



OpenL Tablets Rule Services Usage and Customization Guide

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1 Preface

OpenL Tablets is a Business Rules Management System (BRMS) based on the tables presented in Excel documents. Using unique concepts, OpenL Tablets facilitates treating business documents containing business logic specifications as executable source code.

OpenL Tablets provides a set of tools addressing BRMS related capabilities including *OpenL Tablets Rule Services application* designed for integration of business rules into different customers' applications.

The goal of this document is to explain how to configure Rule Services Core, that is, configure OpenL Tablets Rule Services or integrate the Rule Services Core module into the existing application, for different working environments and how to customize the services to meet particular customer requirements.

The following topics are included in this chapter:

- [Audience](#)
- [How This Guide Is Organized](#)
- [Related Information](#)
- [Typographic Conventions](#)

1.1 Audience

This guide is targeted at rule developers who integrate the Rule Services Core module and set up, configure, and customize OpenL Tablets Rule Services to facilitate the needs of customer rules management applications.

Basic knowledge of Java, Apache Tomcat, Ant, Maven, and Excel is required to use this guide effectively.

1.2 How This Guide Is Organized

Information on how to use this guide	
Section	Description
Introduction	Provides overall information about OpenL Tablets Rule Services.
Rule Services Core	Introduces Rule Services Core functionality.
OpenL Tablets Rule Services Configuration	Describes the default configuration of OpenL Tablets Rule Services, introduces Service Manager, and explains main configuration points.
OpenL Tablets Rule Services Advanced Configuration and Customization	Describes OpenL Tablets Rule Services advanced services configuration and customization.
Appendix A: Tips and Tricks	Describes how to use OpenL Tablets Rule Services from Java code.
Appendix B: Projects on the OpenL Tablets Rule Services Launch	Explains how projects appear upon OpenL Tablets Rule Services launch.
Appendix C: Types of Exceptions in OpenL Tablets Rule Services	Explains typical exceptions in OpenL Tablets Rule Services.
Appendix D: OpenAPI Support	Explains Swagger support in OpenL Tablets.
Appendix E: Programmatically Deploying Rules to a Repository	Describes how to locate a project with rules in the database repository without OpenL Tablets WebStudio deploy functionality.
Appendix F: Backward Compatibility Settings	Describes backward compatibility settings.

Information on how to use this guide	
Section	Description
Appendix G: Deployment Project ZIP Structure	Describes ZIP structure for single and multiple project deployment.
Appendix H: Manifest File for Deployed Projects	Introduces manifest files created during project deployment from OpenL Tablets WebStudio or using the OpenL Tablets Maven plugin.

1.3 Related Information

The following table lists sources of information related to contents of this guide:

Related information	
Title	Description
[OpenL Tablets WebStudio User Guide]	Describes OpenL Tablets WebStudio, a web application for managing OpenL Tablets projects through web browser.
[OpenL Tablets Reference Guide]	Provides overview of OpenL Tablets technology, as well as its basic concepts and principles.
[OpenL Tablets Installation Guide]	Describes how to install and set up OpenL Tablets software.
http://open-tablets.org/	OpenL Tablets open source project website.

1.4 Typographic Conventions

The following styles and conventions are used in this guide:

Typographic styles and conventions	
Convention	Description
Bold	<ul style="list-style-type: none"> Represents user interface items such as check boxes, command buttons, dialog boxes, drop-down list values, field names, menu commands, menus, option buttons, perspectives, tabs, tooltip labels, tree elements, views, and windows. Represents keys, such as F9 or CTRL+A. Represents a term the first time it is defined.
<code>Courier</code>	Represents file and directory names, code, system messages, and command-line commands.
Courier Bold	Represents emphasized text in code.
Select File > Save As	Represents a command to perform, such as opening the File menu and selecting Save As .
<i>Italic</i>	<ul style="list-style-type: none"> Represents any information to be entered in a field. Represents documentation titles.
< >	Represents placeholder values to be substituted with user specific values.
Hyperlink	Represents a hyperlink. Clicking a hyperlink displays the information topic or external source.
[name of guide]	Reference to another guide that contains additional information on a specific feature.

2 Introduction

The majority of OpenL Tablets customers need to expose business rules as SOAP/REST web services. For this purpose, OpenL Tablets Rule Services is provided. To meet requirements of various customer project implementations, OpenL Tablets Rule Services provides the ability to dynamically create web services for customer rules and offers extensive configuration and customization capabilities.

Overall architecture of OpenL Tablets Rule Services is expandable and customizable. All functionality is divided into pieces; each of them is responsible for a small part of functionality and can be replaced by another implementation if it is required. Usually, default implementation is enough to cover all requirements of most customers.

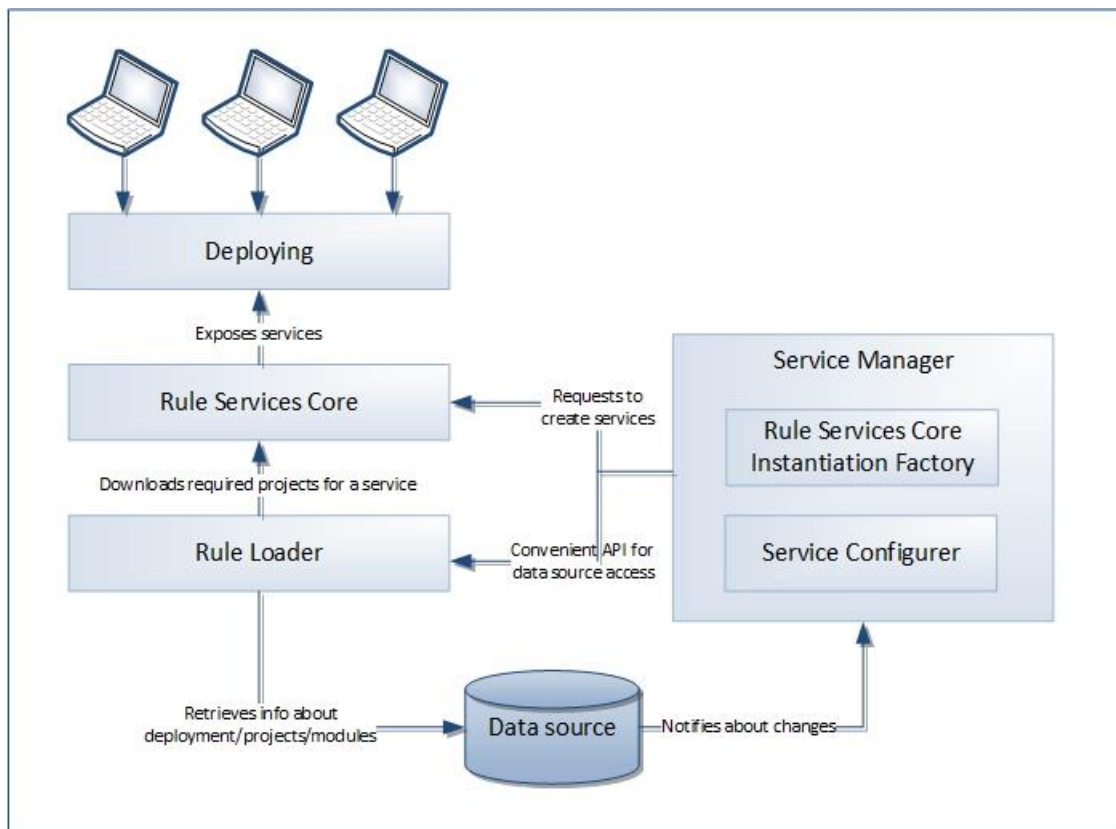


Figure 1: Overall OpenL Tablets Rule Services architecture

OpenL Tablets Rule Services provides the following key features and benefits:

- easily integrating customer business rules into various applications running on different platforms
- using different data sources, such as a central OpenL Tablets production repository or file system of a proper structure
- exposing multiple projects and modules as a single web service according to a project logical structure

The subsequent chapters describe how to set up a data source, Service Configurer, and a service exposing method, and how to integrate OpenL Tablets into the existing application.

OpenL Tablets Rule Services is based on Rule Services Core and supports all features provided by the Rule Services Core module.

The following diagram identifies all components to be configured and customized.

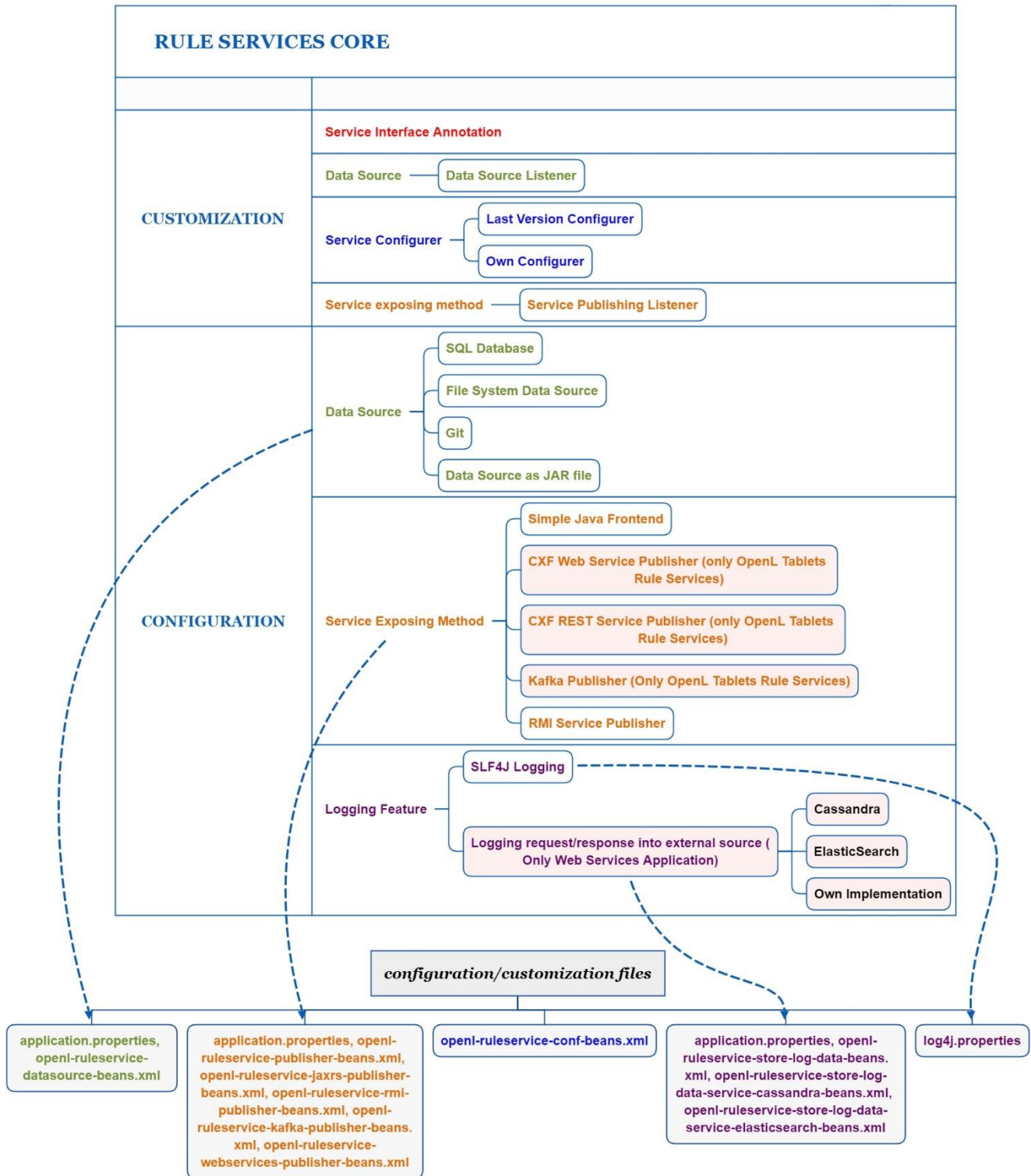


Figure 2: Configurable and customizable components of Rule Services Core

3 Rule Services Core

This section introduces Rule Services Core functionality and includes the following topics:

- [Adding Dependencies into the Project](#)
- [Configuring Spring Integration for Rule Services Core](#)
- [Customizing and Configuring Rule Services Core](#)

3.1 Adding Dependencies into the Project

To use the Rule Services Core within Maven, declare the module dependencies in the project object model (POM) as described in the following example:

```
<dependency>
  <groupId>org.openl.rules</groupId>
  <artifactId>org.openl.rules.ruleservice</artifactId>
  <version>${openl.version}</version>
</dependency>
```

If Apache Maven is not used in the project, it is recommended to download all dependencies via Maven and add all downloaded dependencies into the existing project classpath.

3.2 Configuring Spring Integration for Rule Services Core

This section describes how to configure Spring and Rule Services Core integration and includes the following topics:

- [Adding a Bean Configuration File to the Spring Context Definition](#)
- [Simple Java Frontend Implementation](#)

Adding a Bean Configuration File to the Spring Context Definition

To support the Rule Services Core features, add the `openl-ruleservice-beans.xml` bean configuration file into the application Spring context definition. An example is as follows:

```
<import resource="classpath:openl-ruleservice-beans.xml" />
```

After adding the Rule Services Core beans, Spring configuration has a simple Java frontend service as a default publisher for all OpenL Tablets services.

Simple Java Frontend Implementation

Spring configuration defined in the `openl-ruleservice-beans.xml` file registers the `frontend` bean with default frontend implementation. This bean implements the

`org.openl.rules.ruleservice.simple.RulesFrontend` interface that is designed to interact with deployed OpenL Tablets services.

Method in <code>org.openl.rules.ruleservice.simple.RulesFrontend</code>	
Inceptor	Description
<code>OpenLService findServiceByName(String serviceName)</code>	Find registered OpenL Tablets service by name.
<code>Object execute(String serviceName, String ruleName, Class<?>[] inputParamsTypes, Object[] params)</code>	Invokes a rule with the defined parameter types and parameter values from the deployed OpenL Tablets service.
<code>Object execute(String serviceName, String ruleName, Object... params)</code>	Invokes a rule with the defined parameter values from the deployed OpenL service. Parameter types are automatically defined from sent parameters.
<code>Object getValue(String serviceName, String fieldName)</code>	Returns field value from the defined OpenL Tablets service.
<code>Collection<String> getServiceNames()</code>	Returns a list of registered OpenL Tablets services.
<code>void registerService(OpenLService service)</code>	Registers the OpenL Tablets service.
<code>void unregisterService(String serviceName)</code>	Unregisters the OpenL Tablets service.
<code><T> T buildServiceProxy(String serviceName, Class<T> proxyInterface)</code>	Builds a proxy for the OpenL Tablets service with a defined interface.
<code>T> T buildServiceProxy(String serviceName, Class<T> proxyInterface, ClassLoader classLoader)</code>	Builds a proxy for the OpenL Tablets service with a defined interface and defined class loader.

The `frontend` bean can be injected to user's bean to interact with deployed OpenL Tablets services.

`OpenLServiceFactoryBean` is a factory bean implementation used to create a proxy object to interact with OpenL Tablets service. To create a proxy object, define a bean factory as described in the following example:

```
<bean id="service1" class="org.openl.rules.ruleservice.simple.OpenLServiceFactoryBean">
  <!-- <property name="rulesFrontend" ref="frontend"/> optional. For custom
  implementation of RulesFrontend -->
  <property name="serviceName" value="service1"/>
  <property name="proxyInterface" value="com.myproject.Service1"/>
</bean>
```

In this example, `serviceName` is a name of the deployed OpenL Tablets service and `proxyInterface` is an interface for building a proxy object. All invocations of proxy object methods are delegated to the `execute` method of the `frontend` bean. The invoked method name with its parameters is used as input parameters for the `execute` method.

Note: Proxy beans and proxy objects created by `frontend` bean are automatically updated if the OpenL Tablets service is redeployed into a data source. Nevertheless, these objects are not working while the project is redeployed. To synchronize this process, use Service Publisher listeners described in further sections.

3.3 Customizing and Configuring Rule Services Core

The Rule Services Core module configuration features resemble configuration features for OpenL Tablets Rule Services. The OpenL Tablets Rule Services customization and configuration information is provided in this document and can be applied to Rule Services Core in the same way. For the list of components supported only by OpenL Tablets Rule Services, see diagrams in [Introduction](#).

