Reference Guide
OpenL Tablets BRMS
Release 5.16

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1 Preface

This preface is an introduction to the *OpenL Tablets Reference Guide*. The following topics are included in this preface:

- Audience
- Related Information
- Typographic Conventions

1.1 Audience

This guide is mainly intended for analysts and developers who create applications employing the table based decision making mechanisms offered by OpenL Tablets technology. However, other users can also benefit from this guide by learning the basic OpenL Tablets concepts described herein.

Basic knowledge of Excel® is required to use this guide effectively. Basic knowledge of Java is required to follow the development related sections.

1.2 Related Information

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

Related information	
Title	**Description**
[OpenL Tablets WebStudio User Guide]	Document describing OpenL Tablets WebStudio, a web application for managing OpenL Tablets projects through a web browser.
http://openl-tablets.org/	OpenL Tablets open source project website.

1.3 Typographic Conventions

The following styles and conventions are used in this guide:

Typographic styles and conventions	
Convention	**Description**
Bold	• 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.
`Courier`	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.**
Italic	• Represents any information to be entered in a field. • Represents documentation titles.

Typographic styles and conventions	
Convention	**Description**
< >	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 Introducing OpenL Tablets

This chapter introduces OpenL Tablets and describes its main concepts.

The following topics are included in this section:

- What Is OpenL Tablets?
- Basic Concepts
- System Overview
- Installing OpenL Tablets
- Tutorials and Examples

2.1 What Is OpenL Tablets?

OpenL Tablets is a Business Rules Management System (BRMS) and Business Rules Engine (BRE) based on tables presented in Excel documents. Using unique concepts, OpenL Tablets facilitates treating business documents containing business logic specifications as executable source code. Since the format of tables used by OpenL Tablets is familiar to business users, OpenL Tablets bridges a gap between business users and developers, thus reducing costly enterprise software development errors and dramatically shortening the software development cycle.

In a very simplified overview, OpenL Tablets can be considered as a table processor that extracts tables from Excel documents and makes them accessible from software applications.

The major advantages of using OpenL Tablets are as follows:

- OpenL Tablets removes the gap between software implementation and business documents, rules, and policies.
- Business rules become transparent to developers.
- OpenL Tablets verifies syntax and type errors in all project document data, providing convenient and detailed error reporting.
- OpenL Tablets is able to directly point to a problem in an Excel document.
- OpenL Tablets provides calculation explanation capabilities, enabling expansion of any calculation result by pointing to source arguments in the original documents.
- OpenL Tablets provides cross-indexing and search capabilities within all project documents.

OpenL Tablets supports the `.xls`, `.xlsx`, and `.xlsm` file formats.

2.2 Basic Concepts

This section describes the following main OpenL Tablets concepts:

- Rules
- Tables
- Projects

Rules

In OpenL Tablets, a **rule** is a logical statement consisting of conditions and actions. If a rule is called and all its conditions are true, then the corresponding actions are executed. Basically, a rule is an IF-THEN statement. The following is an example of a rule expressed in human language:

If a service request costs less than 1,000 dollars and takes less than 8 hours to execute, then the service request must be approved automatically.

Instead of executing actions, rules can also return data values to the calling program.

Tables

Basic information OpenL Tablets deals with, such as rules and data, is presented in **tables**. Different types of tables serve different purposes. For more information on table types, see Table Types.

Projects

An **OpenL Tablets project** is a container of all resources required for processing rule related information. Usually, a project contains Excel files, which are called **modules** of the project, and optionally Java code, library dependencies, and other components. For more information on projects, see Working with Projects.

There can be situations where OpenL Tablets projects are used in the development environment but not in production, depending on the technical aspects of a solution.

2.3 System Overview

The following diagram displays how OpenL Tablets is used by different types of users.

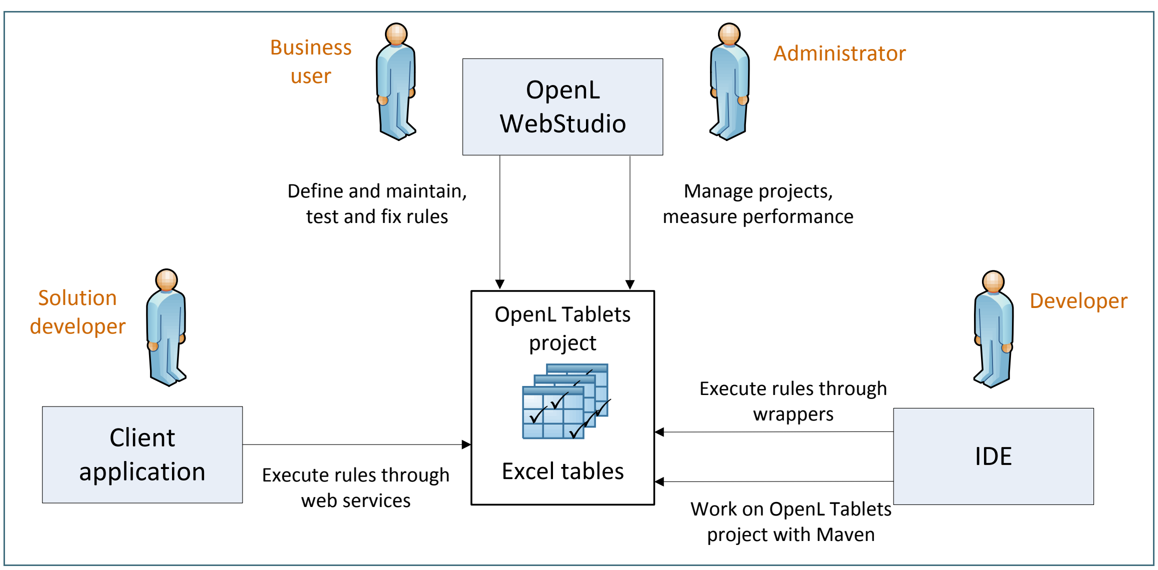


Figure 1: OpenL Tablets overview

A typical lifecycle of an OpenL Tablets project is as follows:

1. A business analyst creates an OpenL Tablets project in OpenL Tablets WebStudio.
2. Optionally, development team may provide the analyst with a project in case of complex configuration.

3. The business analyst creates correctly structured tables in Excel files based on requirements and includes them in the project.

   Typically, this task is performed through Excel or OpenL Tablets WebStudio in a web browser.
4. Business analyst performs unit and integration tests by creating test tables and performance tests on rules through OpenL Tablets WebStudio.

   As a result, fully working rules are created and ready to be used.
5. Development team creates other parts of the solution and employs business rules directly through the OpenL Tablets engine or remotely through web services.
6. Whenever required, a business user updates or adds new rules to project tables.

   OpenL Tablets business rules management applications, such as OpenL Tablets WebStudio, Rules Repository, and OpenL Tablets Web Services, can be set up to provide self-service environment for business user changes.

2.4 Installing OpenL Tablets

OpenL Tablets installation instructions are provided in ***[OpenL Tablets Installation Guide]***.

The development environment is required only for creating OpenL Tablets projects and launching OpenL Tablets WebStudio or OpenL Tablets Web Services. If OpenL Tablets projects are accessed through OpenL Tablets WebStudio or web services, no specific software needs to be installed.

2.5 Tutorials and Examples

OpenL Tablets provides a number of preconfigured projects developed for new users who want to learn working with OpenL Tablets quickly.

These projects are organized into following groups:

- Tutorials
- Examples

Tutorials

OpenL Tablets provides a set of tutorial projects demonstrating basic OpenL Tablets features starting from very simple and following with more advanced projects. Files in the tutorial projects contain detailed comments allowing new users to grasp basic concepts quickly.

To create a tutorial project, proceed as follows:

1. To open Repository Editor, in OpenL Tablets WebStudio, in the top line menu, click the **Repository** item.
2. Click the **Create Project** button 

.
3. In the **Create Project from** window, click the required tutorial name.
4. Click **Create** to complete.

   The project appears in the **Projects** list of Repository Editor.

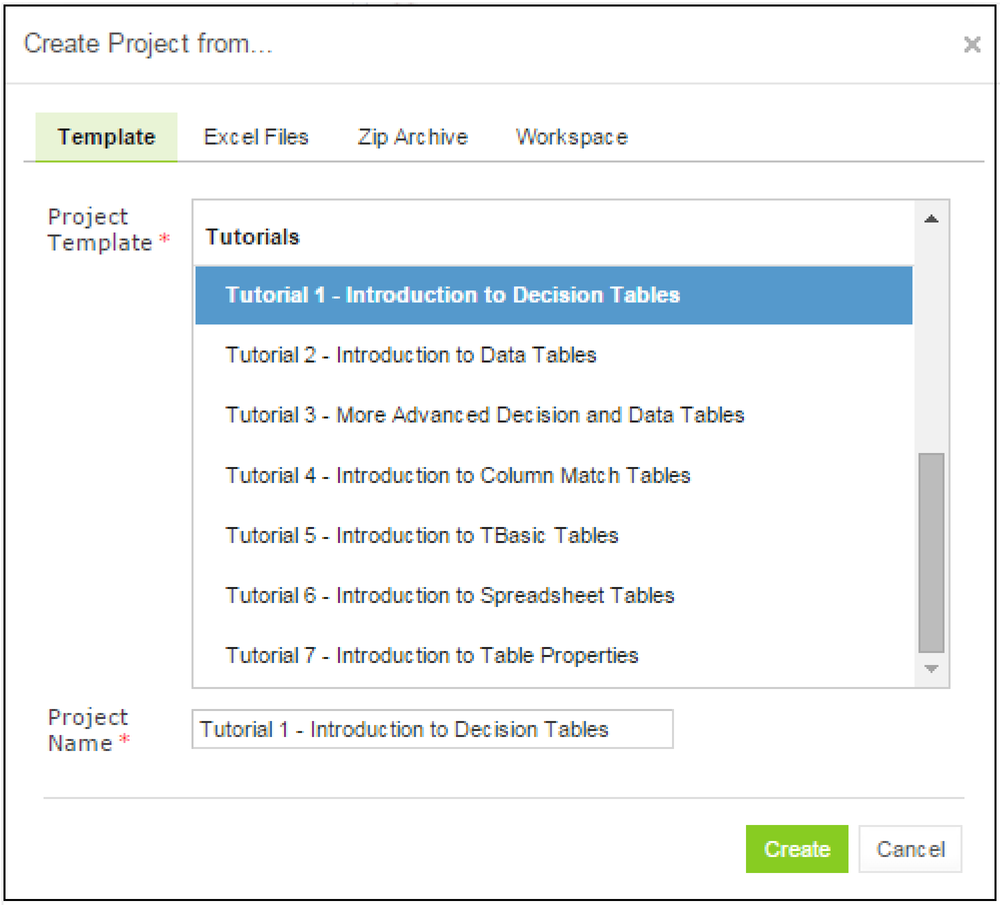


Figure 2: Creating tutorial projects

5. In the top line menu, click **Rules Editor**.
   The project is displayed in the **Projects** list and available for usage. It is highly recommended to start from reading Excel files for examples and tutorials which provide clear explanations for every step involved.

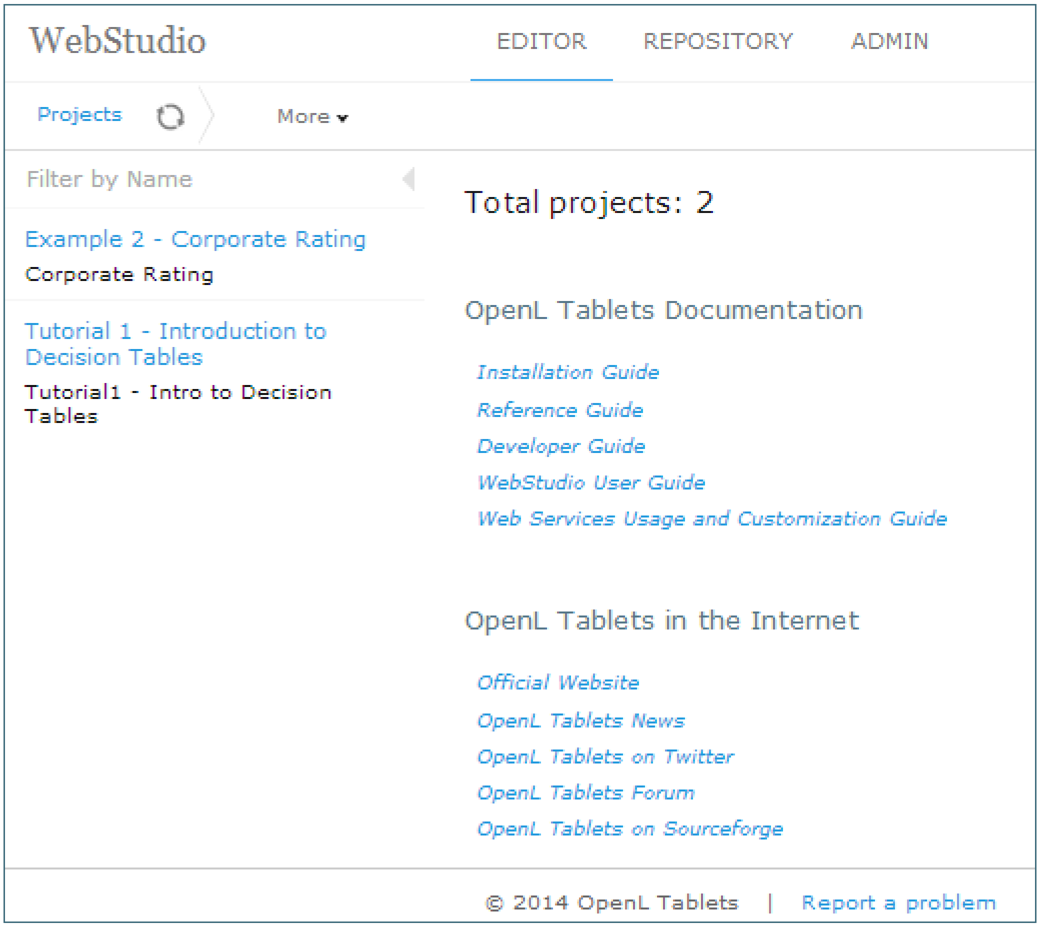


Figure 3: Tutorial project in the OpenL Tablets WebStudio

Examples

In addition to tutorials, OpenL Tablets provides several example projects that demonstrate how OpenL Tablets can be used in various business domains.

To create an example project, follow the steps described in Tutorials, and in the **Create Project from** dialog, select an example to explore. When completed, the example appears in the OpenL Tablets WebStudio Rules Editor as displayed in the Figure 3.

3 Creating Tables for OpenL Tablets

This chapter describes how OpenL Tablets processes tables and provides reference information for each table type used in OpenL Tablets.

The following topics are included in this chapter:

- Table Recognition Algorithm
- Table Properties
- Table Types

3.1 Table Recognition Algorithm

This section describes an algorithm of how the OpenL Tablets engine looks for supported tables in Excel files. It is important to build tables according to the requirements of this algorithm; otherwise, the tables are not recognized correctly.

OpenL Tablets utilizes Excel concepts of workbooks and worksheets, which can be represented and maintained in multiple Excel files. Each workbook is comprised of one or more worksheets used to separate information by categories. Each worksheet, in its turn, is comprised of one or more tables. Workbooks can include tables of different types, each one supporting different underlying logic.

The general table recognition algorithm is as follows:

1. The engine looks into each spreadsheet and tries to identify logical tables.
   Logical tables must be separated by at least one empty row or column or start at the very first row or column. Table parsing is performed from left to right and from top to bottom. The first populated cell that does not belong to a previously parsed table becomes the top-left corner of a new logical table.
2. The engine reads text in the top left cell of a recognized logical table to determine its type.
   If the top left cell of a table starts with a predefined keyword, such table is recognized as an OpenL Tablets table.
   The following are the supported keywords:

Table type keywords	
Keyword	**Table type**
Rules	Decision Table
Data	Data Table
Datatype	Datatype Table
Test	Test Table
Run	Run Table
Method	Method Table
Environment	Configuration Table
Properties	Properties Table
Spreadsheet	Spreadsheet Table
ColumnMatch	Column Match Table
TBasic or Algorithm	TBasic Table

Table type keywords	
Keyword	**Table type**
SimpleRules	Simple Rules Table
SimpleLookup	Simple Lookup Table
TablePart	Table Part

All tables that do not have any of the preceding keywords in the top left cell are ignored. They can be used as comments in Excel files.

3. The engine determines the width and height of the table using populated cells as clues.

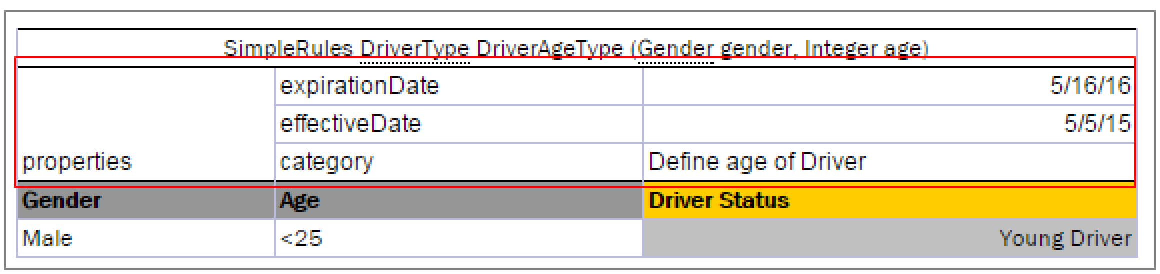
It is a good practice to merge all cells in the first table row, so the first row explicitly specifies the table width. The first row is called the table **header.**

Note: To put a table title before the header row, an empty row must be used between the title and the first row of the actual table.

3.2 Table Properties

For all OpenL Tablets table types, except for Properties Table, Configuration Table and the **Other** type tables, that is, non-OpenL Tablets tables, properties can be defined as containing information about the table. A list of properties available in OpenL Tablets is predefined, and all values are expected to be of corresponding types. The exact list of available properties can vary between installations depending on OpenL Tablets configuration.

Table properties are displayed in the section which goes immediately after the table **header** and before other table contents. The properties section is optional and can be omitted in the table. The first cell in the properties row contains the **properties** keyword and is merged across all cells in column if more than one property is defined. The number of rows in the properties section is equal to the number of properties defined for the table. Each row in the properties section contains a pair of a property name and a property value in consecutive cells, that is, second and third columns.



SimpleRules DriverType DriverAgeType (Gender gender, Integer age)		
	expirationDate	5/16/16
	effectiveDate	5/5/15
properties	category	Define age of Driver
Gender	**Age**	**Driver Status**
Male	<25	Young Driver

Figure 4: Table properties example

The following topics are included in this section:

- Category and Module Level Properties
- Default Value
- System Properties
- Properties for a Particular Table Type
- Business Dimension Properties
- Table Versioning
- Info Properties
- Dev Properties

- Properties Defined in the File Name
- Property State with the Countrywide Value Defined in the File Name

Category and Module Level Properties

Table properties can be defined not only for each table separately, but for all tables in a specific category or a whole module. A separate Properties Table is designed to define this kind of properties. Only properties allowed to be inherited from the category or module level can be defined in this table. Some properties, such as description, can only be defined for a table.

Besides the **Properties** table, the module level properties can also be defined in a name of the Excel file corresponding to the module. For more information on defining properties in the Excel file name, see Properties Defined in the File Name.

Properties defined at the category or module level can be overridden in tables. The priority of property values is as follows:

1. Table.
2. Category.
3. Module.
4. Default value.

Note: The OpenL Tablets engine allows changing property values via the application code when loading rules.

Default Value

Some properties can have default values. A **default value** is a predefined value that can be changed only in the OpenL Tablets configuration. The default value is used if no property value is defined in the rule table or in the **Properties** table.

Properties defined by default are not added to the table's properties section and can only be changed in the **Properties** pane on the right side of OpenL Tablets WebStudio Rules Editor.

System Properties

System properties can only be set and updated by OpenL Tablets, not by users. OpenL Tablets WebStudio defines the following system properties:

- Created By
- Created On
- Modified By
- Modified On

For more information on system properties, see ***[OpenL Tablets WebStudio User Guide].***

Properties for a Particular Table Type

Some properties are used just for particular types of tables. It means that they make sense just for tables of a special type and can be defined only for those tables. Almost all properties can be defined for Decision Tables, except for the **Datatype Package** property intended for Datatype Tables, the **Scope** property used in Properties Tables, the **Auto Type Discovery** property used in Spreadsheet Tables, and the **Precision** property designed for Test Tables.

OpenL Tablets checks applicability of properties and produces an error if the property value is defined for table not intended to contain the property.

Applications using OpenL Tablets rules can utilize properties for different purposes. All properties are organized into the following groups:

Properties group list	
Group	**Description**
Business dimension	Business Dimension Properties
Version	Table Versioning
Info	Info Properties
Dev	Dev Properties

Properties of the **Business Dimension Properties** and **Table Versioning** groups are used for table versioning. They are described in detail further on in this guide.

Table Versioning

In OpenL Tablets, business rules can be versioned in different ways using properties as described in Table Properties. This section describes the most popular versioning properties:

Versioning properties	
Property	**Description**
Business Dimension Properties	Targets advanced rules usage when several rule sets are used simultaneously. This versioning mechanism is more extendable and flexible.
Active Table	Is more suitable for “what-if” analysis.

