUAGE, value="en")
In this example, the header value is hardcoded, but it is also possible to compute a value:

```java
@POST
@Produces(MediaType.TEXT_PLAIN)
@Consumes(MediaType.TEXT_PLAIN)
@ClientHeaderParam(name=HttpHeaders.CONTENT_LANGUAGE, value="{getLanguage}")
String contentLang(String subject);

default String getLanguage() {
    return ...;
}
```

5. Propagating headers on the server

An instance of `org.eclipse.microprofile.rest.client.ext.ClientHeadersFactory`,

```java
public interface ClientHeadersFactory {

/**
 * Updates the HTTP headers to send to the remote service. Note that providers
 * on the outbound processing chain could further update the headers.
 * @param incomingHeaders - the map of headers from the inbound Jakarta RESTful Web Services
 * request. This will
 * be an empty map if the associated client interface is not part of a Jakarta RESTful Web
 * Services request.
 * @param clientOutgoingHeaders - the read-only map of header parameters specified on the
 * client interface.
 * @return a map of HTTP headers to merge with the clientOutgoingHeaders to be sent to
 * the remote service.
 */
MultivaluedMap<String, String> update(MultivaluedMap<String, String> incomingHeaders,
                                         MultivaluedMap<String, String> clientOutgoingHeaders);
}
```

if activated, can do a bulk transfer of incoming headers to an outgoing request. The default instance `org.eclipse.microprofile.rest.client.ext.DefaultClientHeadersFactoryImpl` will return a map consisting of those incoming headers listed in the comma separated configuration property

```java
org.eclipse.microprofile.rest.client.propagateHeaders
```
In order for an instance of ClientHeadersFactory to be activated, the interface must be annotated with org.eclipse.microprofile.rest.client.annotation.RegisterClientHeaders. Optionally, the annotation may include a value field set to an implementation class; without an explicit value, the default instance will be used.

Although a ClientHeadersFactory is not officially designated as a provider, it is now (as of MicroProfile REST Client specification 1.4) subject to injection. In particular, when an instance of ClientHeadersFactory is managed by CDI, then CDI injection is mandatory. When a REST Client is executing in the context of a Jakarta RESTful Web Services implementation, then @Context injection into a ClientHeadersFactory is currently optional. RESTEasy supports CDI injection and does not currently support @Context injection.

### 6. ResponseExceptionMapper

The org.eclipse.microprofile.rest.client.ext.ResponseExceptionMapper is the client side inverse of the jakarta.ws.rs.ext.ExceptionMapper defined in Jakarta RESTful Web Services. That is, where ExceptionMapper.toResponse() turns an Exception thrown during server side processing into a Response, ResponseExceptionMapper.toThrowable() turns a Response received on the client side with an HTTP error status into an Exception. ResponseExceptionMappers can be registered in the same manner as other providers, that is, either programmatically or declaratively. In the absence of a registered ResponseExceptionMapper, a default ResponseExceptionMapper will map any response with status >= 400 to a WebApplicationException.

### 7. Proxy injection by CDI

MicroProfile Rest Client mandates that implementations must support CDI injection of proxies. At first, the concept might seem odd in that CDI is more commonly available on the server side. However, the idea is very consistent with the microservices philosophy. If an application is composed of a number of small services, then it is to be expected that services will often act as clients to other services.

CDI (Contexts and Dependency Injection) is a fairly rich subject and beyond the scope of this Guide. For more information, see Jakarta Contexts and Dependency Injection [https://jakarta.ee/specifications/cdi/3.0/jakarta-cdi-spec-3.0.html] (the specification), Jakarta EE Tutorial [https://eclipse-ee4j.github.io/jakartaeetutorial/], or WELD - CDI Reference Implementation [https://docs.jboss.org/weld/reference/latest-3.1/en-US/html_single/].

The fundamental thing to know about CDI injection is that annotating a variable with jakarta.inject.Inject will lead the CDI runtime (if it is present and enabled) to create an object of the appropriate type and assign it to the variable. For example, in

```java
public interface Book {
    public String getTitle();
    public void setTitle(String title);
}
```
public class BookImpl implements Book {
    private String title;

    @Override
    public String getTitle() {
        return title;
    }

    @Override
    public void setTitle(String title) {
        this.title = title;
    }
}

public class Author {
    @Inject private Book book;

    public Book getBook() {
        return book;
    }
}

The CDI runtime will create an instance of BookImpl and assign it to the private field book when an instance of Author is created;

In this example, the injection is done because BookImpl is assignable to book, but greater discrimination can be imposed by annotating the interface and the field with qualifier annotations. For the injection to be legal, every qualifier on the field must be present on the injected interface. For example:

@Qualifier
@Target({ElementType.TYPE, ElementType.METHOD, ElementType.PARAMETER, ElementType.FIELD})
@Retention(RetentionPolicy.RUNTIME)
public @interface Text {}

@Qualifier
@Target({ElementType.TYPE, ElementType.METHOD, ElementType.PARAMETER, ElementType.FIELD})
@Retention(RetentionPolicy.RUNTIME)
public @interface Graphic {}

@Text
public class TextBookImpl extends BookImpl {
}

@Graphic
public class GraphicNovelImpl extends BookImpl {
}

public class Genius {
    @Inject @Graphic Book book;
}
Here, the class `TextBookImpl` is annotated with the `@Text` qualifier and `GraphicNovelImpl` is annotated with `@Graphic`. It follows that an instance of `GraphicNovelImpl` is eligible for assignment to the field `book` in the `Genius` class, but an instance of `TextBookImpl` is not.

Now, in MicroProfile Rest Client, any interface that is to be managed as a CDI bean must be annotated with `@RegisterRestClient`:

```java
@Path("resource")
@RegisterProvider(MyClientResponseFilter.class)
public static class TestResourceImpl {

    @Inject TestDataBase db;

    @Path("/test/{path}")
    @Consumes("text/plain")
    @Produces("text/html")
    @POST
    public String test(@PathParam("path") String path, @QueryParam("query") String query, String entity) {
        return db.getByName(query);
    }
}

@Path("database")
@RegisterRestClient
public interface TestDataBase {

    @Path("/")
    @POST
    public String getByName(String name);
}
```

Here, the MicroProfile Rest Client implementation creates a proxy for a `TestDataBase` service, allowing easy access by `TestResourceImpl`. Notice, though, that there’s no indication of where the `TestDataBase` implementation lives. That information can be supplied by the optional `@RegisterProvider` parameter `baseUri`:

```java
@Path("database")
@RegisterRestClient(baseUri="https://localhost:8080/webapp")
public interface TestDataBase {

    @Path("/")
    @POST
    public String getByName(String name);
}
```

which indicates that an implementation of `TestDatabase` can be accessed at `https://localhost:8080/webapp`. The same information can be supplied externally with the system variable
<fqn of TestDataBase>/mp-rest/url=<URL>

or

<fqn of TestDataBase>/mp-rest/url=<URL>

which will override the value hardcoded in @RegisterRestClient. For example,

```java
```

A number of other properties will be examined in the course of creating the proxy, including, for example

```java
com.bluemonkeydiamond.TestDatabase/mp-rest/providers
```

a comma separated list of provider classes to be registered with the proxy. See the MicroProfile Client documentation for more such properties.

These properties can be simplified through the use of the configKey field in @RegisterRestClient. For example, setting the configKey as in

```java
@Path("database")
@RegisterRestClient(configKey="bmd")
public interface TestDataBase { ... }
```

allows the use of properties like

```java
bmd/mp-rest/url=https://localhost:8080/webapp
```

Note that, since the configKey is not tied to a particular interface name, multiple proxies can be configured with the same properties.
8. Proxy lifecycle

Proxies should be closed so that any resources they hold can be released. Every proxy created by `RestClientBuilder` implements the `java.io.Closeable` interface, so it is always possible to cast a proxy to `Closeable` and call `close()`. A nice trick to have the proxy interface explicitly extend `Closeable`, which not only avoids the need for a cast but also makes the proxy eligible to use in a try-with-resources block:

```java
@Path("resource")
public interface TestResourceIntf extends Closeable {

    @Path("test")
    @GET
    public String test();
}

TestResourceIntf service = RestClientBuilder.newBuilder()
    .baseUrl("http://localhost:8081")
    .build(TestResourceIntf.class);
try (TestResourceIntf tr = service) {
    String s = service.test();
}
```

9. Asynchronous support

An interface method can be designated as asynchronous by having it return a `java.util.concurrent.CompletionStage`. For example, in

```java
public interface TestResourceIntf extends Closeable {

    @Path("test")
    @GET
    public String test();

    @Path("testasync")
    @GET
    public CompletionStage<String> testAsync();
}
```

the `test()` method can be turned into the asynchronous method `testAsync()` by having it return a `CompletionStage<String>` instead of a `String`.

Asynchronous methods are made to be asynchronous by scheduling their execution on a thread distinct from the calling thread. The MicroProfile Client implementation will have a default means of doing that, but `RestClientBuilder.executorService(ExecutorService)` provides a way of substituting an application specific `ExecutorService`. 
The classes AsyncInvocationInterceptorFactory and AsyncInvocationInterceptor in package org.eclipse.microprofile.rest.client.ext provides a means of communication between the calling thread and the asynchronous thread:

```java
public interface AsyncInvocationInterceptorFactory {
    /**
     * Implementations of this method should return an implementation of the
     * AsyncInvocationInterceptor interface. The MP Rest Client
     * implementation runtime will invoke this method, and then invoke the
     * prepareContext and applyContext methods of the
     * returned interceptor when performing an asynchronous method invocation.
     * Null return values will be ignored.
     * @return Non-null instance of AsyncInvocationInterceptor
     */
    AsyncInvocationInterceptor newInterceptor();
}

public interface AsyncInvocationInterceptor {
    /**
     * This method will be invoked by the MP Rest Client runtime on the "main"
     * thread (i.e. the thread calling the async Rest Client interface method)
     * prior to returning control to the calling method.
     */
    void prepareContext();

    /**
     * This method will be invoked by the MP Rest Client runtime on the "async"
     * thread (i.e. the thread used to actually invoke the remote service and
     * wait for the response) prior to sending the request.
     */
    void applyContext();

    /**
     * This method will be invoked by the MP Rest Client runtime on the "async"
     * thread (i.e. the thread used to actually invoke the remote service and
     * wait for the response) after all providers on the inbound response flow
     * have been invoked.
     * @since 1.2
     */
    void removeContext();
}
```

The following sequence of events occurs:

1. AsyncInvocationInterceptorFactory.newInterceptor() is called on the calling thread to get an instance of the AsyncInvocationInterceptor.