4 OpenL Tablets Rule Services Configuration

OpenL Tablets Rule Services architecture allows extending mechanisms of services loading and deployment according to the particular project requirements.

This section describes OpenL Tablets Rule Services configuration and includes the following topics:

- [OpenL Tablets Rule Services Default Configuration](#)
- [OpenL Tablets Rule Services Default Configuration Files](#)
- [Service Manager](#)
- [Configuration Points](#)

4.1 OpenL Tablets Rule Services Default Configuration

All OpenL Tablets Rule Services configuration is specified in Spring configuration files and `application.properties` files. The `application.properties` file is located inside the application `.war` file (inside `WEB-INF/classes` folder), in a user's directory or in a working directory.

The configuration file located inside the `.war` file contains default settings for all properties. Use it as a reference of possible settings and redefine as required in your configuration file, such as the `application.properties` file located in a user's home directory.

All settings used in `application.properties` file can be defined as JVM options. In this case, JVM options override settings defined in files.

By default, OpenL Tablets Rule Services is configured as follows:

1. A data source is configured as `FileSystemDataSource` located in the "`${user.home}/.openl/datasource`" folder.
2. All services are exposed as REST/SOAP services using the CXF framework.
3. `LastVersionProjectsServiceConfigurer` is used as a default service configurer that takes the last version of each deployment and creates the service for each project using all modules contained in the project.

4.2 OpenL Tablets Rule Services Default Configuration Files

If necessary, modify the OpenL Tablets Rule Services configuration by overriding the existing configuration files. All overridden Spring beans must be defined in the `openl-ruleservice-override-beans.xml` file. The following table lists Spring configuration files used in OpenL Tablets Rule Services:

Spring configuration files used in OpenL Tablets Rule Services	
File	Description
<code>openl-ruleservice-beans.xml</code>	Main configuration file that includes all other configuration files. This file is searched by OpenL Tablets Rule Services in the classpath root.
<code>openl-ruleservice-core-beans.xml</code>	Configuration for <code>ServiceManager</code> and <code>InstantiationFactory</code> .
<code>openl-ruleservice-datasource-beans.xml</code>	Configuration for data sources.
<code>openl-ruleservice-loader-beans.xml</code>	Configuration for rules loader.

Spring configuration files used in OpenL Tablets Rule Services	
File	Description
openl-ruleservice-publisher-beans.xml	Common publisher configurations.
openl-ruleservice-webservice-publisher-beans.xml	Configuration for web services publisher (SOAP)
openl-ruleservice-jaxrs-publisher-beans.xml	Configuration for RESTful services publisher.
openl-ruleservice-rmi-publisher-beans.xml	Configuration for RMI services publisher.
openl-ruleservice-kafka-publisher-beans.xml	Configuration for RMI services publisher.
openl-ruleservice-conf-beans.xml	Configuration for Service Configurer.
openl-ruleservice-store-log-data-beans.xml	Configuration for external request and response storages.
application.properties	Main configuration file containing properties for OpenL Tablets Rule Services configuration.

For more information on configuration files, see [Configuration Points](#).

4.3 Service Manager

Service Manager is the main component of OpenL Tablets Rule Services frontend joining all major parts, such as a loader, rule service publishers, and Service Configurer. For more information on OpenL Tablets Rule Services frontend components, see [\[OpenL Tablets Developer Guide\]](#).

Service Manager manages all currently running services and intelligently controls all operations for deploying, undeploying, and redeploying the services. These operations are only performed in the following cases:

- initial deployment at application startup
- processing after data source update

Service Manager always acts as a data source listener as described in further sections of this chapter.

4.4 Configuration Points

Any part of OpenL Tablets Rule Services frontend can be replaced by the user's own implementation. For more information on the system architecture, see [\[OpenL Tablets Developer Guide\]](#).

If the common approach is used, the following components must be configured:

Configuration components	
Component	Description
Data source	Informs the OpenL Tablets system where to retrieve user's rules.
Service exposing method	Defines the way services are exposed, for example, as a web service or a simple Java framework.

The following sections describe how to configure these components:

- [Configuring a Data Source](#)
- [Service Configurer](#)
- [Service Exposing Methods](#)

- [Configuring System Settings](#)
- [CORS Filter Support](#)
- [Logging Requests to OpenL Tablets Rule Services and Their Responses in a Storage](#)

Note: There is a specific rule of parsing parameter names in methods. The algorithm checks the case of the second letter in a word and sets the first letter case the same as for the second letter. For example, parameters for `MyMethod` (`String fParam, String sParam`) in REST requests are defined as `FParam` and `sParam`.

Configuring a Data Source

The system supports the following data source implementations:

- [File System](#)
- [Relational Database](#)
- [Amazon AWS S3](#)
- [GIT](#)
- [Classpath JAR](#)

File System

Using a file system as a data source for projects means that projects are stored in a local folder. By default, the configuration folder represents a single deployment containing all the projects and does not support multiple deployments and project versions. This data source is used by default.

To configure a local file system as a data source, proceed as follows:

1. In `application.properties`, set `production-repository.factory = repo-file`.
By default, the `${user.home}/.openl/openl-ruleservice/datasource` folder is used as a local folder for projects.
2. To enable versioning support for deployment, set the `ruleservice.datasource.filesystem.supportVersion` setting to `true`.

Note: For proper parsing of Java properties file, the path to the folder must be defined with a slash ("/") as the folders delimiter. Back slash "\" is not allowed.

Relational Database

To use a relational database repository as a data source, proceed as follows:

1. Add the appropriate driver library for a database.
For example, for MySQL 5.6, it is the `mysql-connector-java-5.1.31.jar`.
2. In the `application.properties` file, set repository settings as follows:
 1. Set `production-repository.factory = repo-jdbc`.
 2. Set the value for `production-repository.uri` according to the database as follows:

URL value for databases	
Database	URL value
MySQL, MariaDB	<code>jdbc:mysql://[host][:port]/[schema]</code>
Oracle	<code>jdbc:oracle:thin:@//[HOST][:PORT]/SERVICE</code>
MS SQL	<code>jdbc:sqlserver://[serverName[\instanceName][:portNumber]][;property=value[;property=value]]</code>

```
Postgres jdbc:postgresql://[host][:port]/[schema]
QL
```

For example, for MySQL, `production-repository.uri = jdbc:mysql://localhost:3306/deployment-repository`.

3. Set login and password for a connection to the database in `production-repository.login` and `production-repository.password` settings.

Note: The password must be encoded via Base64 encoding schema if the `production-repository.encode.decode.key` property is not empty.

```
production-repository.factory = repo-jdbc
production-repository.uri = jdbc:h2:mem:repo;DB_CLOSE_DELAY=-1
production-repository.login = root
production-repository.password = admin
# Secret key for password code/decode
secret.key=
#secret.cipher=AES/CBC/PKCS5Padding
```

Amazon AWS S3

To use an AWS S3 repository as a data source, proceed as follows:

1. To build a customized version of OpenL Tablets Rule Services with dependencies on

`*org.openl.rules.repository.aws`, create a `pom.xml` file with the following content:

```
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://maven.apache.org/maven-
v4_0_0.xsd">
  <modelVersion>4.0.0</modelVersion>
  <groupId>com.example.openl</groupId>
  <artifactId>webservice-aws</artifactId>
  <packaging>war</packaging>
  <version>1.0-beta</version>

  <properties>
    <project.build.sourceEncoding>UTF-8</project.build.sourceEncoding>
    <org.openl.version>#Define OpenL Tablets version here#</org.openl.version>
  </properties>
  <dependencies>
    <dependency>
      <groupId>org.openl.rules</groupId>
      <artifactId>org.openl.rules.repository.aws</artifactId>
      <version>${org.openl.version}</version>
    </dependency>
    <dependency>
      <groupId>org.openl.rules</groupId>
      <artifactId>org.openl.rules.ruleservice.ws</artifactId>
      <type>war</type>
      <version>${org.openl.version}</version>
    </dependency>
  </dependencies>
  <dependencyManagement>
    <dependencies>
      <dependency>
        <groupId>com.fasterxml.jackson.core</groupId>
        <artifactId>jackson-databind</artifactId>
        <version>2.9.5</version>
      </dependency>
    </dependencies>
  </dependencyManagement>
```

```

        <groupId>com.fasterxml.jackson.core</groupId>
        <artifactId>jackson-annotations</artifactId>
        <version>2.9.5</version>
    </dependency>
</dependency>
    <groupId>commons-codec</groupId>
    <artifactId>commons-codec</artifactId>
    <version>1.11</version>
</dependency>
</dependencies>
</dependencyManagement>
</project>

```

2. Set the following properties in the `application.properties` file:

```

production-repository.factory = repo-aws-s3
production-repository.bucket-name = yourBucketName
production-repository.region-name = yourS3Region
production-repository.access-key = yourAccessKey
production-repository.secret-key = yourSecretKey

```

GIT

To use a Git repository as a data source, proceed as follows:

1. To build a customized version of OpenL Tablets Rule Services with dependencies on

*`org.openl.rules.repository.git`, create a `pom.xml` file with the following content:

```

<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://maven.apache.org/maven-
v4_0_0.xsd">
    <modelVersion>4.0.0</modelVersion>
    <groupId>com.example.openl</groupId>
    <artifactId>webservice-git</artifactId>
    <packaging>war</packaging>
    <version>1.0-beta</version>

    <properties>
        <project.build.sourceEncoding>UTF-8</project.build.sourceEncoding>
        <org.openl.version>>#Define OpenL Tablets version here#</org.openl.version>
    </properties>
    <dependencies>
        <dependency>
            <groupId>org.openl.rules</groupId>
            <artifactId>org.openl.rules.repository.git</artifactId>
            <version>${org.openl.version}</version>
        </dependency>
        <dependency>
            <groupId>org.openl.rules</groupId>
            <artifactId>org.openl.rules.ruleservice.ws</artifactId>
            <type>war</type>
            <version>${org.openl.version}</version>
        </dependency>
    </dependencies>
</project>

```

2. Build it with Maven: `mvn clean package`.

3. Replace `webservice.war` with the war file you built.

4. Set the following properties to the `application.properties` file (change necessary fields):

```

production-repository.factory = repo-git
production-repository.uri = https://github.com/<your-name>/your-repo.git
production-repository.login = your-login

```

```
production-repository.password = your-password
```

5. Additionally, to override default values, add these optional properties:

```
# Local path for Git repository.
production-repository.local-repository-path = ${ruleservice.openl.home}/git
# The branch where deployed projects can be found.
production-repository.branch = master
# Committer's display name. If null, username will be "OpenL_Deployer".
production-repository.user-display-name =
# Committer's email. If null, email will be empty.
production-repository.user-email =
# Repository connection timeout in seconds. Must be greater than zero.
production-repository.connection-timeout = 60
# Repository changes check interval in seconds. Must be greater than 0.
production-repository.listener-timer-period = 10
```

Classpath JAR

If rule projects with the `rules.xml` project descriptor are packed into a JAR file and placed in the classpath, these projects are deployed in the configured data source at the application launch.

Proceed as follows:

1. Put the JAR file with the project to `\<TOMCAT_HOME>\webapps\<rule services file name>\WEB-INF\lib`.
2. In the `application.properties` file, set up the `ruleservice.datasources.deploy.classpath.jars = true`.

By default, this property is set to `true`.

Note: Project deployment is skipped if the data source already contains the project with the same name.

Service Configurer

This section introduces Service Configurer and includes the following topics:

- [Understanding Service Configurer](#)
- [Deployment Configuration File](#)
- [Service Description](#)
- [Configuring the Deployment Filter](#)

Understanding Service Configurer

Service Configurer resolves a list of services to be exposed, such as modules contained in each service, service interface, and runtime context provision.

Modules for a service can be retrieved for different projects. Each deployment containing in a data source has a set of properties and can be represented in several versions. Deployment consists of projects that also have properties and contain some modules. There can be only one version of a specific project in the deployment.

Each module for a service can be identified by the deployment name, deployment version, project name inside the deployment, and module name inside the project.

Different module gathering strategies according to their needs can be implemented by extending `org.openl.rules.ruleservice.conf.ServiceConfigurer` interface. Users can choose deployments and projects with concrete values of a specific property, such as service for some LOB property or service containing modules with an expiration date before a specific date, or versions of deployments, or both these approaches.

OpenL Tablets users typically need web services containing several rule projects or modules. In this case, multiple modules can be united in one service using the `org.openl.rules.ruleservice.core.ServiceDescription` service description. Service description contains information about the required service, such as the service name, URL, and service class, and can be expanded to contain new configurations. To instantiate several modules, users can rely on the OpenL Tablets multi-module mechanism that combines a group of modules into a single rules engine instance.

The `org.openl.rules.ruleservice.conf.LastVersionProjectsServiceConfigurer` default implementation of Service Configurer retrieves all deployments from a data source and publishes the latest versions of projects with unique version from the corresponding deployment configuration file `rules-deploy.xml`. In other words, if the `version` tag is not used in service description files for the same project versions, only one latest deployment version is published; otherwise, all deployment versions with unique `version` tag are published.

Deployment Configuration File

Default implementation of Service Configurer uses the `rules-deploy.xml` deployment configuration file from the project root folder. This file is created manually or via OpenL Tablets WebStudio. An example of the `rules-deploy.xml` file is as follows:

```
<rules-deploy>
  <isProvideRuntimeContext>true</isProvideRuntimeContext>
  <isProvideVariations>false</isProvideVariations>
  <serviceName>myService</serviceName>
  <serviceClass>com.example.MyService </serviceClass>
  <url>com.example.MyService</url>
  <publishers>
    <publisher>RESTFUL</publisher>

  </publishers>
  <configuration>
    <entry>
      <string>someString</string>
      <string>someString</string>
    </entry>
  </configuration>
</rules-deploy>
```

When deploying a project to OpenL Tablets Rule Services, if the `rules-deploy.xml` file is missing or does not contain the SOAP service defined, only RESTful service is deployed.