Business Dimension Properties

This section introduces the **Business Dimension** group properties and includes the following topics:

- Introducing Business Dimension Properties
- Using Effective and Expiration Date
- Using a Request Date
- Using an Origin Property
- Overlapping of Properties Values for Versioned Rule Tables
- Version Validation in Case of the One Rule Table

Introducing Business Dimension Properties

The properties of the **Business Dimension** group are used to version rules by *property values*. This type of versioning is typically used when there are rules with the same meaning applied under different conditions. In their projects, users can have as many rules with the same name as needed; the system selects and applies the required rule by its properties. For example, calculating employees’ salary for different years can vary by several coefficients, have slight changes in the formula, or both. In this case using the **Business Dimension** properties enables users to apply appropriate rule version and get proper results for every year.

The following table types support versioning by Business Dimension properties:

- Decision tables, including rules, simple rules, and simple lookup table types
- Spreadsheet

- TBasic
- Method
- ColumnMatch

When dealing with almost equal rules of the same structure but with slight differences, for example, with changes in any specific date or state, there is a very simple way to version rule tables by Business Dimension properties. Proceed as follows:

1. Take the original rule table and set Business Dimension properties that indicate by which property the rules must be versioned.
   Multiple Business Dimension properties can be set.
2. Copy the original rule table, set new dimension properties for this table, and make changes in the table data as appropriate.
3. Repeat steps 1 and 2 if more rule versions are required.

Now the rule can be called by its name from any place in the project or application. If there are multiple rules with the same name but different Business Dimension properties, OpenL Tablets reviews all rules and selects the corresponding one according to the specified property values or, in developers' language, by runtime context values.

The following table contains a list of **Business Dimension** properties used in OpenL Tablets:

Business Dimension properties list					
Property	**Name to be used in rule tables**	**Name to be used in context**	**Level at which a property can be defined**	**Type**	**Description**
Effective / Expiration dates	• effectiveDate • expirationDate	currentDate	Module Category Table	Date	Time interval within which a rule table is active. The table becomes active on the effective date and inactive after the expiration date. Multiple instances of the same table can exist in the same module with different effective and expiration date ranges.
Start / End Request dates	• startRequestDate • endRequestDate	requestDate	Module Category Table	Date	Time interval within which a rule table is introduced in the system and is available for usage.
LOB (Line of Business)	lob	lob	Module Category Table	String	LOB for a rule table, that is, business area for which the given rule works and must be used.
US Region	usregion	usRegion	Module Category Table	Enum[]	US regions for which the table works and must be used.
Countries	country	country	Module Category Table	Enum[]	Countries for which the table works and must be used.
Currency	currency	currency	Module Category Table	Enum[]	Currencies for which the table works and must be used.
Language	lang	lang	Module Category Table	Enum[]	Languages for which this table works and must be used.

US States	state	usState	Module Category Table	Enum[]	US states for which this table works and must be used.
Canada Province	caProvinces	caProvince	Module Category Table	Enum[]	Canada provinces of operation for which the table must be used.
Canada Region	caRegions	caRegion	Module Category Table	Enum[]	Canada regions of operation for which the table must be used.
Region	region	region	Module Category	Enum[]	Economic regions for which the table works and must be used.
Origin	origin		Module Category Table	Enum	Origin of rule to enable hierarchy of more generic and more specific rules.

Note for experienced users: A particular rule can be called directly regardless of its dimension properties and current runtime context in OpenL Tablets. This feature is supported by setting the ID property as described in Dev Properties, in a specific rule, and using this ID as the name of the function to call. During runtime, direct rule is executed avoiding the mechanism of dispatching between overloaded rules.

Illustrative and very simple examples of how to use Business Dimension properties are provided further in the guide on the example of **Effective/Expiration Date** and **Request Date.**

Using Effective and Expiration Date

The following Business Dimension properties are intended for versioning business rules depending on specific dates:

Business Dimension properties for versioning on specific dates	
Property	**Description**
Effective Date	Date as of which a business rule comes into effect and produces required and expected results.
Expiration Date	Date after which the rule is no longer applicable. If **Expiration Date** is not defined, the rule works at any time on or after the effective date.

The date *for which* the rule is to be performed must fall into the effective and expiration date time interval.

Users can have multiple versions of the same rule table in the same module with different effective and expiration date ranges. However, these dates cannot overlap with each other, that is, if in one version of the rule effective and expiration dates are 1.2.2010 – 31.10.2010, do not create another version of that rule with effective and expiration dates within this dates frame if no other property is applied.

Consider a rule for calculating a car insurance premium quote. The rule is completely the same for different time periods except for a specific coefficient, a Quote Calculation Factor, or **Factor**. This factor is defined for each model of car.

The further examples display how these properties define which rule to apply for a particular date.

The following figure displays a business rule for calculating the quote for 2011.The effective date is 1/1/2011 and the expiration date is 12/31/2011.

SimpleRules Double Factor (String ModelOfCar)		
properties	effectiveDate	1/1/11
	expirationDate	12/31/11
Model of Car	**Factor for Quote Calculation**	
BMW	20	
Toyota	45	
Bentley	20	

Figure 5: Business rule for calculating a car insurance quote for year 2011

However, the rule for calculating the quote for the year 2012 cannot be used because the factors for the cars differ from the previous year.

The rule names and their structure are the same but with the factor values differ. Therefore it is a good idea to use versioning in the rules.

To create the rule for the year 2012, proceed as follows:

1. To copy the rule table, use the **Copy as New Business Dimension** feature in OpenL Tablets WebStudio as described in ***[OpenL Tablets WebStudio User Guide]***, *Copying Tables* section.
2. Change effective and expiration dates to 1/1/2012 and 12/31/2012 appropriately.
3. Replace the factors as appropriate for the year 2012.

The new table resembles the following:

SimpleRules Double Factor (String ModelOfCar)		
properties	effectiveDate	1/1/12
	expirationDate	12/31/12
Model of Car	**Factor for Quote Calculation**	
BMW	25	
Toyota	40	
Bentley	15	

Figure 6: Business rule for calculating the same quote for the year 2012

To check how the rules work, test them for a certain car model and particular dates, for example, 5/10/2011 and 11/2/2012. The test result for BMW is as follows:

	Test Factor FactorTest		
	context.currentDate	ModelOfCar	_res_
	Current Date	**Model of Car**	**Factor**
1	5/10/11	BMW	20
2	11/2/12	BMW	25

Figure 7: Selection of the Factor based on Effective / Expiration Dates

In this example, the date on which calculation must be performed, per client's request, is displayed in the **Current Date** column. In the first row for BMW, the current date value is 5/10/2011, and since 5/10/2011>= 1/1/2011 and 10/5/2011<= 12/31/2011, the result factor for this date is **20**.

In the second row, the current date value is 2/11/2012, and since 2/11/2012 >= 1/1/2012 and 2/11/2012 <= 12/31/2012, the factor is **25.**

Using a Request Date

In some cases it is necessary to define additional time intervals for which user's business rule is applicable. Table properties related to dates that can be used for selecting applicable rules have different meaning and work with slightly different logic compared to the previous ones.

Request properties used for versioning	
Property	**Description**
Start Request Date	Date when the rule is introduced in the system and is available for usage.
End Request Date	Date from which the system stops using the rule. If not defined, the rule can be used any time on or after the **Start Request Date** value.

The date when the rule is applied must be within the **Start Request Date** and **End Request Date** interval. In OpenL Tablets rules, this date is defined as a **request date**.

Note: Pay attention to the difference between previous two properties: effective and expiration dates identify the date to which user's rules are applied. In contrast, request dates identify when user's rules are used, or called from the application.

Users can have multiple rules with different start and end request dates, where dates must intersect. In such cases, priority rules are applied as follows:

1. The system selects the rule with the latest **Start Request** date.

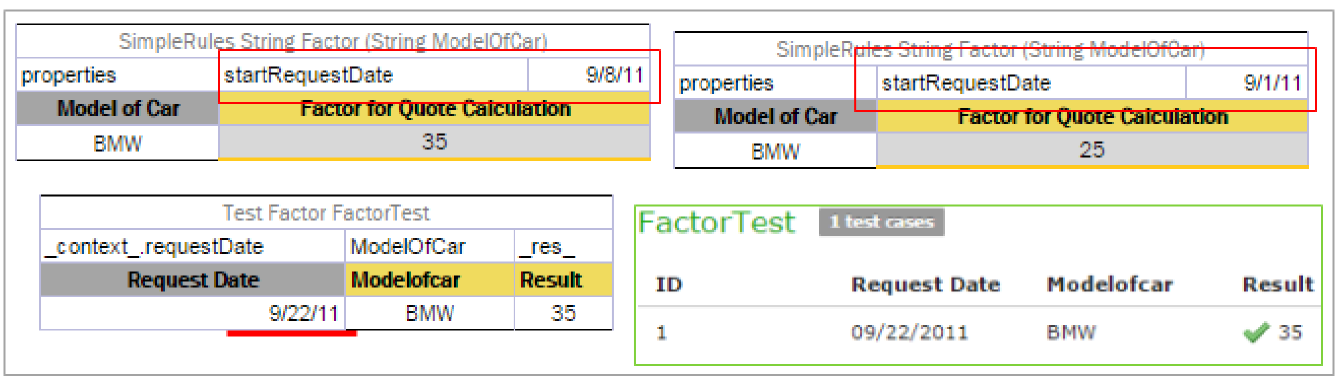


Figure 8: Example of the priority rule applied to rules with intersected Start Request date

2. If there are rules with the same **Start Request** date, OpenL Tablets selects the rule with the earliest **End Request** date.

SimpleRules String Factor (String ModelOfCar)		
properties	startRequestDate	9/1/11
	endRequestDate	10/10/11
Model of Car	**Factor for Quote Calculation**	
BMW	25	

SimpleRules String Factor (String ModelOfCar)		
properties	startRequestDate	9/1/11
	endRequestDate	11/17/11
Model of Car	**Factor for Quote Calculation**	
BMW	35	

Test Factor FactorTest		
context.requestDate	ModelOfCar	_res_
Request Date	**Modelofcar**	**Result**
10/7/11	BMW	25

FactorTest 1 test cases

ID	Request Date	Modelofcar	Result
1	10/07/2011	BMW	✔ 25

Figure 9: Example of the priority rule applied to the rules with End Request date

If the start and end request dates coincide completely, the system displays an error message saying that such table already exists.

Note: A rule table version with exactly the same **Start Request Date** or **End Request Date** cannot be created because it causes an error message.

Note: In some particular cases, request date is used to define the date when the business rule was called for the very first time.

Consider the same rule for calculating a car insurance quote but add date properties, **Start Request Date** and **End Request Date**, in addition to the effective and expiration dates.

For some reason, the rule for the year 2012 must be entered into the system in advance, for example, from 12/1/2011. For that purpose, add 12/1/2011 as **Start Request Date** to the rule as displayed in the following figure. Adding this property tells OpenL Tablets that the rule is applicable from the specified **Start Request** date.

SimpleRules Double Factor (String ModelOfCar)		
properties	startRequestDate	12/1/11
	endRequestDate	5/1/12
	effectiveDate	1/1/12
	expirationDate	12/31/12
Model of Car	**Factor for Quote Calculation**	
BMW	25	
Toyota	45	
Bentley	20	

Figure 10: The rule for calculating the quote is introduced from 12/1/2011

Assume that a new rule with different factors from 2/3/2012 is introduced as displayed in the following figure.

SimpleRules Double Factor (String ModelOfCar)		
properties	startRequestDate	2/3/12
	effectiveDate	1/1/12
	expirationDate	12/31/12
Model of Car	Factor for Quote Calculation	
BMW	35	
Toyota	35	
Bentley	20	

Figure 11: The rule for calculating the Quote is introduced from2.3.2011

However, the US legal regulations require that the same rules for premium calculations must be used; therefore users must stick to the previous rules for older policies. In this case, storing a request date in the application helps to solve this issue. By the provided request date, OpenL Tablets will be able to select rules available in the system on the designated date.

The following figure displays results of testing the rules for BMW for particular request dates and effective dates.

	Test Factor FactorTest			
	context.requestDate	_context_.currentDate	ModelOfCar	_res_
	Request Date	Current Date	Model of Car	Factor
1	3/10/12	10/5/12	BMW	35
2	12/29/12	10/15/12	BMW	35
3	1/14/12	8/16/12	BMW	25

Figure 12: Selection of the Factor based on Start / End Request Dates

In this example, the dates *for* which the calculation is performed are displayed in the **Current Date** column. The dates when the rule is run and calculation is performed are displayed in the **Request Date** column.

Pay attention to the row where **Request Date** is 3/10/2012. This date falls in the both start and end Request date intervals displayed in Figure 10 and Figure 11. However, the **Start Request** date in Figure 11 is later than the one defined in the rule in Figure 10. As a result, correct factor value is **35.**

Using an Origin Property

The **Origin** Business Dimension property indicates the origin of rules used to generate a hierarchy of more generic and more specific rules. This property has two values, **Base** and **Deviation**. A rule with the **Deviation** property value has higher priority than a rule with the **Base** value or a rule without property value. A rule with the **Base** property value has higher priority than a rule without property value. As a result, selecting the correct version of the rule table does not require any specific value to be assigned in the runtime context, and the correct rule table is selected based on the hierarchy.

An example is as follows.

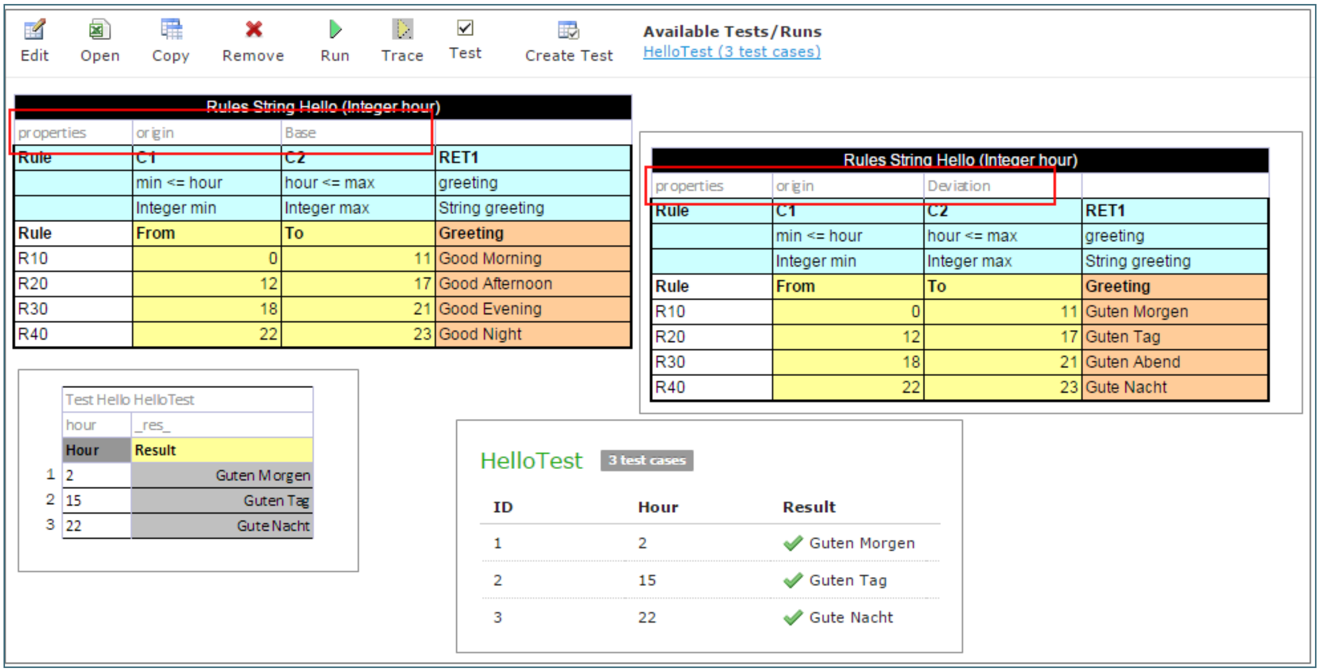


Figure 13: Example Rule table with origin property

Overlapping of Properties Values for Versioned Rule Tables

By using different sets of Business Dimension properties, a user can flexibly apply versioning to rules, keeping all rules in the system. OpenL Tablets runs validation to check gaps and overlaps of properties values for versioned rules.

There are two types of overlaps by Business Dimension properties, “good” and “bad” overlaps. The following diagram illustrates overlap of properties, representing properties value sets of a versioned rule as circles. For simplicity, two sets are displayed.

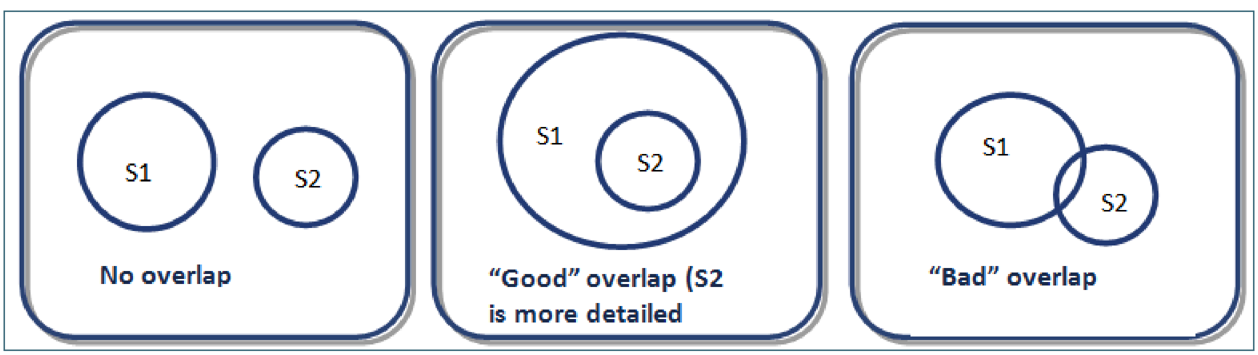


Figure 14: Example of logic for “good” and “bad” overlaps

The **No overlap** case means that property value sets are totally different and the only one rule table can be selected according to the specified client request in runtime context. An example is as follows:

SimpleRules DoubleValue **AccidentPremium** ()		
properties	state	CA
Per Accident Premium		
$150		

SimpleRules DoubleValue **AccidentPremium** ()		
properties	state	NY
Per Accident Premium		
$145		

Figure 15: Example of No overlap case

The **"Good" overlap** case describes the situation when several rule versions can be selected according to the client request as there are intersections among their sets, but one of the sets completely embeds another one. In this situation, the rule version with the most detailed properties set, that is, the set completely embedded in all other sets, is selected for execution.

Note: If a property value is not specified in the table, the property value is all possible values, that is, any value. It also covers the case when a property is defined but its value is not set, that it, the value field is left empty.

Detailed properties values mean that all these values are mentioned, or included, or implied in properties values of other tables. Consider the following example.

SimpleRules DoubleValue **AccidentPremium** ()
Per Accident Premium
$135

SimpleRules DoubleValue **AccidentPremium** ()		
properties	state	NY, CA, FL
Per Accident Premium		
$145		

SimpleRules DoubleValue **AccidentPremium** ()		
properties	state	CA
Per Accident Premium		
$150		

Test AccidentPremium **AccidentPremiumTest**	
context.usState	_res_
US State	**Expected Accident Premium**
DE	$135
NY	$145
CA	$150

Figure 16: Example of a rule with "good" overlapping

The first rule table is the most general rule: there are no specified states, so this rule is selected for any client request. It is the same as if the property state is defined with all states listed in the table. The second rule table has several states values set, that is, NY, CA, and FL. The last rule version has the most detailed properties set as it can be selected only if the rule is applied to the California state.

The following diagram illustrates example overlapping.

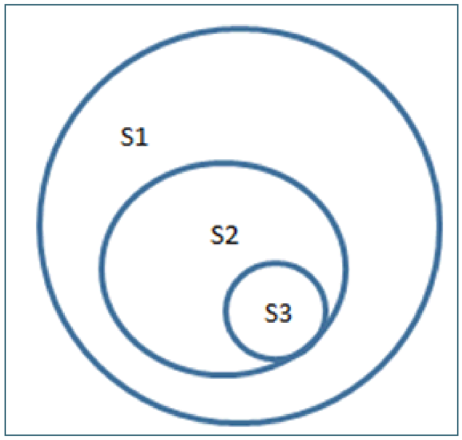


Figure 17: Logic of properties set inclusion

For the Delaware state, the only the first rule is applicable, that is, 135$ Accident Premium. If the rule is applied to the New York state, then the first and second rule versions are suitable by property values, but according to the “good” overlapping logic, the premium is 145$ because the second rule table is executed. And, finally, Accident Premium for the California state is 150$ despite the fact that this property is set in all three rule tables: absence of property state in the first table means the full list of states set.

The **“Bad” overlap** is when there is no certain result variant. “Bad” overlap means that sets Si and Sj have intersections but are not embedded. When a “bad” overlap occurs, the system displays the ambiguous error message.

Consider the following example.

SimpleRules DoubleValue **AccidentPremium** ()		
properties	state	NY, CA
Per Accident Premium		
$145		

SimpleRules DoubleValue **AccidentPremium** ()		
properties	state	FL, CA
Per Accident Premium		
$150		

Figure 18: Example of a rule with “bad” overlapping

For the California state, there are two possible versions of the rule, and “good” overlapping logic is not applicable. Upon running this test case, an error on ambiguous method dispatch is returned.