2. AsyncInvocationInterceptor.prepareContext() is executed on the calling thread to store information to be used by the request execution.
3. `AsyncInvocationInterceptor.applyContext()` is executed on the asynchronous thread.

4. All relevant outbound providers such as interceptors and filters are executed on the asynchronous thread, followed by the request invocation.

5. All relevant inbound providers are executed on the asynchronous thread, followed by executing `AsyncInvocationInterceptor.removeContext()`.

6. The asynchronous thread returns.

An `AsyncInvocationInterceptorFactory` class is enabled by registering it on the client interface with `@RegisterProvider`.

10. SSL

The MicroProfile Client `RestClientBuilder` interface includes a number of methods that support the use of SSL:

```java
RestClientBuilder hostnameVerifier(HostnameVerifier hostnameVerifier);
RestClientBuilder keyStore(KeyStore keyStore, String keystorePassword);
RestClientBuilder sslContext(SSLContext sslContext);
RestClientBuilder trustStore(KeyStore trustStore);
```

For example:

```java
KeyStore trustStore = ... ;
HostnameVerifier verifier ... ;
TestResourceIntf service = RestClientBuilder.newBuilder()
  .baseUrl("http://localhost:8081/")
  .trustStore(trustStore)
  .hostnameVerifier(verifier)
  .build(TestResourceIntf.class);
```

It is also possible to configure `HostnameVerifier`, `KeyStore`, and `TrustStore` using configuration properties:

- `com.bluemonkeydiamond.TestResourceIntf/mp-rest/hostnameVerifier`
- `com.bluemonkeydiamond.TestResourceIntf/mp-rest/keyStore`
- `com.bluemonkeydiamond.TestResourceIntf/mp-rest/keyStorePassword`
- `com.bluemonkeydiamond.TestResourceIntf/mp-rest/keyStoreType`
- `com.bluemonkeydiamond.TestResourceIntf/mp-rest/trustStore`
- `com.bluemonkeydiamond.TestResourceIntf/mp-rest/trustStorePassword`
• com.bluemonkeydiamond.TestResourceIntf/mp-rest/trustStoreType

The values of the 
"../mp-rest/keyStore" and "../mp-rest/trustStore" parameters can be either classpath resources (e.g., "classpath:/client-keystore.jks") or files (e.g., "file:/home/user/client-keystore.jks").
Chapter 52. AJAX Client

RESTEasy resources can be accessed in JavaScript using AJAX using a proxy API generated by RESTEasy.

52.1. Generated JavaScript API

RESTEasy can generate a JavaScript API that uses AJAX calls to invoke Jakarta RESTful Web Services operations.

Example 52.1. First Jakarta RESTful Web Services JavaScript API example

Let's take a simple Jakarta RESTful Web Services API:

```java
@Path("orders")
public interface Orders {
  @Path("{id}")
  @GET
  public String getOrder(@PathParam("id") String id)
  { return "Hello " + id; }
}
```

The preceding API would be accessible using the following JavaScript code:

```javascript
var order = Orders.getOrder({id: 23});
```

52.1.1. JavaScript API servlet

In order to enable the JavaScript API servlet the user must configure it in the web.xml file as such:

```xml
<servlet>
  <servlet-name>RESTEasy JSAPI</servlet-name>
  <servlet-class>org.jboss.resteasy.jsapi.JSAPIServlet</servlet-class>
</servlet>

<servlet-mapping>
  <servlet-name>RESTEasy JSAPI</servlet-name>
  <url-pattern>/rest-js</url-pattern>
</servlet-mapping>
```
52.1.2. JavaScript API usage

Each Jakarta RESTful Web Services resource class will generate a JavaScript object of the same name as the declaring class (or interface), which will contain every Jakarta RESTful Web Services method as properties.

Example 52.2. Structure of Jakarta RESTful Web Services generated JavaScript

For example, if the Jakarta RESTful Web Services resource X defines methods Y and Z:

```java
@Path("/")
public interface X{
    @GET
    public String  Y();
    @PUT
    public void  Z(String entity);
}
```

Then the JavaScript API will define the following functions:

```javascript
var X = {
    Y : function(params){…},
    Z : function(params){…}
};
```

Each JavaScript API method takes an optional object as single parameter where each property is a cookie, header, path, query or form parameter as identified by their name, or the following special parameters:

**Warning**
The following special parameter names are subject to change.

<table>
<thead>
<tr>
<th>Property name</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$entity</td>
<td></td>
<td>The entity to send as a PUT, POST request.</td>
</tr>
<tr>
<td>$contentType</td>
<td>As determined by @Consumes.</td>
<td>The MIME type of the body entity sent as the Content-Type header.</td>
</tr>
<tr>
<td>$accepts</td>
<td>Determined by @Provides, defaults to &quot;/&quot;.</td>
<td>The accepted MIME types sent as the Accept header.</td>
</tr>
<tr>
<td>Property name</td>
<td>Default</td>
<td>Description</td>
</tr>
<tr>
<td>---------------</td>
<td>---------</td>
<td>-------------</td>
</tr>
<tr>
<td>$callback</td>
<td></td>
<td>Set to a function(httpCode, XMLHttpRequest, value) for an asynchronous call. If not present, the call will be synchronous and return the value.</td>
</tr>
<tr>
<td>$apiURL</td>
<td>Determined by container</td>
<td>Set to the base URI of your Jakarta RESTful Web Services endpoint, not including the last slash.</td>
</tr>
<tr>
<td>$username</td>
<td></td>
<td>If username and password are set, they will be used for credentials for the request.</td>
</tr>
<tr>
<td>$password</td>
<td></td>
<td>If username and password are set, they will be used for credentials for the request.</td>
</tr>
</tbody>
</table>

Example 52.3. Using the API

Here is an example of Jakarta RESTful Web Services API:

```java
@Path("foo")
public class Foo{
    @Path("{id}")
    @GET
    public String get(@QueryParam("order") String order, @HeaderParam("X-Foo") String header, @MatrixParam("colour") String colour, @CookieParam("Foo-Cookie") String cookie){
        
    }
    @POST
    public void post(String text){
    }
}
```

We can use the previous Jakarta RESTful Web Services API in JavaScript using the following code:

```javascript
var text = Foo.get({order: 'desc', 'X-Foo': 'hello',
    colour: 'blue', 'Foo-Cookie': 123987235444});
Foo.put({$entity: text});
```
52.1.3. Work with @Form

@Form is a RESTEasy specific annotation that allows the user to re-use any @*Param annotation within an injected class. The generated JavaScript API will expand the parameters for use automatically. Support we have the following form:

```java
public class MyForm {
    @FormParam("stuff")
    private String stuff;

    @FormParam("number")
    private int number;

    @HeaderParam("myHeader")
    private String header;
}
```

And the resource is like:

```java
@Path("/")
public class MyResource {

    @POST
    public String postForm(@Form MyForm myForm) {
    }

}
```

Then the method can be called from JavaScript API like following:

```javascript
MyResource.postForm({ stuff:"A", myHeader:"B", number:1 });
```

Also, @Form supports prefix mappings for lists and maps:

```java
public static class Person {
    @Form(prefix="telephoneNumbers") List<TelephoneNumber> telephoneNumbers;
    @Form(prefix="address") Map<String, Address> addresses;
}

public static class TelephoneNumber {
    @FormParam("countryCode") private String countryCode;
    @FormParam("number") private String number;
}

public static class Address {
    @FormParam("street") private String street;
    @FormParam("houseNumber") private String houseNumber;
}
@Path("person")
public static class MyResource {
  @POST
  public void postForm(@Form Person p) {...}
}

From JavaScript the API could be called like this:

```javascript
MyResource.postForm({
  telephoneNumbers:[
    {"telephoneNumbers[0].countryCode":31},
    {"telephoneNumbers[0].number":12345678},
    {"telephoneNumbers[1].countryCode":91},
    {"telephoneNumbers[1].number":9717738723}
  ],
  address:[
    {"address[INVOICE].street":"Main Street"},
    {"address[INVOICE].houseNumber":2},
    {"address[SHIPPING].street":"Square One"},
    {"address[SHIPPING].houseNumber":13}
  ]
});
```

52.1.4. MIME types and unmarshalling.

The Accept header sent by any client JavaScript function is controlled by the $accepts parameter, which overrides the @Produces annotation on the Jakarta RESTful Web Services endpoint. The returned value however is controlled by the Content-Type header sent in the response as follows:

<table>
<thead>
<tr>
<th>MIME</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>text/xml,application/xml,application/*+xml</td>
<td>The response entity is parsed as XML before being returned. The return value is thus a DOM Document.</td>
</tr>
<tr>
<td>application/json</td>
<td>The response entity is parsed as JSON before being returned. The return value is thus a JavaScript Object.</td>
</tr>
<tr>
<td>Anything else</td>
<td>The response entity is returned raw.</td>
</tr>
</tbody>
</table>

Example 52.4. Unmarshalling example

The RESTEasy JavaScript client API can automatically unmarshall JSON and XML:

@Path("orders")
public interface Orders {
Let's look at what the preceding Jakarta RESTful Web Services API would give on the client side:

// this returns a JSON object
var orderJSON = Orders.getOrderJSON({id: "23"});
orderJSON.id == "23";

// this one returns a DOM Document whose root element is the order, with one child (id) whose child is the text node
var orderXML = Orders.getOrderXML({id: "23"});
orderXML.documentElement.childNodes[0].childNodes[0].nodeValue == "23";

// this one returns a DOM Document whose root element is the order, with one child (id) whose child is the text node
var orderXML = Orders.getOrderXML({id: "23"});
orderXML.documentElement.childNodes[0].childNodes[0].nodeValue == 52.1.5. MIME types and marshalling.

The Content-Type header sent in the request is controlled by the $contentType parameter which overrides the @Consumes annotation on the Jakarta RESTful Web Services endpoint. The value passed as entity body using the $entity parameter is marshalled according to both its type and content type:
Your text
52.2. Using the JavaScript API to build AJAX queries

The RESTEasy JavaScript API can also be used to manually construct your requests.

52.2.1. The REST object

The REST object contains the following read-write properties:

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>apiURL</td>
<td>Set by default to the Jakarta RESTful Web Services root URL, used by every JavaScript client API functions when constructing the requests.</td>
</tr>
<tr>
<td>log</td>
<td>Set to a function(string) in order to receive RESTEasy client API logs. This is useful to debug the client API and place the logs where you can see them.</td>
</tr>
</tbody>
</table>

Example 52.6. Using the REST object

The REST object can be used to override RESTEasy JavaScript API client behaviour:

```javascript
// Change the base URL used by the API:
REST.apiURL = "http://api.service.com";

// log everything in a div element
REST.log = function(text){
    jQuery("#log-div").append(text);
};
```

52.2.2. The REST.Request class

The REST.Request class is used to build custom requests. It has the following members:
Table 52.5. The REST.Request class

<table>
<thead>
<tr>
<th>Member</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>execute(callback)</td>
<td>Executes the request with all the information set in the current object. The value is never returned but passed to the optional argument callback.</td>
</tr>
<tr>
<td>setAccepts(acceptHeader)</td>
<td>Sets the Accept request header. Defaults to <em>/</em>.</td>
</tr>
<tr>
<td>setCredentials(username, password)</td>
<td>Sets the request credentials.</td>
</tr>
<tr>
<td>setEntity(entity)</td>
<td>Sets the request entity.</td>
</tr>
<tr>
<td>setContentType(contentTypeHeader)</td>
<td>Sets the Content-Type request header.</td>
</tr>
<tr>
<td>setURI(uri)</td>
<td>Sets the request URI. This should be an absolute URI.</td>
</tr>
<tr>
<td>setMethod(method)</td>
<td>Sets the request method. Defaults to GET.</td>
</tr>
<tr>
<td>setAsync(async)</td>
<td>Controls whether the request should be asynchronous. Defaults to true.</td>
</tr>
<tr>
<td>addCookie(name, value)</td>
<td>Sets the given cookie in the current document when executing the request. Beware that this will be persistent in your browser.</td>
</tr>
<tr>
<td>addQueryParameter(name, value)</td>
<td>Adds a query parameter to the URI query part.</td>
</tr>
<tr>
<td>addMatrixParameter(name, value)</td>
<td>Adds a matrix parameter (path parameter) to the last path segment of the request URI.</td>
</tr>
<tr>
<td>addHeader(name, value)</td>
<td>Adds a request header.</td>
</tr>
</tbody>
</table>

Example 52.7. Using the REST.Request class

The REST.Request class can be used to build custom requests:

```javascript
var r = new REST.Request();
r.setURI("http://api.service.com/orders/23/json");
r.setMethod("PUT");
r.setContentType("application/json");
r.setEntity({id: "23"});
r.addMatrixParameter("JSESSIONID", "12309812378123");
r.execute(function(status, request, entity){
  log("Response is ", status);
});
```

52.3. Caching Features

RESTEasy AJAX Client works well with server side caching features. But the buggy browsers cache will always prevent the function to work properly. To use the RESTEasy caching feature with its AJAX client, enable the 'antiBrowserCache' option:
The above setting should be set once before calling any APIs.
Chapter 53. RESTEasy WADL Support

RESTEasy has support to generate WADL for its resources. It supports several different containers. The following text shows how to use this feature in different containers.

53.1. RESTEasy WADL Support for Servlet Container (Deprecated)

Note

The content introduced in this section is outdated, and the ResteasyWadlServlet class is deprecated because it doesn’t support the GRAMMAR generation. Please check the ResteasyWadlDefaultResource introduced in the later section.

RESTEasy WADL uses ResteasyWadlServlet to support servlet container. It must be registered in the web.xml to enable WADL feature. Here is an example to show the usages of ResteasyWadlServlet in web.xml:

```
<servlet>
  <servlet-name>RESTEasy WADL</servlet-name>
  <servlet-class>org.jboss.resteasy.wadl.ResteasyWadlServlet</servlet-class>
</servlet>

<servlet-mapping>
  <servlet-name>RESTEasy WADL</servlet-name>
  <url-pattern>/application.xml</url-pattern>
</servlet-mapping>
```

The preceding configuration in web.xml shows how to enable ResteasyWadlServlet and map it to /application.xml, so then the WADL can be accessed from the configured URL:

```
/application.xml
```

53.2. RESTEasy WADL Support for Servlet Container (Updated)

This section introduces the recommended way to enable WADL support in a Servlet Container. First, add a class that extends the ResteasyWadlDefaultResource to serve a resource path. Here is an example:
As the sample shows above, it implements the `ResteasyWadlDefaultResource` and serves this URL by default:

```
/application.xml
```

To enable the GRAMMAR generation, extend the `ResteasyWadlDefaultResource` like this:

```
public class MyWadlResource extends ResteasyWadlDefaultResource {
    public MyWadlResource()
    {
        ResteasyWadlGrammar wadlGrammar = new ResteasyWadlWriter.ResteasyWadlGrammar();
        wadlGrammar.enableSchemaGeneration();
        getWadlWriter().setWadlGrammar(wadlGrammar);
    }
}
```

With the above setup, the WADL module will generate GRAMMAR automatically and register the service under this url:

```
/wadl-extended/xsd0.xsd
```

Above is the basic usage of the WADL module under a servlet container deployment.
53.3. RESTEasy WADL support for Sun JDK HTTP Server

RESTEasy provides a ResteasyWadlDefaultResource to generate WADL info for its embedded containers. Here is an example to show how to use it with RESTEasy's Sun JDK HTTP Server container:

```java
com.sun.net.httpserver.HttpServer httpServer = com.sun.net.httpserver.HttpServer.create(new InetSocketAddress(port), 10);
contextBuilder.getDeployment().getActualResourceClasses().add(ResteasyWadlDefaultResource.class);
contextBuilder.bind(httpServer);
ResteasyWadlDefaultResource.getServices().put("/", ResteasyWadlGenerator.generateServiceRegistry(contextBuilder.getDeployment()));
httpServer.start();
```

From the above code example, we can see how ResteasyWadlDefaultResource is registered in the deployment:

```java
contextBuilder.getDeployment().getActualResourceClasses().add(ResteasyWadlDefaultResource.class);
```

Another important task is to use ResteasyWadlGenerator to generate the WADL info for the resources in the deployment:

```java
ResteasyWadlDefaultResource.getServices().put("/", ResteasyWadlGenerator.generateServiceRegistry(contextBuilder.getDeployment()));
```

After the above configuration is set, users can access "/application.xml" to fetch the WADL info, because ResteasyWadlDefaultResource has @PATH set to "/application.xml" as default:
53.4. RESTEasy WADL support for Netty Container

RESTEasy WADL support for Netty Container is similar to the support for JDK HTTP Server. It uses ResteasyWadlDefaultResource to serve '/application.xml' and ResteasyWadlGenerator to generate WADL info for resources. Here is the sample code:

```java
@Path("/application.xml")
public class ResteasyWadlDefaultResource

ResteasyDeployment deployment = new ResteasyDeploymentImpl();
NettyJaxrsServer netty = new NettyJaxrsServer();
netty.setDeployment(deployment);
netty.setPort(port);
netty.setRootResourcePath("");
netty.setSecurityDomain(null);
netty.start();

deployment.getRegistry().addPerRequestResource(ResteasyWadlDefaultResource.class);

ResteasyWadlDefaultResource.getServices().put("/",
    ResteasyWadlGenerator.generateServiceRegistry(deployment));
```

Please note for all embedded containers like JDK HTTP Server and Netty Container, if the resources in the deployment changes at runtime, the ResteasyWadlGenerator.generateServiceRegistry() needs to be re-run to refresh the WADL info.

53.5. RESTEasy WADL Support for Undertow Container

The RESTEasy Undertow Container is an embedded Servlet Container, and RESTEasy WADL provides a connector to it. To use RESTEasy Undertow Container together with WADL support, add these three components into project maven dependencies:

```xml
<dependency>
    <groupId>org.jboss.resteasy</groupId>
    <artifactId>resteasy-wadl</artifactId>
    <version>${project.version}</version>
</dependency>

<dependency>
    <groupId>org.jboss.resteasy</groupId>
    <artifactId>resteasy-wadl-undertow-connector</artifactId>
    <version>${project.version}</version>
</dependency>
```
The resteasy-wadl-undertow-connector provides a WadlUndertowConnector to help use WADL in RESTEasy Undertow Container. Here is the code example:

```java
UndertowJaxrsServer server = new UndertowJaxrsServer().start();
WadlUndertowConnector connector = new WadlUndertowConnector();
connector.deployToServer(server, MyApp.class);
```

The MyApp class shown in above code is a standard Jakarta RESTful Web Services Application class in your project:

```java
@ApplicationPath("/base")
public static class MyApp extends Application {
    @Override
    public Set<Class<?>> getClasses() {
        HashSet<Class<?>> classes = new HashSet<Class<?>>();
        classes.add(YourResource.class);
        return classes;
    }
}
```

After the Application is deployed to the UndertowJaxrsServer via WadlUndertowConnector, the user can access the WADL info at "/application.xml" prefixed by the @ApplicationPath in the Application class. To override the @ApplicationPath, use the other method in WadlUndertowConnector:

```java
public UndertowJaxrsServer deployToServer(UndertowJaxrsServer server, Class<? extends Application> application, String contextPath)
```

The "deployToServer" method shown above accepts a "contextPath" parameter, which can be used to override the @ApplicationPath value in the Application class.
Chapter 54. RESTEasy Tracing Feature

54.1. Overview

Tracing feature is a way for the users of the RESTEasy to understand what's going on internally in the container when a request is processed. It's different from the pure logging system or profiling feature, which provides more general information about the request and response.

The tracing feature provides more internal states of the Jakarta RESTful Web Services container. For example, it could be able to show what filters a request is going through, or how long a request is processed and other kinds of information.

Currently it doesn't have a standard or spec to define the tracing feature, so the tracing feature is tightly coupled with the concrete Jakarta RESTful Web Services implementation itself. This chapter, discusses the design and usage of the tracing feature.

54.2. Tracing Info Mode

The RESTEasy tracing feature supports three logging mode:

- OFF
- ON_DEMAND
- ALL

"ALL" will enable the tracing feature. "ON_DEMAND" mode will give the control to the client side: A client can send a tracing request via HTTP header and get the tracing info back from response headers. "OFF" mode disables the tracing feature, and is the default mode.

54.3. Tracing Info Level

The tracing info has three levels:

- SUMMARY
- TRACE
- VERBOSE

The "SUMMARY" level will emit some brief tracing information. The "TRACE" level will produce more detailed tracing information, and the "VERBOSE" level will generate extremely detailed tracing information.

The tracing feature relies on the JBoss Logging framework to produce the tracing info. The JBoss Logging configuration controls the final output of the tracing info.
54.4. Basic Usages

By default, the tracing feature is turned off. To enable the tracing feature, add the following dependency in your project:

```xml
<dependency>
    <groupId>org.jboss.resteasy</groupId>
    <artifactId>resteasy-tracing-api</artifactId>
</dependency>
```

Because the tracing feature is an optional feature, the above dependency is provided by the resteasy-extensions [https://github.com/resteasy/resteasy-extensions] project.

After including the dependency in the project, set the tracing mode and tracing level via the context-param parameters in the project's web.xml file. Here is the example:

```xml
<context-param>
    <param-name>resteasy.server.tracing.type</param-name>
    <param-value>ALL</param-value>
</context-param>
<context-param>
    <param-name>resteasy.server.tracing.threshold</param-name>
    <param-value>SUMMARY</param-value>
</context-param>
```

Besides the above configuration, the user needs to make sure that the underlying JBoss Logger is configured properly, so the tracing output can be viewed. Here is an example of the "logging.properties":

```properties
# Additional logger names to configure (root logger is always configured)
#loggers=org.foo.bar, org.foo.baz
# Root logger level
logger.level=ALL

handlers for the root logger
logger.handlers=CONSOLE, FILE

Declare handlers for additional loggers
logger.org.foo.bar.handlers=XXX, YYYY

File handler configuration
handler.CONSOLE=org.jboss.logmanager.handlers.ConsoleHandler
handler.CONSOLE.properties=autoFlush
handler.CONSOLE.level=ALL
handler.CONSOLE.autoFlush=true
handler.CONSOLE.formatter=PATTERN

handler.FILE=org.jboss.logmanager.handlers.FileHandler
handler.FILE.level=ALL
handler.FILE.properties=autoFlush, fileName
handler.FILE.autoFlush=true
handler.FILE.fileName=/tmp/jboss.log

The log format pattern for both loggers
formatter.PATTERN=org.jboss.logmanager.formatters.PatternFormatter
formatter.PATTERN.properties=pattern
formatter.PATTERN.pattern=%d{HH:mm:ss,SSS} %-5p [%c{1}] %m%n
```

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In above setting, the logger level is set to "ALL", and the output log file to "/tmp/jboss.log". This example is reporting all the tracing information.

After enabling the tracing feature above, the tracing output looks like the following:

There are several part to the entries in the log information above.
• Level Of The Log Entry

The entries log level is reported, such as "TRACE", "INFO", "DEBUG". The tracing feature maps its own tracing info levels to the JBoss Logger output levels like this.

• The Request Scope Id

A request id is listed:

```
org.jboss.resteasy.plugins.server.servlet.Servlet3AsyncHttpRequest@721299ff
```

This identifies which request the log entry belongs to.

• The Type Of The Tracing Log

tracing log entries are divided into multiple categories, such as "START_HEADERS", "REQUEST_FILTER", "FINISHED", etc.

• The Detail Of The Log Entry

The last part of a log entry is the detail message of this entry.

In next section describes how the tracing info is fetched from client side.

### 54.5. Client Side Tracing Info

From the client side, request can be sent to the server side. If the server side is configured properly to produce tracing info, the info will be sent back to client side via response headers. For example, a request is sent to the server like this:

```
$ curl -i http://localhost:8081/foo
```

The tracing information is retrieved from the response header follows:

```
HTTP/1.1 200 OK
X-RESTEasy-Tracing-026:
    org.jboss.resteasy.plugins.server.servlet.Servlet3AsyncHttpRequest@7a49a8aa MBW [ ---- / 61.57 ms | ---- %] [org.jboss.resteasy.plugins.providers(InputStreamProvider @1cbf0b08) is skipped
...
Date: Wed, 27 Mar 2019 09:39:50 GMT
Connection: keep-alive
X-RESTEasy-Tracing-000:
    org.jboss.resteasy.plugins.server.servlet.Servlet3AsyncHttpRequest@7a49a8aa START [ ---- / ---- ms | ---- %] baseUri=[http://localhost:8081/] requestUri=[http://localhost:8081/]
    type=GET authScheme=[n/a] accept=/* accept-encoding=n/a accept-charset=n/a accept-language=n/a content-type=n/a content-length=n/a
...
```
RESTEasy Tracing Feature

From above output, the tracing info is in the response headers, and it is marked in sequence as in the form of "X-RESTEasy-Tracing-nnn".

54.6. Json Formatted Response

The tracing log can be returned to client side in JSON format. To use this feature, the user must specify a JSON provider for the tracing module to generate JSON formatted info. There are two JSON providers to choose from. Both support JSON data marshalling. The first choice is to use the jackson2 provider:

```xml
<dependency>
  <groupId>org.jboss.resteasy</groupId>
  <artifactId>resteasy-jackson2-provider</artifactId>
</dependency>
```

The second choice is to use the json-binding provider:

```xml
<dependency>
  <groupId>org.jboss.resteasy</groupId>
  <artifactId>resteasy-json-binding-provider</artifactId>
</dependency>
```

After including one of the above modules, send a request to server. The JSON formatted tracing information will be returned. Here is a request example (the example is provided at last section of this chapter):

```
```

In the above curl command, "X-RESTEasy-Tracing-Accept-Format: JSON" was added into the request header. This is requesting the json formatted tracing info from server, and the tracing info in response header is as follows:

X-RESTEasy-Tracing-000:

```
localhost:8081/ | requestUri=[http://localhost:8081/type] method=[GET] authScheme=[n/a] accept=*/* accept-encoding=n/a accept-charset=n/a accept-language=n/a content-type=n/a content-length=n/a
```
The above text is the raw output from the response. It can be formatted it to make it readable:

```
[
  "X-RESTEasy-Tracing-000": {
    "event": "START",
    "duration": 0,
    "timestamp": 195286694509932,
type] method=[GET] authScheme=[n/a] accept=*/* accept-encoding=n/a accept-charset=n/a accept-
language=n/a content-type=n/a content-length=n/a ",
    "requestId": "org.jboss.resteasy.plugins.server.servlet.Servlet3AsyncHttpServletRequest@7f8a33b9"
  },
  {
    "event": "START_HEADERS",
    "duration": 0,
    "timestamp": 195286695053606,
    "text": "Other request headers: Accept=[*/*] Host=[localhost:8081] User-Agent=[curl/7.54.0] X-RESTEasy-Tracing-
Accept-Format=[JSON]",
    "requestId": "org.jboss.resteasy.plugins.server.servlet.Servlet3AsyncHttpServletRequest@7f8a33b9"
  },
  {
    "event": "PRE_MATCH_SUMMARY",
    "duration": 14563,
    "timestamp": 195286697637157,
    "text": "PreMatchRequest summary: 0 filters",
    "requestId": "org.jboss.resteasy.plugins.server.servlet.Servlet3AsyncHttpServletRequest@7f8a33b9"
  },
  ...
  {
    "event": "FINISHED",
    "duration": 0,
    "timestamp": 195286729758836,
    "text": "Response status: 200",
    "requestId": "org.jboss.resteasy.plugins.server.servlet.Servlet3AsyncHttpServletRequest@7f8a33b9"
  }
]
```

From above shows the tracing info is returned as JSON text.
54.7. ON_DEMAND Mode Usage

To use the ON_DEMAND mode, set the tracing mode via the context-param parameters in the project’s web.xml file. Here is the example:

```xml
<context-param>
    <param-name>resteasy.server.tracing.type</param-name>
    <param-value>ON_DEMAND</param-value>
</context-param>
```

From the client side, the user can send a request with additional tracing headers to enable the tracing feature and set the tracing level at per-request level. Here is the trigger header to enable the tracing information for this request:

```
X-RESTEasy-Tracing-Accept
```

By putting this header with any value in your header, the tracing information will be enabled for the request. To control the tracing level, send this header with relative level value in the request:

```
X-RESTEasy-Tracing-Threshold
```

Here is an example showing how to send the request with tracing feature enabled:

```
$ curl --header "X-RESTEasy-Tracing-Accept: ok" --header "X-RESTEasy-Tracing-Threshold: VERBOSE"
   -i http://localhost:8081/foo
```

Here is the tracing information:

```
X-RESTEasy-Tracing-026:
org.jboss.resteasy.plugins.server.servlet.Servlet3AsyncHttpRequest@5e84478b MBW
[ ---- /  5.95 ms |  ---- %]
[org.jboss.resteasy.plugins.providers.FileProvider @37a3c619] is skipped
X-RESTEasy-Tracing-027: org.jboss.resteasy.plugins.server.servlet.Servlet3AsyncHttpRequest@5e84478b MBW
[ ---- /  5.96 ms |  ---- %]
[org.jboss.resteasy.plugins.providers.ByteArrayProvider @646b8da5] is skipped
X-RESTEasy-Tracing-028: org.jboss.resteasy.plugins.server.servlet.Servlet3AsyncHttpRequest@5e84478b MBW
[ ---- /  5.97 ms |  ---- %]
[org.jboss.resteasy.plugins.providers.StreamingOutputProvider @3b2a4bf4] is skipped
X-RESTEasy-Tracing-029: org.jboss.resteasy.plugins.server.servlet.Servlet3AsyncHttpRequest@5e84478b MBW
[ ---- /  5.98 ms |  ---- %]
[org.jboss.resteasy.plugins.providers.ReaderProvider @24729366] is skipped
X-RESTEasy-Tracing-030: org.jboss.resteasy.plugins.server.servlet.Servlet3AsyncHttpRequest@5e84478b MBW
[ ---- /  5.99 ms |  ---- %]
```

---

302
In addition, this header can be used to set the tracing info format:

X-RESTEasy-Tracing-Accept-Format

For example, set the value to 'JSON' to get the JSON formatted tracing info. Here is the command example:

```
```

The JSON formatted tracing info from the response header will look like this:
RESTEasy Tracing Feature

X-RESTEasy-Tracing-000:

localhost:8081/ requestUri=[http://localhost:8081/level] method=[GET] authScheme=[n/a] accept="/" accept-encoding=n/a accept-charset=n/a accept-language=n/a content-type=n/a content-length=n/a

{"event":"START","duration":0,"timestamp":110867532563245,"text":"Other request headers: Accept=[*/]",

{"event":"PRE_MATCH_SUMMARY","duration":5361,"timestamp":110867532671984,"text":PreMatchRequest summary;

{"event":"REQUEST_FILTER_SUMMARY","duration":3675,"timestamp":110867532425024,"text":Request summary;

{"event":"MATCH_RUNTIME_RESOURCE","duration":0,"timestamp":110867532447068,"text":Matched resource: template=[org.jboss.resteasy.core.registry.ClassExpression @335ce24a] reg exp=[\Q\E.(*)\Q\E] matches=[org.jboss.resteasy.core.registry.SegmentNode @3f56d6f02]

{"event":"REQUEST_FILTER","duration":9518,"timestamp":110867532500069,"text":Filter by [org.jboss.resteasy.plugins.providers.jackson.PatchMethodFilter @748a2754 #2147483647]

{"event":"REQUEST_FILTER","duration":3702,"timestamp":110867532501873,"text":Filter by [org.jboss.resteasy.plugins.providers.sse.SseEventSinkInterceptor @7dad480d #2147483647]

{"event":"REQUEST_FILTER_SUMMARY","duration":49575,"timestamp":110867532502607,"text":Request summary;


{"event":"DISPATCH_RESPONSE","duration":0,"timestamp":110867532584991,"text":Response:

{"event":"RESPONSE_FILTER","duration":7044,"timestamp":110867532650026,"text":Filter by [org.jboss.resteasy.plugins.interceptors.MessageSanitizerContainerResponseFilter @bba8498]

{"event":"MBW_FIND","duration":0,"timestamp":110867532675539,"text":Find MBW for type=[java.lang.String] genericType=[java.lang.String] mediaType=[[jakarta.ws.rs.core.MediaType @1cc060ef]] annotations=[@jakarta.ws.rs.GET()],
lev el]","requestId":"org.jboss.resteasy.plugins.server.servlet.Servlet3AsyncHttpRequest@78dd0a57"

{"event":"MBW_SELECTED","duration":0,"timestamp":110867532677198,"text":[org.jboss.resteasy.plugins.providers.StringTextStar
mbw @23ffcf54] IS writeable,

{"event":"MBW_SKIPPED","duration":0,"timestamp":110867532683918,"text":[org.jboss.resteasy.plugins.providers.FileProvider
mbw @23ffcf54] IS writeable,

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Above is the basic usage introduction of the ON_DEMAND tracing mode.

54.8. List Of Tracing Events

The tracing events are defined in RESTEasyServerTracingEvent [https://github.com/resteasy/resteasy-extensions/blob/master/tracing/src/main/java/org/jboss/resteasy/tracing/api/RESTEasyServerTracingEvent.java]. Here is a complete list of the tracing events and its descriptions:

- **DISPATCH_RESPONSE**
  Resource method invocation results to Jakarta RESTful Web Services Response.

- **EXCEPTION_MAPPING**
  ExceptionMapper invoked.

- **FINISHED**
  Request processing finished.

- **MATCH_LOCATOR**
  Matched sub-resource locator method.

- **MATCH_PATH_FIND**
  Matching path pattern.

- **MATCH_PATH_NOT_MATCHED**
  Path pattern not matched.

- **MATCH_PATH_SELECTED**
  Path pattern matched/selected.

- **MATCH_PATH_SKIPPED**
  Path pattern skipped as higher-priority pattern has been selected already.

- **MATCH_RESOURCE**
  Matched resource instance.
• MATCH_RESOURCE_METHOD
  Matched resource method.
• MATCH_RUNTIME_RESOURCE
  Matched runtime resource.
• MATCH_SUMMARY
  Matching summary.
• METHOD_INVOKE
  Resource method invoked.
• PRE_MATCH
  RESTEasy HttpRequestPreprocessor invoked.
• PRE_MATCH_SUMMARY
  RESTEasy HttpRequestPreprocessor invoked.
• REQUEST_FILTER
  ContainerRequestFilter invoked.
• REQUEST_FILTER_SUMMARY
  ContainerRequestFilter invocation summary.
• RESPONSE_FILTER
  ContainerResponseFilter invoked.
• RESPONSE_FILTER_SUMMARY
  ContainerResponseFilter invocation summary.
• START
  Request processing started.
• START_HEADERS
  All HTTP request headers.

54.9. Tracing Example

The "resteasy-example" project, contains a RESTEasy Tracing Example  [https://github.com/resteasy/resteasy-examples/tree/master/tracing-example] to show the usages of tracing features. Please check the example to see the usages in action.
Chapter 55. Validation

RESTEasy provides the support for validation mandated by the Jakarta RESTful Web Services [https://jakarta.ee/specifications/restful-ws/], given the presence of an implementation of the Bean Validation specification [https://beanvalidation.org/2.0/spec/] such as Hibernate Validator [http://hibernate.org/validator/].

Validation provides a declarative way of imposing constraints on fields and properties of beans, bean classes, and the parameters and return values of bean methods. For example, in

```java
@Path("all")
@TestClassConstraint(5)
public class TestResource
{
    @Size(min=2, max=4)
    @PathParam("s")
    String s;

    private String t;

    @Size(min=3)
    public String getT()
    {
        return t;
    }

    @PathParam("t")
    public void setT(String t)
    {
        this.t = t;
    }

    @POST
    @Path("/{s}/t/{u}" polymorphic)
    @Pattern(regexp="^[a-c]*")
    public String post(@PathParam("u") String u)
    {
        return u;
    }
}
```

the field `s` is constrained by the Bean Validation built-in annotation `@Size` to have between 2 and 4 characters, the property `t` is constrained to have at least 3 characters, and the `TestResource` object is constrained by the application defined annotation `@TestClassConstraint` to have the combined lengths of `s` and `t` less than 5:

```
@Constraint(validatedBy = TestClassValidator.class)
@Target({TYPE})
@Retention(RUNTIME)
```
public @interface TestClassConstraint
{
    String message() default "Concatenation of s and t must have length > {value}";
    Class<?>[] groups() default {};
    Class<? extends Payload>[] payload() default {};
    int value();
}

public class TestClassValidator implements ConstraintValidator<TestClassConstraint, TestResource>
{
    int length;

    public void initialize(TestClassConstraint constraintAnnotation)
    {
        length = constraintAnnotation.value();
    }

    public boolean isValid(TestResource value, ConstraintValidatorContext context)
    {
        boolean b = value.retrieveS().length() + value.getT().length() < length;
    }
}

See the links above for more about how to create validation annotations.

Also, the method parameter u is constrained to have no more than 5 characters, and the return value of method post is constrained by the built-in annotation @Pattern to match the regular expression "[a-c]+".

The sequence of validation constraint testing is as follows:

1. Create the resource and validate property, and class constraints.

2. Validate the resource method parameters.

3. If no violations have been detected, call the resource method and validate the return value

**Note.** Though fields and properties are technically different, they are subject to the same kinds of constraints, so they are treated the same in the context of validation. Together, they will both be referred to as "properties" herein.

**55.1. Violation reporting**

If a validation problem occurs, either a problem with the validation definitions or a constraint violation, RESTEasy will set the return header org.jboss.resteasy.api.validation.Validation.VALIDATION_HEADER ("validation-exception") to "true".

If RESTEasy detects a structural validation problem, such as a validation annotation with a missing validator class, it will return a String representation of a jakarta.validation.ValidationException. **For example**
jakarta.validation.ValidationException: HV000028: Unexpected exception during isValid call.
[org.jboss.resteasy.test.validation.TestValidationExceptions$OtherValidationException]

If any constraint violations are detected, RESTEasy will return a report in one of a variety of formats. If one of "application/xml" or "application/json" occur in the "Accept" request header, RESTEasy will return an appropriately marshalled instance of org.jboss.resteasy.api.validation.ViolationReport:

```java
@XmlElement(name="violationReport")
@XmlAccessorType(XmlAccessType.FIELD)
public class ViolationReport
{
...

    public ArrayList<ResteasyConstraintViolation> getPropertyViolations()
    {
        return propertyViolations;
    }

    public ArrayList<ResteasyConstraintViolation> getClassViolations()
    {
        return classViolations;
    }

    public ArrayList<ResteasyConstraintViolation> getParameterViolations()
    {
        return parameterViolations;
    }

    public ArrayList<ResteasyConstraintViolation> getReturnValueViolations()
    {
        return returnValueViolations;
    }

    ...
}
```

where org.jboss.resteasy.api.validation.ResteasyConstraintViolation is defined:

```java
@XmlElement(name="resteasyConstraintViolation")
@XmlAccessorType(XmlAccessType.FIELD)
public class ResteasyConstraintViolation implements Serializable
{
...

    /**
     * @return type of constraint
     */
    public ConstraintType.Type getConstraintType()
```
Validation

```java
{
    return constraintType;
}

/**
 * @return description of element violating constraint
 */
public String getPath()
{
    return path;
}

/**
 * @return description of constraint violation
 */
public String getMessage()
{
    return message;
}

/**
 * @return object in violation of constraint
 */
public String getValue()
{
    return value;
}

/**
 * @return String representation of violation
 */
public String toString()
{
    return "[" + type() + "][" + path + "][" + message + "][" + value + "]";
}

/**
 * @return String form of violation type
 */
public String type()
{
    return constraintType.toString();
}
}

\n\nand \texttt{org.jboss.resteasy.api.validation.ConstraintType} is the enumeration

```
If both "application/xml" or "application/json" occur in the "Accept" request header, the media type is chosen according to the ranking given by implicit or explicit "q" parameter values. In the case of a tie, the returned media type is indeterminate.

If neither "application/xml" or "application/json" occur in the "Accept" request header, RESTEasy returns a report with a String representation of each ResteasyConstraintViolation, where each field is delimited by '[' and ']', followed by a '', with a final '' at the end. For example,

```java
[PROPERTY]
[s]
[size must be between 2 and 4]
[a]

[PROPERTY]
[t]
[size must be between 3 and 5]
[x]

[CLASS]
[]
[Concatenation of s and t must have length > 5]
[org.jboss.resteasy.validation.TestResource@68467a6f]

PARAMETER
[test.<cross-parameter>]
[Parameters must total <= 7]
[[5, 7]]

RETURN_VALUE
[g.<return value>]
[size must be between 2 and 4]
[abcde]
```

where the four fields are

1. type of constraint
2. path to violating element (e.g., property name, class name, method name and parameter name)
3. message
4. violating element

The ViolationReport can be reconstituted from the String as follows:

```java
Client client = ClientBuilder.newClient();
Invocation.Builder request = client.target(...).request();
Response response = request.get();
if (Boolean.valueOf(response.getHeaders().getFirst(Validation.VALIDATION_HEADER)))
{
```
String s = response.readEntity(String.class);
ViolationReport report = new ViolationReport(s);

If the path field is considered to be too much server side information, it can be surpressed by setting the parameter "resteasy.validation.suppress.path" to "true". In that case, "*" will be returned in the path fields. [See Section 3.4, "Configuration" for more information about application configuration.]

55.2. Validation Service Providers

The form of validation mandated by the Jakarta RESTful Web Services specification, based on Bean Validation 1.1 or greater, is supported by the RESTEasy module resteasy-validator-provider, which produces the artifact resteasy-validator-provider-<version>.jar. Validation is turned on by default (assuming resteasy-validator-provider-<version>.jar is available), though parameter and return value validation can be turned off or modified in the validation.xml configuration file. See the Hibernate Validator [https://docs.jboss.org/hibernate/stable/validator/reference/en-US/html_single/?v=6.0] documentation for the details.

RESTEasy obtains a bean validation implementation by looking in the available META-INF/services/jakarta.ws.rs.Providers files for an implementation of ContextResolver<GeneralValidator>, where org.jboss.resteasy.spi.GeneralValidator is

```java
public interface GeneralValidator {
    /**
     * Validates all constraints on {@code object}.
     *
     * @param object object to validate
     * @param groups the group or list of groups targeted for validation (defaults to
     *        {@link Default})
     * @return constraint violations or an empty set if none
     * @throws IllegalArgumentException if object is {@code null} or if the varargs groups
     * @throws ValidationException if a non recoverable error happens during the validation process
     */
    public abstract void validate(HttpRequest request, Object object, Class<?>... groups);
    /**
     * Validates all constraints placed on the parameters of the given method.
     *
     * @param <T> the type hosting the method to validate
     * @param object the object on which the method to validate is invoked
     * @param method the method for which the parameter constraints is validated
     * @param parameterValues the values provided by the caller for the given method's
     * parameters
     * @param groups the group or list of groups targeted for validation (defaults to
     *        {@link Default})
     * @return a set with the constraint violations caused by this validation;
     * will be empty if no error occurs, but never @code null
     * @throws IllegalArgumentException if object is @code null or if any of the parameters
     * valid
     */
    public abstract void validateParameterValues(HttpRequest request, Object object, Method method,
                                                 Object[] parameterValues, Class<?>... groups)
```
The methods and the javadoc are adapted from the Bean Validation 1.1 classes jakarta.validation.Validator and jakarta.validation.executable.ExecutableValidator.

RESTEasy module resteasy-validator-provider supplies an implementation of GeneralValidator. An alternative implementation may be supplied by implementing ContextResolver<GeneralValidator> and org.jboss.resteasy.spi.validation.GeneralValidator.

A validator intended to function in the presence of CDI must also implement the subinterface
Validation

public interface GeneralValidatorCDI extends GeneralValidator
{
   /**
    * Indicates if validation is turned on for a class.
    * This method should be called from the resteasy-core module. It should
test if injectorFactory is an instance of CdiInjectorFactory, which indicates
that CDI is active. If so, it should return false. Otherwise, it should
return the same value returned by GeneralValidator.isValidatable().
   *
   * @param clazz Class to be examined
   * @param injectorFactory the InjectorFactory used for clazz
   * @return true if and only if validation is turned on for clazz
   */
   public boolean isValidatable(Class<?> clazz, InjectorFactory injectorFactory);

   /**
    * Indicates if validation is turned on for a class.
    * This method should be called only from the resteasy-cdi module.
    *
    * @param clazz Class to be examined
    * @return true if and only if validation is turned on for clazz
    */
   public abstract boolean isValidatableFromCDI(Class<?> clazz);

   /**
    * Throws a ResteasyViolationException if any validation violations have been detected.
    * The method should be called only from the resteasy-cdi module.
    *
    * @param request
    */
   public void checkViolationsFromCDI(HttpRequest request);

   /**
    * Throws a ResteasyViolationException if either a ConstraintViolationException or a
    * ResteasyConstraintViolationException is embedded in the cause hierarchy of e.
    *
    * @param request
    * @param e
    */
   public void checkForConstraintViolations(HttpRequest request, Exception e);
}

The validator in resteasy-validator-provider implements GeneralValidatorCDI.

55.3. Validation Implementations

As mentioned above, RESTEasy validation requires an implementation of the Bean Validation specification [https://beanvalidation.org/2.0/spec/] such as Hibernate Validator [http://hibernate.org/validator/]. Hibernate Validator is supplied automatically when RESTEasy is running in the context of WildFly. Otherwise, it should be made available. For example, in maven
<dependency>
    <groupId>org.hibernate.validator</groupId>
    <artifactId>hibernate-validator</artifactId>
</dependency>
Chapter 56. Internationalization and Localization

With the help of the JBoss Logging project, all log and exception messages in RESTEasy are internationalized. That is, they have a default value in English which can be overridden in any given locale by a file which gives translated values. For more information about internationalization and localization in Java, see, for example, http://docs.oracle.com/javase/tutorial/i18n. For more about JBoss Logging Tooling, see https://jboss-logging.github.io/jboss-logging-tools/, Chapters 4 and 5.

56.1. Internationalization

Each module in RESTEasy that produces any text in the form of logging messages or exception messages has an interface named org.jboss.resteasy...i18n.Messages which contains the default messages. Those modules which do any logging also have an interface named org.jboss.resteasy...i18n.LogMessages which gives access to an underlying logger. With the exception of the resteasy-core-spi module, all messages are in the Messages class. resteasy-core-spi has exception messages in the Messages class and log messages in the LogMessages class.

Each message is prefixed by the project code “RESTEASY” followed by an ID which is unique to RESTEasy. These IDs belong to the following ranges:

<table>
<thead>
<tr>
<th>Range</th>
<th>Module</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000-2999</td>
<td>resteasy-core-spi log messages</td>
</tr>
<tr>
<td>3000-4499</td>
<td>resteasy-core-spi exception messages</td>
</tr>
<tr>
<td>4500-4999</td>
<td>resteasy-client</td>
</tr>
<tr>
<td>5000-5499</td>
<td>providers/resteasy-atom</td>
</tr>
<tr>
<td>5500-5999</td>
<td>providers/fastinfoset</td>
</tr>
<tr>
<td>6000-6499</td>
<td>providers/resteasy-html</td>
</tr>
<tr>
<td>6500-6999</td>
<td>providers/jaxb</td>
</tr>
<tr>
<td>7500-7999</td>
<td>providers/multipart</td>
</tr>
<tr>
<td>8000-8499</td>
<td>providers/resteasy-hibernatevalidator-provider</td>
</tr>
<tr>
<td>8500-8999</td>
<td>providers/resteasy-validator-provider</td>
</tr>
<tr>
<td>9500-9999</td>
<td>async-http-servlet-3.0</td>
</tr>
<tr>
<td>10000-10499</td>
<td>cache-core</td>
</tr>
<tr>
<td>10500-10999</td>
<td>resteasy-cdi</td>
</tr>
<tr>
<td>11500-11999</td>
<td>resteasy-jsapi</td>
</tr>
</tbody>
</table>
For example, the Jakarta XML Binding provider contains the interface