Project configuration		
Tag	Description	Required
<code>isProvideRuntimeContext</code>	Identifies, if set to <code>true</code> , that a project provides a runtime context. The default value is defined in the <code>application.properties</code> file.	No
<code>isProvideVariations</code>	Identifies, if set to <code>true</code> , that a project provides variations. The default value is defined in the <code>application.properties</code> file.	No

Project configuration		
Tag	Description	Required
serviceName	Defines a service name. The service name defined in the file is displayed for a deployed project in the embedded mode only. Otherwise, the service name is derived from its path. A default pattern is "{deployment_configuration_name}/{project_name}".	No
serviceClass	Defines a service class. If it is not defined, a generated class is used.	No
rmiServiceClass	Define a service class to be used by RMI publisher.	Yes, if RMI is used
version	Defines a service version.	No
url	Defines URL for a service.	No
annotationTemplateClassName	Defines an interface being used as a template to annotate dynamic generated interface class.	No
groups	Defines a list of comma-separated groups used for this project.	No
publishers	Defines a list of publishers for a project.	No
configuration	Is used as extension point for custom service configuration.	No
lazy-modules-for-compilation	Defines a list of modules to be loaded in case lazy loading mechanism is used. Module names can contain Ant path expressions.	No
jackson.serializationInclusion	Serialization option for JSON based services.	No
jackson.dateFormat	Used to define date format is used in JSON.	No
jackson.caseInsensitiveProperties	Deserialization option for JSON based services.	No
jackson.failOnUnknownProperties	Deserialization option for JSON based services. For more information on this property, see Configuring JSON Payload Serialization and Deserialization .	No

Project configuration												
Tag	Description	Required										
jackson.propertyNamingStrategy	Used to configure names of output spreadsheet attributes. Supported attribute name strategies are as follows:											
	<table border="1"> <thead> <tr> <th>Strategy</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>org.openl.rules.serialization.spr.LowerCamelCaseStrategy</td> <td>All name elements, excluding the first one, start with a capitalized letter, followed by lowercase ones. The first letter is lowercased, and there are no separators. Example: columnName.</td> </tr> <tr> <td>org.openl.rules.serialization.spr.SnakeCaseStrategy</td> <td>All letters are lowercase with underscores used as separators between name elements. Example: columnname_rowname.</td> </tr> <tr> <td>org.openl.rules.serialization.spr.LowerCaseStrategy</td> <td>All letters are lowercase with no separators. Example: columnname.</td> </tr> <tr> <td>org.openl.rules.serialization.spr.UpperCamelCaseStrategy</td> <td>All name elements start with a capitalized letter, followed by lowercase ones, and there are no separators. Example: ColumnNameRowName.</td> </tr> </tbody> </table>	Strategy	Description	org.openl.rules.serialization.spr.LowerCamelCaseStrategy	All name elements, excluding the first one, start with a capitalized letter, followed by lowercase ones. The first letter is lowercased, and there are no separators. Example: columnName.	org.openl.rules.serialization.spr.SnakeCaseStrategy	All letters are lowercase with underscores used as separators between name elements. Example: columnname_rowname.	org.openl.rules.serialization.spr.LowerCaseStrategy	All letters are lowercase with no separators. Example: columnname.	org.openl.rules.serialization.spr.UpperCamelCaseStrategy	All name elements start with a capitalized letter, followed by lowercase ones, and there are no separators. Example: ColumnNameRowName.	
Strategy	Description											
org.openl.rules.serialization.spr.LowerCamelCaseStrategy	All name elements, excluding the first one, start with a capitalized letter, followed by lowercase ones. The first letter is lowercased, and there are no separators. Example: columnName.											
org.openl.rules.serialization.spr.SnakeCaseStrategy	All letters are lowercase with underscores used as separators between name elements. Example: columnname_rowname.											
org.openl.rules.serialization.spr.LowerCaseStrategy	All letters are lowercase with no separators. Example: columnname.											
org.openl.rules.serialization.spr.UpperCamelCaseStrategy	All name elements start with a capitalized letter, followed by lowercase ones, and there are no separators. Example: ColumnNameRowName.											
rootClassNamesBinding	Defines a list of classes for automatically define inheritance between defined classes and properly registering them.	No										

Service Description

Commonly each service is represented by rules and service interface and consists of the following elements:

Service description	
Service	Description
Service name	Unique service identifier. If a service name is defined in the <code>rules-deploy.xml</code> file, it is displayed for the service in the embedded mode only. Otherwise, the service name is generated from the path as <code>"{deployment_configuration_name}/{project_name}"</code> .
Service URL	URL path for the service. It is absolute for the console start and relative to the context root for the <code>ws.war</code> case.
Service class	Interface of the service to be used at the server and the client side.
Version	Number of the service version.
Rules	Module or a set of modules to be combined as a single rules module.
Provide runtime context flag	Identifier of whether the runtime context must be added to all rule methods. If it is set to <code>true</code> , the <code>IRulesRuntimeContext</code> argument must be added to each method in the service class.
Support variations flag (optional)	Identifier of whether the current service supports variations. For more information on variations, see Variations .

Configuring the Deployment Filter

The system provides the ability to set up the Deployment Filter to filter deployments from configured data source when several applications use the same data source. Filtering selects deployments by name.

The property `ruleservice.datasource.deployments` is defined in the `application.properties` file and it is disabled by default.

To enable the Deployment Filter, set the exact deployment names using a comma separator, or use the wildcard character to enable the filter to match patterns in the deployment name:

```
ruleservice.datasource.deployments = foo-deployment, bar-*
```

The wildcard character “*” matches any characters in the deployment name as follows:

- If a single asterisk is used, any of the `foo-*`, `*deployment.single` wildcard character patterns detect `foo-deployment`.
- If multiple asterisks are used, any of the `*deploy*`, `*deployment*` single wildcard character patterns detect `foo-deployment`.

Service Exposing Methods

Common flow of service exposing is as follows:

1. Retrieve service descriptions from a data source.
2. Undeploy the currently running services that are not in services defined by Service Configurer. Some services can become unnecessary in the new version of the product.
3. Redeploy currently running services that are still in services defined by Service Configurer, such as service update.
4. Deploy new services not represented earlier.

To set the method of exposing services, configure a Spring bean with the `ruleServiceManager` name in `openl-ruleservice-publisher-beans.xml`.

This bean supports mapping a concrete publisher for a service configuration or uses a default publisher if the publisher is not defined in the `rules-deploy.xml` deployment configuration file.

To add a publisher, use any framework by implementations of

`org.openl.rules.ruleservice.publish.RuleServicePublisher` interface and register it in the `ruleServicePublisher` bean.

OpenL Tablets Rule Services supports following publisher implementations out of the box:

- [CXF SOAP Publisher](#)
- [CXF REST Publisher](#)
- [RMI Publisher](#)
- [Kafka Publisher](#)

CXF SOAP Publisher

CXF SOAP Publisher implementation class is

`org.openl.rules.ruleservice.publish.JAXWSRuleServicePublisher`. The Spring configuration for CXF Web Service Publisher is defined in the `openl-ruleservice-webservice-publisher-beans.xml` file.

Note: The full web service address is `webserver_context_path/ws_app_war_name/url_specified_by_you` in the `rules-deploy.xml` file or `deployment name/project name` if not specified.

Configuring Aegis Databinding

The setting is deprecated. It is defined in the `application.properties` file. The default values are as follows:

```
ruleservice.aegisbinding.readXsiTypes = true
ruleservice.aegisbinding.writeXsiTypes = true
ruleservice.aegisbinding.ignoreNamespaces = false
```

For more information on Aegis databinding, see CXF Aegis databinding documentation.

CXF REST Publisher

CXF REST Service Publisher implementation class is

`org.openl.rules.ruleservice.publish.JAXRSRuleServicePublisher`. The Spring configuration for this publisher is located in the `openl-ruleservice-jaxrs-publisher-beans.xml` file.

Note: The full web service address is `webserver_context_path/ws_app_war_name/REST/url_specified_by_you` in `rules-deploy.xml` file or `deployment name/project name` if not specified. If a project is not deployed to CXF SOAP Publisher at the same time, the service address will be without the `REST` part in the address.

The following URL can be used to retrieve a list of methods for a service:

```
webserver_context_path/ws_app_war_name/admin/services/{serviceName}/methods/
```

Configuring HTTP Status for Responses

The system can be configured to use the HTTP 200 status for all RESTful services requests even if service execution fails. To enable this feature, set `ruleservice.jaxrs.responseStatusAlwaysOK = true` in the `application.properties` file.

Defining a Date Format for JSON Serialization and Deserialization

REST services support the ISO-8601 standard for date type representation and accept the `yyyy-MM-dd'T'HH:mm:ss.SSS` format. Time and time zones are optional in requests. Time zones in ISO-8601 are represented as local time, with the location unspecified, as UTC, or as an offset from UTC. For more information on the ISO-8601 standard, see https://en.wikipedia.org/wiki/ISO_8601.

Date format can be defined in the `ruleservice.jackson.defaultDateFormat` property, in the `application.properties` file. The default date format value is as follows:

```
ruleservice.jackson.defaultDateFormat=yyyy-MM-dd'T'HH:mm:ss.SSS
```

This value is used by the system for all published projects that do not have the date format defined in the deployment configuration `rules-deploy.xml` file.

The `jackson.defaultDateFormat` value must be in the same syntax of the date time pattern as `SimpleDateFormat` described in <https://docs.oracle.com/en/java/javase/11/docs/api/java.base/java/text/SimpleDateFormat.html>.

Note that changing this setting affects all projects in the system. To change the date format for a particular project, modify the date format in the `rules-deploy.xml` deployment configuration file as follows:

```
<rules-deploy>
...
  <configuration>
    <entry>
      <string>jackson.defaultDateFormat</string>
      <string>yyyyMMddHHmmss</string>
```

```

        </entry>
    </configuration>
</rules-deploy>

```

Configuring JSON Payload Serialization and Deserialization

Default JSON properties serialization and deserialization behavior can be changed via `ruleservice.jackson.serializationInclusion`, `ruleservice.jackson.caseInsensitiveProperties`, and `ruleservice.jackson.failOnUnknownProperties` in the `application.properties` file. The default value for this property is set as follows:

```

ruleservice.jackson.serializationInclusion = USE_DEFAULTS
ruleservice.jackson.caseInsensitiveProperties = false
ruleservice.jackson.failOnUnknownProperties = false

```

These values are used by the system for all published projects that do not have these properties defined in the `rules-deploy.xml` file.

`ruleservice.jackson.serializationInclusion` is used for JSON serialization. Supported values are as follows:

serializationInclusion property values	
Value	Description
ALWAYS	A property is always included, regardless of the property value.
NON_ABSENT	Properties with no null values including no content null values are used.
NON_DEFAULT	All values except for the following are included: <ul style="list-style-type: none"> values considered empty primitive or wrapper default values date and time values that have a timestamp of `0L`, that is, `long` value of milliseconds since epoch
NON_EMPTY	Properties with empty values are excluded.
NON_NULL	Properties with non-null values are included.
USE_DEFAULTS	Defaults settings or annotations either from the class level or ObjectMapper level are used.

For more information on serialization values, see <https://fasterxml.github.io/jackson-annotations/javadoc/2.6/com/fasterxml/jackson/annotation/JsonInclude.Include.html>.

JSON payload of the same datatype with different `serializationInclusion` property values are as follows:

Datatype MyType	
Long	num
String	str
Object	obj
Integer[]	intArr
int[]	intArr2
Optional	opt
Optional	opt2
LocalDateTime	ldt
LocalDate	ld
LocalTime	lt
ZonedDateTime	zdt
boolean	b

Figure 3: JSON payload of the same datatype with different `serializationInclusion` values

`ruleservice.jackson.caseInsensitiveProperties` is a JSON deserialization. The system matches JSON property names to a Java class ignoring case sensitivity if this property is enabled.

`ruleservice.jackson.failOnUnknownProperties` is a JSON deserialization. The system fails if a missing field in a datatype is present in the JSON request. By default, the system ignores JSON properties in a request that cannot be matched to existing Java classes.

Note: Changing these settings affects all projects in the system. To modify `serializationInclusion` for a particular project, modify the `rules-deploy.xml` deployment configuration file as follows:

```
<rules-deploy>
...
  <configuration>
    <entry>
      <string>jackson.serializationInclusion</string>
      <string>NON_ABSENT</string>
    </entry>
    <entry>
      <string>jackson.failOnUnknownProperties</string>
      <string>>true</string>
    </entry>
    <entry>
      <string>jackson.caseInsensitiveProperties </string>
      <string>NON_ABSENT</string>
    </entry>
  </configuration>
</rules-deploy>
```

OpenL Tablets Rule Services uses a Jackson library to serialize an object to JSON and deserialize JSON to an object. This library supports configuration via MixIn annotation. For more information on MixIn annotations, see Jackson documentation <https://github.com/FasterXML/jackson-docs/wiki/JacksonMixInAnnotations>.

To register MixIn classes for a project, annotate the MixIn class with the `org.openl.rules.ruleservice.databinding.annotation.MixinClassFor` or `org.openl.rules.ruleservice.databinding.annotation.MixinClassFor` annotation and add this class to the `rules-deploy.xml` deployment configuration file as described further in this section. These annotations expect the class name that is used for registering MixIn class in the object mapper.

JAXB annotations is supported in the MixIn classes out of the box because the system is configured to use `com.fasterxml.jackson.module.jaxb.JaxbAnnotationIntrospector` as a secondary annotation interceptor in the object mapper for the deployed service.

Example of the Jackson MixIn class implementation is as follows:

```
@MixinClass("org.openl.generated.beans.Customer")
public abstract class CustomerMixin {

    @JsonProperty(required = true)
    protected Integer customerID;

    @JsonIgnore
    protected Integer privateField;

    @JsonFormat(pattern = "yyyy-MM-dd")
    protected Date dob;

    @JsonProperty("genderCd")
    @ApiModelProperty(example = "male")
    protected String gender;
}
```

Example of the deployment configuration file is as follows:

```
<rules-deploy>
...
  <configuration>
    <entry>
      <string>rootClassNamesBinding</string>
      <string>org.example.custom.mixin.CustomerMixin</string>
    </entry>
  </configuration>
</rules-deploy>
```

RMI Publisher

RMI Service Publisher implementation class is

`org.openl.rules.ruleservice.publish.RmiRuleServicePublisher`. The Spring configuration for this publisher is located in the `openl-ruleservice-rmi-publisher-beans.xml` file.

Note: The full RMI service address is `rmi://hostname:port/rmi name` specified by you in `rules.xml` file.

The appropriate port and host name for RMI can be defined in the `application.properties` file.

By default, these properties are defined as follows:

```
ruleservice.rmiPort = 1099 // Port for RMI
ruleservice.rmiHost = 127.0.0.1 // Used as host for RMI
```

Kafka Publisher

The system handles messages from the Kafka input topic and publishes rules calculation results to an output topic or dead letter topic if any error occurs during message processing.

Only Kafka brokers 0.11.0 and later are supported.

The following topics are included in this section:

- [Modes for Exposing Services](#)
- [Supported Message Headers](#)
- [Custom Message Serialization](#)
- [Date Format Definition and JSON Serialization and Deserialization Configuration](#)
- [Spring Kafka Integration Support](#)

Modes for Exposing Services

Kafka Publisher allows exposing the services in the following modes:

Modes for exposing OpenL Tablets services	
Mode	Description
A user configures Kafka settings for each rules method to expose as a service.	<ul style="list-style-type: none"> • All messages in all input topics belong to one rule method and have the same format. • One Kafka Consumer and two Kafka producers, that is, output topic and dead letter topic, are created for each exposed method. • Input topic, output topic, and DLT must be created for each method.

Modes for exposing OpenL Tablets services	
Mode	Description
A user configures Kafka settings for a service.	<ul style="list-style-type: none"> All methods from this service are exposed as services. Messages in the input topic belong to different rule methods and are of different format, depending on the method input parameters. The method name is set via Kafka Headers. One Kafka consumer and two producers, that is, output topic and dead letter topic, are created for a service. One input topic, one output topic, and one DLT is enough for the OpenL Tablets service. A service can be exposed in both modes at the same time.

The following topics are included in this section:

- [Enabling Kafka Publisher for a Service](#)
- [Configuring Application Level Kafka Settings](#)
- [Configuring Service Level Kafka Settings](#)

Enabling Kafka Publisher for a Service

By default, Kafka Publisher is not used for deployed projects. To enable it, add the Kafka Publisher type to `rules-deploy.xml` as follows:

```
<rules-deploy>
...
  <publishers>
    <publisher>KAFKA</publisher>
  </publishers>
...
</rules-deploy>
```

Configuring Application Level Kafka Settings

OpenL Tablets Rule Services can be configured via the `application.properties` file or environment variables. Kafka-related settings are as follows:

Application level Kafka settings		
Property name	Default value	Description
<code>ruleservice.kafka.bootstrap.servers</code>	<code>localhost:9092</code>	Comma separated Kafka broker hosts.
<code>ruleservice.kafka.group.id</code>	<code>openl-webservice</code>	Group name for all Kafka consumers created by the application.

Configuring Service Level Kafka Settings

If an OpenL Tablets service is configured to use Kafka Publisher, the OpenL Tablets service must contain the `kafka-deploy.yaml` file in the same place where `rules-deploy.xml` deployment configuration is located.

Service level Kafka settings	
Kafka settings for a service	Kafka setting for each rules method that want to expose as a service
<pre>service: in.topic.name: in-topic-for-service out.topic.name: out-topic-for-service dlt.topic.name: dlt-topic-for-service consumer.configs: auto.offset.reset: earliest</pre>	<pre>method.configs: - method.name: method1 in.topic.name: in-topic-for-method1 out.topic.name: out-topic-for-method1 dlt.topic.name: dlt-topic-for-method1 - method.name: method2 in.topic.name: in-topic-for-method2 out.topic.name: out-topic-for-method2 dlt.topic.name: dlt-topic-for-method2 consumer.configs: auto.offset.reset: earliest</pre>

Configuring Kafka consumers or Kafka producer is supported via `producer.configs`, `consumer.configs`, and `dlt.producer.configs`. These settings can be used for a service or each method.

The default configuration for all methods or service is supported if `producer.configs`, `consumer.configs` and `dlt.producer.configs` are defined at the top level of `kafka-deploy.yaml`.