Note: For the matter of simplicity, only one property, **state,** is defined in examples of this section. A rule table can have any number of properties specified which are analyzed on overlapping.

Note: Only properties specified in runtime context are analyzed during execution.

Version Validation in Case of the One Rule Table

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.

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

An example is as follows. Consider a Decision table **Hello** overloaded with the **lob** property.

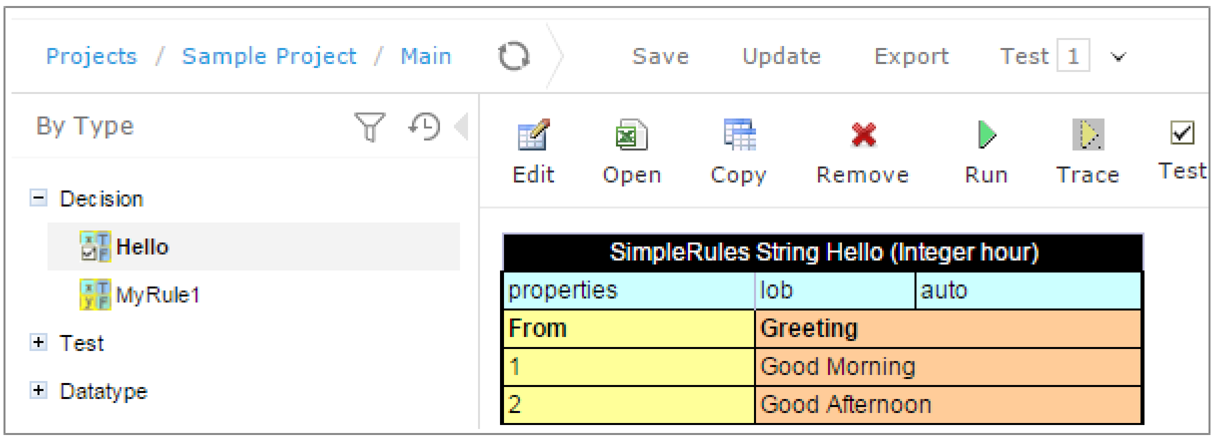


Figure 19: Example single overloaded rule

Create a test table with set context. Define a value of context which does not match the property's value. The following examples illustrate different system behavior.

An example of dispatching.validation = false is as follows.

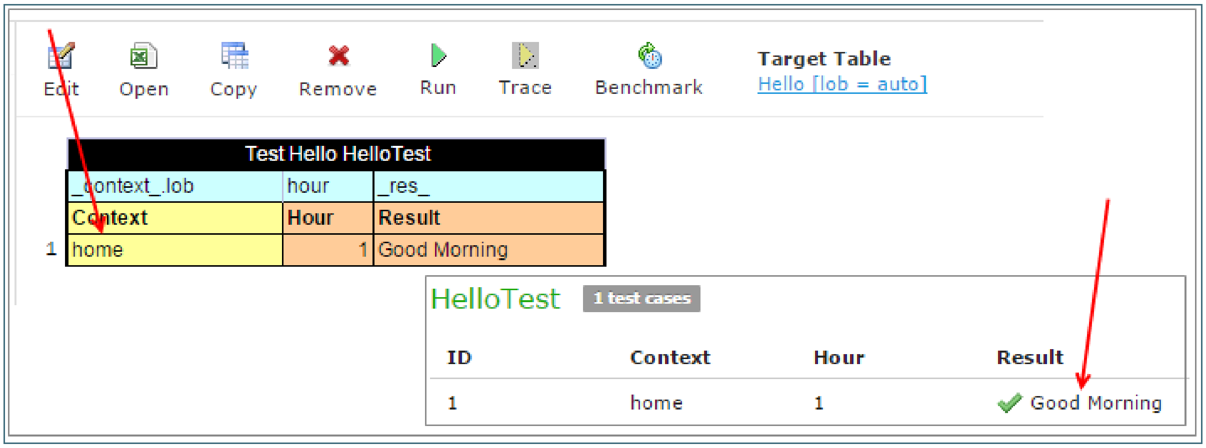


Figure 20: Example dispatching.validation = false mode

An example of dispatching.validation = true is as follows.

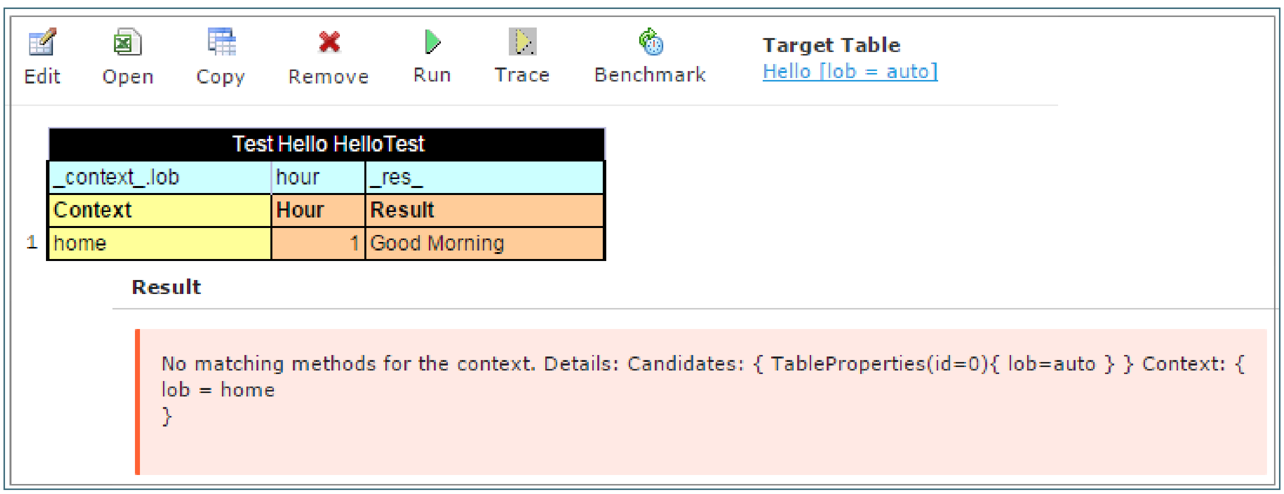


Figure 21: Example dispatching.validation =true mode

Active Table

Table versioning allows storing the previous versions of the same rule table in the same rules file. The active table versioning mechanism is based on two properties, **version** and **active**. The **version** property must be different for each table, and only one of them can have **true** as a value for the **active** property.

All table versions must have the same identity, that is, exactly the same signature and dimensional properties values. Table types also must be the same.

An example of an inactive table version is as follows.

Rules DoubleValue driverRiskScore(String driverRisk)		
	version	0.0.1
	active	false
properties	category	Driver-Scoring
C1		RET1
risk == driverRisk		score
String risk		DoubleValue score
Driver Risk		**Score**
High Risk Driver		100
		0

Figure 22: An inactive table version

Info Properties

The **Info** group includes properties that provide useful information. This group enables users to easily read and understand rule tables.

The following table provides a list of **Info** properties along with their brief description:

Info properties list				
Property	**Name to be used in rule tables**	**Level at which property can be defined and overridden**	**Type**	**Description**
Category	category	Category, Table	String	Category of the table. By default, it is equal to the name of the Excel sheet where the table is located. If the property level is specified as **Table**, it defines a category for the current table. It must be specified if scope is defined as **Category** in the **Properties** table.
Description	description	Table	String	Description of a table that clarifies use of the table. An example is *Car price for a particular Location/Model*.
Tags	tags	Table	String[]	Tag that can be used for search. The value can consist of any number of comma-separated tags.
Created By	createdBy	Table	String	Name of a user who created the table in OpenL Tablets WebStudio.
Created On	createdOn	Table	Date	Date of table creation in OpenL Tablets WebStudio.
Modified By	modifiedBy	Table	String	Name of a user who last modified the table in OpenL Tablets WebStudio.
Modified On	modifiedOn	Table	Date	Date of the last table modification in OpenL Tablets WebStudio.

Dev Properties

The **Dev** properties group impacts the OpenL Tablets features and enables system behavior management depending on a property value.

For example, the **Scope** property defines whether properties are applicable to a particular category of rules or for the module. If **Scope** is defined as **Module**, the properties are applied for all tables in the current module. If **Scope** is defined as **Category**, use the **Category** property to specify the exact category to which the property is applicable.

Properties catPolicyScoring	
scope	Category
category	Policy-Scoring
lob	category_Policy-Scoring_Lob

Figure 23: The properties are defined for the 'Police-Scoring' category

The following topics are included in this section:

- Dev Properties List
- Variation Related Properties
- Using the Precision Property in Testing

Dev Properties List

The **Dev** group properties are listed in the following table:

<table>
<tr><th colspan="6">Dev group properties</th></tr>
<tr><th>Property</th><th>Name to be used in rule tables</th><th>Type</th><th>Table type</th><th>Level at which property can be defined</th><th>Description</th></tr>
<tr><td>ID</td><td>id</td><td>Table</td><td>All</td><td>Table</td><td>Unique ID to be used for calling a particular table in a set of overloaded tables without using business dimension properties.
Note: Constraints for the ID value are the same as for any OpenL function.</td></tr>
<tr><td>Build Phase</td><td>buildPhase</td><td>String</td><td>All</td><td>Module, Category, Table</td><td>Property used to manage dependencies between build phases.
Note: Reserved for future use.</td></tr>
<tr><td>Validate DT</td><td>validateDT</td><td>String</td><td>Decision Table</td><td>Module, Category, Table</td><td>Validation mode for decision tables. In the wrong case an appropriate warning is issued. Possible values are as follows:
<table>
<tr><th>Value</th><th>Description</th></tr>
<tr><td>on</td><td>Checks for uncovered or overlapped cases.</td></tr>
<tr><td>off</td><td>Validation is turned off.</td></tr>
<tr><td>gap</td><td>Checks for uncovered cases.</td></tr>
<tr><td>overlap</td><td>Checks for overlapped cases.</td></tr>
</table></td></tr>
</table>

Dev group properties					
Property	**Name to be used in rule tables**	**Type**	**Table type**	**Level at which property can be defined**	**Description**
Fail On Miss	failOnMiss	Boolean	Decision Table	Module, Category, Table	Rule behavior in case no rules were matched: • If the property is set to `TRUE`, an error occurs along with the corresponding explanation. • If the property is set to `FALSE`, the table output is set to `NULL`.
Scope	scope	String	Properties	Module, Category	Scope for the Properties table.
Datatype Package	datatypePackage	String	DataType	Table	Name of the Java package for generating the datatype.
Recalculate	recalculate	Enum		Module, Category, Table	Way of a table recalculation for a variation. Possible values are **Always**, **Never**, and **Analyze.**
Cacheable	cacheable	Boolean		Module, Category, Table	Identifier of whether to use cache while recalculating the table, depending on the rule input.
Precision	precision	Integer	Test Table	Module, Category, Table	Precision of comparing the returned results with the expected ones while launching test tables.
Auto Type Discovery	autoType	Boolean	Properties Spreadsheet	Module, Category, Table	Auto detection of datatype for a value of the **Spreadsheet** cell with formula. The default value is `false`. If the value is `true`, the type can be left undefined.

Variation Related Properties

This section describes *variations* and the properties required to work with them, namely *Recalculate* and *Cacheable*.

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

The following **Dev** properties are used to manage rules recalculation for variations:

Dev properties	
Property	**Description**
Cacheable	Switches on or off using cache while recalculating the table. It can be evaluated to `true` or `false`. If it is set to `true`, all calculation results of the rule are cached and can be used in other variations; otherwise calculation results are not cached. It is recommended to set Cacheable to `true` if recalculating a rule with the same input parameters is suggested. In this case, OpenL does not recalculate the rule, instead, it retrieves the results from the cache.

Dev properties		
Property	**Description**	
Recalculate	Explicitly defines the recalculation type of the table for a variation. It can take the following values:	
	Value	**Description**
	Always	If the Recalculate property is set to **Always** for a rule, the rule is entirely recalculated for a variation. This value is useful for rule tables which are supposed to be recalculated.
	Never	If the Recalculate property is set to **Never** for a rule, the system does not recalculate the rule for a variation. It can be set for rules which new results users are not interested in and which are not required for a variation.
	Analyze	It must be used for the top level rule tables to ensure recalculation of the included rules with the **Always** value. The included table rules with the **Never** value are ignored.

By default, the properties are set as follows:

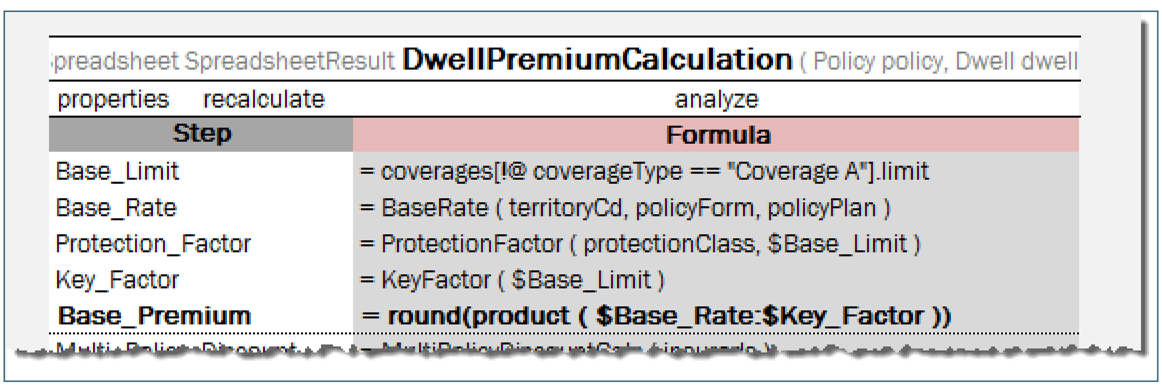
```
recalculate = always;
cacheable = false.
```

To provide an illustrative example of how to use variation related properties, consider the Spreadsheet rule **DwellPremiumCalculation,** as displayed in the following figure, which calculates a home insurance premium quote. The quote includes calculations of **Protection** and **Key** factors which values are dependent on **Coverage A** limit as defined in the **ProtectionFactor** and **KeyFactor** simple rules. The insurer requests to vary Coverage A limit of the quote to verify how limit variations impact the **Key** factor.

DwellPremiumCalculation is a top level rule and during recalculation of the rule, only some results are of interest. That is why recalculation type, or the **recalculate** property, must be defined as **Analyze** for this rule.

As the interest of the insurer is to get a new value of the **Key** factor for a new **Coverage A** limit value, recalculation type of the **KeyFactor** rule must be determined as **Always**.

On the contrary, the **Protection** factor is not interesting for the insurer, so the **ProtectionFactor** rule is not required to be recalculated. To optimize the recalculation process, recalculation type of the rule must be set up as **Never**. Moreover, other rules tables, such as the **BaseRate** rule, which are not required to be recalculated, must have the recalculation property set to **Never**.



preadsheet SpreadsheetResult **DwellPremiumCalculation** (Policy policy, Dwell dwell		
properties	recalculate	analyze
Step		**Formula**
Base_Limit		= coverages[!@ coverageType == "Coverage A"].limit
Base_Rate		= BaseRate (territoryCd, policyForm, policyPlan)
Protection_Factor		= ProtectionFactor (protectionClass, $Base_Limit)
Key_Factor		= KeyFactor ($Base_Limit)
Base_Premium		**= round(product ($Base_Rate:$Key_Factor))**

Figure 24: Spreadsheet table which contains Recalculate Property

SimpleLookup DoubleValue **ProtectionFactor** (ProtectionClas		
properties	recalculate	never
Protection Class / Limit	<= 100	> 100
1	0.8	1
2	0.9	1
3	1	1
8B	1.2	1.3
9	1.2	1.4
10	1.5	1.5

Figure 25: Decision table with defined Recalculate Property

SimpleRules DoubleValue **KeyFactor** (DoubleValue lim		
properties	recalculate	always
CoverageA Amount	**Key Factor**	
0 - 75	0.923	
75 - 80	0.933	
80 - 85	0.948	
85 - 90	0.962	
90 - 95	0.981	
95 - 100	1	
100 - 105	1.023	
105 - 110	1.045	
110 - 115	1.072	

Figure 26: Usage of Variation Recalculate Properties

Consider that the **Coverage A** limit of the quote is 90 and **Protection Class** is 9. A modified value of **Coverage A** limit for a variation is going to be 110. The following spreadsheet results after the first calculation and the second recalculation are obtained:

Step	Formula
Base_Limit	90.0; 90
Base_Rate	275.0
Protection_Factor	1.2
Key_Factor	0.962
Base_Premium	317.0

Step	Formula
Base_Limit	110.0; 110
Base_Rate	275.0
Protection_Factor	1.2
Key_Factor	1.045
Base_Premium	345.0

Figure 27: Results of DwellPremiumCalculation with recalculation = Analyze

Note that the **Key** factor is recalculated, but the **Protection** factor remains the same and the initial value of **Protection Factor** parameter is used.

If the recalculation type of DwellPremiumCalculation is defined as **Always**, OpenL Tablets ignores and does not analyze recalculation types of nested rules and recalculates all cells as displayed in the following figure.

Step	Formula
Base_Limit	90.0: 90
Base_Rate	275.0
Protection_Factor	1.2
Key_Factor	0.962
Base_Premium	317.0

Step	Formula
Base_Limit	110.0: 110
Base_Rate	275.0
Protection_Factor	1.4
Key_Factor	1.045
Base_Premium	402.0

Figure 28: Results of DwellPremiumCalculation with recalculation = Always

Using the Precision Property in Testing

This section describes how to use the precision property. The property must be used for testing purpose and is only applicable to the test tables.

There are cases when it is impossible or not needed to define the exact numeric value of an expected result in test tables. For example, non-terminating rational numbers such as π (3.1415926535897…) must be approximated so that it can be written in a cell of a table.

The **Precision** property is used as a measure of accuracy of the expected value to the returned value to a certain precision. Assume the precision of the expected value *A* is *N*. The expected value *A* is true only if

$|A - B| < 1/10^N$, where B – returned value.

It means that if the expected value is close enough to the returned value, the expected value is considered to be true.

Consider the following examples. A simple rule FinRatioWeight has two tests, FinRatioWeightTest1 and FinRatioWeightTest2:

s DoubleValue FinRatioWeight (FinancialRatio fin	
Financial Ratio	**Financial Ratio Weight**
Cash Liquidity Ratio	0.111207645
Quick Ratio	0.054117651
Current Ratio	0.420000001
Operating Profit Margin	0.414674703

Figure 29: An example of Simple Rule

The first test table has the **Precision** property defined with value 5:

Test FinRatioWeight FinRatioWeightTest1		
properties	precision	5
financialRatio	_res_	
Financial Ratio	**Financial Ratio Weight**	
Cash Liquidity Ratio	0.11121358	
Quick Ratio	0.05410091	

Figure 30: An Example of Test table with Precision Dev property

FinRatioWeightTest1 2 test cases 1

Financial Ratio	Financial Ratio Weight
Cash Liquidity Ratio	✔ 0.111207645
Quick Ratio	✘ 0.054117651 Expected: 0.05410091

Figure 31: An example of Test with precision defined

When this test is launched, the first test case is passed because |0.11121358 - 0.111207645| = $0.5935*10^{-5}$ < 0.00001; but the second is failed because |0.05410091 - 0.054117651| = $1.6741*10^{-5}$ > 0.00001.

OpenL Tablets allows specifying precision for a particular column which contains expected result values using the following syntax:

```
_res_ (N)
_res_.$<ColumnName>$<RowName> (N)
_res_.<attribute name> (N)
```

An example of the table using shortcut definition is as follows.

Test **FinRatioWeight** FinRatioWeightTest2	
financialRatio	_res_ (2)
Financial Ratio	**Financial Ratio Weight**
Current Ratio	0.42
Operating Profit Margin	0.41

Figure 32: Example of using shortcut definition of Precision Property

FinRatioWeightTest2 2 test cases

Financial Ratio	Financial Ratio Weight
Current Ratio	✔ 0.420000001
Operating Profit Margin	✔ 0.414674703

Figure 33: An example of Test with precision for the column defined

Precision property shortcut definition is required when results of the whole test are considered with one level of rounding, and some expected result columns are rounded to another number of figures to the right of a decimal point.

Precision defined for the column has higher priority than precision defined at the table level.

Precision can be zero or a negative value, Integer numbers only.

Properties Defined in the File Name

Module level properties, or table properties applied to all tables of a module, can be defined in the module file name. The following conditions must be met for such properties definition:

- A file name pattern is configured directly in a rules project descriptor, in the `rules.xml` file, as the `properties-file-name-pattern` tag, or via OpenL Tablets WebStudio as **Properties pattern for a file name** in the **Project** page.
- The module file name matches the pattern.

  The file name pattern can include the following:
  - text symbols
  - table property names enclosed in '%' marks
  - wildcards, or characters that may be substituted for any of a defined subset of all possible characters

  For more information on wildcards that can be used in a pattern as regular expressions, see http://docs.oracle.com/javase/7/docs/api/java/util/regex/Pattern.html.