```java
org.jboss.resteasy.plugins.providers.jaxb.i18.Messages
```

which looks like

```java
@MessageBundle(projectCode = "RESTEASY")
public interface Messages {

    Messages MESSAGES = org.jboss.logging.Messages.getBundle(Messages.class);
    int BASE = 6500;

    @Message(id = BASE + 00, value = "Collection wrapping failed, expected root element name of 
    (0) got (1)", format=Format.MESSAGE_FORMAT)
    String collectionWrappingFailedLocalPart(String element, String localPart);

    @Message(id = BASE + 05, value = "Collection wrapping failed, expect namespace of (0) got 
    (1)", format=Format.MESSAGE_FORMAT)
    String collectionWrappingFailedNamespace(String namespace, String uri);

    ...}
```

The value of a message is retrieved by referencing a method and passing the appropriate parameters. For example,

```java
throw new JAXBUnmarshalException(Messages.MESSAGES.collectionWrappingFailedLocalPart(wrapped.element(),
                                   ele.getName().getLocalPart()));
```
56.2. Localization

When RESTEasy is built with the "i18n" profile, a template properties file containing the default messages is created in a subdirectory of target/generated-translation-files. In the Jakarta XML Binding provider, for example, the

goes in the

directory, and the first few lines are

```plaintext
# Id: 6500
# Message: Collection wrapping failed, expected root element name of {0} got {1}
# @param 1: element -
# @param 2: localPart -
collectionWrappingFailedLocalPart=Collection wrapping failed, expected root element name of {0} got {1}
# Id: 6505
# Message: Collection wrapping failed, expect namespace of {0} got {1}
# @param 1: namespace -
# @param 2: uri -
collectionWrappingFailedNamespace=aaa {0} bbb {1} ccc
```

To provide the translation of the messages for a particular locale, the file should be renamed, replacing "locale", "COUNTRY", and "VARIANT" as appropriate (possibly omitting the latter two), and copied to the src/main/resources directory. In the Jakarta XML Binding provider, it would go in

For testing purposes, each module containing a Messages interface has two sample properties files, for the locale "en" and the imaginary locale "xx", in the src/test/resources directory. They are copied to src/main/resources when the module is built and deleted when it is cleaned.

The Messages.i18n_xx.properties file in the Jakarta XML Binding provider, for example, looks like

```plaintext
# Id: 6500
# Message: Collection wrapping failed, expected root element name of {0} got {1}
# @param 1: element -
# @param 2: localPart -
collectionWrappingFailedLocalPart=Collection wrapping failed, expected root element name of {0} got {1}
# Id: 6505
# Message: Collection wrapping failed, expect namespace of {0} got {1}
# @param 1: namespace -
# @param 2: uri -
collectionWrappingFailedNamespace=aaa {0} bbb {1} ccc
...```
Note that the value of collectionWrappingFailedNamespace is modified.
Chapter 57. Maven and RESTEasy

JBoss’s Maven Repository is at: https://repository.jboss.org/nexus/content/groups/public/

RESTEasy is modularized into 20 plus components. Each component is accessible as a Maven artifact. As a convenience RESTEasy provides a BOM containing the complete set of components with the appropriate versions for the “stack”.

It is recommended to declare the BOM in your POM file, that way you will always be sure to get the correct version of the artifacts. In addition, you will not need to declare the version of each RESTEasy artifact called out in the dependencies section.

Declare the BOM file in the dependencyManagement section of the POM file like this. Note that Maven version 2.0.9 or higher is required to process BOM files.

```xml
<dependencyManagement>
  <dependencies>
    <dependency>
      <groupId>org.jboss.resteasy</groupId>
      <artifactId>resteasy-bom</artifactId>
      <version>${version.resteasy}</version>
      <type>pom</type>
      <scope>import</scope>
    </dependency>
  </dependencies>
</dependencyManagement>
```

Declare the specific RESTEasy artifacts you require in the dependencies section of the POM file like this.

```xml
<dependencies>
  <dependency>
    <groupId>org.jboss.resteasy</groupId>
    <artifactId>resteasy-client</artifactId>
  </dependency>
  ....
</dependencies>
```

It is possible to reference a RESTEasy artifact version not in the current BOM by specifying a version in the dependency itself.
<dependencies>
  <dependency>
    <groupId>org.jboss.resteasy</groupId>
    <artifactId>resteasy-client</artifactId>
    <version>${version.some.other}</version>
  </dependency>
  ...
</dependencies>
Chapter 58. Migration from older versions

58.1. Migration to RESTEasy 3.0 series

Many facilities from RESTEasy 2 appear in a different form in RESTEasy 3. For example, much of the client framework in RESTEasy 2 is formalized, in modified form, in JAX-RS 2.0. RESTEasy versions 3.0.x implement both the older deprecated form and the newer conformant form. The deprecated form is moved to legacy module in RESTEasy 3.1 and finally removed in RESTEasy 4. For more information on upgrading from various deprecated facilities in RESTEasy 2, see http://docs.jboss.org/resteasy/docs/resteasy-upgrade-guide-en-US.pdf

58.2. Migration to RESTEasy 3.1 series

RESTEasy 3.1.0.Final release comes with many changes compared to previous 3.0 point releases. User discernible changes in RESTEasy 3.1.0.Final include

• module reorganization
• package reorganization
• new features
• minor behavioral changes
• miscellaneous changes

In this chapter we focus on changes that might cause existing code to fail or behave in new ways. The audience for this discussion may be partitioned into three subsets, depending on the version of RESTEasy currently in use, the API currently in use, and the API to be used after an upgrade to RESTEasy 3.1. The following APIs are available:

1. **RESTEasy 2**: RESTEasy 2 implements the JAX-RS 1 specification, and adds a variety of additional facilities, such as a client API, a caching system, an interceptor framework, etc. All of these user facing classes and interfaces comprise the RESTEasy 2 API.

2. **RESTEasy 3**: RESTEasy 3 implements the JAX-RS 2 specification, and adds some additional facilities. Many of the non-spec facilities from the RESTEasy 2 API are formalized, in altered form, in JAX-RS 2, in which case the older facilities are deprecated. The non-deprecated user facing classes and interfaces in RESTEasy 3 comprise the RESTEasy 3 API.

These definitions are rather informal and imprecise, since the user facing classes / interfaces in Resteasy 3.0.19.Final, for example, are a proper superset of the user facing classes / interfaces in RESTEasy 3.0.1.Final. For this discussion, we identify the API with the version currently in use in a given project.
Now, there are three potential target audiences of users planning to upgrade to RESTEasy 3.1.0.Final:

1. Those currently using RESTEasy API 3 with some RESTEasy 3.0.x release
2. Those currently using RESTEasy API 2 with some RESTEasy 2.x or 3.0.x release and planning to upgrade to RESTEasy API 3
3. Those currently using RESTEasy API 2 with some RESTEasy 2.x or 3.0.x release and planning to continue to use RESTEasy API 2

Of these, users in Group 2 have the most work to do in upgrading from RESTEasy API 2 to RESTEasy API 3. They should consult the separate guide Upgrading from RESTEasy 2 to RESTEasy 3 [http://docs.jboss.org/resteasy/docs/resteasy-upgrade-guide-en-US.pdf].

Ideally, users in Groups 1 and 3 might make some changes to take advantage of new features but would have no changes forced on them by reorganization or altered behavior. Indeed, that is almost the case, but there are a few changes that they should be aware of.

1. Upgrading with RESTEasy 3 API

All RESTEasy changes are documented in JIRA issues. Issues that describe detectable changes in release 3.1.0.Final that might impact existing applications include

- RESTEASY-1341: Build method of org.jboss.resteasy.client.jaxrs.internal.ClientInvocationBuilder always return the same instance. [https://issues.jboss.org/browse/RESTEASY-1341]

When a `build()` method from

- org.jboss.resteasy.client.jaxrs.internal.ClientInvocationBuilder in resteasy-client,
- org.jboss.resteasy.specimpl.LinkBuilderImpl in resteasy-core,
- org.jboss.resteasy.specimpl.ResteasyUriBuilder in resteasy-jaxrs

is called, it will return a new object. This behavior might be seen indirectly. For example,

```java
Builder builder = client.target(generateURL(path)).request();
...
Link link = new LinkBuilderImpl().uri(href).build();
...
URI uri = uriInfo.getBaseUriBuilder().path("test").build();
```

- RESTEASY-1433: Compile with JDK 1.8 source/target version [https://issues.jboss.org/browse/RESTEASY-1433]
As it says. Depending on the application, it might be necessary to recompile with a target of JDK 1.8 so that calls to RESTEasy code can work.