An example of `consumer.configs` is as follows:

```
auto.offset.reset: earliest
```

An example of the `method.configs` is as follows:

```
- method.name: method1
  in.topic.name: in-topic-for-method1
  out.topic.name: out-topic-for-method1
  dlt.topic.name: dlt-topic-for-method1
- method.name: method2
  in.topic.name: in-topic-for-method2
  out.topic.name: out-topic-for-method2
  dlt.topic.name: dlt-topic-for-method2
```

Kafka consumers for all methods are configured to use `auto.offset.reset = earliest` as described in the previous example.

For a complete list of configuration properties, see <https://kafka.apache.org/documentation/#consumerconfigs> and <https://kafka.apache.org/documentation/#producerconfigs>.

Supported Message Headers

Configurations `out.topic.name` and `dlt.topic.name` are optional, and the system can handle an output topic name and DLT topic name from record headers. A list of supported headers is as follows:

Supported message headers	
Header name	Description
methodName	Method name. If an OpenL Tablets service is configured to use one input topic for all rule methods, this header defines a rule method name to invoke. If a rule method name is not unique in rules, for example, when overloading is used for a method, <code>methodParameters</code> header must be used as well.
methodParameters	Comma separated list of rule method types. Wildcards are supported.
kafka_correlationId	Information to correlate requests and replies.
kafka_replyPartition	Partition number on which to send the reply.

Supported message headers	
Header name	Description
kafka_replyTopic	Default reply topic. If this header is defined, the output topic from a header is used by Kafka Publisher for this message.
kafka_replyDltPartition	Partition number on which to send the reply DLT topic.
kafka_replyDltTopic	Default reply DLT topic. If this header is defined, the DLT topic from a header is used by Kafka Publisher for this message.
kafka_dlt-exception-fqcn	Exception class name for a record published sent to a dead-letter topic.
kafka_dlt-exception_message	Exception message for a record published to a dead-letter topic.
kafka_dlt-original-offset	Original offset for a record published to a dead-letter topic.
kafka_dlt-original-topic	Original topic for a record published to a dead-letter topic.
kafka_dlt-original-partition	Original partition for a record published to a dead-letter topic.
kafka_dlt-original-message-key	Original message key for a record published to a dead-letter topic.

Custom Message Serialization

By default, Kafka Publisher uses the JSON format.

To use custom serializers and deserializers, do the following:

- Implement custom deserializer for input parameters via the implementation `org.openl.rules.ruleservice.kafka.ser.MessageDeserializer` class.
- Register a custom implemented deserializer in the `value.serializer` Kafka configuration property for particular consumers.

Date Format Definition and JSON Serialization and Deserialization Configuration

JSON configuration is the same as described for the REST services:

- [Defining a Date Format for JSON Serialization and Deserialization](#)
- [Configuring JSON Payload Serialization and Deserialization](#)

Note: The same JSON serialization and deserialization configuration is used for REST publisher and Kafka publisher.

Spring Kafka Integration Support

Kafka Publisher supports Spring Kafka headers to work with Spring Kafka Request Reply design pattern implementation out of the box.

Configuring System Settings

There are several options extending rules behavior in OpenL Tablets:

- [Dispatching Table Properties](#)
- [Table Dispatching Validation Mode](#)
- [Configuring a Number of Threads to Rules Compilation](#)
- [Enabling Logging to Console](#)
- [Configuring the Instantiation Strategy](#)

These settings are defined in the `application.properties` configuration file.

Dispatching Table Properties

Previously selecting tables that correspond to the current runtime context was processed by Java code. Now rules dispatching is the responsibility of the generated Dispatcher decision table. Such table is generated for each group of methods overloaded by dimension properties. The Dispatcher table works like all decision tables, so the first rule matched by properties is executed even if there are several tables matched by properties. Previously, in Java code dispatching, `AmbiguousMethodException` would be thrown in such case.

To support both functionalities, the `dispatching.mode` system property is introduced. It has the following possible values:

dispatching.mode property values	
Value	Description
java	Dispatching is processed by Java code. The benefit of such approach is stricter dispatching: if several tables are matched by properties, <code>AmbiguousMethodException</code> is thrown.
dt	Deprecated. Dispatching is processed by the Dispatcher decision table.

If the system property is not specified or if the `dispatching.mode` property has an incorrect value, the Java approach is used by default.

Table Dispatching Validation Mode

An explanation of table dispatching validation is as follows.

Consider a rule table for which some business dimension properties are set up. There is only one version of this rule table. The following table describes options of versioning functionality behavior for this case depending on the `dispatching.validation` property value located in `webstudio\WEB-INF\conf`:

Value of dispatching.validation property	
Value	Versioning behavior description
True	Versioning functionality works as for a rule that has only one version. OpenL Tablets reviews properties values of this rule table and executes the rule if the specified properties values match runtime context. Otherwise, the No matching methods for context error message is returned.
False	OpenL Tablets ignores properties of this rule table, and this rule is always executed and returns the result value despite of runtime context.

For table testing, dispatching validation is enabled by setting the `dispatching.validation` property value to `true`. The property is located in the `application.properties` file. In this case, versioning functionality works as for a rule that has only one version, and OpenL Tablets reviews properties values of this rule table and executes the rule if the specified properties values match runtime context. In production, this property value must be set to `false`.

By default, the `dispatching.validation` value is set to `false` in OpenL Tablets Rule Services and to `true` in OpenL Tablets WebStudio.

Configuring a Number of Threads to Rules Compilation

The system supports parallel rules compilation. Rules compilation consumes a large amount of memory. If the system tries to compile too many rules at once, it fails with an out of memory exception.

Use the `ruleservice.instantiation.strategy.maxthreadsforcompile` property in the `application.properties` file to limit the number of threads to compile rules.

By default, only three threads are used to compile rules in parallel:

```
ruleservice.instantiation.strategy.maxthreadsforcompile = 3
```

For example, to permit only one thread to compile rules, set value to one as follows:

```
ruleservice.instantiation.strategy.maxthreadsforcompile = 1
```

Enabling Logging to Console

To enable logging all requests to OpenL Tablets Rule Services and their responds to standard output, set the `ruleservice.logging.enabled` property in the `application.properties` file to `true`. This feature is very valuable in development. By default, it is disabled.

Configuring the Instantiation Strategy

The system provides an ability to change an instantiation strategy. The property `ruleservice.instantiation.strategy.lazy` is defined in the `application.properties` file.

By default, the lazy initialization strategy is enabled:

```
ruleservice.instantiation.strategy.lazy = true
```

Modules are compiled upon the first request and can be unloaded in future for memory save.

To disable the lazy initialization strategy, set `ruleservice.instantiation.strategy.lazy = false`. All modules are compiled on the application launch.

CORS Filter Support

Cross-Origin Resource Sharing (CORS) is a specification which is a standard mechanism that enables cross-origin requests. The specification defines a set of `Access-Control-*` headers that allow the browser and server to communicate about which requests are allowed. The filter also protects against HTTP response splitting. If request is invalid or is not permitted, the request is rejected with HTTP status code 403 (Forbidden). For more information on CORS, see <https://fetch.spec.whatwg.org/>.

The CORS filter supports the following initialization parameters:

CORS initialization parameters	
Attribute	Description
<code>cors.allowed.origins</code>	A list of origins that are allowed to access the resource. A <code>*</code> can be specified to enable access to resource from any origin. Otherwise, an allowed list of comma-separated origins can be provided. Examples: <code>https://www.w3.org</code> , <code>https://www.example.com</code> . The empty string means that no origin is allowed to access the resource.
<code>cors.allowed.methods</code>	A comma separated list of HTTP methods that can be used to access the resource using cross-origin requests. These methods are also included as a part of the <code>Access-Control-Allow-Methods</code> header in pre-flight response. Example: <code>GET,POST</code> .
<code>cors.allowed.headers</code>	A comma separated list of request headers for making an actual request. These headers are also returned as a part of the <code>Access-Control-Allow-Headers</code> header in pre-flight response. Example: <code>Origin,Accept</code> .

CORS initialization parameters	
Attribute	Description
<code>cors.preflight.maxage</code>	The number of seconds a browser is allowed to cache the result of the pre-flight request. This attribute is included as a part of the <code>Access-Control-Max-Age</code> header in the pre-flight response. A negative value prevents a CORS filter from adding this response header to the pre-flight response.

The default CORS configuration is as follows:

```
cors.allowed.origins =
cors.allowed.methods = GET, OPTIONS, HEAD, PUT, POST
cors.allowed.headers = Content-Type, Accept, api_key, Authorization
cors.preflight.maxage = 7200
```

Logging Requests to OpenL Tablets Rule Services and Their Responds in a Storage

The system provides an ability to store all requests to OpenL Tablets Rule Services and their responds in a storage. The setting is defined in the `application.properties` file. The following topics describe logging setup:

- [Understanding Logging to an External Storage](#)
- [Enabling Logging to an External Storage](#)
- [Storing Log Records in Apache Cassandra](#)
- [Storing Log Records in the Relational Database](#)
- [Storing Log Records in Elasticsearch](#)
- [Storing Log Records in Hive](#)

Understanding Logging to an External Storage

OpenL Tablets Rule Services supports storing requests and responses for SOAP, REST, and Kafka publishers in the external storage. This feature is designed to support any external storage and use the Apache Casandra or Elasticsearch out of the box.

For each request to OpenL Tablets Rule Services, the system creates an object of the `org.openl.rules.ruleservice.storelogdata.StoreLogData` class, which is populated with data during request processing and then can be stored in the configured storage. It contains the following data:

<code>org.openl.ruleservice.logging.LoggingInfo</code> class data	
Field name	Description
<code>requestMessage</code>	Request data for logging, such as request body, URL, request header, and request content type.
<code>responseMessage</code>	Response data for logging, such as response body, response status, and response header.
<code>incomingMessageTime</code>	Time when request is received by the server.
<code>outcomingMessageTime</code>	Time when response message preparation is completed and the message is ready to be sent to the client.
<code>service</code>	OpenL Tablets service used for the call. Data includes service name, compiled OpenL Tablets rules, and other information.
<code>inputName</code>	Method used for the call.
<code>parameters</code>	Parameters of the call, which is an array of objects after binding request message to models.

When the logging data is collected, the system invokes the storing service responsible for saving logging data. The storing service must implement the `org.openl.rules.ruleservice.storelogdata.StoreLogDataService` interface.

Enabling Logging to an External Storage

By default, logging requests to OpenL Tablets Rule Services and their responds is disabled:

```
ruleservice.store.logs.enabled = false
```

To enable logging, set `ruleservice.store.logs.enabled = true`.

Storing Log Records in Apache Cassandra

Apache Cassandra is a free and open-source, distributed, wide column storage database that can be used as external storage. To start using Apache Cassandra, proceed as follows:

1. Download the OpenL Tablets Rule Services full web application at <http://openl-tablets.org/downloads> or use the following Maven command:

```
mvn dependency:copy -Dartifact=org.openl.rules:org.openl.rules.ruleservice.ws.full:<openl version here>;war -DoutputDirectory=.
```

2. Enable the Cassandra Storing Log feature using the `ruleservice.store.logs.cassandra.enabled=true` setting in the `application.properties` file.
3. Set up Cassandra connection settings defined in the `application.properties` file as described in the following lines:

```
datastax-java-driver.basic.load-balancing-policy.local-datacenter = datacenter1
datastax-java-driver.basic.contact-points.0 = 127.0.0.1:9042
datastax-java-driver.basic.session-keyspace = openl_ws_logging
datastax-java-driver.advanced.protocol.version = V4
datastax-java-driver.advanced.auth-provider.username =
datastax-java-driver.advanced.auth-provider.password =
```

For more information on Cassandra, see <https://docs.datastax.com/en/developer/java-driver/4.5/manual/core/configuration/>. For more information on connection configuration options, see <https://docs.datastax.com/en/developer/java-driver/4.5/manual/core/configuration/reference/>.

4. Before running the application, create a keyspace in Cassandra as described in https://docs.datastax.com/en/cql/3.1/cql/cql_reference/create_keyspace_r.html.
5. To create a schema in the Cassandra database, start OpenL Tablets Rule Services for the first time with the `ruleservice.store.logs.cassandra.schema.create = true` property.

By default, this option is enabled. When the schema is created, set this property to the `false` value.

As a result, the following table with the `openl_log_data` name is created in the Cassandra database:

LoggingRecord table created in the Cassandra database		
Column name	Type	Description
ID	TEXT	Unique ID for the request. It is a primary key for the record.
INCOMINGTIME	TIMESTAMP	Incoming request time.
METHOD_NAME	TEXT	Method of a service that was called.
OUTCOMINGTIME	TIMESTAMP	Outgoing response time.
PUBLISHER_TYPE	TEXT	Request source, such as web service or REST service.
REQUEST	TEXT	Request body.

LoggingRecord table created in the Cassandra database		
Column name	Type	Description
RESPONSE	TEXT	Response body.
SERVICE_NAME	TEXT	Deployment service that was called.
URL	TEXT	URL of the request.

Note: Only methods annotated with `org.openl.rules.ruleservice.storelogdata.cassandra.annotation.StoreLogDataToCassandra` are used for storing their requests and responses in Apache Cassandra. The system supports customization to use different tables for each OpenL Tablets project, use product specific table names, and configure a set of columns of tables. For more information on customization using annotations, see [Service Customization through Annotations](#).

Storing Log Records in the Relational Database

To start using a relational database, proceed as follows:

1. Download the OpenL Tablets Rule Services full web application at <http://openl-tablets.org/downloads> or use the following Maven command:

```
mvn dependency:copy -Dartifact=org.openl.rules:org.openl.rules.ruleservice.ws.full:<openl version here>:war -DoutputDirectory=.
```
2. Enable the relational database Storing Log feature using the `ruleservice.store.logs.db.enabled=true` setting in the `application.properties` file.
3. Set up the Hibernate connection settings defined in the `application.properties` file as described in the following lines:

```
hibernate.connection.driver_class=oracle.jdbc.driver.OracleDriver
hibernate.connection.url=
hibernate.connection.username=
hibernate.connection.password=
hibernate.show_sql=false
hibernate.hbm2ddl.auto=update
hibernate.connection.provider_class=org.hibernate.hikaricp.internal.HikariCPConnectionProvider
hibernate.hikari.connectionTimeout=20000
hibernate.hikari.minimumIdle=10
hibernate.hikari.maximumPoolSize=20
hibernate.hikari.idleTimeout=300000
```

Relational database is supported via the Hibernate framework. Hibernate connection properties, such as `hibernate.connection.driver_class` and `hibernate.connection.url`, must be used to configure a connection to a relational database. For a full list of properties, see Hibernate documentation at https://docs.jboss.org/hibernate/orm/5.6/userguide/html_single/Hibernate_User_Guide.html#database.

If table creating is enabled in Hibernate, the system creates the following table with the `openl_log_data` name:

Table created in the relational database		
Column name	Type	Description
ID	TEXT	Unique ID for the request. It is a primary key for the record.
INCOMINGTIME	TIMESTAMP	Incoming request time.
METHOD_NAME	TEXT	Method of a service that was called.
OUTCOMINGTIME	TIMESTAMP	Outgoing response time.

Table created in the relational database		
Column name	Type	Description
PUBLISHER_TYPE	TEXT	Request source, such as web service or REST service.
REQUEST	TEXT	Request body.
RESPONSE	TEXT	Response body.
SERVICE_NAME	TEXT	Deployment service that was called.
URL	TEXT	URL of the request.

Note: Only methods annotated with

`org.openl.rules.ruleservice.storelogdata.db.annotation.StoreLogDataToDB` are used for storing their requests and responses in a relational database. The system supports customization to use different tables for each OpenL Tablets project, use product specific table names, and configure a set of columns for tables. For more information on customization using annotations, see [Service Customization through Annotations](#).

Storing Log Records in Elasticsearch

Elasticsearch is supported as external storage out of the box. **Elasticsearch** is a distributed, open source search and analytics engine for all types of data, including textual, numerical, geospatial, structured, and unstructured data. Raw data flows into Elasticsearch from a variety of sources, including logs, system metrics, and web applications. This raw data is parsed, normalized, and enriched before it is indexed in Elasticsearch. Once indexed in Elasticsearch, users can run complex queries against their data and use aggregations to retrieve complex summaries of their data. For more information on Elasticsearch, see <https://www.elastic.co/what-is/elasticsearch>.