  If a table property value is supposed to be a date, the **Date** format must be specified right after the property name and colon as follows:

  `...<text>%<property name>%<text>%<property name>:<date format>%...`

  For more information on date formats description and examples, see http://docs.oracle.com/javase/7/docs/api/java/text/SimpleDateFormat.html.

File name pattern definition can use wildcards. For example, the `AUTO-%effectiveDate:MMddyyyy%-.*` pattern is defined. Then for the `AUTO-01012013-01012013.xls` file name, the module property **Effective date = 01 Jan 2013** is retrieved and the last part of the file name with the date is ignored as `.*` stands for any symbols.

In the following example, the **Auto Rating** project is configured in the way so that a user can specify the **US State** and **Effective date** properties values using the module file name:

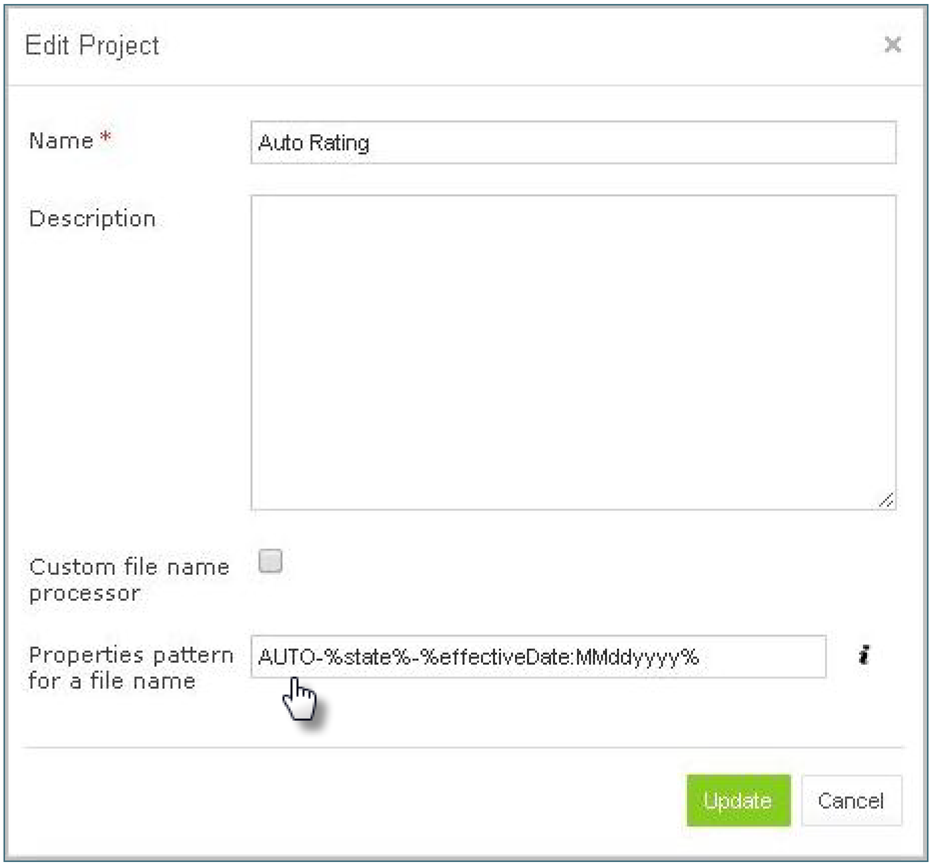


Figure 34: File name pattern configured via OpenL Tablets WebStudio

```
<properties-file-name-pattern>AUTO-%state%-%startRequestDate:MMddyyyy%</properties-file-name-pattern>
```

Figure 35: File name pattern in a rules project descriptor directly

For instance, for the **Auto Rating** project module with the file name `AUTO-FL-01012014.xlsx`, the module properties **US State= 'Florida'**, **Effective date = 01 Jan 2014** will be retrieved and inherited by module tables.

If a file name does not match the pattern, module properties are not defined.

To view detailed information about the properties added to the file name pattern, click information icon next to the **Properties pattern for a file name** field.

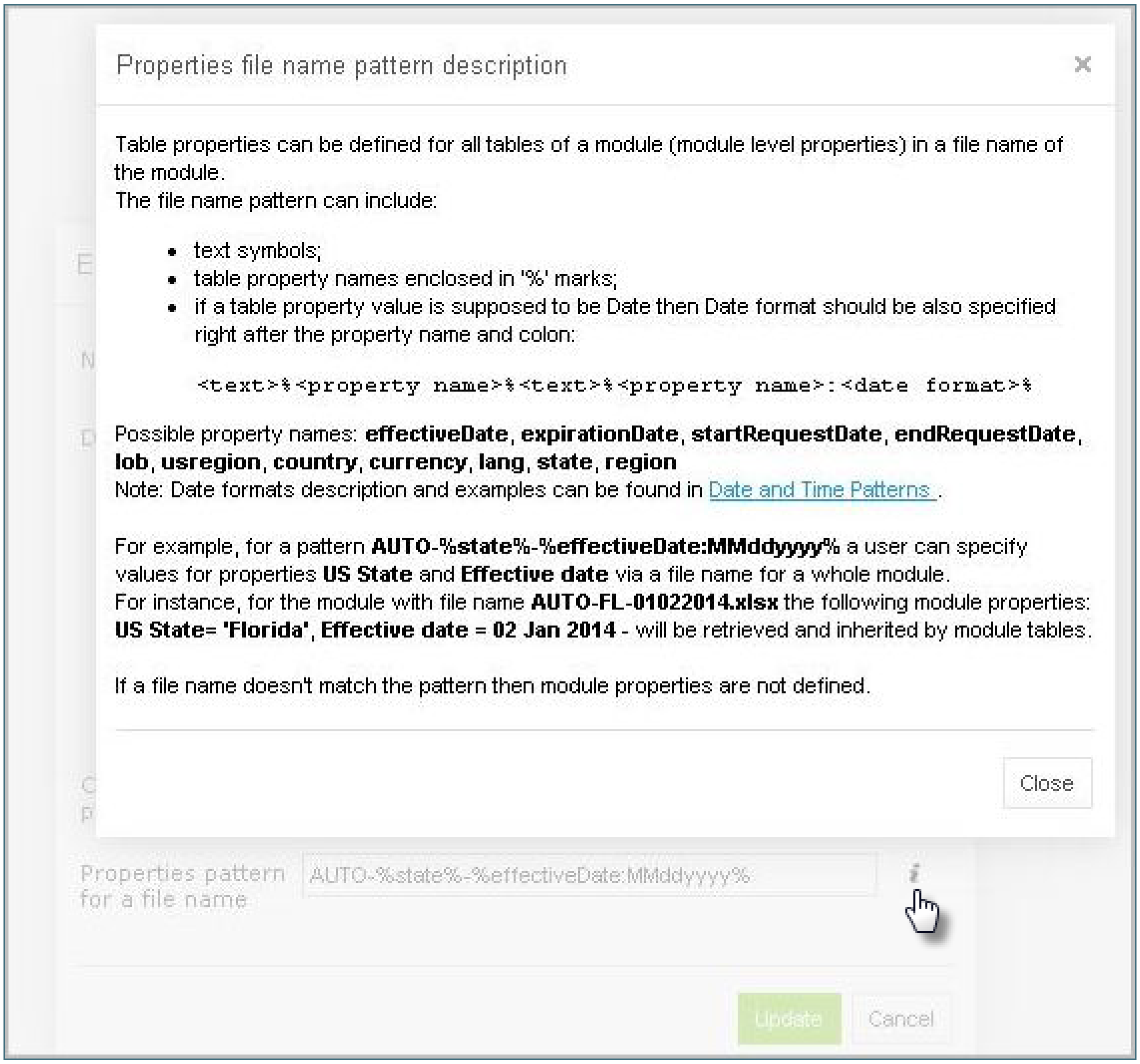


Figure 36: Properties file name pattern description

The same property cannot be defined both in a file name and **Properties** table of the module.

Note for experienced users: This section describes default implementation of properties definition in the file name. To use a custom implementation, specify the required file name processor class in a rules project descriptor. When the **Custom file name processor** check box is selected, the **File name processor class** field is displayed.

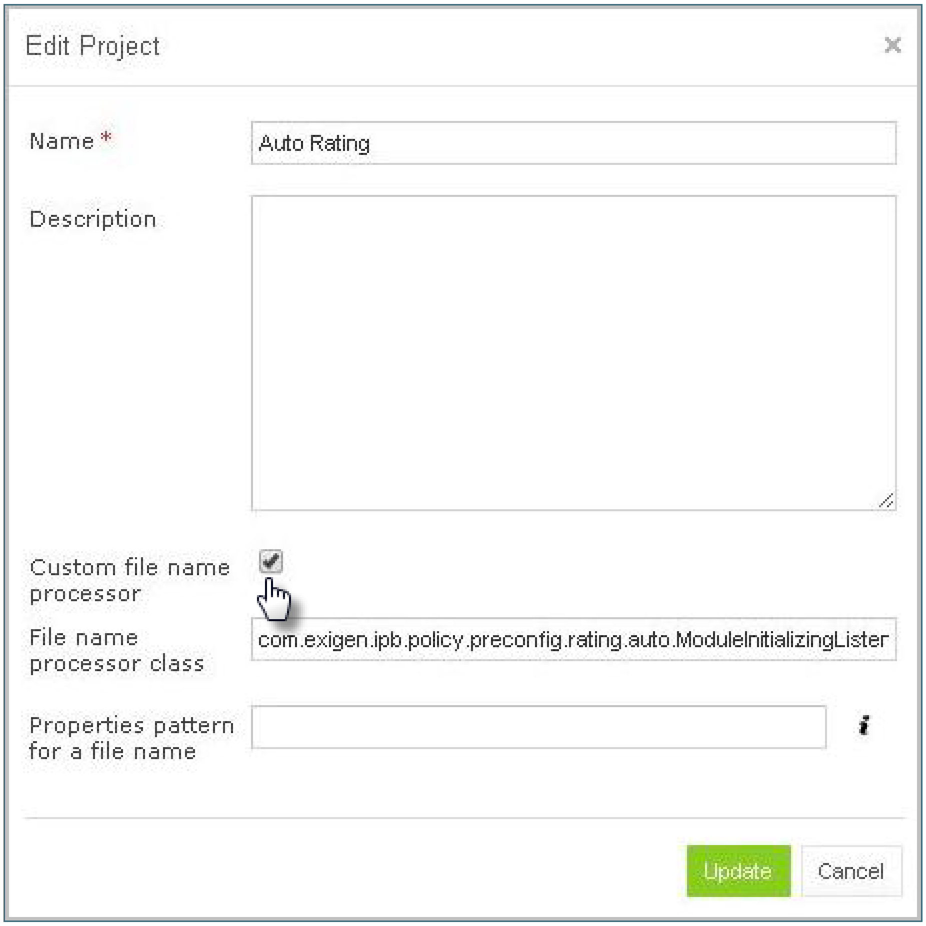


Figure 37: Custom file name processor class

Property State with the Countrywide Value Defined in the File Name

If the CW value, which stands for **country wide**, is set to the **Property State** in a file name, the rules of the corresponding module work for any state. Usually, only one value can be indicated in the file name, and listing all values in a filename is not available. This feature enables listing all values for property state in a file name by defining the **CW** value instead. It is useful when, for instance, there are particular files with rules for particular states, and a file with rules common for all states.

To enable the feature, the following conditions must be met:

- Define a file name processor class `org.openl.rules.project.resolving.CWPropertyFileNameProcessor.`
  A file name processor class is configured directly in a rules project descriptor, in the `rules.xml` file, as the `properties-file-name-processor` tag, or via OpenL Tablets WebStudio as **File name processor class** in the **Project** page.
- Define the **Properties** pattern for a file name as described in Properties Defined in the File Name.

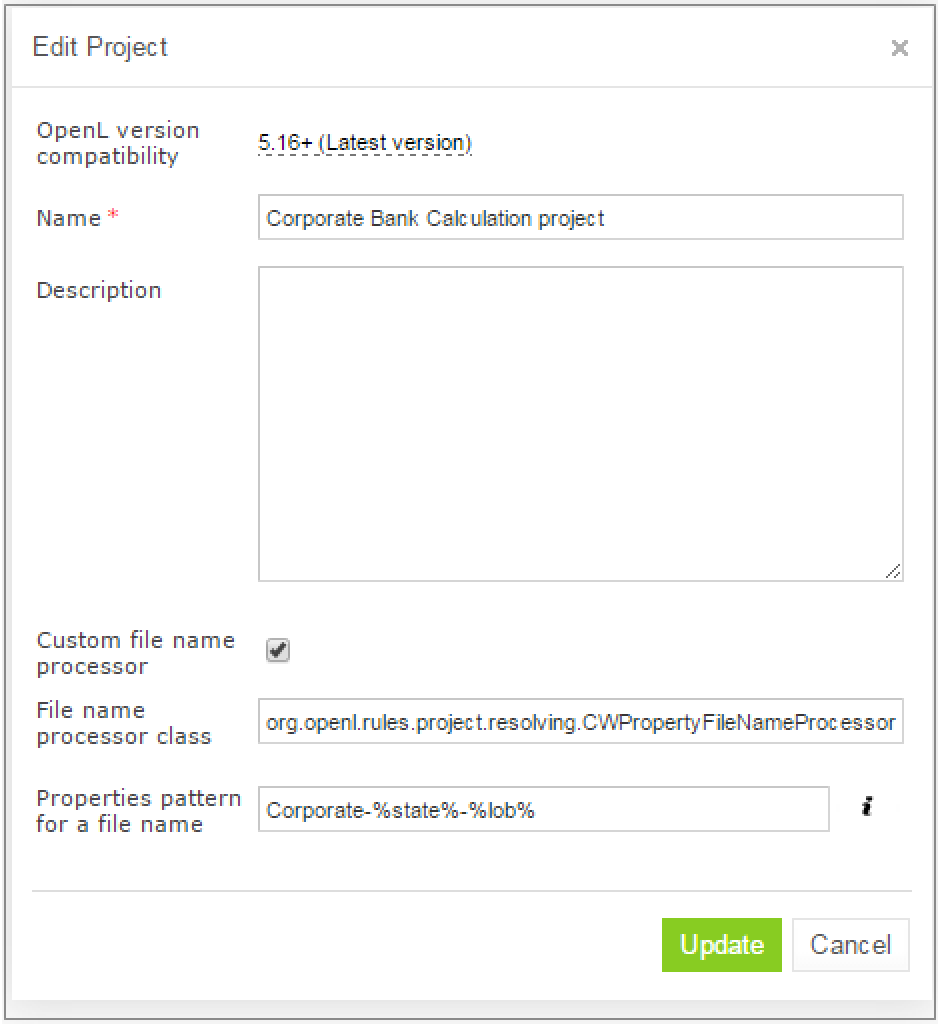


Figure 38: Enabling CW value for state property from file name feature via WebStudio

For instance, consider the **Corporate Bank Calculation** project configured as displayed in the previous figure. The project module with the `CORPORATE-CW-TEST.xlsx` file name has the following property values:

- US State is any state
- lob = test

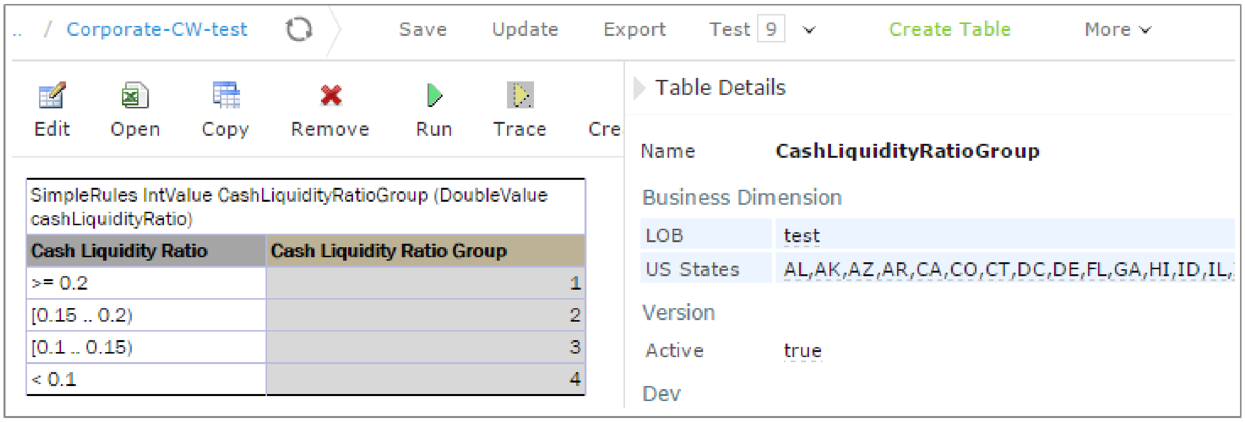


Figure 39: Decision table overloaded with all states

3.3 Table Types

OpenL Tablets supports the following table types:

- Decision Table
- Datatype Table
- Data Table
- Test Table
- Run Table
- Method Table
- Configuration Table
- Properties Table
- Spreadsheet Table
- Column Match Table
- TBasic Table
- Table Part

Decision Table

A **decision table** contains a set of rules describing decision situations where the state of a number of conditions determines execution of a set of actions and returned value. It is a basic table type used in OpenL Tablets decision making.

The following topics are included in this section:

- Decision Table Structure
- Rules Tables
- Lookup Tables
- Simple Decision Tables
- Decision Table Interpretation
- Local Parameters in Decision Table
- Transposed Decision Tables
- Representing Arrays
- Representing Date Values

- Representing Boolean Values
- Ranges Types in OpenL
- Using Calculations in Table Cells
- Using Referents from Return Column Cells

Decision Table Structure

An example of a decision table is as follows:

Rules String Hello (Integer hour)		
C1	C2	RET1
min <= hour	hour <= max	greeting
Integer min	Integer max	String greeting
From	To	Greeting
0	11	Good Morning
12	17	Good Afternoon
18	21	Good Evening
22	23	Good Night

Figure 40: Decision table

The following table describes its structure:

Decision table structure		
Row number	**Mandatory**	**Description**
1	Yes	Table header, which has the following pattern: `<keyword> <rule header>` where `<keyword>` is either 'Rules' or 'DT' and `<rule header>` is a signature of a method used to access the decision table and provide input parameters.
2 and 3	No	Rows containing table properties. Each application using OpenL Tablets rules can utilize properties for different purposes. Although the provided decision table example contains two property rows, there can be any number of property rows in a table, including no rows at all.

<table>
<tr><th colspan="3">Decision table structure</th></tr>
<tr><th>Row number</th><th>Mandatory</th><th>Description</th></tr>
<tr><td>4</td><td>Yes</td><td>Row consisting of the following cell types:
<table>
<tr><th>Type</th><th>Description</th><th>Examples</th></tr>
<tr><td>Condition column header</td><td>Identifies that the column contains a rule condition and its parameters. It must start with the “C” character followed by a number, or be “MC1” for the 1st column with merged rows.</td><td><code>C1, C5, C8</code>
<code>MC1</code></td></tr>
<tr><td>Horizontal condition column header</td><td>Identifies that the column contains a horizontal rule condition and its parameters. It must start with the “HC” character followed by a number.
Horizontal conditions are used in lookup tables only.</td><td><code>HC1, HC5, HC8</code></td></tr>
<tr><td>Action column header</td><td>Identifies that the column contains rule actions. It must start with the “A” character followed by a number.</td><td><code>A1, A2, A5</code></td></tr>
<tr><td>Return value column header</td><td>Identifies that the column contains values to be returned to the calling program. A table can have multiple return columns, however, only the first fired not blank value is returned.</td><td><code>RET1</code></td></tr>
</table>
All other cells in this row are ignored and can be used as comments.
If a table contains action columns, the engine executes actions for all rules with true conditions. If a table has a return column, the engine stops processing rules after the first executed rule. If a return column has a blank cell and the rule is executed, the engine does not stop and continues checking rules in the table.</td></tr>
</table>

<table>
<tr><th colspan="3">Decision table structure</th></tr>
<tr><th>Row number</th><th>Mandatory</th><th>Description</th></tr>
<tr><td>5</td><td>Yes</td><td>Row containing cells with expression statements for condition, action, and return value column headers. OpenL Tablets supports Java grammar enhanced with OpenL Tablets Business Expression (BEX) grammar features. For more information on the BEX language, see Appendix A: BEX Language Overview.
In most cases, OpenL Tablets Business Expression grammar covers all the variety of expression statements and an OpenL user does not need to learn Java syntax.
The code in these cells can use any Java objects and methods visible to the OpenL Tablets engine as elsewhere. For more information on enabling the OpenL Tablets engine to use custom Java packages, see Configuration Table.
Purpose of each cell in this row depends on the cell above is as follows:
<table>
<tr><th>Cell above</th><th>Purpose</th></tr>
<tr><td>Condition column header</td><td>Specifies the logical expression of the condition. It can reference parameters in the method header and parameters in cells below.
The cell can contain several expressions, but the last expression must return a Boolean value. All condition expressions must be true to execute a rule.</td></tr>
<tr><td>Horizontal condition</td><td>The same as Condition column header.</td></tr>
<tr><td>Action column header</td><td>Specifies expression to be executed if all conditions of the rule are true. The expression can reference parameters in the rule header and parameters in the cells below.</td></tr>
<tr><td>Return value column header</td><td>Specifies expression used for calculating the return value. The type of the last expression must match the return value specified in the rule header. The explicit return statement with the keyword “return” is also supported.
This cell can reference parameters in the rule header and parameters in the cells below.</td></tr>
</table></td></tr>
<tr><td>6</td><td>Yes</td><td>Row containing parameter definition cells. Each cell in this row specifies the type and name of parameters in the cells below it.
Parameter name must be one word corresponding to Java identification rules.
Parameter type must be one of the following:
• simple data types
• aggregated data types or Java classes visible to the engine
• one-dimensional arrays of the above types as described in Representing Arrays</td></tr>
<tr><td>7</td><td>Yes</td><td>Descriptive column titles. The rule engine does not use them in calculations but they are intended for business users working with the table. Cells in this row can contain any arbitrary text and be of any layout that does not correspond to other table parts. The height of the row is determined by the first cell in the row.</td></tr>
<tr><td>8 and below</td><td>Yes</td><td>Concrete parameter values. Any cell can contain expression instead of concrete value and calculate the value. This expression can reference parameters in the rule header and any parameters of condition columns.</td></tr>
</table>

A user can merge cells of parameter values to substitute multiple single cells when the same value needs to be defined in these single cells. During rule execution, OpenL Tables unmerges these cells.