- RESTEASY-1484: CVE-2016-6346: Abuse of GZIPInterceptor in can lead to denial of service attack [https://issues.jboss.org/browse/RESTEASY-1484]

Prior to release 3.1.0.Final, the default behavior of RESTEasy was to use GZIP to compress and decompress messages whenever “gzip” appeared in the Content-Encoding header. However, decompressing messages can lead to security issues, so, as of release 3.1.0.Final, GZIP compression has to be enabled explicitly. For details, see Chapter GZIP Compression/Decompression.

**Note.** Because of some package reorganization due to RESTEASY-1531 (see below), the GZIP interceptors, which used to be in package `org.jboss.resteasy.plugins.interceptors.encoding` are now in `org.jboss.resteasy.plugins.interceptors`.

- RESTEASY-1531: Restore removed RESTEasy internal classes into a deprecated/disabled module [https://issues.jboss.org/browse/RESTEASY-1531]

This issue is related to refactoring deprecated elements of the RESTEasy 2 API into a separate module, and, ideally, would have no bearing at all on RESTEasy 3. However, a reorganization of packages has led to moving some non-deprecated API elements in the resteasy-core module:

- `org.jboss.resteasy.client.ClientURI` is now `org.jboss.resteasy.annotations.ClientURI`

- `org.jboss.resteasy.core.interception.JaxrsInterceptorRegistryListener` is now `org.jboss.resteasy.core.interception.jaxrs.JaxrsInterceptorRegistryListener`

- `org.jboss.resteasy.spi.interception.DecoratorProcessor` is now `org.jboss.resteasy.spi.DecoratorProcessor`

- All of the dynamic features and interceptors in the package `org.jboss.resteasy.plugins.interceptors.encoding` are now in `org.jboss.resteasy.plugins.interceptors`

### 2. Upgrading with RESTEasy 2 API

Most of the deprecated classes and interfaces from RESTEasy 2 have been segregated in a separate module, resteasy-legacy, as of release 3.1.0.Final. A few remain in module resteasy-jaxrs for technical reasons. Eventually, all such classes and interfaces will be removed from RESTEasy. Most of the relocated elements are internal, so ensuring that resteasy-legacy is on
the classpath will make most changes undetectable. One way to do that, of course, is to include it in an application's WAR. In the context of WildFly, it is also possible to use a jboss-deployment-structure.xml file in the WEB-INF directory of your WAR file. For example:

```xml
<jboss-deployment-structure>
  <deployment>
    <dependencies>
      <module name="org.jboss.resteasy.resteasy-legacy"/>
    </dependencies>
  </deployment>
</jboss-deployment-structure>
```

There are a few API classes and interfaces from resteasy-jaxrs that have moved to a new package in resteasy-legacy. These are

- `org.jboss.resteasy.annotations.ClientResponseType` is now `org.jboss.resteasy.annotations.legacy.ClientResponseType`
- `org.jboss.resteasy.spi.Link` is now `org.jboss.resteasy.client.Link`
- `org.jboss.resteasy.spi.LinkHeader` is now `org.jboss.resteasy.client.LinkHeader`

### 58.3. Migration to RESTEasy 3.5+ series

RESTEasy 3.5 series is a spin-off of the old RESTEasy 3.0 series, featuring Jakarta RESTful Web Services implementation.

The reason why 3.5 comes from 3.0 instead of the 3.1 / 4.0 development streams is basically providing users with a selection of RESTEasy 4 critical / strategic new features, while ensuring full backward compatibility. As a consequence, no major issues are expected when upgrading RESTEasy from 3.0.x to 3.5.x. The 3.6 and all other 3.x minors after that are backward compatible evolutions of 3.5 series.

The natural upgrade path for users already on RESTEasy 3.1 series is straight to RESTEasy 4 instead.

### 58.4. Migration to RESTEasy 4 series

User migrating from RESTEasy 3.0 and 3.5+ series should be aware of the changes mentioned in the Section 58.2, "Migration to RESTEasy 3.1 series". In addition to that, the aspects from the following sections are to be considered.
1. Public / private API

The `resteasy-jaxrs` and `resteasy-client` modules in RESTEasy 3 contain most of the framework classes and there's no real demarcation between what is internal implementation detail and what is for public consumption. In WildFly, the artifact archives from those modules are also included in a public module. Given the common expectation of full backward compatibility of whatever comes from public modules, to allow for easier project evolution and maintenance, in RESTEasy 4.0.0.Final those big components have been split as follows:

1.1. resteasy-core-spi

The public classes of the former `resteasy-jaxrs` module; the following packages are included:

- org.jboss.resteasy.annotations
- org.jboss.resteasy.api.validation
- org.jboss.resteasy.spi
- org.jboss.resteasy.plugins.providers.validation

1.2. resteasy-core

The internal details of the former `resteasy-jaxrs` module, including classes from the following packages:

- org.jboss.resteasy.core
- org.jboss.resteasy.mock
- org.jboss.resteasy.plugins
- org.jboss.resteasy.specimpl
- org.jboss.resteasy.tracing
- org.jboss.resteasy.util

1.3. resteasy-client-api

The public classes from the former `resteasy-client` module, basically whatever is used for configuring the RESTEasy client additions:

- ClientHttpEngine and ClientHttpEngineBuilder
- ProxyBuilder and ProxyConfig
- ResteasyClient
Migration from older versions

- ResteasyClientBuilder
- ResteasyWebTarget

1.4. resteasy-client

The remainings of the former resteasy-client module, internal details.

As a consequence of the split, all modules except resteasy-core-spi and resteasy-client-api are effectively private / internal. User applications and integration code should not directly rely on classes from those modules, which can be changed without going through any formal deprecation process.

Unfortunately, the refactoring that led to this implied some unavoidable class moves and changes breaking backward compatibility. A detailed list of the potentially problematic changes is available on the refactoring PR [https://github.com/resteasy/Resteasy/pull/1697].

2. Deprecated classes and modules removal

All classes and modules that were deprecated in RESTEasy 3 have been dropped in 4. In particular, this includes the legacy modules (resteasy-legacy, security-legacy) that were introduced in 3.1.

In addition to the legacy modules, few other modules have been dropped for multiple different reasons, including dependency on unsupported / abandoned libraries, better options available, etc:

- resteasy-jackson-provider, users should rely on resteasy-jackson2-provider instead;
- resteasy-jettison-provider, users should rely on resteasy-jackson2-provider instead;
- abdera-atom-provider;
- resteasy-yaml-provider;
- resteasy-rx-java, users should rely on resteasy-rx-java2 instead;
- tjws.

The resteasy-validator-provider-11 is also gone, with the resteasy-validator-provider one now supporting Bean Validation 2.0.

3. Behavior changes

With the ClientHttpEngine based on Apache HTTP Client 4.0 having gone (it was previously deprecated) and the engine based on version 4.3 of the same library being the default, the user might want to double check the notes about connection close in Section 50.3.4, “Apache HTTP Client 4.3 APIs”.

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The conversion of String objects to MediaType objects is quite common in RESTEasy; for performances reasons a cache has been added to store the results of that conversion; by default the cache keeps the result of 200 conversions, but the number can be configured by setting the org.jboss.resteasy.max_mediatype_cache_size system property.

4. Other changes

- In releases 3.x, when bean validation (Chapter 55, Validation) threw instances of exceptions
  - jakarta.validation.ConstraintDefinitionException,
  - jakarta.validation.ConstraintDeclarationException, or
  - jakarta.validation.GroupDefinitionException, they were wrapped in a org.jboss.resteasy.api.validation.Resteasy.ResteasyViolationException, which org.jboss.resteasy.api.validation.ResteasyViolationExceptionMapper, the built-in implementation of jakarta.ws.rs.ext.ExceptionMapper<jakarta.validation.ValidationException>, then turned into descriptive text. As of release 4.0.0, instances of ConstraintDefinitionException, etc., are thrown as is. They are still caught by ResteasyViolationExceptionMapper, so, in general, there is no detectable change. It should be noted, however, that an implementation of ExceptionMapper<ResteasyViolationException>, which, prior to release 4.0.0, would have caught wrapped instances of ConstraintDefinitionException, will not catch unwrapped instances.

- The ResteasyProviderFactory is now an abstract class and is meant to be created using its getInstance() and newInstance() methods. Moreover, on client side, the resolution of the current instance is cached for each thread local context classloader.

- The ResteasyClient and ResteasyClientBuilder are now abstract classes (from resteasy-client-api) and are not meant for user direct instantiation; plain Jakarta RESTful Web Services API usage is expected instead:

```java
//ResteasyClient client = new ResteasyClientBuilder().build(); NO!
//if plain Jakarta RESTful Web Services is enough ...
Client client = ClientBuilder.newClient();
...
//if RESTEasy API is needed ...
ResteasyClient client = (ResteasyClient)ClientBuilder.newClient();

//ResteasyClientBuilder builder = new ResteasyClientBuilder(); NO!
//if plain Jakarta RESTful Web Services is enough ...
ClientBuilder builder = ClientBuilder.newBuilder();
...
//if RESTEasy API is needed ...
ResteasyClientBuilder builder = (ResteasyClientBuilder)ClientBuilder.newBuilder();
```
• The package org.jboss.resteasy.plugins.stats (which contains a resource and some related classes) has been moved out of the resteasy-jaxb-provider module into a new resteasy-stats module.
Chapter 59. Books You Can Read

There are a number of great books that you can learn REST and Jakarta RESTful Web Services from

- RESTful Web Services [http://oreilly.com/catalog/9780596529260/] by Leonard Richardson and Sam Ruby. A great introduction to REST.

- RESTful Java with JAX-RS [http://oreilly.com/catalog/9780596158040/] by Bill Burke. Overview of REST and detailed explanation of JAX-RS. Book examples are distributed with RESTEasy.

- RESTful Web Services Cookbook [http://oreilly.com/catalog/9780596808679/] by Subbu Allamaraju and Mike Amundsen. Detailed cookbook on how to design RESTful services.