The system uses Java High Level REST Client to communicate with the Elasticsearch servers that process application requests.

To start using Elasticsearch, proceed as follows:

1. Download the OpenL Tablets Rule Services full web application at <http://openl-tablets.org/downloads> or use the following Maven command:

```
mvn dependency:copy -Dartifact=org.openl.rules:org.openl.rules.ruleservice.ws.full:<openl version here>:war -DoutputDirectory=.
```

2. Set up Elasticsearch connection settings defined in the `application.properties` file as follows:

```
ruleservice.store.logs.elasticsearch.enabled = true
elasticsearch.hosts = http://127.0.0.1:9200
```

The following properties can be modified to configure Elasticsearch:

Elasticsearch configuration properties	
Property	Description
<code>ruleservice.store.logs.elasticsearch.enabled</code>	To store Elasticsearch logs, this property must be set to <code>true</code> .
<code>elasticsearch.hosts</code>	To enable using multiple Elasticsearch servers, use a comma-separated list. An example is as follows: <code>elasticsearch.hosts = http://127.0.0.1:9200, http://127.0.0.1:9201</code>

As a result, the following index with the default `openl_log_data` name is created in Elasticsearch:

openl_log_data table created in the Elasticsearch database		
Column name	Type	Description
ID	TEXT	Unique ID for the request. It is a primary key for the record.
INCOMINGTIME	TIMESTAMP	Incoming request time.
METHOD_NAME	TEXT	Method of a service that was called.
OUTCOMINGTIME	TIMESTAMP	Outgoing response time.
PUBLISHER_TYPE	TEXT	Request source, such as web service or REST service.
REQUEST	TEXT	Request body stored as JSON for search in Kibana.
REQUESTBODY	STRING	Request body.
RESPONSEBODY	STRING	Response body stored as JSON for search in Kibana.
RESPONSEBODY	STRING	Response body.
SERVICE_NAME	TEXT	Deployment service that was called.
URL	TEXT	URL of the request.

Note: Only methods annotated with `org.openl.rules.ruleservice.storelogdata.elasticsearch.annotation.StoreLogDataToElasticsearch` are used for storing their requests and responses to Elasticsearch. The system supports customization to use different tables for each OpenL Tablets project, use product specific table names, and configure a set of columns of the tables. For more information on customization using annotations, see [Service Customization through Annotations](#).

Storing Log Records in Hive

Apache Hive is supported as external storage out of the box. The Hive data warehouse software facilitates reading, writing, and managing large datasets residing in distributed storage using SQL. Structure can be projected onto data already in storage. A command line tool and JDBC driver are provided to connect users to Hive.

The system uses the JDBC driver to communicate with the Hive server that process application requests.

To start using Hive, proceed as follows:

1. Download the OpenL Tablets Rule Services full web application at <http://openl-tablets.org/downloads> or use the following Maven command:

```
mvn dependency:copy -Dartifact=org.openl.rules:org.openl.rules.ruleservice.ws.all:<openl version here>:war -DoutputDirectory=.
```

2. Set up Hive connection settings defined in the `application.properties` file as follows:

```
ruleservice.store.logs.hive.enabled = true
hive.connection.url = jdbc:hive2://localhost:10000/default
hive.connection.username =
hive.connection.password =
hive.connection.pool.maxSize = 10
```

The following properties can be modified to configure Hive:

Hive configuration properties	
Property	Description
<code>ruleservice.store.logs.hive.enabled</code>	Property to enable storing Hive logs.
<code>hive.connection.url</code>	URL for connecting to the Hive server. An example is as follows: <code>hive.connection.url = jdbc:hive2://localhost:10000/default</code>

Hive configuration properties	
Property	Description
hive.connection.username	Username for connecting to the Hive server.
hive.connection.password	Password for connecting to the Hive server.
hive.connection.pool.maxSize	OpenL Tablets uses HikariCP JDBC connection pool for managing Hive connections. The default pool size is 10. For more information on HikariCP, see https://github.com/brettwooldridge/HikariCP .
ruleservice.store.logs.hive.table.create	If set to true, property that enables the SQL script to create a table before making a record in it.

As a result, the following table with the default `openl_log_data` name is created in Hive:

openl_log_data table created in the Hive database		
Column name	Type	Description
ID	STRING	Unique ID for the request. It is a primary key for the record.
INCOMINGTIME	TIMESTAMP	Incoming request time.
METHODNAME	STRING	Method of a service that was called.
OUTCOMINGTIME	TIMESTAMP	Outgoing response time.
PUBLISHERTYPE	STRING	Request source, such as web service or REST service.
REQUEST	STRING	Request body stored as JSON.
RESPONSE	STRING	Response body stored as JSON.
SERVICENAME	STRING	Deployment service that was called.
URL	STRING	URL of the request.

Note: Only methods annotated with `org.openl.rules.ruleservice.storelogdata.hive.annotation.StoreLogDataToHive` are used for storing their requests and responses to Hive. The system supports customization to use different tables for each OpenL Tablets project, use product specific table names, and configure a set of columns of the tables. For more information on customization using annotations, see [Service Customization through Annotations](#).

5 OpenL Tablets Rule Services Advanced Configuration and Customization

This section describes OpenL Tablets Rule Services advanced services configuration and customization and explains the following:

- [OpenL Tablets Rule Services Customization Algorithm](#)
- [Data Source Listeners](#)
- [Service Publishing Listeners](#)
- [Dynamic Interface Support](#)
- [Service Customization through Annotations](#)
- [Variations](#)
- [Customization of Log Requests to OpenL Tablets Rule Services and Their Responds in a Storage](#)

5.1 OpenL Tablets Rule Services Customization Algorithm

If a project has specific requirements, OpenL Tablets Rule Services customization algorithm is as follows:

1. Create a Maven project that extends OpenL Tablets Rule Services.
2. Add or change the required points of configuration.
3. Add the following dependency to the `pom.xml` file with the version used in the project specified:

```
<dependency>
  <groupId>org.openl.rules</groupId>
  <artifactId>org.openl.rules.ruleservice.ws</artifactId>
  <version>5.X.X</version>
  <type>war</type>
  <scope>runtime</scope>
</dependency>
```

4. Use the following Maven plugin to control the OpenL Tablets Rule Services building with user's custom configurations and classes:

```
<plugin>
  <groupId>org.apache.maven.plugins</groupId>
  <artifactId>maven-war-plugin</artifactId>
  <configuration>
    <warSourceDirectory>webapps/ws</warSourceDirectory>
    <!--Define war name here-->
    <warName>${war.name}-${project.version}</warName>
    <packagingExcludes>
      <!--Exclude unnecessary libraries from parent project here-->
      WEB-INF/lib/org.openl.rules.ruleservice.ws.lib-*.jar
    </packagingExcludes>
    <!--Define paths for resources. Developer has to create a file with the same
    name to overload existing file in the parent project-->
    <webResources>
      <resource>
        <directory>src/main/resources</directory>
      </resource>
      <resource>
        <directory>war-specific-conf</directory>
      </resource>
    </webResources>
  </configuration>
```

```
</plugin>
```

5. If necessary, add customized spring beans into `openl-ruleservice-override-beans.xml` in `src/main/resources`.

5.2 Data Source Listeners

A data source registers data source listeners and notifies some components of OpenL Tablets Rule Services about modifications. The only available event type on the production repository modification is about newly added deployment.

A service manager is always a data source listener because it must handle all modifications in the data source.

Users can add their own listener implementing `org.openl.rules.ruleservice.loader.DataSourceListener` for additional control of data source modifications with the required behavior and register it in data source via Spring configuration.

5.3 Service Publishing Listeners

Service publishing listeners notify about the deployed or undeployed OpenL Tablets projects. Users can add their own listeners implementing `org.openl.rules.ruleservice.publisher.RuleServicePublisherListener` for additional control of deploying and undeploying projects with the required behavior and add them to the Spring configuration. The system automatically finds and registers all Spring beans implemented `RuleServicePublisherListener` interface as a publishing listener.

The `org.openl.rules.ruleservice.publisher.RuleServicePublisherListener` interface has the following methods:

Method in <code>org.openl.rules.ruleservice.publisher.RuleServicePublisherListener</code>	
Inceptor	Description
<code>onDeploy(OpenLService)</code>	Invoked each time when the OpenL Tablets service is deployed with the publisher that fires this listener.
<code>onUndeploy(String serviceName)</code>	Invoked each time when the service with the defined name is undeployed.

5.4 Dynamic Interface Support

OpenL Tablets Rule Services supports interface generation for services at runtime. This feature is called **Dynamic Interface Support**. If a static interface is not defined for a service, the system automatically generates an interface at runtime with all methods defined in the module or, in case of a multimodule, in the list of modules.

This feature is enabled by default. To use a dynamic interface, do not define a static interface for a service in `rules-deploy.xml` service description file.

It is not a good practice to use all methods from a module in a generated interface because of the following limitations:

- All return types and method arguments in all methods must be transferrable through network.
- An interface for web services must not contain the method designed for internal usage.

The system provides a mechanism for filtering methods in modules by including or excluding them from the dynamic interface.

This configuration can be applied to projects using the `rules.xml` file. An example is as follows:

```
<project>
  <name>project-name</name>
  <modules>
    <module>
      <name>module-name</name>
      <rules-root path="rules/Calculation.xlsx"/>
      <method-filter>
        <includes>
          <value>.*determinePolicyPremium.*</value>
          <value>.*vehiclePremiumCalculation.*</value>
        </includes>
      </method-filter>
    </module>
  </modules>
  <classpath>
    <entry path="lib/*"/>
  </classpath>
</project>
```

For filtering methods, define the `method-filter` tag in the `rules.xml` file. This tag contains the `includes` and `excludes` tags. The algorithm is as follows:

- If the `method-filter` tag is not defined in the `rules.xml`, the system generates a dynamic interface with all methods provided in the module or modules for multimodule.
- If the `includes` tag is defined for method filtering, the system uses the methods which names match a regular expression of defined patterns.
- If the `includes` tag is not defined, the system includes all methods.
- If the `excludes` tag is defined for method filtering, the system uses methods which method names do not match a regular expression for defined patterns.
- If the `excludes` tag is not defined, the system does not exclude the methods.

If OpenL Tablets Dynamic Interface feature is used, a client interface can also be generated dynamically at runtime. Apache CXF supports the dynamic client feature. For more information on dynamic interface support by Apache CXF, see <http://cxf.apache.org/docs/dynamic-clients.html>.

Note: If a project is empty and does not contain any method, it is unavailable as a service.

5.5 Service Customization through Annotations

This section describes interface customization using annotations. The following topics are included:

- [Interceptors for Methods](#)
- [Method Return Type Customization through Annotations](#)
- [REST Endpoint Customization through Annotations](#)
- [Customization through Annotations for Dynamic Generated Interfaces](#)

Interceptors for Methods

Required Maven dependency for OpenL Tablets Rule Services annotations is `org.openl.rules:org.openl.rules.ruleservice.annotation`. Use the provided scope for dependency because this dependency already exists in OpenL Tablets Rule Services and it must not be included in the deployment distributive to avoid class duplication in the Java ClassLoader.

Interceptors for service methods can be specified using the following annotations:

- `@org.openl.rules.ruleservice.core.interceptors.annotations.ServiceCallBeforeInterceptor`
This annotation is used to define “before” interceptors for the annotated method. The goal of these interceptors is to add extra logic before service method invocation, such as validation for service method arguments, or to change values in input arguments. A class of the “before” interceptor must implement the `org.openl.rules.ruleservice.core.interceptors.ServiceMethodBeforeAdvice` interface.

An example is as follows:

```
public class RequestModelValidator implements ServiceMethodBeforeAdvice {
    public void before(Method interfaceMethod, Object proxy,
        Object... args) throws Throwable {
        if (args == null || args.length == 0) {
            throw new IllegalArgumentException("Service method should have at least one
argument");
        }
        //other validation logic
    }
}
```

To use the “before” interceptor, proceed as follows:

```
@ServiceMethodBeforeAdvice({ RequestModelValidator.class })
Result doSomething(RequestModel requestModel);
```

- `@org.openl.rules.ruleservice.core.interceptors.annotations.ServiceCallAroundInterceptor`
This annotation is used to define “around” interceptors. A class for the “around” interceptor must implement the `org.openl.rules.ruleservice.core.interceptors.ServiceMethodAroundAdvice` interface. “Around” interceptors are used to add around logic for service method invocation. An example is when arguments of the case service method must be converted to another type before using them in service rules, and the results also require additional processing before return.

An example is as follows:

```
public class MyMethodAroundInterceptor implements ServiceMethodAroundAdvice<Response> {
    @Override
    public Response around(Method interfaceMethod, Method proxyMethod, Object proxy,
Object... args) throws Throwable {
        Result res = (Result) proxyMethod.invoke(proxy, args);
        return new Response("SUCCESS", res);
    }
}
```

To use the “around” interceptor, proceed as follows:

```
@ServiceCallAroundInterceptor({ MyMethodAroundInterceptor.class })
Response doSomething(RequestModel requestModel);
```

- `@org.openl.rules.ruleservice.core.interceptors.annotations.ServiceCallAfterInterceptor`
This annotation is used to defined “after” interceptors. This type of interceptions is used for result processing or error handling before return by the service method.

The following table describes “after” interceptor types:

Inceptor types for the <code>@ServiceCallAfterInterceptor</code> annotation	
Inceptor	Description
After Returning	Intercepts the result of a successfully calculated method, with a possibility of post processing of the return result, including result conversion to another type. In this case, the type must be specified as the return type for the method in the service class. After Returning interceptors must be a subclass of <code>org.openl.rules.ruleservice.core.interceptors.AbstractServiceMethodAfterReturningAdvice</code> .

Inceptor types for the @ServiceCallAfterInterceptor annotation

Inceptor	Description
After Throwing	Intercepts a method that has an exception thrown, with a possibility of post processing of an error and throwing another type of exception. After Returning interceptors must be a subclass of <code>org.openl.rules.ruleservice.core.interceptors.AbstractServiceMethodAfterThrowingAdvice</code> .

Example of the “after” interceptor implementation with after returning logic is as follows:

```
public class SpreadsheetResultConverter extends
    AbstractServiceMethodAfterReturningAdvice<ResponseDTO> {

    @Override
    public ResponseDTO afterReturning(Method interfaceMethod,
        Object result, Object... args) {
        SpreadsheetResult = (SpreadsheetResult) result;
        return mapSpreadsheetResultToResponseDTO(spreadsheetResult);
    }

    private ResponseDTO mapSpreadsheetResultToResponseDTO(SpreadsheetResult result) {
        ResponseDTO response = new ResponseDTO();
        response.setPremium((Double) result.getFieldValue("$Value$PremiumStep"));
        // Do some other mapping logic...
        return response;
    }
}
```

Example of the “after” interceptor implementation with after throwing logic is as follows:

```
public class ExceptionHandlingAdvice extends
    AbstractServiceMethodAfterThrowingAdvice <ResponseDTO> {
    private static final Logger LOG = LoggerFactory
        .getLogger(ExceptionHandlingAdvice.class);

    @Override
    public ResponseDTO afterThrowing(Method iMethod, Exception t, Object... args) {
        LOG.error(t.getMessage(), t);
        return new ResponseDTO("INTERNAL_ERROR", t.getMessage());
    }
}
```

To use the “after” interceptor, proceed as follows:

```
@ServiceCallAfterInterceptor({ SpreadsheetResultConverter.class,
    ExceptionHandlingAdvice.class })
ResponseDTO doSomething(Request request);
```

Use `@org.openl.rules.ruleservice.core.interceptors.annotations.NotConvertor` or `@org.openl.rules.ruleservice.core.interceptors.annotations.UseOpenMethodReturnType` on an interceptor implementation class when an interceptor must return a type of the generated class that is not available at compilation time to use as a generic parameter of the interceptor class. The `NotConvertor` annotation instructs the system that the interceptor does not change the return type of the method even if `Object` or any other class is used as a generic parameter of the class. The `UseOpenMethodReturnType` annotation instructs the system that the interceptor returns the original type of the rules method even if any other type is used as a generic parameter of the interceptor class.