The additional **Rule** column with merged cells is used as the first column when the return value must be a list of values written in multiple rows of the same column, that is, a vertically arranged array. The Rule column determines the height of the result value list.

Rules DoubleValue[] **DriverPremiums** (DriverType driverType, MaritalS			
Rule	C1	C2	RET1
	driverType	maritalStatus	
	DriverType		
Rule	**Driver Age**	**Marital Status**	**Driver Premiums**
R1	Young Driver	Married	$700
			$720
R2		Single	$300
			$300
	Senior Driver		$500
R3			$200
R4			$0

Figure 41: A table with the Rule column as the first column

Results of running DriverPremiums

ID	driverType	maritalStatus	Result
1	Young Driver	Married	Collection of DoubleValue 700 720

Figure 42: Result in the vertically arranged array format

Rules Tables

A **rules table** is a regular decision table with vertical conditions only, that is, Cn and MC1 columns.

By default, each row of the decision table is a separate rule. Even if some cells of condition columns are merged, OpenL Tablets treats them as unmerged. This is the most common scenario.

The MC1 column plays the role of the Rule column in a table. It determines the height of the result value list. An example is as follows.

Rules Double[] DeductibleList(String coverageName, String brand)		
MC1	C2	RET1
coverageName	brand	
String	String	
Coverage Name	**Brand Name**	**List of Deductibles**
Flood Coverage	Brand X	200
Earthquake Coverage	Brand Y	10000
		500
Earthquake Coverage	Brand X	0
Removal Coverage	Brand Z	100
		5000
		100

Figure 43: A Decision table with merged condition values

Earthquake Coverage for Brand Y and Brand X has a different list of values, so they are not merged although their first condition is the same.

Results of running DeductibleList

ID	coverageName	brand	Result
1	Removal Coverage	Brand Z	Collection of Double 100 5000 100

Figure 44: A list of values as a result

Lookup Tables

This section introduces lookup tables and includes the following topics:

- Understanding Lookup Tables
- Lookup Tables Implementation Details

Understanding Lookup Tables

A **lookup table** is a special modification of the decision table which simultaneously contains vertical and horizontal conditions and returns value on crossroads of matching condition values.

That means condition values can appear either on the left of the lookup table or on the top of it. The values on the left are called **vertical** and values on the top are called **horizontal**.

The horizontal conditions are marked as HC1, HC2 and so on. Every lookup matrix must start from the HC or RET column. The first HC or RET column must go after all vertical conditions, such as C, Rule, and comment columns. The RET section can be placed in any place of the lookup headers row. HC columns do not have the Titles section.

A lookup table must have the following components:

- at least one vertical condition C

- at least one horizontal condition HC
- exactly one return column RET

A lookup table can also have a rule column.

A lookup table cannot have a comment column in the horizontal conditions part.

Rules DoubleValue **CarPrice** (Car car, Address billingAddress)				
C1	C2	HC1	HC2	RET1
country	region	brand	model	
Country	String	CarBrand	String	
Country	**Region**	**BMW**		
		Z4 sDrive35i	**Z4 sDrive30i**	
USA	Pacific West	$51,650	$45,750	
USA	West	$52,000	$44,050	
USA	Mid Atlantic	$52,450	$46,550	
GreatBritain	England	$53,650	$47,750	
GreatBritain	Wales	$53,650	$47,750	
GreatBritain	Scotland	$53,650	$47,750	

Figure 45: A lookup table example

Colors identify how values are related to conditions. The same table represented as a decision table is as follows:

Rules DoubleValue **CarPrice** (Car car, Address billingAddress)				
C1	C2	C3	C4	RET1
country	region	brand	model	
Country	String	CarBrand	String	
Country	**Region**	**Brand**	**Model**	**Price**
USA	Pacific West	BMW	Z4 sDrive35i	$51,650
USA	West	BMW	Z4 sDrive35i	$52,000
USA	Mid Atlantic	BMW	Z4 sDrive35i	$52,450
GreatBritain	England	BMW	Z4 sDrive35i	$53,650
GreatBritain	Wales	BMW	Z4 sDrive35i	$53,650
GreatBritain	Scotland	BMW	Z4 sDrive35i	$53,650
USA	Pacific West	BMW	Z4 sDrive30i	$45,750
USA	West	BMW	Z4 sDrive30i	$44,050
USA	Mid Atlantic	BMW	Z4 sDrive30i	$46,550
GreatBritain	England	BMW	Z4 sDrive30i	$47,750
GreatBritain	Wales	BMW	Z4 sDrive30i	$47,750
GreatBritain	Scotland	BMW	Z4 sDrive30i	$47,750

Figure 46: Lookup table representation as a decision table

Lookup Tables Implementation Details

This section describes internal OpenL Tablets logic.

At first, the table goes through parsing and validation.

- On parsing, all parts of the table, such as header, columns headers, vertical conditions, horizontal conditions, return column, and their values, are extracted.
- On validation, OpenL checks if the table structure is proper.

Then OpenL Tablets transforms a lookup table into a regular decision table internally and processes it as a regular decision table.

Simple Decision Tables

Practice shows that most of decision tables have a simple structure: there are conditions for each input parameter of a decision table that check equality of input and condition values, and a return column. Because of this fact, OpenL Tablets have a simplified decision table representation. A simple decision table allows skipping condition and to return columns declarations, and thus the table consists of a header, column titles and condition and return values, and, optionally, properties. Restrictions for a simple decision table are as follows:

- Condition values must be of the same type or be an array or range of the same type as input parameters.
- Return values must have the type of the return type from the decision table header.

The following topics are included in this section:

- Simple Rules Table
- Simple Lookup Table
- Ranges and Arrays in Simple Decision Tables

Simple Rules Table

A regular decision table which has simple conditions for each parameter and simple return can be easily represented as a **simple rules table.**

The simple rules table header format is as follows:

```
SimpleRules <Return type> RuleName(<Parameter type 1> parameterName1, (<Parameter type 2>
parameterName 2….)
```

The following is an example of a simple rules table header:

SimpleRules InjuryRating VehicleInjuryRating (BodyType bodyType, AirbagType airbagType, Boolean hasRollBar)			
Body Type	**Airbags**	**Roll Bar**	**Injury Rating**
Convertible		No	Extremely High
	No		Extremely High
	Driver		High
	Driver&Passenger		Moderate
	Driver&Passenger&Side		Low

Figure 47: Simple rules table example

If a string value contains a comma, the value must be delimited with the backslash (\) separator forwarded by comma as for **Driver, Passenger, Side** in the following example. Otherwise, it is treated as an array of string elements as described in Ranges and Arrays in Simple Decision Tables.

SimpleRules String vehicleInjuryRating(Str	
Body Type	Airbags
Convertible	
	No
	Driver
	Driver \, Passenger
	Driver \, Passenger \, Side

Figure 48: Comma within a string value in a Simple Rule table

Simple Lookup Table

A lookup decision table with simple conditions that check equality of an input parameter and a condition value and a simple return can be easy represented as **simple lookup table**. This table is similar to simple rules table but has horizontal conditions. The number of parameters to be associated with horizontal conditions is determined by the height of the first column title cell.

The simple lookup table header format is as follows:

```
SimpleLookup <Return type> RuleName(<Parameter type 1> parameterName1, (<Parameter type 2>
parameterName2,….)
```

The following is an example of a simple lookup table.

SimpleLookup DoubleValue getCarPriceSimple(Country countryName, String regionName, CarBrand carBrand, String carModel)					
Country	Region	BMW	BMW	Porche	Porche
		Z4 sDrive35i	Z4 sDrive30i	911 Carrera 4S	911 Targa 4
USA	Pacific West	$51,650	$45,750	$93,200	$90,400
USA	West	$52,000	$44,050	$93,200	$90,400
USA	Mid Atlantic	$52,450	$46,550	$93,200	$90,400
GreatBritain	England	$53,650	$47,750	$94,200	$91,400
GreatBritain	Wales	$53,650	$47,750	$95,200	$92,400
GreatBritain	Scotland	$53,650	$47,750	$96,200	$93,400
Belarus	Minsk	$56,650	$49,750	$93,200	$90,400
Belarus	Vitebsk	$56,650	$49,750	$93,200	$90,400
Belarus	Grodna	$56,650	$49,750	$93,200	$90,400

Figure 49: Simple lookup table example

If a string value contains a comma, the value must be delimited with the backslash (\) separator forwarded by comma. Otherwise, it is treated as an array of string elements as described in [Ranges and Arrays in Simple Decision Tables.]

Ranges and Arrays in Simple Decision Tables

Range and array data types can be used in simple rules tables and simple lookup tables. If a condition is represented as an array or range, the rule is executed for any value from that array or range. As an example, in Figure 49 there is the same Car Price for all regions of Belarus and Great Britain, so, using an array, three rows for each of these countries can be replaced by a single one as displayed in the following table.

SimpleLookup DoubleValue getCarPriceSimpleArray1(Country countryName, String regionName, CarBrand carBrand, String carModel)					
Country	Region	BMW	BMW	Porche	Porche
		Z4 sDrive35i	Z4 sDrive30i	911 Carrera 4S	911 Targa 4
USA	Pacific West	$51,650	$45,750	$93,200	$90,400
USA	West	$52,000	$44,050	$93,200	$90,400
USA	Mid Atlantic	$52,450	$46,550	$93,200	$90,400
GreatBritain	England,Wales,Scotland	$53,650	$47,750	$94,200	$91,400
Belarus	Minsk,Vitebsk,Grodna	$56,650	$49,750	$93,200	$90,400

Figure 50: Simple lookup table with an array

If a string array element contains a comma, the element must be delimited with the backslash (\) separator forwarded by comma.

The following example explains how to use a range in a simple rules table.

SimpleRules RegionRisk **Region** (Integer vehicleZip)	
ZIP Code	**Region Risk Value**
10001 .. 10027	1
10598	2
21854	
22859	
23401	
23402 .. 23409	
24603	
24700	
24701	3
24800	
24803	4
25200	10
31200	12

Figure 51: Simple rules table with a Range

OpenL looks through the **Condition** column, that is, **ZIP Code**, meets a range, which is not necessary the first one, and defines that all the data in the column are IntRange, where Integer is defined in the header, **Integer vehicleZip.**

A range and array cannot be used in the same **Condition** column. Otherwise, OpenL issues an exception.

Decision Table Interpretation

Rules inside decision tables are processed one by one in the order they are placed in the table. A rule is executed only when all its conditions are true. If at least one condition returns false, all other conditions in the same row are ignored. Absence of a parameter in a condition cell is interpreted as a true value. Blank action and return value cells are ignored.

The following example contains empty case interpretation. For **Senior Driver**, the marital status of the driver does not matter. Although there is no combination of **Senior Driver** and **Single** mode, the result value is 500 as for an empty marital status value.

SimpleRules DoubleValue DriverPremium (DriverType driverType, MaritalStatus maritalStatus)		
Driver Age	**Marital Status**	**Driver Premium**
Young Driver	Married	$700
Young Driver	Single	$720
Young Driver	Married	$300
Young Driver	Single	$300
Senior Driver		$500
		$0

Results of running DriverPremium

ID	driverType	maritalStatus	Result
1	Senior Driver	Single	500

Figure 52: Empty case interpretation in the Decision table

Local Parameters in Decision Table

When declaring a decision table, the header must contain the following information:

- column type
- code snippet
- declarations of parameters
- titles

Recent experience shows that in 95% of cases, users put very simple logic in code snippet, such as just access to a field from input parameters. In this case, parameter declaration for a column is useless and can be skipped.

The following topics are included in this section:

- Simplified Declarations
- Performance Tips

Simplified Declarations

Case#1

The following image represents a situation when users must provide an expression and simple equal operation for condition declaration.

Rules String test4(boolean hadTraining)	
C1	RET1
hadTraining == localParam	eligibility
boolean localParam	String eligibility
Training	**Eligibility**
No	Not Eligible
	Eligible

Figure 53: Decision Table requiring an expression and simple equal operation for condition declaration

This code snippet can be simplified as displayed in the following example.

Rules String test4(boolean hadTraining)	
C1	RET1
hadTraining	eligibility
	String eligibility
Training	**Eligibility**
No	Not Eligible
	Eligible

Figure 54: Simplified Decision Table

OpenL Engine creates the required parameter automatically when a user omits parameter declaration with the following information:

1. The parameter name will be **P1**, where 1 is index of the parameter.
2. The type of the parameter will be the same as the expression type.
   In this example, it will be Boolean.

In the next step, OpenL Tablets will create an appropriate condition evaluator.

Case#2

The following image represents the situation when a user can omit the parameter name in declaration.

Rules String test2(String ageType)	
C1	RET1
P1.equals(ageType)	eligibility
String	String eligibility
Driver	**Eligibility**
Young Driver	Not Eligible
Senior Driver	Not Eligible
	Eligible

Figure 55: Decision Table where user can omit name in declaration

As mentioned in the previous case, the OpenL Tablets engine generates the parameter name and users can use it in the expression, but in this case, users must provide a local parameter type because the expression type differs from the parameter type.

Case#3

The following example illustrates the **Greeting** rule with the **min <= value and value < max** condition expression.

Rules String **Greeting** (Integer hour)		
C1		RET1
min <= hour and hour < max		greeting + ", World!"
Integer min	Integer max	String greeting
From	**To**	**Greeting**
0	12	Good Morning
12	18	Good Afternoon
18	22	Good Evening
22	24	Good Night

Figure 56: The Greeting rule

Instead of the full expression **min <= value and value < max**, a user can simply use **value** and OpenL Tablets automatically recognizes the full condition.

Rules String **Greeting** (Integer hour)		
C1		RET1
hour		greeting + ", World!"
Integer min	Integer max	String greeting
From	**To**	**Greeting**
0	12	Good Morning
12	18	Good Afternoon
18	22	Good Evening
22	24	Good Night

Figure 57: Simplified Greeting rule

Performance Tips

OpenL Tablets enables users to create and maintain tests to insure reliable work of all rules. A business analyst performs unit and integration tests by creating test tables and performance tests on rules through OpenL Tablets WebStudio. As a result, fully working rules are created and ready to be used.

To speed up rules execution, put simple conditions before more complicated ones.

In the following example, simple condition is located before a more complicated one.

Rules DoubleValue BankLimitIndex (Bank bank, String bankRatingGroup)		
C1	C2	
bankRatingGroup	(bankRatings[select first having ratingAgency == agency]!=null) && (contains(ratingArray, bankRatings[select first having ratingAgency == agency].rating))	
String[]	RatingAgency agency	String[] ratingArray
Bank Rating Group / Country, Financial Data	**Agency**	**Rating of Agency**
	Moody's Investors Service	Aaa, Aa1, Aa2, Aa3, A1, A2, A3, Baa1, Baa2, Baa3
	Fitch	AAA, AA+, AA, AA-, A+, A, A-, BBB+, BBB, BBB-
R1	Standard & Poor's	AAA, AA+, AA, AA-, A+, A, A-, BBB+, BBB, BBB-
	Moody's Investors Service	Ba1, Ba2, Ba3, B1, B2, B3
	Fitch	BB+, BB, BB-, B+, B, B-
R1, R2	Standard & Poor's	BB+, BB, BB-, B+, B, B-

Figure 58: Simple condition location

The main benefit of this approach is performance: expected results are found much faster.

Time for executing the OpenL Tablets rules heavily depends on complexity of condition expressions. To improve performance, use simple decision table types and simplified condition declarations.

Transposed Decision Tables

Sometimes decision tables look more convenient in the transposed format where columns become rows and rows become columns. For example, an initial and transposed version of decision table resembles the following:

Rules String Hello (Integer hour)			
Rule	C1	C2	RET1
	min <= hour	hour <= max	greeting
	Integer min	Integer max	String greeting
Rule	From	To	Greeting
R10	0	11	Good Morning
R20	12	17	Good Afternoon
R30	18	21	Good Evening
R40	22	23	Good Night

Rules String Hello (Integer hour)							
Rule			Rule	R10	R20	R30	R40
C1	min <= hour	Integer min	From	0	12	18	22
C2	hour <= max	Integer max	To	11	17	21	23
RET1	greeting	String greeting	Greeting	Good Morning	Good Afternoon	Good Evening	Good Night

Figure 59: Transposed decision table

OpenL Tablets automatically detects transposed tables and is able to process them correctly.

Representing Arrays

For all tables that have properties of the `enum[]` type or fields of the array type, arrays can be defined as follows:

- horizontally
- vertically
- as comma separated arrays

The first option is to arrange array values horizontally using multiple subcolumns. The following is an example of this approach:

String[] set				
Number Set				
1	3	5	7	9
2	4	6	8	

Figure 60: Arranging array values horizontally

In this example, the contents of the `set` variable for the first rule are `[1,3,5,7,9]`, and for the second rule, `[2,4,6,8]`. Values are read from left to right.

The second option is to present parameter values vertically as follows:

	String[] set
#	**Number Set**
1	1
	3
	5
	7
	9
2	2
	4
	6
	8

Figure 61: Arranging array values vertically

In the second case, the boundaries between rules are determined by the height of the leftmost cell. Therefore, an additional column must be added to the table to specify boundaries between arrays.

In both cases, empty cells are not added to the array.

The third option is to define an array by separating values by a comma. If the value itself contains a comma, it must be escaped using back slash symbol “\” by putting it before the comma.

Data Policy policyProfile4			
properties	category	Policy-Data	
name		**Policy**	Policy4
drivers	>driverProfiles3	**Drivers**	test1,test3\,4,test2
vehicles	>autoProfiles3	**Vehicles**	1965 VW Bug
clientTier		**Client Tier**	Elite
clientTerm		**Client Term**	Long Term

Figure 62: Array values separated by comma

In this example, the array consists of the following values:

- test 1
- test 3, 4
- test 2

Rules String hello2(String income1, String income2)		
C1	C2	R
array1	contains(array2, income2)	g
String[] array1	String[] array2	S
Array1	Array2	G
firstValue	value1, value2, value3	
secondValue		
value1	singleValue	
value2		
value3		

Figure 63: Array values separated by comma. The second example

In this example, the array consists of the following values:

- value1
- value2
- value3

Representing Date Values

To represent date values in table cells, either Excel format or the following format must be used for the text:

'<month>/<date>/<year>

The value must always be preceded with an apostrophe to indicate that it is text. Excel treats these values as plain text and does not convert to any specific date format.

The following are valid date value examples:

'5/7/1981

'10/20/2002

‘10/20/02

OpenL Tablets recognizes all Excel date formats.

Representing Boolean Values

OpenL Tablets supports either Excel Boolean format or the following formats of Boolean values as a text:

- true, yes, y
- false, no, n

OpenL Tablets recognizes the Excel Boolean value, such as native Excel Boolean value TRUE or FALSE. For more information on Excel Boolean values, see Excel help.

Range Types in OpenL

This section introduces data types used for ranges and describes how range types are used in decision tables. The following topics are included:

- Range Type Overview
- Using Range Types in Decision Tables

Range Type Overview

In OpenL, the following data types are designed to work with ranges:

- IntRange
- DoubleRange

For more information on these data types used for ranges, see Range Data Types.

Using Range Types in Decision Tables

This section describes how range types are used in decision tables. Consider the following example of the decision table.

SimpleRules DriverType DriverAgeType (Gender gender, Integer age)		
Gender	**Age**	**Driver Status**
Male	<25	Young Driver
Female	<20	Young Driver
	71+	Senior Driver
		Standard Driver

Figure 64: Decision table with IntRange

The column Age contains an expression statement of the IntRange type implicit. The cell may contain values of different types.

When using IntRange, the expression statement cell can be of the following types:

- Byte
- Short
- Int

Be careful with using `Integer.MAX_VALUE` in a decision table. If there is a range with `max_number` equal to `Integer.MAX_VALUE`, for example, `[100; 2147483647]`, it is not included to range. This is a known limitation.

When using DoubleRange, the code statement cell can be of the following types:

- Byte
- Short
- Integer
- Long
- Float
- Double

Using Calculations in Table Cells

OpenL Tablets can perform mathematical calculations involving method input parameters in table cells. For example, instead of returning a concrete number, a rule can return a result of a calculation involving one of the input parameters. The calculation result type must match the type of the cell. Text in cells containing calculations must start with an apostrophe followed by =. Excel treats such values as a plain text. Alternatively, OpenL Tablets code can be enclosed by `{ }`.