- `@org.openl.rules.ruleservice.core.annotations.ServiceExtraMethod`
This annotation is used to define the extra method absent in OpenL rules. Additional method implementation must implement `org.openl.rules.ruleservice.core.annotations.ServiceExtraMethodHandler` interface, and it exposes methods that differ in signature with the rules or do not exist in the Excel sheet.

For example, an Excel file contains the `String hello(String)` method and this method must be exposed as `String hello(Integer)`.

The advice class uses the same class loader that is used to compile the OpenL Tablets project. It means that a user can access all datatype classes generated by the system for a particular project. An additional method can be used when additional mapping between the OpenL Tablets model and external model is required, for example:

```
public static class LoadClassExtraMethod implements ServiceExtraMethodHandler<Object> {
    @Override
    public Object invoke(Method interfaceMethod, Object serviceBean, Object... args)
    throws Exception {
        // MyBean is Datatype defined in OpenL
        Class<?> myBeanClass = Thread.currentThread().getContextClassLoader()
            .loadClass("org.openl.generated.beans.MyBean");
        Object myBean = myBeanClass.newInstance();
        // ... Do some mapping below and then return result
        return myBean;
    }
}
```

Note: Java byte code does not have argument names in interfaces, so they are named as 'arg0', 'arg1', and so on. To request more meaningful names for parameters, use the `@org.openl.rules.ruleservice.core.annotations.Name` annotation together with `@ServiceExtraMethod`.

Use the `org.openl.rules.ruleservice.core.interceptors.IOpenMemberAware` and `org.openl.rules.ruleservice.core.interceptors.IOpenClassAware` interfaces if a reference to the compiled `IOpenClass` or `IOpenMember` object is required in an interceptor implementation class.

Method Return Type Customization through Annotations

By default, OpenL Tablets applies the

`org.openl.rules.ruleservice.core.interceptors.converters.SPRTToPlainConverterAdvice` interceptor to all spreadsheet table methods that return `SpreadsheetResult` and `org.openl.rules.ruleservice.core.interceptors.converters.VariationResultSPRTToPlainConverterAdvice` interceptor to all variations methods that correspond to spreadsheet table methods that return `SpreadsheetResult`. These annotations transform the spreadsheet table result to the generated Java bean and return it instead of `SpreadsheetResult`.

Note: If any interceptor is used on the method, the `SPRTToPlainConverterAdvice` or `VariationResultSPRTToPlainConverterAdvice` interceptors must be added manually to keep default behavior.

To change default behavior, define `@`

`org.openl.rules.ruleservice.core.interceptors.annotations.ServiceCallAfterInterceptor` with an empty value on the method to return `SpreadsheetResult`.

REST Endpoint Customization through Annotations

By default, URLs and HTTP method type for methods are determined automatically by the system. The path for the methods equals the corresponding service method name, and HTTP method type depends on used arguments: if the service method has at least one argument, a HTTP method type is set to POST, otherwise, to GET.

The following JAX-RS annotations can be used to override the default behavior of service method publishing:

JAX-RS annotations to override the default behavior of service method publishing

Annotation	Import details
@POST	import javax.ws.rs.POST;
@GET	import javax.ws.rs.GET;
@Path	import javax.ws.rs.Path;

- @POST annotation overrides a default method type.
Service methods annotated @POST accepts only POST requests. Usage example is as follows:

```
@POST
MyResponse someMethod();
```
- @GET annotation overrides a default method type.
Service method annotated @GET accepts only GET requests. Usage example is as follows:

```
@GET
MyResponse someMethod(MyType myType);
```
- @Path annotation overrides a default URL method path.
Usage example is as follows:

```
@Path("/customPrefix/someMethod")
MyResponse someMethod(MyType myType);
```

Required Maven dependency is as follows:

```
<dependency>
  <groupId>jakarta.ws.rs</groupId>
  <artifactId>jakarta.ws.rs-api</artifactId>
  <version>2.1.5</version>
  <scope>provided</scope>
</dependency>
```

Note: It is not necessary to declare pairs of @POST + @Path or @GET + @Path because OpenL Tablets provides the capability to define a single annotation and generate the other one automatically.

All other JAX-RS annotations, such as @PUT, @DELETE, @QueryParam, and @PathParam, are also supported by OpenL Tablets. For more information on JAX-RS annotation, see <https://docs.oracle.com/javaee/7/api/javax/ws/rs/package-summary.html>.

Customization through Annotations for Dynamic Generated Interfaces

Annotation customization can be used for dynamically generated interfaces. This feature is only supported for projects that contain the `rules-deploy.xml` deployment configuration file. To enable customization through annotation, proceed as follows:

1. Add the `annotationTemplateClassName` tag to the `rules-deploy.xml` file.

An example is as follows:

```
<rules-deploy>
  <isProvideRuntimeContext>>true</isProvideRuntimeContext>
  <isProvideVariations>>false</isProvideVariations>
  <serviceName>dynamic-interface-test3</serviceName>
  <annotationTemplateClassName>org.openl.ruleservice.dynamicinterface.test.MyTemplateClass</annotationTemplateClassName>
  <url></url>
</rules-deploy>
```

2. Define a template interface with the annotated methods with the same signature as in a generated dynamic interface.

This approach supports replacing argument types in the method signature with types assignable from generated types in the generated interface.

Example: `SubType` is a subclass of class `MyType`. Consider the following methods are generated in the generated interface:

```
void someMethod(IRulesRuntimeContext context, MyType myType);
void someMethod(IRulesRuntimeContext context, SubType otherType);
```

Add an annotation to the first method using the same method signature in the template interface as follows:

```
@ServiceCallAfterInterceptor(value = { MyAfterAdvice.class })
void someMethod(IRulesRuntimeContext context, MyType myType);
```

If the `MyType` class is also generated at runtime, use a super type of the `MyType` class. An example is as follows:

```
@ServiceCallAfterInterceptor(value = { MyAfterAdvice.class })
void someMethod(IRulesRuntimeContext context, @RulesType("MyType") Object myType);
```

This example uses the `@org.openl.rules.ruleservice.core.interceptors.RulesType` annotation. If this annotation is missed, this template method is applied to both methods because `Object` is assignable from both types `MyType` and `SubType`.

The `@RulesType` annotation value accepts the following:

- canonical class name
- datatype name
- custom SpreadsheetResult name

Use this annotation if more details are required to define a template method.

Note: A user can also use class level annotations for a dynamically generated class. It can be useful for JAX-WS or JAX-RS interface customization.

5.6 Variations

In highly loaded applications, performance of execution is a crucial point in development. There are many approaches to speed up the application. One of them is to calculate rules with variations.

A **variation** stands for additional calculation of the same rule with a slight modification in its arguments. Variations are very useful when a rule must be calculated several times with similar arguments. The idea of this approach is to once calculate rules for particular arguments and then recalculate only the rules or steps that depend on the modified, by variation, fields in those arguments.

The following topics are included:

- [Variations Algorithm](#)
- [Predefined Variations](#)
- [Variations Factory](#)
- [Enabling Variations Support](#)

Variations Algorithm

A rule that can be calculated with variations must have the following methods in a service class:

- original method with a corresponding rule signature
- method with injected variations

The method enhanced with variations has a signature similar to the original method. Add the argument of the `org.openl.rules.variation.VariationsPack` type as the last argument. The return type must be generic `org.openl.rules.variation.VariationsResult<T>`, where `T` is the return type of the original method.

The `VariationsPack` class contains all required variations to be calculated. The `VariationsResult<T>` class contains results of the original calculation, without any modifications of arguments, and all calculated variations that can be retrieved by variation ID. There can be errors during calculation of a specific variation. The following methods are used to get result of a particular variation:

Methods for getting result of a particular variation	
Method	Description
<code>getResultForVariation(String variationID)</code>	Returns the result of a successfully calculated variation.
<code>getFailureErrorForVariation(String variationID)</code>	Returns the corresponding error message.

Note: When using a user's own service class instead of the one generated by default, the original method must be defined for each method with variations.

Note: The result of the original calculation can be retrieved in the same manner as for all variations, by using the special `Original calculation ID` in code as `org.openl.rules.project.instantiation.variation.NoVariation.ORIGINAL_CALCULATION`.

Predefined Variations

A variation typically has a unique ID and is responsible for modifying arguments and restoring original values. The ID is a `String` value used to retrieve the result of the calculation with this variation.

By default, the variation's abstract class `org.openl.rules.project.instantiation.variation.Variation` has two methods, `applyModification` and `revertModifications`. The first method modifies arguments; the second rolls back the changes. For this purpose, a special instance of `Stack` is passed to both these methods: in the `applyModification` method, the previous values must be stored; in `revertModifications`, the previous values can be retrieved from the `Stack` and saved into arguments.

The following table describes predefined variation types in the `org.openl.rules.variation` package:

Predefined variation types in the <code>org.openl.rules.variation</code> package	
Variation type	Description
<code>NoVariation</code>	Empty variation without any modifications. It is used for the original calculation and has a predefined <code>Original calculation ID</code> .
<code>ArgumentReplacementVariation</code>	Variation that replaces an entire argument. It was introduced because <code>JXPathVariation</code> cannot replace a value of a root object, or argument. The argument index, value to be set instead of the argument, and ID are required to construct this variation.
<code>JXPathVariation</code>	Variation that modifies an object field or replaces an element in the array defined by the special path. <code>JXPath</code> is used to analyze paths and set values to corresponding fields, therefore use <code>JXPath</code> -consistent path expressions. The following data is required for this variation: <ul style="list-style-type: none"> • index of the argument to be modified • path to the field that must be modified in the <code>JXPath</code> notation • value to be set instead of the original field value • ID For more information on <code>JXPath</code> , see http://commons.apache.org/jxpath/ .

Predefined variation types in the <code>org.openl.rules.variation</code> package	
Variation type	Description
<code>ComplexVariation</code>	Variation that combines multiple variations as a single variation. It is applicable when different fields or arguments must be modified.
<code>DeepCloningVariation</code>	Variation used to avoid reverting changes of a specific variation that will be delegated to <code>DeepCloningVariation</code> . This variation clones user's arguments and thus allows avoiding any problems caused by changes in arguments. This variation is not recommended because of performance drawbacks: the argument cloning takes time so the variations usage can be useless.

If predefined implementations do not satisfy user needs, implement user's own type of variation that inherits the `org.openl.rules.variation.Variation` class. Custom implementations can be faster than the predefined variations in case they use direct access to fields instead of a reflection as in `JXPathVariation`.

Note: Data binding for custom implementations of variation must be provided to pass the variations through SOAP in OpenL Tablets Rule Services.

Variations Factory

The `org.openl.rules.project.VariationsFactory` class is a utility class for simple creation of predefined variations. It uses the following arguments:

Variations factory arguments	
Argument	Description
<code>variationId</code>	Unique ID for a variation.
<code>argumentIndex</code>	0-based index of an argument to be modified.
<code>path</code>	Path to the field to be modified, or just a dot <code>.</code> to modify the root object, that is, the argument.
<code>valueToSet</code>	Value to be set by path.
<code>cloneArguments</code>	Identifier of whether cloning must be used.

Usually `VariationsFactory` creates the `JXPathVariation` variation which covers most cases of variations usage. When a dot `.` is specified as a `path`, `ArgumentReplacementVariation` is constructed. The `cloneArguments` option says to `VariationsFactory` to wrap created variation by `DeepCloningVariation`.

An alternative way is to use a special `VariationDescription` bean that contains all fields described previously in this section. It is useful to transmit a variation in OpenL Tablets Rule Services and define variations in rules.

Enabling Variations Support

Default value for all deployed services is defined in the `ruleservice.isSupportVariations` property in `application.properties`. By default, it is disabled. A variation can be enabled and disabled on the project level using the `rules-deploy.xml` deployment configuration file. An example is as follows:

```
<rules-deploy>
...
  <isProvideVariations>false</isProvideVariations>
...
</rules-deploy>
```

5.7 Customization of Log Requests to OpenL Tablets Rule Services and Their Responds in a Storage

This section describes advanced customization for logging requests to OpenL Tablets Rule Services and their responds in a storage if different parts of the input and output data must be stored separately. It also describes how to customize a structure of tables and indexes in a storage.

The following topics are included:

- [Storage Service for Log Requests and Their Responds](#)
- [Customization for Apache Cassandra](#)
- [Customization for the Relational Database](#)
- [Customization for Elasticsearch](#)
- [Customization for Hive](#)

Storage Service for Log Requests and Their Responds

This section describes storage service used for log requests and responds and includes the following topics:

- [Log Request and Response Storage Service Overview](#)
- [Collecting Data from Requests and Their Responds and Populating Custom Values](#)
- [Log Requests and Their Responds Customization Using Annotations](#)

Log Request and Response Storage Service Overview

OpenL Tablets Rule Services supports the Apache Cassandra, Elasticsearch, and relational database storages to log request and their responds out of the box. This part of the system is designed customizable and extendable via the `org.openl.rules.ruleservice.storelogdata.StoreLogDataService` interface to support the third-party storages.

The `StoreLogDataService` interface has the following methods:

StoreLogDataService interface methods	
Method	Description
<code>boolean isEnabled()</code>	Identifies whether the log storing service is enabled.
<code>void save(StoreLogData storeLogData)</code>	Saves <code>storeLogData</code> data to a storage.

The implementation class of this interface must be registered in the application Spring context. The system discovers all implementation of the interface automatically and uses all found services at the same time.

`org.openl.rules.ruleservice.storelogdata.StoreLogData` is a class that contains all available data from the request and respond. This class has the `getCustomValues()` method that returns a map for interested values that can be stored separately from request payload.

Custom implementation of the `StoreLogDataService` interface supports all features described in this document.

Annotation on the called method

`@org.openl.rules.ruleservice.storelogdata.annotation.SkipFaultStoreLogData` instructs the system to skip storing fault requests and their responds in a storage.

Collecting Data from Requests and Their Responds and Populating Custom Values

Populating custom values in the `StoreLogData` object and collecting data for service methods is defined using the `@org.openl.rules.ruleservice.storelogdata.annotation.PrepareStoreLogData` annotation.

@PrepareStoreLogData has following attributes	
Attribute	Description
<code>value</code>	Mandatory reference to the <code>StoreLogDataAdvice</code> interface implementation. The implementation class defines which data is collected.
<code>bindToServiceMethodAdvice</code>	Optional reference to an implementation of the <code>ServiceMethodAdvice</code> interface. It defines that the implementation of the <code>theStoreLogDataAdvice</code> interface must be invoked before or after the corresponding <code>ServiceMethodAdvice</code> implementation. It is used when required data for collecting is not more available after result transformation.
<code>before</code>	Optional attribute specifying the order of the called data collecting advice. If the <code>bindToServiceMethodAdvice</code> attribute is present, <code>before</code> determines the advice execution relative to the defined interceptor, otherwise relative to the base method. The default value is false, that is, execution happens after method or interceptor.

Implement a single method in the `StoreLogDataAdvice` interface for collecting data to be used along with the `@Value` annotation in entities or directly from `StoreLogData.getCustomValues()`.

Using more than one `@PrepareStoreLogData` to logically decouple the code of collecting a data is allowed for the same method.

All these annotations can be used on fields or on getter or setter methods in entity classes.

The `org.openl.rules.ruleservice.storelogdata.advice.StoreLogDataAdvice` interface has only one method to implement. An example is as follows:

```
public class CollectDataStoreLogDataAdvice implements StoreLogDataAdvice {
    @Override
    public void prepare(Map<String, Object> values, Object[] args, Object result, Exception
ex) {
        values.put("state", ((CalculationResult) result).getState());
    }
}
```

To programmatically control whether a call to the service must be stored or skipped, use the `org.openl.rules.ruleservice.storelogdata.StoreLogDataHolder.get().ignore()` line of code in implementation of `StoreLogDataAdvice`.

If compound object serialization to string is required in `StoreLogDataAdvice`, use the `org.openl.rules.ruleservice.storelogdata.advice.ObjectSerializerAware` interface. It injects the `org.openl.rules.ruleservice.storelogdata.ObjectSerializer` instance automatically via the `void setObjectSerializer(ObjectSerializer objectSerializer)` method. `ObjectSerializer` provides functionality to serialize an object to a string with the same mechanism used in the invoked publisher. For example, it produces a JSON string for REST or Kafka services and XML for SOAP services.

Log Requests and Their Responds Customization Using Annotations

OpenL Tablets Rule Services has annotations for mapping requests and their responds data to entity classes. The `org.openl.rules: org.openl.rules.ruleservice.ws.storelogdata` Maven dependency is required for the log requests and their respond annotations. Use the `provided` scope for dependency as it already exists in

OpenL Tablets Rule Services and it must not be included in the deployment distributive to avoid class duplication in ClassLoader.

The `org.openl.rules.ruleservice.storelogdata.StoreLogDataMapper` class maps OpenL Tablets annotations to the entity class.

The following annotations located in the `org.openl.rules.ruleservice.storelogdata.annotation` package are supported:

Annotations supported by StoreLogDataMapper		
Annotation	Field Type	Description
<code>IncomingTime</code>	<code>ZonedDateTime</code>	Incoming request time.
<code>OutcomingTime</code>	<code>ZonedDateTime</code>	Outgoing response time.
<code>MethodName</code>	<code>String</code>	Method of a service that is called.
<code>ServiceName</code>	<code>String</code>	Deployment service name that is called.
<code>Publisher</code>	<code>String</code>	Request source, such as web service or REST service or Kafka.
<code>Request</code>	<code>String</code>	Request body, such as JSON for REST service, XML for SOAP service, and message body for Kafka.
<code>Response</code>	<code>String</code>	Response body, such as JSON for REST service, XML for SOAP service, and message body for Kafka.
<code>Url</code>	<code>String</code>	URL of the request if available.
<code>Value</code>	<code>Object</code>	Value from the map that is returned by <code>StoreLogData.getCustomValues()</code>
<code>KafkaMessageHeader</code>	<code>byte[]</code>	Kafka message header data. The <code>value</code> attribute with a defined header name is required. The <code>type</code> attribute is used to define a producer or consumer message to use.

All annotations described in this section have an optional `converter` attribute for converting a collected type into the required field type. Use implementation of the `org.openl.rules.ruleservice.storelogdata.Converter` interface for the `converter` attribute. A usage example of this interface is as follows:

```
public final class ZonedDateTimeToDateConverter implements Converter<ZonedDateTime, Date> {
    @Override
    public Date apply(ZonedDateTime value) {
        return value != null ? Date.from(value.toInstant()) : null;
    }
}
```

Customization for Apache Cassandra

This section describes customization for Apache Cassandra and automatically creating a table schema for entity classes. The following topics are described:

- [Log Requests and Responds Customization for Apache Cassandra](#)
- [Automatically Creating a Cassandra Table Schema Creation for Entity Classes](#)

Log Requests and Responds Customization for Apache Cassandra

Service storing log requests and their responds for Apache Cassandra requires a Cassandra driver version 4.x. The Cassandra driver uses a new mapping model between object in the code and a table in a database. For more

information on mapping, see <https://docs.datastax.com/en/developer/java-driver/4.3/manual/mapper/>. The nutshell working with this model assumes that there are three objects: Entity, Dao, and Mapper interface.

For a method, to enable logging requests and their responds to Apache Cassandra, annotate calling method with the `@org.openl.rules.ruleservice.storelogdata.cassandra.annotation.StoreLogDataToCassandra` annotation. The annotation has an optional attribute that obtains entity classes. If `@StoreLogDataToCassandra` is used with an empty value, the default table described in [Storing Log Records in Apache Cassandra](#) is used. If more than one entity class is used in the value attribute for the `@StoreLogDataToCassandra` annotation, the system splits data and stores it in multiple Cassandra tables.

An entity is a simple data container that represents a row in the product table. For more information on entities, see <https://docs.datastax.com/en/developer/java-driver/4.3/manual/mapper/entities/>.

Cassandra entity example is as follows:

```
@Entity
@EntitySupport(PersonOperations.class)
@CqlName("person")
public class Person {
    @PartitionKey()
    @Value("id")
    private String id;
    @PartitionKey(1)
    @Value(value = "birthday")
    private ZonedDateTime birthday;
    @Request
    private String request;
    @Response
    private String response;
...
}
```

A **data access object** (DAO) defines a set of query methods to insert entities into a storage. For more information on DAO, see <https://docs.datastax.com/en/developer/java-driver/4.3/manual/mapper/daos/>.

DAO interface example to insert a Person entity is as follows:

```
@Dao
public interface PersonDao {
    @Insert
    CompletionStage<Void> insert(Person entity);
}
```

Mapper interface is a top-level entry point for mapper features used to obtain DAO instances. For more information on Mapper interface, see <https://docs.datastax.com/en/developer/java-driver/4.3/manual/mapper/mapper/>.

Mapper example that obtains PersonDao is as follows:

```
@Mapper
public interface PersonMapper {
    @DaoFactory
    PersonDao getDao();
}
```

Generate an implementation for these interfaces to use it at runtime. To generate the code annotation processor, add it to the Maven build script. For more information on how to configure the annotation processor, see <https://docs.datastax.com/en/developer/java-driver/4.3/manual/mapper/config/>.

An example of using Maven plugin to generate implementations is as follows:

```

<plugin>
  <artifactId>maven-compiler-plugin</artifactId>
  <configuration>
    <annotationProcessorPaths>
      <path>
        <groupId>com.datastax.oss</groupId>
        <artifactId>java-driver-mapper-processor</artifactId>
        <version>${cassandra.driver.version}</version>
      </path>
    </annotationProcessorPaths>
  </configuration>
</plugin>

```

The `@org.openl.rules.ruleservice.storelogdata.cassandra.annotation.EntitySupport` annotation is used to define a class that instantiates a mapper instance with generated mapper builder and implements insert operation. This annotation must be used on the entity class as follows:

```

@Entity
@EntitySupport(PersonOperations.class)
@CqlName("person")
public class Person {
  ...
}
public class PersonOperations implements EntityOperations<PersonDao, Person> {
  @Override
  public PersonDao buildDao(CqlSession cqlSession) throws DaoCreationException {
    PersonMapper entityMapper = new PersonMapperBuilder(cqlSession).build();
    return entityMapper.getDao();
  }
  @Override
  public CompletionStage<Void> insert(PersonDao, Person person) {
    return personDao.insert(person);
  }
}

```

Automatically Creating a Cassandra Table Schema for Entity Classes

The system uses the ClassLoader CQL scripts that are located in the same package and have the same names as entity classes and the `.cql` file extension to create Cassandra schema tables automatically on application launch.

Cassandra identifiers, such as keyspace, table, and column names, are case-insensitive by default. There are several naming strategies to map names and fields. By default, it is `SNAKE_CASE_INSENSITIVE` that divides the Java name into words, splits on upper-case characters, lower-cases everything concatenates the words with underscore separators, and makes the result a case-insensitive CQL name. For example, `Product => product`, `productId => product_id`.

The default strategy can be modified. For more information on naming strategies, see <https://docs.datastax.com/en/developer/java-driver/4.3/manual/mapper/entities/#naming-strategy>.

An example is as follows:

```

CREATE TABLE IF NOT EXISTS person(
  id text,
  birthday timestamp,
  request text,
  response text,
  ...
}

```

Customization for the Relational Database

OpenL Tablets Rule Services uses Hibernate implementation to store requests and their responds in the relational database.

To enable logging requests and their responses to the relational database, mark the method with the `org.openl.rules.ruleservice.storelogdata.db.annotation.StoreLogDataToDB` annotation. It resembles `@StoreLogDataToCassandra` described in [Log Requests and Responds Customization for Apache Cassandra](#), and it has entity classes as optional attributes.

If entity classes are not defined in `@StoreLogDataToDB`, all records are stored in `openl_log_data`.

A custom relational database entity example is as follows:

```
@Entity(name = "person")
public class Person {

    @Id
    @GeneratedValue(strategy = GenerationType.SEQUENCE, generator = "person_generator")
    @SequenceGenerator(name = "person_generator", sequenceName = "openl_log_data_generator",
allocationSize = 50)
    private Long id;

    @IncomingTime
    private Date incomingTime;

    @OutcomingTime(converter = ZonedDateTimeToDateConvertor.class)
    private ZonedDateTime outcomingTime;

    @Request
    private String requestBody;

    @Response
    private String responseBody;
}
```

Customization for Elasticsearch

OpenL Tablets Rule Services uses Spring Data Elasticsearch REST template implementation to store requests and their responds to Elasticsearch.

To enable logging requests and their responses to Elasticsearch, mark the method with the `org.openl.rules.ruleservice.storelogdata.elasticsearch.annotation.StoreLogDataToElasticsearch` annotation. It is similar to `@StoreLogDataToCassandra` described in [Log Requests and Responds Customization for Apache Cassandra](#), and it has entity classes as optional attributes.

If entity classes are not defined in `@StoreLogDataToElasticsearch`, all records are stored in the index described in [Storing Log Records in Elasticsearch](#).

If only one entity class is defined, for example,

`@StoreLogDataToElasticsearch(CustomElasticEntity.class)`, the system uses an index defined in the custom entity.

If multiple entity classes are defined, for example, `@StoreLogDataToElasticsearch(ElasticEntity1.class, ElasticEntity2.class, ..., ElasticEntityN.class)`, the system splits data into multiple Elasticsearch indexes.

Custom Elasticsearch entity example is as follows:

```

@Document(indexName = "person")
public class Person {

    @WithStoreLogDataConverter(converter = RandomUUID.class)
    @Id
    private String id;

    @IncomingTime(converter = ZonedDateTimeToDateConverter.class)
    private Date incomingTime;

    @OutcomingTime(converter = ZonedDateTimeToDateConverter.class)
    private Date outcomingTime;

    @Request
    private String requestBody;

    @Response
    private String responseBody;

    @WithStoreLogDataConverter(converter = JSONRequest.class)
    @QualifyPublisherType(PublisherType.RESTFUL)
    private Object request;

    @WithStoreLogDataConverter(converter = JSONResponse.class)
    @QualifyPublisherType(PublisherType.RESTFUL)
    private Object response;
}

```

Document annotation identifies a domain object to be persisted in Elasticsearch.

To store information from requests and responses and make it searchable, that is, filter the entities in the index by parameters which were used in request or response, for example, in Kibana,

`org.openl.rules.ruleservice.storelogdata.elasticsearch.JSONRequest` and `org.openl.rules.ruleservice.storelogdata.elasticsearch.JSONResponse` converters must be used.

Customization for Hive

OpenL Tablets Rule Services stores its requests and responds in Hive.

To enable logging requests and their responses to Hive, mark the method with the `org.openl.rules.ruleservice.storelogdata.hive.annotation.StoreLogDataToHive` annotation. It resembles `@StoreLogDataToCassandra` described in [Log Requests and Responds Customization for Apache Cassandra](#), and it has entity classes as optional attributes.

If entity classes are not defined in `@StoreLogDataToHive`, all records are stored in the table described in [Storing Log Records in Hive](#).

If only one entity class is defined, for example, `@StoreLogDataToHive(CustomHiveEntity.class)`, the system uses a table defined in the custom entity.

If multiple entity classes are defined, for example, `@StoreLogDataToHive(HiveEntity1.class, HiveEntity2.class, ..., HiveEntityN.class)`, the system splits data into multiple Hive tables.

Custom Hive entity example is as follows:

```

@Entity("person_data")
public class Person {

    @Value(converter = RandomUUID.class)
    private String id;
}

```

```
@IncomingTime
private ZonedDateTime incomingTime;

@OutcomingTime
private ZonedDateTime outcomingTime;

@Request
private String request;

@Response
private String response;

@ServiceName
private String serviceName;

@MethodName
private String methodName;

@Publisher
private String publisherType;

@Url
private String url;
}
```

Entity annotation identifies a domain object to be persisted in Hive.

The system uses the ClassLoader SQL scripts which are located in the same package and have the same names as entity classes and the .sql file extension to create Hive table automatically on application launch. For more information on how to enable this feature, see [Storing Log Records in Hive](#).

Appendix A: Tips and Tricks

This appendix provides useful additional information on OpenL Tablets Rule Services usage and customization and includes the following topics:

- [Using OpenL Tablets Rule Services from Java Code](#)
- [Using OpenL Tablets REST Services from Java Code](#)

Using OpenL Tablets Rule Services from Java Code

This section illustrates how to write a client code that invokes OpenL Tablets Rule Services projects. Another way can be used to invoke services, but it is recommended to use Apache CXF framework to prevent additional effort for data binding.

A project in OpenL Tablets Rule Services can be exposed via a static interface or dynamic interface generated in runtime. A client code is different in each case. If the project uses a static interface, use the `ClientFactoryBean` class from CXF. For more information on using CXF for a static interface, see CXF documentation.

The following example illustrates client code generation for the `MyClass` static interface. Note that Aegis is deprecated starting with this release.

```
ClientProxyFactoryBean = new ClientProxyFactoryBean();
clientProxyFactoryBean.setServiceClass(MyClass.class);
clientProxyFactoryBean.setWsdLocation(getAddress() + "?wsdl");
//OpenL databinding factory
AegisDatabindingFactoryBean = new AegisDatabindingFactoryBean();
//Set variations support. Recommend using the same value as a project in server. Can't be
false if service uses variations feature.
aegisDatabindingFactoryBean.setSupportVariations(true);
aegisDatabindingFactoryBean.setWriteXsiTypes(true);
//In case you need custom binding classes.
Set<String> overrideTypes = new HashSet<String>();
overrideTypes.add(<Some class>.class.getCanonicalName());
aegisDatabindingFactoryBean.setOverrideTypes(overrideTypes);
clientProxyFactoryBean.setDataBinding(aegisDatabindingFactoryBean.createAegisDatabinding());

MyClass myClass =(MyClass) clientProxyFactoryBean.create();
```

A dynamic client can be used for both static interface and dynamic interface generated in runtime configuration. A dynamic client is a feature of CXF framework. For dynamic interface, use the `JaxWsDynamicClientFactory` factory. For more information on using CXF for a dynamic interface, see CXF documentation.

The following example illustrates creation of a dynamic client:

```
JaxWsDynamicClientFactory dynamicClientFactory = JaxWsDynamicClientFactory.newInstance();
ClassLoader oldClassLoader = Thread.currentThread().getContextClassLoader();
List<String> bindingFiles = new ArrayList<String>() {
    private static final long serialVersionUID = 1L;
    {
        add("binding.xml");
    }
};
Client client = dynamicClientFactory.createClient(<Service WSDL URL>, bindingFiles);
```

Binding.xml file content is as follows:

```
<jaxb:bindings version="2.2" xmlns:jaxb="http://java.sun.com/xml/ns/jaxb"
```

```
xmlns:xjc="http://java.sun.com/xml/ns/jaxb/xjc"
xmlns:xs="http://www.w3.org/2001/XMLSchema">
  <jaxb:globalBindings generateElementProperty="false" collectionType="indexed"/>
</jaxb:bindings>
```

Using OpenL Tablets REST Services from Java Code

This section describes how to write a client code that invokes OpenL Tablets REST services projects. Another way can be used to invoke services, but it is recommended to use Apache CXF framework to prevent additional effort for data binding.

The following example illustrates client code generation for the JSON content type:

```
JacksonObjectMapperFactoryBean = new JacksonObjectMapperFactoryBean();
jacksonObjectMapperFactoryBean.setEnableDefaultTyping(true);
Set<String> overrideTypes = new HashSet<String>();
overrideTypes.add(SomeClass.class.getName());

jacksonObjectMapperFactoryBean.setOverrideTypes(overrideTypes);
ObjectMapper mapper = jacksonObjectMapperFactoryBean.createJacksonDataBinding();

final JacksonJsonProvider jsonProvider = new JacksonJsonProvider();

WebClient webClient = WebClient.create#REST service url#,
    new ArrayList<Object>() {
        private static final long serialVersionUID = 5636807402394548461L;
        {
            add(jsonProvider);
        }
    });

webClient.type(MediaType.APPLICATION_JSON);

Response response = webClient.get();
```

Note: If you use POST request for more than one argument, create a DTO that contains field with method argument names and send this DTO object via `webClient.post()` method.