The following decision table demonstrates calculations in table cells.

SimpleRules Integer **AmPmTo24** (Integer ampmHr, String ampm)		
AM/PM hour	**AM or PM**	**24 hour**
12	AM	0
1-11	AM	=ampmHr
12	PM	12
1-11	PM	=ampmHr+12

Figure 65: Decision table with calculations

The table transforms a twelve hour time format into a twenty four hour time format. The column `RET1` contains two cells that perform calculations with the input parameter `ampmHr`.

Calculations use regular Java syntax, similar to the one used in conditions and actions.

Note: Excel formulas are not supported by OpenL Tablets. They are used as pre-calculated values.

Using Referents from Return Column Cells

When a condition value from a cell in the Return column must be called, specify the value by using `$C<n>` `<variable name>` in the **Return** column.

Rules String **RiskOfWorkWithCorporate** (String riskOfProfile, String riskOfOperations, String riskOfGeography)			
C1	C2	C3	RET1
riskOfProfile	riskOfOperations	riskOfGeography	
String profile	String operations	String geography	String
Risk of Prof	**Risk of Operatio**	**Risk of Geography**	**Total Risk**
LOW	LOW	LOW	LOW
LOW	LOW	MIDDLE	=$C1.profile
LOW	LOW	HIGH	LOW
LOW	MIDDLE	LOW	=$C2.operations
LOW	MIDDLE	MIDDLE	LOW

Figure 66: A Decision table with referents inside the Return column

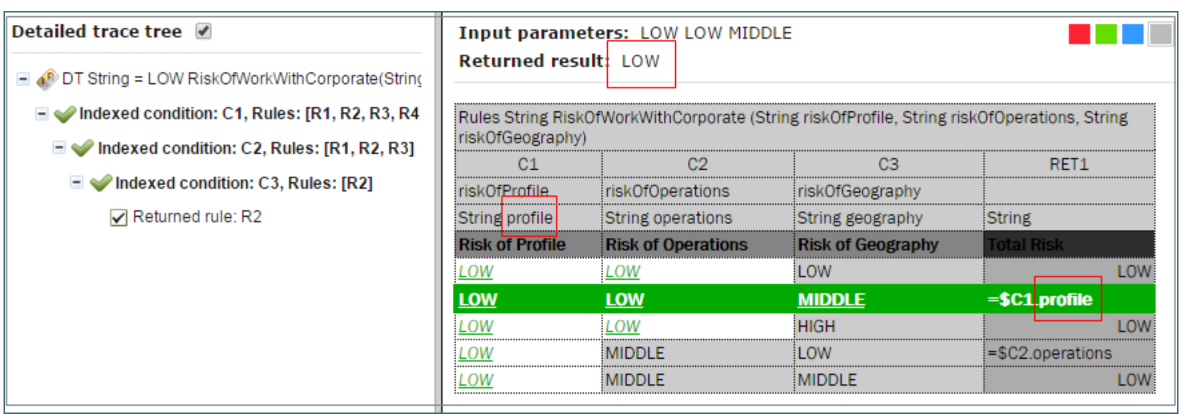


Figure 67: Tracing Decision table with referents

Datatype Table

This section describes datatype tables and includes the following topics:

Introducing Datatype Tables

A **Datatype table** defines an OpenL Tablets data structure. A Datatype table is used for the following purposes:

- create a hierarchical data structure combining multiple data elements and their associated datatypes in hierarchy
- define the default values
- create vocabulary for data elements

A data type defined by Datatype table is called a **custom data type**. Datatype tables enable users to create their own data model which is logically suited for usage in a particular business domain.

For more information on creating vocabulary for data elements, see Alias Data Types.

A Datatype table has the following structure:

1. The first row is the header containing the **Datatype** keyword followed by the name of the data type.
2. Every row, starting with the second one, represents one attribute of the data type.
   The first column contains attribute types, and the second column contains corresponding attribute names.
3. The third column is optional and defines default values for fields.

Consider the case when a hierarchical logical data structure must be created. The following example of a Datatype table defines a custom data type called **Person**. The table represents a structure of the **Person** data object and combines **Person's** data elements, such as name, social security number, date of birth, gender, and address.

Datatype Person	
String	name
String	ssn
Date	dob
Gender	gender
Address	address

Figure 68: Datatype table Person

Note that data attribute, or element, address of **Person** has, by-turn, custom datatype **Address** and consists of zip code, city and street attributes.

Datatype Address	
String	zipCode
String	city
String	street

Figure 69: Datatype table Address

The following example extends the **Person** data type with default values for specific fields.

Datatype Person		
String	name	
String	ssn	
Date	dob	
Gender	gender	Male
Address	address	

Figure 70: Datatype table with default values

The **Gender** field has the given value **Male** for all newly created instances if other value is not provided.

Note for experienced users: Java beans can be used as custom data types in OpenL Tablets. If a Java bean is used, the package where the Java bean is located must be imported using a configuration table as described in Configuration Table.

The following is an example of a Datatype table defining a custom data type called **Person**. The table represents a structure of the **Person** data object and combines **Person's** data elements, such as name, social security number, date of birth, gender, and address. If necessary, default values can be defined in the Datatype table for the fields of complex type when combination of fields exists with default values.

Datatype Corporate		
String	corporateID	
String	corporateFullName	
Industry	industry	other
Ownership	ownership	private
Integer	numberOfEmployees	1
FinancialData	financialData	_DEFAULT_
QualityIndicators	qualityIndicators	_DEFAULT_

*Figure 71: Datatype table containing value _DEFAULT_*

FinancialData refers to the FinancialData datatype for default values.

Datatype FinancialData		
Date	reportDate	01/01/2010
Double	cashAndEquivalents	0
Double	inventory	0
Double	currentAssets	0.0001
Double	currentLiabilities	0.0001
Double	equity	0
Double	revenue	0.0001
Double	operatingProfit	0
Double	monthlyCashTurnover	0
Double	monthlyAccountsTurnover	0

Figure 72: Datatype table with defined default values

During execution, the system takes default values from FinancialData datatype.

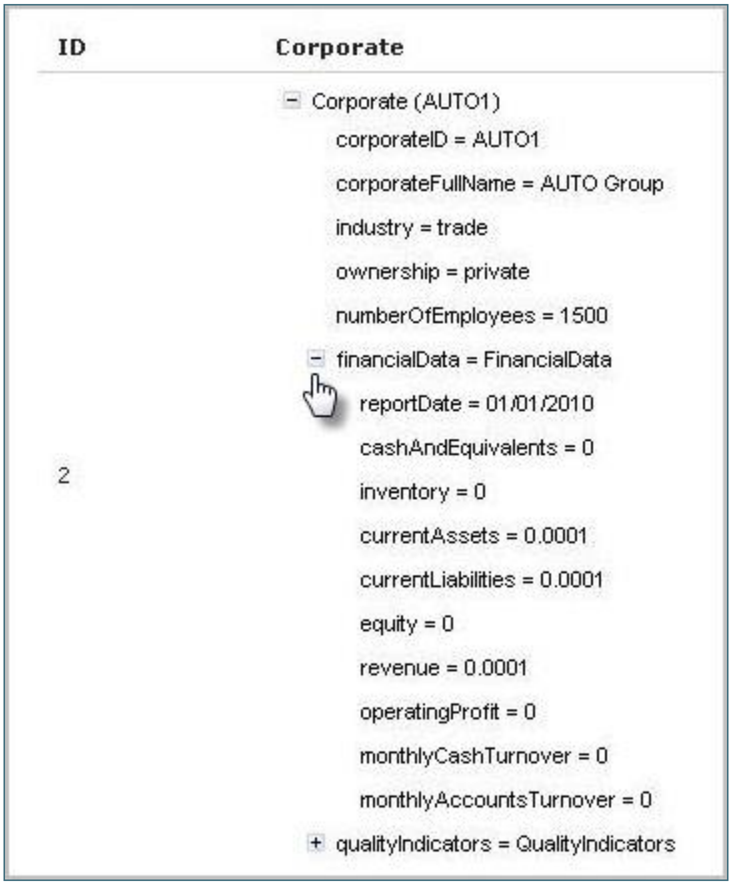


Figure 73: Datatype table with default values

Note: Referring to default values _DEFAULT_ is not possible for array types.

Inheritance in Data Types

In OpenL Tablets, one data type can be inherited from another one.

A new data type that inherits from another one contains all fields defined in the parent data type. If a child datatype defines fields that are already defined in the parent data type, warnings or errors, if the same field is declared with different types in the child and the parent data type, are displayed.

To specify inheritance, the following header format is used in the Datatype table:

```
Datatype <TypeName> extends <ParentTypeName>
```

Alias Data Types

Alias data types are used to define a list of possible values for a particular data type, that is, to create a vocabulary for data.

The alias datatype is created as follows:

1. The first row is the header.

   It starts with the **Datatype** keyword, followed by the alias datatype name. The predefined datatype is in angle brackets on the basis of which the alias datatype is created at the end.
2. The second and following rows list values of the alias datatype.

The values can be of the indicated predefined datatype only.

In the example described in Introducing Datatype Tables, the data type **Person** has an attribute **gender** of the **Gender** datatype which is the following alias data type.

Datatype Gender <String>
Male
Female

Figure 74: Example of Alias Datatype table with String parameters

Thus, data of Gender datatype can only be **Male** or **Female**.

OpenL Tablets checks all data of the alias datatype one whether its value is in the defined list of possible values. If the value is outside of the valid domain, or defined vocabulary, OpenL Tablets displays an appropriate error. Usage of alias datatypes provides data integrity and allows users to avoid accidental mistakes in rules.

Data Table

A **data table** contains relational data that can be referenced by its table name from other OpenL Tablets tables or Java code as an array of data.

Data tables are widely used during testing rules process when a user defines all input test data in data tables and reuses them in several test tables of a project by referencing the data table from test tables. As a result, different tests use the same data tables to define input parameter values, for example, to avoid duplicating data.

Data tables can contain data types supported by OpenL Tablets or types loaded in OpenL Tablets from other sources. For more information on data types, see Datatype Table and Working with Data Types.

The following topics are included in this section:

- Using Simple Data Tables
- Using Advanced Data Tables
- Specifying Data for Aggregated Objects
- Ensuring Data Integrity

Using Simple Data Tables

Simple data tables define a list of values of data types that have a simple structure.

1. The first row is the header of the following format:

   ```
   Data <data type> <data table name>
   ```

   where data type is a type of data the table contains, it can be any predefined or alias data type. For more information on predefined and alias data types, refer to Working with Data Types and Datatype Table.
2. The second row is a keyword **this**.
3. The third row is a descriptive table name intended for business users.
4. In the fourth and following rows, values of data are provided.

An example of a data table containing an array of numbers is as follows.

Data Integer **numbers**
this
Numbers
10
20
30
40
50

Figure 75: Simple data table

Using Advanced Data Tables

Advanced data tables are used for storing information of a complex structure, such as custom data types. For more information on data types, see Datatype Table.

1. The first row of an advanced data table contains text in the following format:
   `Data <data type> <data table name>`
2. Each cell in the second row contains an attribute name of the data type.
3. The third row contains attribute display names.
4. Each row starting from the fourth one contains values for specific data rows.

The following diagram displays a datatype table and a corresponding data table with concrete values below it.

Datatype Person	
String	name
String	ssn

Data Person p1	
name	ssn
Name	**SSN**
Jonh	555-55-0001
Paul	555-55-0002
Peter	555-55-0003
Mary	555-55-0004

Figure 76: Datatype table and a corresponding data table

There might be a situation when a user needs a Data table column with unique values, while other columns contain values that are not unique. In this case, add a column with the predefined _PK_ attribute name, standing for the primary key.

Data Person **person2**				
_PK_	name	dob	gender	maritalStatus
person ID	**Name**	**DOB**	**Gender**	**Marital Status**
1	Jonh	1/1/1980	Male	Single
2	Peter	5/7/1981	Male	Single
3	Peter	10/20/1982	Male	Single
4	Mary	7/7/1987	Female	Married

Figure 77: A Data table with unique _PK_ column

If the _PK_ column is not defined, the first column of the table is used as a primary key.

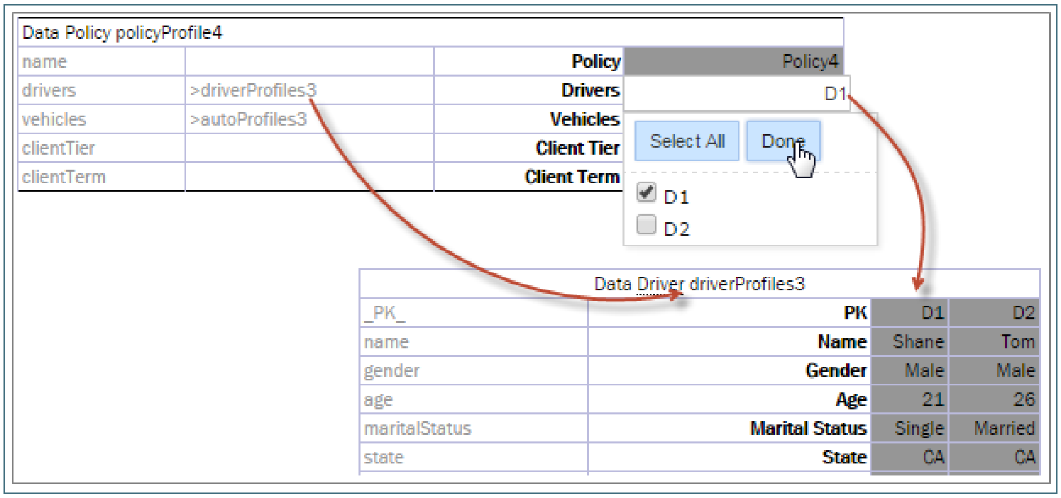


Figure 78: Referring from one Data table to another using a primary key

Specifying Data for Aggregated Objects

Assume that the data, which values are to be specified and stored in a data table, is an object of a complex structure with an attribute that is another complex object. The object that includes another object is called an **aggregated object.** To specify an attribute of an aggregated object in a data table, the following name chain format must be used in the row containing data table attribute names:

```
<attribute name of aggregated object>.<attribute name of object>
```

To illustrate this approach, assume there are two data types, `ZipCode` and `Address`, defined:

Datatype ZipCode	
String	zip1
String	zip2

Datatype Address	
String	street
String	city
ZipCode	zip

Figure 79: Complex data types defined by Datatype tables

In the data types structure, the `Address` data type contains a reference to the `ZipCode` data type as its attribute `zip`. An example of a data table that specifies values for both data types at the same time is as follows.

Data Address addresses			
street	city	zip.zip1	zip.zip2
Street1	**City**	**Zip1**	**Zip2**
1600 Pennsylvania Avenue	Washington	20500	
1085 Summit Dr	Beverly Hills	90210	2814

Figure 80: Specifying values for aggregated objects

In the preceding example, columns **Zip1** and **Zip2** contain values for the `ZipCode` data type referenced by the `Address` aggregated data type.

Note: The attribute name chain can be of any arbitrary depth, for example, `account.person.address.street`.

If a data table must store information for an array of objects, OpenL Tablets allows defining attribute values for each element of an array. The following format must be used in the row of data table attribute names:

```
<attribute name of aggregated object>[i].<attribute name of object>
```

where `i` – sequence number of an element, starts from 0.

The following example illustrates this approach.

Data Policy policies					
name	driver	vehicles[0].model	vehicles[0].price	vehicles[1].model	vehicles[1].price
Policy	**Driver**	**Vehicle Model**	**Vehicle Price**	**Vehicle Model**	**Vehicle Price**
Policy1	Sara	Honda Odyssey	$ 39,000	Ford C-Max	
Policy2	Shane	Toyota Camry	$ 12,000		
Policy3	Spencer	VW Bug	$ 1,500	Mazda 3	$ 40,000

Figure 81: Specifying values for an array of aggregated objects

The first policy, **Policy1,** contains two vehicles: **Honda Odyssey** and **Ford C-Max**; the second policy, **Policy2,** contains the only vehicle **Toyota Camry**; the third policy, **Policy3,** contains two vehicles: **VW Bug** and **Mazda 3**.

Note: The approach is valid for simple cases with an array of simple Datatype values, and for complex cases with a nested array of an array, for example, `policy.vehicles[0].coverages[2].limit`.

Note: All mentioned formats of specifying data for aggregated objects are applicable to the input values or expected result values definition in the Test and Run tables.

Ensuring Data Integrity

If a data table contains values defined in another data table, it is important to specify this relationship. The relationship between two data tables is defined using **foreign keys**, a concept that is used in database management systems. Reference to another data table must be specified in an additional row below the row where attribute names are entered. The following format must be used:

```
> <referenced data table name> <column name of the referenced data table>
```

In the following example, the **cities** data table contains values from the **states** table**.** To ensure that correct values are entered, a reference to the **code** column in the **states** table is defined.

Data City cities	
city	state
	>states code
City	State
Fairbanks	AK
Beverly Hills	CA

Data SupportedState states	
name	code
State/Possession	Abbreviation
ALABAMA	AL
ALASKA	AK
AMERICAN	AS
ARIZONA	AZ
ARKANSAS	AR
CALIFORNIA	CA
COLORADO	CO
CONNECTICUT	CT
DELAWARE	DE

Figure 82: Defining a reference to another data table

If an invalid state abbreviation is entered in the **cities** table**,** OpenL Tablets reports an error.

The target column definition is not required if it is the first column or _PK_ column in the referenced data table. For example, if a reference is made to the **name** column in the **states** table**,** the following simplified reference can be used:

```
>states
```

If a data table contains values defined as a part of another data table, the following format can be used:

```
> <referenced data table name>.<attribute name> <column name>
```

The difference from the previous format is that an attribute name of the referenced data table, which corresponding values are included in the other data table, is specified additionally.

If <column name> is omitted, the reference by default is constructed using the first column or _PK_ column of the referenced data table.

In the following diagram, the **claims** data table contains values defined in the **policies** table and related to the **vehicle** attribute. A reference to the **name** column of the **policies** table is omitted as this is the first column in the table.

Data Policy policies				
name	driver	vehicle.model	vehicle.year	vehicle.price
Policy	Driver	Vehicle Model	Vehicle Year	Vehicle Price
Policy1	Sara	Honda Odyssey	2005	$39,000
Policy2	Shane	Toyota Camry	2002	$12,000
Policy3	Spencer	VW Bug	1965	$1,500

Data Claim claims				
id	lossDate	vehicle	damage	payment
		>policies.vehicle		
Policy	Date of Loss	Vehicle of Policy	Damage Description	Payment
Claim1	02 July 2012	Policy2	broken side window	$350
Claim2	14 March 2013	Policy3	damaged bumper	$200

Figure 83: Defining a reference to another data table

Note: To ensure that correct values are provided, cell data validation lists can be used in Excel, thus limiting the range of values that can be entered.

Note: The same syntax of data integration is applicable to the input values or expected result values definition in the Test and Run tables.

Note: The attribute path can be of any arbitrary depth, for example, `>policies.coverage.limit`.

Test Table

A **test table** is used to perform unit and integration tests on executable rule tables, such as decision tables, spreadsheet tables, and method tables. It calls a particular table, provides test input values, and checks whether the returned value matches the expected value.

For example, in the following diagram, the table on the left is a decision table but the table on the right is a unit test table that tests data of the decision table.

Rules DoubleValue RiskFactor3 (Date MyDate)		
C1	RET1	
dayOfWeek(MyDate)		
IntRange		
Day of Week	Risk Factor (%)	Comments
[2 .. 5]	75%	Monday-to-Wednesday
6	85%	Friday RF
	100%	Week-end RF

Test RiskFactor3 RiskFactor3Test	
MyDate	_res_
Date	Result
12/21/2012	0.85
12/22/2012	1.0
12/19/2012	0.75

Figure 84: Decision table and its unit test table

A test table has the following structure:

1. The first row is the table header, which has the following format:
   `Test <rule table name> <test table name>`
   Test is a keyword that identifies a test table. The second parameter is the name of the rule table to be tested. The third parameter is the name of the test table.
2. The second row provides a separate cell for each input parameter of the rule table followed by the **_res_** column, which typically contains the expected test result values.
3. The third row contains display values intended for business users.
4. Starting with the fourth row, each row is an individual test case.

For more information on how to specify values of input parameters and expected test results of complex constructions, see Specifying Data for Aggregated Objects and Ensuring Data Integrity.

Note for experienced users: Test tables can be used to execute any Java method. In this case, a method table must be used as a proxy.

When a test table is called, the OpenL Tablets engine calls the specified rule table for every row in the test table and passes the corresponding input parameters to it.

Application runtime context values are defined in the runtime environment. Test tables for a table, overloaded by business dimension properties, must provide values for the runtime context significant for the tested table. Runtime context values are accessed in the test table through the **_context_** prefix. An example of a test table with the context value Lob follows:

Test driverAgeType driverAgeTypeTest		
driver	_context_.lob	_res_
>testDrivers1		
Driver	**Lob**	**Expected Age Type**
Sara	Home	Standard Driver
Spencer, Sara's Son	Home	Old Driver
Sara	Auto	High Risk Driver
Spencer, Sara's Son	Auto	Young Driver

Figure 85: An example of a test table with a context value

For a full list of runtime context variables available, their description, and related Business Dimension versioning properties, see Context Variables Available in Test Tables.

The **_description_** column can be used for entering useful information.

The **_error_** column of the test table can be used for a test algorithm where the **error** function is used. The OpenL Tablets Engine compares an error message to the value of the **_error_** column to decide if test is passed.

Test driverRiskScoreTest driverRiskTest		
driverRisk	_res_	_error_
Driver Risk	Expected Risk	Expected Error
High Risk Driver	100	
		My Exception

Figure 86: An example of a test table with an expected error column

If OpenL Tablets projects are accessed and modified through OpenL Tablets WebStudio, UI provides convenient utilities for running tests and viewing test results. For more information on using OpenL Tablets WebStudio, see ***[OpenL Tablets WebStudio User Guide]***.

The following topics are included in this section:

- Context Variables Available in Test Tables
- Testing Spreadsheet Result

Context Variables Available in Test Tables

The following runtime context variables are used in OpenL Tablets and their values can be specified in OpenL test tables using syntax `_context_.<context name>` in a column header:

Context variables of OpenL Tablets					
Context	**Context name used in rule tables**	**Type**	**Related versioning properties**	**Property names used in rule tables**	**Description**
Current Date	currentDate	Date	Effective / Expiration dates	effectiveDate, expirationDate	Date on which the rule is performed.
Request Date	requestDate	Date	Start / End Request dates	startRequestDate, endRequestDate	Date when the rule is applied.
Line of Business	lob	String	LOB (Line of Business)	lob	Line of business for which the rule is applied.
US State	usState	Enum	US States	state	US state where the rule is applied.
Country	country	Enum	Countries	country	Country where the rule is applied.

Context variables of OpenL Tablets					
Context	**Context name used in rule tables**	**Type**	**Related versioning properties**	**Property names used in rule tables**	**Description**
US Region	usRegion	Enum	US Region	usregion	US region where the rule is applied.
Currency	currency	Enum	Currency	currency	Currency with which the rule is applied.
Language	lang	Enum	Language	lang	Language in which the rule is applied.
Region	region	Enum	Region	region	Economic region where the rule is applied.
Canada Province	caProvince	Enum	Canada Province	caProvinces	Canada province of operation where the rule is applied.
Canada Region	caRegion	Enum	Canada Region	caRegions	Canada region of operation where the rule is applied.

For more information on how property values relate to runtime context values and what rule table is executed, see Business Dimension Properties.

Testing Spreadsheet Result

Cells of a spreadsheet result, which is returned by the rule table, can be tested as displayed in the following spreadsheet table.

Spreadsheet SpreadsheetResult test (String coverageId, int coveredProperty, double koef)				
Step	**Code**	**Formula**	**Value**	**Text : String**
Coverage_Id	COVERAGE_ID			= coverageId
Covered_Property	COVERED_PROPERTY_COVERAGE	= $Value	= coveredProperty + 1	
Final_Premium	FINAL_PREMIUM	= $Value	= koef * $Formula$Covered_Property	

Figure 87: A sample spreadsheet table

For testing purposes, a standard test table is used. Cells of the spreadsheet are accessed using the `_res_.$<column name>$<row name>` expression.

Testmethod test TestSpr				
coverageId	coveredProperty	koef	_res_.$Formula$Final_Premium	_res_.$Text$Coverage_Id
Income Coverage Id	Income Covered Property	Income Koefficient	Result of Final Premium	Result of Coverage Id
myTestCoverage	4	1,23	6,15	myTestCoverage

Figure 88: Test for the sample spreadsheet table

Columns marked with the green color determine income values, and columns marked with lilac determine the expected values for a specific number of cells. It is possible to test as many cells as needed.

The result of running this test in OpenL Tablets WebStudio is provided in the following output table.

TestSprTestAll

Input Parameters			Result				
Coverage Id	coveredPropertyfff		Step	Code	Formula	Value	Text : String
myTestCoverage	4	1.23	Coverage_Id	COVERAGE_ID			myTestCoverage; myTestCoverage
			Covered_Property	COVERED_PROPERTY_COVERAGE	5.0	5.0	
			Final_Premium	FINAL_PREMIUM	6.15; 6.15	6.15	

Figure 89: The sample spreadsheet test results

If the Custom Spreadsheet Result feature is activated, it is even possible to test cells of the resulting spreadsheet which contain values of complex types, such as:

- array of values
- custom data type with several attributes
- another spreadsheets nested in the current one

For this purpose, the same syntax described in Specifying Data for Aggregated Objects can be used, namely:

```
_res_.$<column name>$<row name>[i]
_res_.$<column name>$<row name>.<attribute name>
_res_.$<column of Main Spreadsheet>$<row of Main Spreadsheet>.$<column of Nested
     Spreadsheet>$<row of Nested Spreadsheet>
_res_.$<column of Main Spreadsheet>$<row of Main Spreadsheet>[i].$<column of Nested
Spreadsheet>$<row of Nested Spreadsheet>
```

where `i` – sequence number of an element, starts from 0.

Consider an advanced example provided in the following figure. The **PolicyCalculation** spreadsheet table performs lots of calculations regarding an insurance policy, including specific calculations for vehicles and a main driver of the policy. In order to evaluate vehicle and drivers, for example, calculate their score and premium, the **VehicleCalculation** and **DriverCalculation** spreadsheet tables are invoked in cells of the PolicyCalculation rule table.

Spreadsheet SpreadsheetResult PolicyCalculation (Policy policy)	
	Value
Vehicles : SpreadsheetResult[]	= VehicleCalculation (vehicles)
MainDriver : SpreadsheetResult	= DriverCalculation (drivers[0])
Score	= sum(GetScore($Vehicles)) + GetScore($MainDriver) + ClientTierScore(clientTier)
Eligibility : EligibilityType	= PolicyEligibility (clientTerm, $Score)
Premium	= sum(GetPremium($Vehicles)) + GetPremium($MainDriver) - ClientDiscount (clientTier)

Figure 90: Example of the PolicyCalculation spreadsheet table

Spreadsheet SpreadsheetResult VehicleCalculation (Vehicle vehicle)	
	Value
Age : Integer	= CurrentYear() - year
TheftRating : TheftRating	= VehicleTheftRating (bodyType, price, onHighTheftProbabilityList)
InjuryRating : InjuryRating	= VehicleInjuryRating (bodyType, airbagType, hasRollBar)

Figure 91: Example of the VehicleCalculation spreadsheet table

Spreadsheet SpreadsheetResult DriverCalculation (Driver driver)	
	Value
DriverType : DriverType	= DriverAgeType (gender, age)
Eligibility : EligibilityType	= DriverEligibility ($DriverType, hadTraining)
DriverRisk : DriverRisk	= DriverRisk (numDUI, numAccidents, numMovingViolations)
Score	= DriverTypeScore ($DriverType, $Eligibility) + DriverRiskScore ($DriverRisk)
Premium	= DriverPremium ($DriverType, maritalStatus, state)+ DriverRiskPremium ($DriverRisk) + AccidentPremium () * numAccidents

Figure 92: The advanced sample spreadsheet table

The structure of the resulting **PolicyCalculation** spreadsheet is rather complex. Any cell of the result can be tested as illustrated in the **PolicyCalculationTest** test table.

Test PolicyCalculation PolicyCalculationTest			
policy	_res_.$Value$Premium	_res_.$Value$MainDriver.$Value$Score	_res_.$Value$Vehicles[0].$Value$Age
> testPolicy1			
Policy	**Expected Premium**	**Expected Driver Score**	**Expected Vehicle 1 Age**
Policy1	827.5	0	9
Policy2	2550	130	49

Figure 93: Test for the advanced sample spreadsheet table

Run Table

A **run table** calls a particular rule table multiple times and provides input values for each individual call. Therefore, run tables are similar to test tables, except they do not perform a check of values returned by the called method.

Note for experienced users: Run tables can be used to execute any Java method.

An example of a run method table is as follows.

Run append appendRun	
firstWord	secondWord
First Word	**Second Word**
Hi,	John!
Hello,	Mary!
Good morning,	Bob!

Figure 94: Run table

This example assumes there is a rule `append` defined with two input parameters, `firstWord` and `secondWord`. The run table calls this rule three times with three different sets of input values.

A run table has the following structure:

1. The first row is a table header, which has the following format:
   `Run <name of rule table to call> <run table name>`
2. The second row contains cells with rule input parameter names.
3. The third row contains display values intended for business users.
4. Starting with the fourth row, each row is a set of input parameters to be passed to the called rule table.

For more information on how to specify values of input parameters which have complex constructions, see Specifying Data for Aggregated Objects and Ensuring Data Integrity.

Method Table

A **method table** is a Java method described within a table. An example of a method table is as follows:

Method String getGreeting(String name)
return "Hi, "+name;

Figure 95: Method table

The first row is a table header, which has the following format:

```
<keyword> <return type> <table name> (<input parameters>)
```

where <keyword> is either **Method** or **Code**.

The second row and the following rows are the actual code to be executed. They can reference parameters passed to the method and all Java objects and tables visible to the OpenL Tablets engine. This table type is intended for users experienced in programming in developing rules of any logic and complexity.

Configuration Table

OpenL Tablets allows externalizing business logic into Excel files, or modules. There are cases when rule tables of one module need to call rule tables placed in another module. A **configuration table** is used to indicate module dependency.

Another common purpose of a configuration table is when OpenL Tablets rules need to use objects and methods defined in the Java environment. To enable use of Java objects and methods in Excel tables, the module must have a configuration table. A **configuration table** provides information to the OpenL Tablets engine about available Java packages.

A configuration table is identified by the keyword **Environment** in the first row. No additional parameters are required. Starting with the second row, a configuration table must have two columns. The first column contains commands and the second column contains input strings for commands.

The following commands are supported in configuration tables:

Configuration table commands	
Command	**Description**
dependency	Adds a dependency module by its name. All data from this module becomes accessible in the current module. A dependency module can be located in the current project or its dependency projects.
import	Imports the specified Java package so that its objects and methods can be used in tables.
include	Includes another Excel file so that its tables and data can be referenced in tables of the current file.
language	Provides language import functionality.
extension	Expands OpenL Tablets capabilities with external set of rules. After adding, external rules are complied with OpenL Tablets rules and work jointly.
vocabulary	Allows using user created dynamic classes in OpenL Tablets.

An example of a configuration table is as follows.

Environment	
dependency	Rating Common
	Rating Domain Model
import	org.apache.commons.lang

Figure 96: Configuration table

Properties Table

A **properties** table is used to define the module and category level properties inherited by tables. The properties table has the following structure:

Properties table elements

Element	Description
Properties	Reserved word that defines the type of the table. It can be followed by a Java identifier. In this case, the properties table value becomes accessible in rules as a field of such name and of the **TableProperties** type.
scope	Identifies levels on which the property inheritance is defined. Available values are as follows:

Scope level	Description
Module	Identifies properties defined for the whole module and inherited by all tables in it. There can be only one table with the **Module** scope in one module.

Properties property_test1	
scope	**Module**
effectiveDate	4/7/10
expirationDate	4/28/11
lang	EN
currency	USD
state	CA

Figure 97: A properties table with the Module level scope

Scope level	Description
Category	Identifies properties applied to all tables where the category name equals the name specified in the **category** element.

Properties property_test2	
scope	**Category**
category	**Testing**
country	CA,CH,DE,FR
lob	Home
lang	GER
currency	CAD

Figure 98: A properties table with the Category level scope

Element	Description
category	Defines the category if the **scope** element is set to **Category.** If no value is specified, the category name is retrieved from the sheet name.
Module	Identifies that properties can be overridden and inherited on the module level.

Spreadsheet Table

In OpenL Tablets, a **spreadsheet** table is an analogue of the Excel table with rows, columns, formulas, and calculations as contents. Spreadsheets can also call decision tables or other executable tables to make decisions on values, and based on those, make calculations.

The format of the spreadsheet table header is as follows:

```
Spreadsheet SpreadsheetResult <table name> (<input parameters>)
```

or

```
Spreadsheet <return type> <table name> (<input parameters>)
```

The following table describes the spreadsheet table header syntax:

Spreadsheet table header syntax	
Element	**Description**
Spreadsheet	Reserved word that defines the type of the table.
SpreadsheetResult	Type of the return value. SpreadsheetResult returns the calculated content of the whole table.
<return type>	Data type of the returned value. If only a single value is required, its type must be defined here as a return datatype and calculated in the row or column named **RETURN.**
<table name>	Valid name of the table as for any executable table.
<input parameters>	Input parameters as for any executable table.

The first column and row of a spreadsheet table, after the header, make the table column and row names. Values in other cells are the table values. An example is as follows.

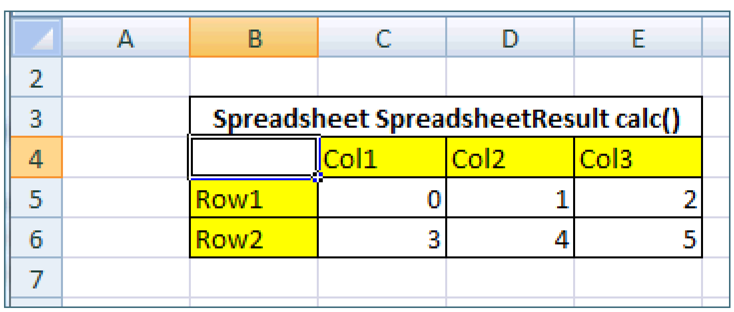


Figure 99: Spreadsheet table organization

A spreadsheet table cell can contain:

- simple values, such as a string or numeric values
- values of other data types

  In this case, the datatype must be defined explicitly, that is, for numeric cell value or cell formula, it must be DoubleValue, and for text, it must be String. The data type for a whole row or column of the cell can be specified using the following syntax:

  ```
  <column name or row name> : <data type>
  ```

Note: If both column and row of the cell have a data type specified, the data type of the column is taken.

- formulas that start with an apostrophe followed by = or, alternatively, are enclosed by { }
- another cell value or a range of another cell values referenced in a cell formula

  The following table describes how a cell value can be referenced in a spreadsheet table.

Referencing another cell		
Cell name	**Reference**	**Description**
`$columnName`	By column name.	Used to refer to the value of another column in the same row.
`$rowName`	By row name.	Used to refer to the value of another row in the same column.
`$columnName$rowName`	Full reference.	Used to refer to the value of another row and column.

For more information on how to specify range of cells, see Using Ranges in Spreadsheet Table. Below is an example of a spreadsheet table with different calculations for an auto insurance policy. Table cells contain simple values, formulas, references to the value of another cell, and other information.

Spreadsheet SpreadsheetResult VehicleCalculation (Vehicle vehicle)	
	Value
Vehicle : Vehicle	= vehicle
Age	= CurrentYear() - year
BasePremium	= BasePremium (carType)
VehicleDiscount	= VehicleDiscount (airbagType, hasAlarm)
PreliminaryPremium	= $BasePremium * (1 - $VehicleDiscount)
MinPremium	180
FinalPremium	= max ($PreliminaryPremium, $MinPremium)

Figure 100: Spreadsheet table with calculations as content

The following topics are included in this section:

- Parsing a Spreadsheet Table
- Accessing Spreadsheet Result Cells
- Using Ranges in Spreadsheet Table
- Custom Spreadsheet Result

Parsing a Spreadsheet Table

OpenL Tablets processes spreadsheet tables in two different ways depending on the return type:

1. A spreadsheet returns the **SpreadsheetResult** datatype.
2. A spreadsheet returns any other datatype different from **SpreadsheetResult**.

In the first case, users get the SpreadsheetResult type that is an analog of result matrix. All calculated cells of the spreadsheet table are accessible through this result. The following example displays a spreadsheet table of this type.

Spreadsheet SpreadsheetResult processDriver(Driver driver)	
	Value
Driver:Driver	{driver}
Age Type:String	{driverAgeType($Driver)}
Eligibility:String	{driverEligibility($Driver, $Age Type)}
Driver Risk:String	{driverRisk($Driver)}
Score	{driverTypeScore($Age Type, $Eligibility) + driverRiskScore($Driver Risk)}
Premium	{driverPremium($Driver, $Age Type) + driverRiskPremium($Driver Risk) + driverAccidentPremium($Driver, $Driver Risk)}

Figure 101: Spreadsheet table returns the SpreadsheetResult datatype

In the second case, the returned result is a datatype as in all other rule tables, so there is no need for **SpreadsheetResult** in the rule table header. The cell with the RETURN key word for a row will be returned. OpenL Tablets calculates the cells required just for that result calculation. In the following example, the **License_Points** cell is not included in the **Tier Factor** calculation and can simply be skipped:

Spreadsheet DoubleValue **TierFactor** (Policy policy)		
Step	**Formula**	**Value**
Credit_Rating_Points	=CreditRatingPoints (creditRating)	
Violations_Points	= ViolationPoints (drivers)	
License_Points	= sum (LicensedYearsPoints (drivers, policyEffectiveDate))	
Total_Points	= sum ($Credit_Rating_Points:$Violatione_Points)	
Tier_Factor	= tierFactor = mapTierPointsToFactor ($Total_Points)	
RETURN	**= $Tier_Factor**	

Figure 102: Spreadsheet table returning a single value

Accessing Spreadsheet Result Cells

A value of the SpreadsheetResult type means that this is actually a table, or matrix, of values which can be of different types. A cell is defined by its table column and row. Therefore, a value of particular spreadsheet cell can be accessed by cell's column and row names and indicating its datatype as follows:

```
(<data type>) <spreadsheet result variable>.$<column name>$<row name>
```

The following example demonstrates how to get a value of the **FinancialRatingCalculation** spreadsheet result that is calculated in the **Value** column and **FinancialRating** row of the spreadsheet.

Spreadsheet SpreadsheetResult CorporateRatingCalculation (Corporate corporate)		
properties	description	Corporate Rating is the level of company's creditworthiness (Financial Rating) corrected by the level of Risk of Work with it.
Step		**Value**
CheckCurrentFinancialData : void		= SetNonZeroValues(financialData)
FinancialRatingCalculation : SpreadsheetResult		= FinancialRatingCalculation(financialData, industry)
FinancialRating		= (DoubleValue) $FinancialRatingCalculation.$Value$FinancialRating
RiskOfProfile : String		= RiskOfProfile (corporate)
RiskOfOperations : String		= RiskOfOperations (qualityIndicators)
RiskOfGeography : String		= RiskOfGeography (qualityIndicators)

Figure 103: Accessing Spreadsheet Result cell value

The spreadsheet cell can also be accessed using the `getFieldValue(String <cell name>)` function, for instance, `(DoubleValue) $FinancialRatingCalculation.getFieldValue ("$Value$FinancialRating")`. This is a more complicated option.

Note: If the cell name in columns or rows contains forbidden symbols, such as space or percentage, the cell cannot be accessed. For more information on symbols that are not allowed, see Java method documentation.

Using Ranges in Spreadsheet Table

The following syntax is used to specify a range in a spreadsheet table:

```
$FirstValue:$LastValue
```

An example of using a range this way in the **TotalAmount** column is as follows.

Spreadsheet SpreadsheetResult **IncomeForecast** (Double bonusRate, Double sharePrice)				
	Year1	**Year2**	**Year3**	**TotalAmount**
Salary	45,000	= round ($Year1$Salary * 1.10)	=round ($Year1$Salary * 1.20)	= sum($Year1:$Year3)
Shares	0	0	1,000	= sum($Year1:$Year3)
Bonus	=$Salary * bonusRate	= $Salary * bonusRate	= $Salary * bonusRate	= sum($Year1:$Year3)
bonusRate	=bonusRate	=bonusRate	=bonusRate	
sharePrice	=sharePrice	=sharePrice	=sharePrice	
MinSalary	= $Salary	= $Salary	= $Salary	= sum($Year1:$Year3)
MaxSalary	= $Salary + $Bonus + $Shares * sharePrice	= $Salary + $Bonus + $Shares * sharePrice	= $Salary + $Bonus + $Shares * sharePrice	= sum($Year1:$Year3)

Figure 104: Using ranges of Spreadsheet table in functions

Note: In expressions, such as `min/max($FirstValue:$LastValue)`, there must be no space before and after the colon (:) operator.

Note: It is impossible to make math operations under ranges which names are specified with spaces. Please use step names without spaces.

Custom Spreadsheet Result

Usage of spreadsheet tables that return the SpreadsheetResult type can be improved by having a separate type for each spreadsheet table, that is, custom spreadsheet result data type, which is determined as follows:

```
SpreadsheetResult<Spreadsheet table name>
```

This feature provides the following advantages:

- possibility to explicitly define the type of the returned value
  In other words, there is no need to indicate a datatype when accessing the cell.
- test spreadsheet cell of any complex type
  For more information on test spreadsheet result, see Testing Spreadsheet Result.

By default, the feature is enabled in OpenL Tablets WebStudio and disabled in OpenL Tablets Web Services. For more information on how disable this feature, see ***[OpenL Tablets WebStudio User Guide]***, *System Settings* section.

To understand how this functionality works, consider the following spreadsheet.

Spreadsheet SpreadsheetResult test (String coverageId, int coveredProperty, double koef)				
Step	**Code**	**Formula**	**Value**	**Text : String**
Coverage_Id	COVERAGE_ID			= coverageId
Covered_Property	COVERED_PROPERTY_COVERAGE	= $Value	= coveredProperty + 1	
Final_Premium	FINAL_PREMIUM	= $Value	= koef * $Formula$Covered_Property	

Figure 105: An example of a spreadsheet

The return type is **SpreadsheetResult**, but with the custom spreadsheet result feature turned on, it becomes **SpreadsheetResulttest** datatype. Now it is possible to access any calculated cell in a very simplified way without indicating its datatype, for example, as displayed in the following figure.