Appendix B: Projects on the OpenL Tablets Rule Services Launch

When OpenL Tablets Rule Services is launched using the `openl:port/webservice` link, the system displays a list of deployed projects.



Figure 4: List of projects displayed upon OpenL Tablets Rule Services launch

The successfully deployed projects appear with the green check mark that can be clicked to expand the list of available methods for the project.

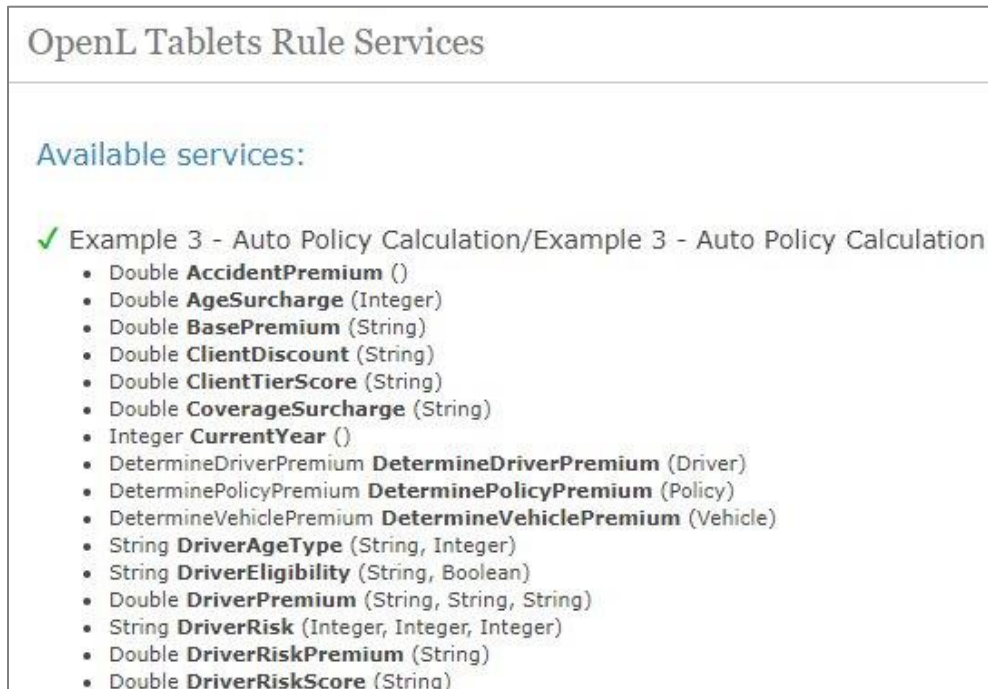


Figure 5: Expanding project methods

Projects deployed with errors are marked with the red cross mark that is clickable and displays the error message.

OpenL Tablets Rule Services

Available services:

- ✓ Example 3 - Auto Policy Calculation/Example 3 - Auto Policy Calculation
Started time: 6/16/2021, 11:28:20 AM
[WSDL](#) [WADL](#) [Swagger UI](#) [OpenAPI.JSON](#) [OpenAPI.YAML](#)
- ✗ Sample Project/Sample Project
Type 'Integer' is not found.
Started time: 6/16/2021, 11:57:59 AM
[MANIFEST.MF](#)

Figure 6: Viewing error message for a project

Appendix C: Types of Exceptions in OpenL Tablets Rule Services

The following table describes exception types in OpenL Tablets Rule Services:

Exception types in OpenL Tablets Rule Services			
Cause	Status code	REST	SOAP
error("Some message") in rules	400	{ message : "Some message", type : "USER_ERROR" }	<soap:Envelope> <soap:Body> <soap:Fault> <faultcode>soap:Server</faultcode> <faultstring>Some message</faultstring> <detail> <type>USER_ERROR</type> </detail> </soap:Fault> </soap:Body> </soap:Envelope>
Runtime execution error in OpenL rules, such as NPE, CCE, and DivByZero.	500	{ message : "Cannot convert 'lab2' to Double", type : "RULES_RUNTIME" }	<soap:Envelope> <soap:Body> <soap:Fault> <faultcode>soap:Server</faultcode> <faultstring>Cannot convert 'lab2' to Double</faultstring> <detail> <type>RULES_RUNTIME</type> </detail> </soap:Fault> </soap:Body> </soap:Envelope>
Compilation and parsing errors.	500	{ message : "Missed condition column in Rules table", type : "COMPILATION" }	<soap:Envelope> <soap:Body> <soap:Fault> <faultcode>soap:Server</faultcode> <faultstring>Missed condition column in Rules table</faultstring> <detail> <type>COMPILATION</type> </detail> </soap:Fault> </soap:Body> </soap:Envelope>
Other exception outside the OpenL engine, such as NPE, CCE, and AccessException.	500	{ message : "Cannot be null", type : "SYSTEM" }	<soap:Envelope> <soap:Body> <soap:Fault> <faultcode>soap:Server</faultcode> <faultstring>Cannot be null</faultstring> <detail> <type>SYSTEM</type> </detail> </soap:Fault> </soap:Body> </soap:Envelope>

Exception types in OpenL Tablets Rule Services			
Cause	Status code	REST	SOAP
Validation errors in input parameters, such as a value outside of a valid domain or wrong value in the context.	500	<pre>{ message : "'Mister' is outside of valid domain ['Male', 'Female']", type : "RULES_RUNTIME" }</pre>	<pre><soap:Envelope> <soap:Body> <soap:Fault> <faultcode>soap:Server</faultcode> <faultstring>'Mister' is outside of valid domain ['Male', 'Female']</faultstring> <detail> <type>RULES_RUNTIME</type> </detail> </soap:Fault> </soap:Body> </soap:Envelope></pre>

Appendix D: OpenAPI Support

Swagger is an open-source software framework backed by a large ecosystem of tools that helps developers design, build, document, and consume RESTful web services. While most users identify Swagger by the Swagger UI tool, the Swagger toolset includes support for automated documentation, code generation, and test-case generation. For more information on Swagger, see <https://swagger.io/docs/>.

In OpenL, Swagger v3 (OpenAPI) is used. It allows directly accessing project methods, data types, and methods, and enables simple, convenient, and quick running or testing of rules deployed as services.

To use Swagger, in OpenL Tablets Rule Services, click the Swagger (UI) link, select the required rule, click **Try it out**, enter input parameters, and click **Execute**.

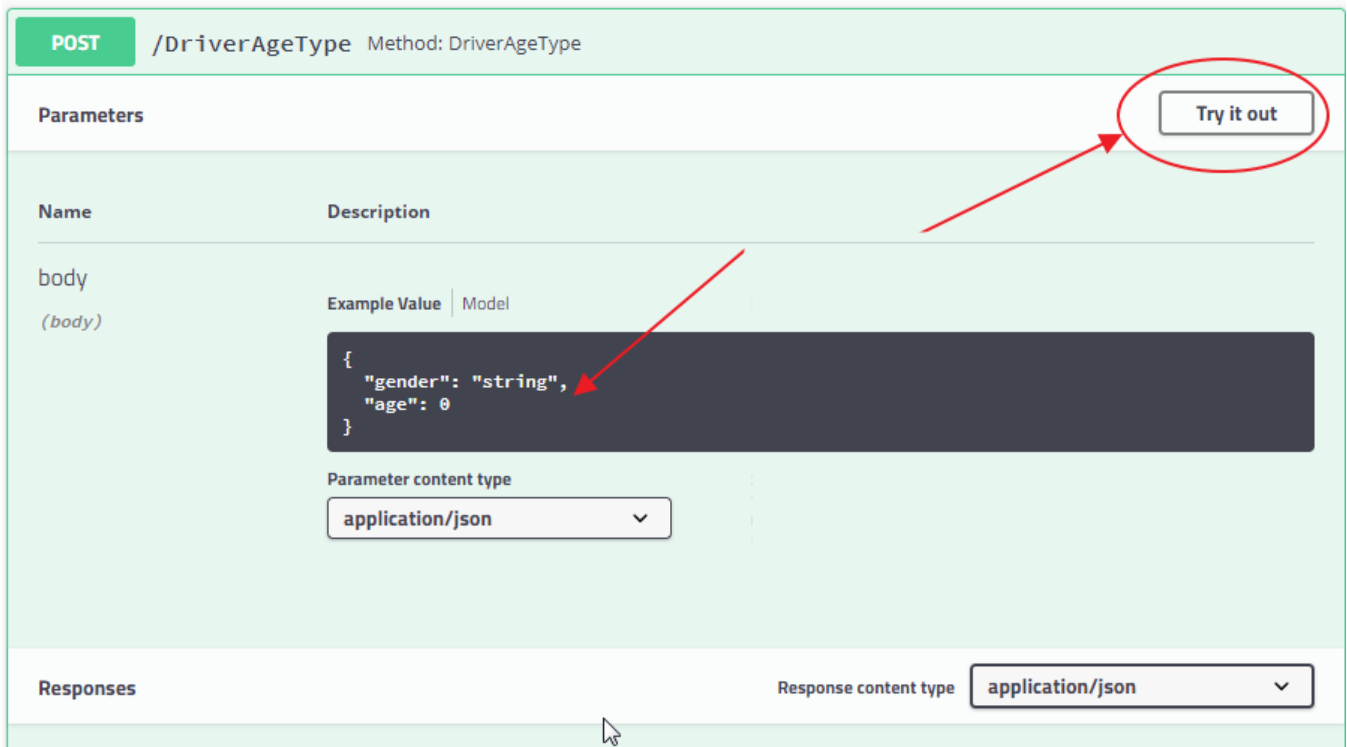


Figure 7: Using Swagger UI

Appendix E: Programmatically Deploying Rules to a Repository

If a user does not use OpenL Tablets WebStudio deploy functionality to locate a project with rules in the database repository, use the `deploy(File zipFile, String config)` method of the `org.openl.rules.workspace.deploy.ProductionRepositoryDeployer` class in the `WEB-INF\lib\org.openl.rules.workspace-5.X.X.jar` library.

The first method parameter `zipFile` contains the path to the project zip file, and the `config` parameter sets the location of the `deployer.properties` file, containing the same properties as described in [Configuring a Data Source](#).

Appendix F: Backward Compatibility Settings

This appendix describes backward compatibility settings and includes the following topics:

- [Version in Deployment Name](#)
- [Custom Spreadsheet Type](#)

Version in Deployment Name

If the Deployment repository is created in an OpenL Tablets version older than 5.20, the **Version in deployment name** option must be enabled for backward compatibility.

The 5.20 version of the OpenL Tablets Deployment repository contains only actual deployments which are exposed as services. Each new deployment updates the current deployment, while older versions are hidden in history and cannot be loaded into the RuleService directly. Different API versions of services are located in different deployments. They are distinguished by a suffix generated in OpenL Tablets WebStudio according to the API version in `rules-deploy.xml`. As a result, services are exposed more quickly. However, if a user created a repository in the OpenL Tablets version older than 5.20 and migrated to a newer OpenL Tablets Rule Services, enable the **Version in deployment name** option to expose services correctly.

In this case, add the following property to the `application.properties` file:

```
version-in-deployment-name = true
```

If you create a new repository, omit this property or set it to `false`.

Custom Spreadsheet Type

In OpenL Tablets, **custom spreadsheet type** is used by default. To enable support of the previously created rules based on other types, in the `application.properties` configuration file, set this property to `false`.

Appendix G: Deployment Project ZIP Structure

Deployment projects described in this section can be built via **OpenL Maven Plugin** or archived manually. The following topics are included:

- [Single Project Deployment Structure](#)
- [Multiple Projects Deployment Structure](#)

Single Project Deployment Structure

Deployable single project must be archived into ZIP file and have the following structure:

```
deployment.zip:
  rules.xml           OpenL Tablets project descriptor
  rules-deploy.xml   OpenL Tablets project deployment configuration
  *.xlsx             Excel files with rules
```

OpenL Tablets project descriptor and project deployment configuration are optional and can be skipped in deployment archive.

Multiple Projects Deployment Structure

Deployable multiple projects must be archived into ZIP file and have the following structure:

```
deployment.zip:
  deployment.yaml    OpenL Tablets deployment descriptor
  project-1          OpenL Tablets project folder #1
    rules.xml
    rules-deploy.xml
    *.xlsx
  project-2          OpenL Tablets project folder #2
    rules.xml
    rules-deploy.xml
    *.xlsx
  project-*          OpenL Tablets project folder #N
    rules.xml
    rules-deploy.xml
    *.xlsx
```

This type of deployment is useful when several projects have mutual dependencies and must be deployed as single deployment.

OpenL Tablets deployment descriptor is a marker which tells OpenL Tablets Engine that this type of deployment may contain several OpenL Tablets projects. This file is mandatory and may optionally contain the `name` property to customize deployment name:

```
name: openl-multiple-project-deployment
```

Appendix H: Manifest File for Deployed Projects

When a user deploys the OpenL Tablets project from OpenL Tablets WebStudio or using the OpenL Tablets Maven plugin, the MANIFEST.MF file is generated. This file contains information about deployment author, deployment time, project version, and OpenL Tablets version used for deployment.

If OpenL Tablets Maven plugin is used for deployment, the manifest file contains the following information:

Manifest file contents for OpenL Tablets Maven plugin deployed project	
Attribute	Description
Build-Date	Current zone datetime in the ISO8601 format.
Built-By	Name of the user currently logged in.
Created-By	OpenL Maven Plugin <OpenL version>
Implementation-Title	Deployment project name. Default format is project.groupId:project.artifactId.
Implementation-Version	Project version from the Maven pom.xml file.
Implementation-Vendor	Deployment project vendor. By default, it is project organization.

If the project is deployed in OpenL Tablets WebStudio, the manifest file contains the following information:

Manifest file contents for a project deployed in OpenL Tablets WebStudio	
Attribute	Description
Build-Date	Current zone datetime.
Build-Number	Git revision ID or database revision value.
Built-By	Name of the user currently logged in OpenL Tablets WebStudio.
Implementation-Title	Deployment project name.
Branch-Name	Git branch if the project is connected to Git.
Created-By	OpenL Tablets WebStudio version.

The manifest file is available in OpenL Tablets Rule Services, on the main page, for each deployed service.

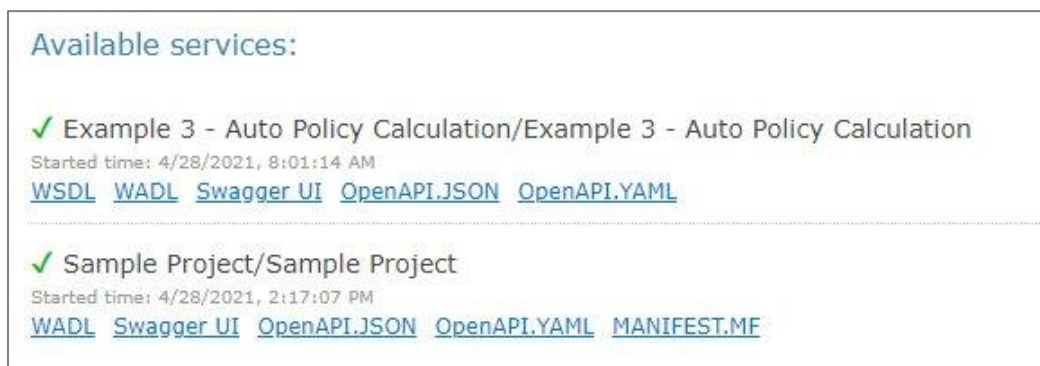


Figure 8: Manifest file available for the deployed project

If the project was deployed in a different way and it does not contain the manifest file, no link to it appears after the project name.

An example of the file contents is as follows:


```
{
  "entries": {},
  "mainAttributes": {
    "Manifest-Version": "1.0",
    "Build-Date": "2021-02-18T04:01:42.783666-08:00",
    "Created-By": "OpenL WebStudio v.5.23.11",
    "Implementation-Title": "Sample Project",
    "Build-Branch": "master",
    "Build-Number": "2dfeebe54fb8f252e88dd7e9f3b6d90cde315997",
    "Implementation-Version": "DEFAULT-2021-02-18_04-01-34",
    "Built-By": "DEFAULT"
  }
}
```

Figure 9: Manifest file contents example