Rules String **CheckFinalPremium** (String coverageId, int coveredProperty, double koef)	
C1	RET1
test(coverageId, coveredPremium, koef).$Value$Final_Premium < upperBound	
DoubleValue upperBound	String
Is Final Premium less than upper bound?	**Message**
1000	Final premium is less than 1000
2000	Final premium is less than 2000
3000	Final premium is less than 3000
	Final premium is more than 3000

Figure 106: Calling Spreadsheet cell

In this example, the spreadsheet table cell is accessed from the returned custom spreadsheet result.

Column Match Table

A **column match** table has an attached algorithm. The algorithm denotes the table content and how the return value is calculated. Usually this type of table is referred to as a **decision tree.**

The format of the column match table header is as follows:

```
ColumnMatch <ALGORITHM> <return type> <table name> (<input parameters>)
```

The following table describes the column match table header syntax:

Column match table header syntax	
Element	**Description**
ColumnMatch	Reserved word that defines the type of the table.
<ALGORITHM>	Name of the algorithm. This value is optional.
<return type>	Type of the return value.
<table name>	Valid name of the table.
<input parameters>	Input parameters as for any executable table.

The following predefined algorithms are available:

Predefined algorithms	
Element	**Reference**
MATCH	MATCH Algorithm
SCORE	SCORE Algorithm
WEIGHTED	WEIGHTED Algorithm

Each algorithm has the following mandatory columns:

Algorithm mandatory columns	
Column	**Description**
Names	Names refer to the table or method arguments and bind an argument to a particular row. The same argument can be referred in multiple rows. Arguments are referenced by their short names. For example, if an argument in a table is a Java bean with the **some** property, it is enough to specify **some** in the names column.

<table>
<tr><th colspan="2">Algorithm mandatory columns</th></tr>
<tr><th>Column</th><th>Description</th></tr>
<tr><td>Operations</td><td>The operations column defines how to match or check arguments to values in a table. The following operations are available:
<table>
<tr><th>Operation</th><th>Checks for</th><th>Description</th></tr>
<tr><td>match</td><td>equality or belonging to a range</td><td>The argument value must be equal to or within a range of check values.</td></tr>
<tr><td>min</td><td>minimally required value</td><td>The argument must not be less than the check value.</td></tr>
<tr><td>max</td><td>maximally allowed value</td><td>The argument must not be greater than the check value.</td></tr>
</table>
The min and max operations work with numeric and date types only.
The min and max operations can be replaced with the match operation and ranges. This approach adds more flexibility because it enables verifying all cases within one row.</td></tr>
<tr><td>Values</td><td>The values column typically has multiple sub columns containing table values.</td></tr>
</table>

The following topics are included in this section:

- MATCH Algorithm
- SCORE Algorithm
- WEIGHTED Algorithm

MATCH Algorithm

The **MATCH** algorithm allows mapping a set of conditions to a single return value.

Besides the mandatory columns, such as names, operations, and values, the **MATCH** table expects that the first data row contains **Return Values**, one of which is returned as a result of the ColumnMatch table execution.

ColumnMatch <MATCH> Boolean needApproval(Expense expense)							
names	operation	values					
Name	**Operation**	**Values**					
Return Values		**YES**	**YES**	**YES**	**YES**	**NO**	**NO**
area	match	Hardware	Software	Hardware	Software		
money	min	50000	20000	100000	40000		
paysCompany	match	TRUE	TRUE	FALSE	FALSE		
area	match					Hardware	Software
money	max					20000	10000

Figure 107: An example of the MATCH algorithm table

The MATCH algorithm works up to down, and left to right. It takes an argument from the upper row and matches it against check values from left to right. If they match, the algorithm returns the corresponding return value, which is the one in the same column as the check value. If values do not match, the algorithm switches to the next row. If no match is found in the whole table, the **null** object is returned.

If the return type is primitive, such as **int, double,** or **Boolean,** a runtime exception is thrown.

The MATCH algorithm supports **AND** conditions. In this case, it checks whether all arguments from a group match the corresponding check values, and checks values in the same value sub column each time. The **AND** group of arguments is created by indenting two or more arguments. The name of the first argument in a group must be left unintended.

SCORE Algorithm

The **SCORE** algorithm calculates the sum of weighted ratings or scores for all matched cases. The **SCORE** algorithm has the following mandatory columns:

- names
- operations
- weight
- values

The algorithm expects that the first row contains **Score,** which is a list of scores or ratings added to the result sum if an argument matches the check value in the corresponding sub column.

ColumnMatch <SCORE> int scoreIssue(Issue issue)								
names	operation	weight	values					
Name	**Operation**	**Weight**	**Values**					
Score			10	5	3	3	2	1
area	match	1	Loss	Profit	Budget	Expenses	HR	
mundane	match	2	FALSE					
money	match	3	1000000+	100000+	25000+		10000+	200+

Figure 108: An example of the SCORE algorithm table

The SCORE algorithm works up to down and left to right. It takes the argument value in the first row and checks it against values from left to right until a match is found. When a match is found, the algorithm takes the score value in the corresponding sub column and multiples it by the weight of that row. The product is added to the result sum. After that, the next row is checked. The rest of the check values on the same row are ignored after the first match. The 0 value is returned if no match is found.

The following limitations apply:

- Only one score can be defined for each row.
- AND groups are not supported.
- Any amount of rows can refer to the same argument.
- The SCORE algorithm return type is always Integer.

WEIGHTED Algorithm

The **WEIGHTED** algorithm combines the SCORE and simple MATCH algorithms. The result of the SCORE algorithm is passed to the MATCH algorithm as an input value. The MATCH algorithm result is returned as the WEIGHTED algorithm result.

The WEIGHTED algorithm requires the same columns as the SCORE algorithm. Yet it expects that first three rows are **Return Values, Total Score,** and **Score. Return Values** and **Total Score** represent the MATCH algorithm, and the **Score** row is the beginning of the SCORE part.

ColumnMatch <WEIGHTED> String scoreIssueImportance(Issue issue)								
names	operation	weight	values					
Name	**Operation**	**Weight**	**Values**					
Return Values			**CRITICAL**	**HIGH**	**Moderate**	**Low**		
Total Score	**min**		30	20	10	0		
Score			10	5	3	3	2	1
area	match	1	Loss	Profit	Budget	Expenses	HR	
mundane	match	2	FALSE					
money	match	3	1000000+	100000+	25000+		10000+	200+

Figure 109: An example of the WEIGHTED algorithm table

The WEIGHTED algorithm requires the use of an extra method table that joins the SCORE and MATCH algorithm. Testing the SCORE part can become difficult in this case. Splitting the WEIGHTED table into separate SCORE and MATCH algorithm tables is recommended.

TBasic Table

A **TBasic** table is used for code development in a more convenient and structured way rather than using Java or Business User Language (BUL). It has several clearly defined structural components. Using Excel cells, fonts, and named code column segments provides clearer definition of complex algorithms.

In a definite UI, it can be used as a workflow component.

The format of the TBasic table header is as follows:

```
TBasic <ReturnType> <TechnicalName> (ARGUMENTS)
```

The following table describes the TBasic table header syntax:

Tbasic table header syntax	
Element	**Description**
TBasic	Reserved word that defines the type of the table.
ReturnType	Type of the return value.
TechnicalName	Algorithm name.
ARGUMENTS	Input arguments as for any executable table.

The following table explains the recommended parts of the structured algorithm:

Algorithm parts	
Element	**Description**
Algorithm precondition or preprocessing	Executed when the component starts execution.
Algorithm steps	Represents the main logic of the component.
Postprocess	Identifies a part executed when the algorithm part is executed.
User functions and subroutines	Contains user functions definition and subroutines.

Table Part

The **Table Part** functionality enables the user to split a large table into smaller parts, or partial tables. Physically, in the Excel workbook, the table is represented as several table parts which logically are processed as one rules table.

This functionality is suitable for cases when a user is dealing with `.xls` file format using a rules table with more than 256 columns or 65,536 rows. To create such a rule table, a user can split the table into several parts and place each part on a separate worksheet.

Splitting can be vertical or horizontal. In vertical case, the first N1 rows of an original rule table are placed in the first table part, the next N2 rows in the second table part, and so on. In horizontal case, the first N1 columns of the rule table are placed in the first table part, the next N2 columns in the second table part, and so on. The header of the original rule table and its properties definition must be copied to each table part in case of horizontal splitting. Merging of table parts into the rule table is processed as depicted in the following figures.

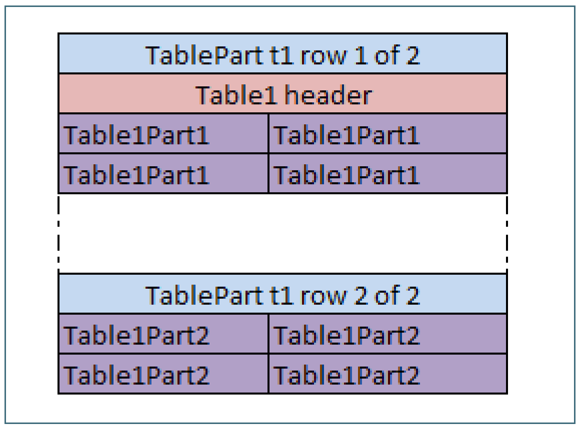


Figure 110: Vertical merging of table parts

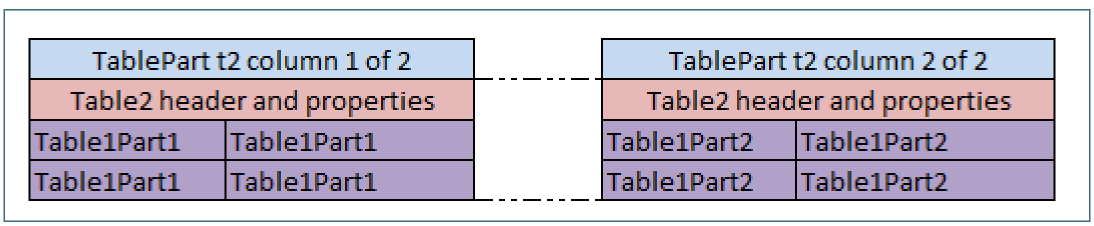


Figure 111: Horizontal merging of table parts

All table parts must be located within one Excel file.

Splitting can be applied to any tables of decision, data, test and run types.

The format of the TablePart header is as follows:

```
TablePart <table id> <split type> {M} of {N}
```

The following table describes the TablePart header syntax:

Table Part header syntax	
Element	**Description**
TablePart	Reserved word that defines the type of the table.

Table Part header syntax	
Element	**Description**
<table id>	Unique name of the rules table. It can be the same as the rules table name if the rules table is not overloaded by properties.
<split type>	Type of splitting. It is set to **row** for vertical splitting and **column** for horizontal splitting.
{M}	Sequential number of the table part: 1, 2, and so on.
{N}	Total number of table parts of the rule table.

The following examples illustrate vertical and horizontal splitting of the **RiskOfWorkWithCorporate** decision rule.

TablePart *RiskOfWorkWithCorporate* row 1 of 2

SimpleRules String **RiskOfWorkWithCorporate** (String ri

Risk of Profile	Risk of Operations	Risk of Geography	Total Risk
LOW	LOW	LOW	LOW
LOW	LOW	MIDDLE	LOW
LOW	LOW	HIGH	LOW
LOW	MIDDLE	LOW	LOW
LOW	MIDDLE	MIDDLE	LOW

Figure 112: Table Parts example. Vertical splitting part 1

TablePart *RiskOfWorkWithCorporate* row 2 of 2

LOW	MIDDLE	HIGH	MIDDLE
LOW	HIGH	LOW	LOW
LOW	HIGH	MIDDLE	MIDDLE
LOW	HIGH	HIGH	MIDDLE
MIDDLE	LOW	LOW	LOW
MIDDLE	LOW	MIDDLE	MIDDLE

Figure 113: Table Parts example. Vertical splitting part2

TablePart *RiskOfWorkWithCorporate* column 1 of 2

SimpleRules String **RiskOfWorkWithCorporate** (St

Risk of Profile	Risk of Operations
LOW	LOW
LOW	LOW
LOW	LOW
LOW	MIDDLE
LOW	MIDDLE

Figure 114: Table Part example. Horizontal splitting part 1

TablePart *RiskOfWorkWithCorporate* column 2 of 2

SimpleRules String **RiskOfWorkWithCorporate** (St

Risk of Geography	Total Risk
LOW	LOW
MIDDLE	LOW
HIGH	LOW
LOW	LOW
MIDDLE	LOW

Figure 115: Table Parts example. Horizontal splitting part 2

4 OpenL Tablets Functions and Supported Data Types

This chapter is intended for OpenL Tablets users to help them better understand how their business rules are processed in the OpenL Tablets system.

To implement business rules logic, users need to instruct OpenL Tablets what they want to do. For that, one or several rule tables with user's rules logic description must be created.

Usually rules operate with some data from user's domain to perform certain actions or return some results. The actions are performed using functions, which, in turn, support particular data types.

This section describes data types and functions for business rules management in the system and introduces basic principles of using arrays.

The section includes the following topics:

- Working with Arrays
- Working with Data Types
- Working with Functions

4.1 Working with Arrays

An **array** is a collection of values of the same type. Separate values of an array are called **array elements.** An **array element** is a value of any data type available in the system, such as IntValue, Double, Boolean, and String. For more information on OpenL Tablets Data Types, see Working with Data Types.

Square brackets in the name of the data type indicate that there is an array of values in the user's rule to be dealt with. For example, the `String[]` expression can be used to represent an array of text elements of the **String** data type, such as US state names, for example, CA, NJ, and VA. Users use arrays for different purposes, such as calculating statistics and representing multiple rates.

The following topics are included in this section:

- Working with Arrays from Rules
- Array Index Operators
- Functions to Work with Arrays
- Rules Applied to Array

Working with Arrays from Rules

Datatype arrays can be used in rules as follows:

Using datatype arrays in rules	
Method	**Description**
By numeric index, starting from 0	In this case, by calling `drivers[5]`, a user gets the sixth element of the datatype array.

Using datatype arrays in rules	
Method	**Description**
By user defined index	This case is a little more complicated. The first field of datatype is considered to be the user defined index. For example, if there is a **Driver** data type with the first String field name, a data table can be created, initializing two instances of **Driver** with the following names: John and David. Then in rules, the required instance can be called by `drivers["David"]`. All Java types, including primitives, and data types can be used for user specific indexes. When the first field of data type is of `int` type called `id`, to call the instance from array, wrap it with quotes as in `drivers["7"]`. In this case, a user does not get the eighth element in the array, but the **Driver** with ID=7. For more information on data tables, see Data Table.
By conditional index	Another case is to use conditions that consider which elements must be selected. For this purpose, SELECT operators are used, which specify conditions for selection. For more information on how to use SELECT operators, see Array Index Operators.
By other array index operators and functions	Any index operator listed in Array Index Operators or a function designed to work with arrays can be applied to an array in user's rules. The full list of OpenL Tablets array functions is provided in Appendix B: Functions Used in OpenL Tablets.

Array Index Operators

Array index operators are operators which facilitate working with arrays in rules. Index operators are specified in square brackets of the array and apply particular actions to array elements.

This section provides detailed description of index operators along with examples. OpenL Tablets supports the following index operators:

- SELECT Operators
- ORDER BY Operators
- SPLIT BY Operator
- TRANSFORM TO Operators
- Array Index Operators and Arrays of the SpreadsheetResult Type
- Advanced Usage of Array Index Operators

SELECT Operators

There are cases requiring conditions that determine the elements of the array to be selected. For example, if there is a data type **Driver** with such fields as **name** of the String type, **age** of the Integer type, and other similar data, and all drivers with the name **John** aged under **20** must be selected, use the following SELECT operator realizing conditional index:

```
arrayOfDrivers[select all having name == "John" and age < 20]
```

The following table describes the SELECT operator types:

SELECT operator types	
Type	**Description**
Returns the first element satisfying the condition	Returns the first matching element or null if there is no such element. **Syntax:** `array[!@ <condition>]` or `array[select first having <condition>]` **Example:** `arrayOfDrivers[!@ name == "John" and age < 20]`

SELECT operator types	
Type	**Description**
Returns all elements satisfying the condition	Returns the array of matching elements or empty array if there are no such elements. **Syntax:** `array[@ <condition>]` or `array [select all having <condition>]` **Example:** `arrayOfDrivers[@ numAccidents > 3]`

ORDER BY Operators

These operators are intended to sort elements of the array. Consider a data type **Claim** with such fields as **lossDate** of the Date type, **paymentAmount** of the Double type, and other similar data, and all claims must be sorted by loss date starting with the earliest one. In this case, use the ORDER BY operator, such as `claims[order by lossDate].`

The following table describes ways of sorting:

ORDER BY sorting methods	
Method	**Description**
Sort elements by increasing order	**Syntax:** `array[^@ <expression>]` or `array[order by <expression>]` or `array[order increasing by <expression>]` **Example:** `claims[^@ lossDate]`
Sort elements by decreasing order	**Syntax:** `array[v@ <expression>]` or `array[order decreasing by <expression>]` **Example:** `claims[v@ paymentAmount]`

The operator returns the array with ordered elements. It saves element order in case of equal elements. `<expression>` by which ordering is performed must have a comparable type, such as Date, String, Number.

SPLIT BY Operator

To split array elements into groups by definite criteria, use SPLIT BY operator, which returns a collection of arrays with elements in each array of the same criteria. For example, `codes = {"5000", "2002", "3300", "2113"}; codes[split by substring(0,1)]` will produce three collections, `{"5000"}, {"2002", "2113"} and {"3300"}` united by codes with the equal first number.

Syntax: `array[~@ <expression>]` or `array[split by <expression>]`

Example: `orders[~@ orderType]`

where orders of `Order[]` datatype, custom datatype **Order** has a field **orderType** for defining a category of **Order**. The operator in the example produces `Order[][]` split by different categories.

The SPLIT BY operator returns a two-dimensional array containing arrays of elements split by an equal value of `<expression>`. The relative element order is preserved.

TRANSFORM TO Operators

This operator turns source array elements into another transformed array in a quick way. Assume that a collection of claims is available, and **claim ID** and **loss date** information for each claim in the form of array of strings needs to be returned. Use the TRANSFORM TO operator, such as `claims[transform to id + " - " + dateToString(lossDate, "dd.MM.YY")].`

The following table describes methods of transforming:

TRANSFORM TO methods	
Method	**Description**
Transforms elements and returns the whole transformed array	**Syntax:** array[*@ <expression>] or array[transform to <expression>] **Example:** drivers[transform to name] or drivers[*@ name]
Transforms elements and returns unique elements of the transformed array only	**Syntax:** array[*!@ <expression>] or array[transform unique to <expression>] **Example:** drivers[transform unique to vehicle]drivers[*!@ vehicle]

The example above produces collection of vehicles, and in this collection, each vehicle is listed only once, without identical vehicles.

The operator returns array of the <expression> type. The order of the elements is preserved.

Any field, method of the collection element, or any OpenL Tablets function can be used in <condition> / <expression>, for example: claims[order by lossDate], where lossDate is a field of the **Claim** array element; arrayOfCarModels[@ contains("Toyota")], where contains is a method of String element of the arrayOfCarModels array.

Array Index Operators and Arrays of the SpreadsheetResult Type

Array index operators can be used with arrays which elements are of SpreadsheetResult data type. In order to refer to a cell of SpreadsheetResult element in the operator condition, the full reference $columnName$rowName is used.

Consider an example with select operator. There is a rule which selects and returns spreadsheet result with value **2** in the $Formula$EmployeeClassId cell.

Method SpreadsheetResult FirstEmpl1(SpreadsheetResult[] allEmployeeClassPremiums)
return allEmployeeClassPremiums[select first having $Formula$EmployeeClassId == 2];

Figure 116: index operator applied on array of SpreadsheetResults

where the spreadsheet result element of allEmployeeClassPremiums array is calculated from the following spreadsheet table:

Spreadsheet SpreadsheetResult EmployeeClassPremium (EmployeeClass employeeClass)	
Step	**Formula**
EmployeeClassId	= id

Figure 117: Spreadsheet for allEmployeeClassPremiums array result calculation

Advanced Usage of Array Index Operators

Consider a case when the name of the array element needs to be referred explicitly in condition or expression. For example, the policy has a collection of drivers of Driver[] datatype and a user wants to select all policy drivers of the age less than 19, except for the primary driver. The following syntax with an explicit definition of the Driver d collection element can be used:

```
policy.drivers[(Driver d) @ d != policy.primaryDriver && d.age < 19]
```

The expression can be written without type definition in case when the element type is known:

```
policy.drivers[(d) @ d != policy.primaryDriver && d.age < 19]
```

Note for experienced users: Array index operators can be applied to lists. Usually it requires using a named element to define a type of list components, such as `List claims = policy.getClaims(); claims[(Claim claim) order by claim.date]` or `List claims = policy.getClaims(); claims[(Claim claim) ^@ date]`.

Functions to Work with Arrays

This section provides detailed description of the **Length** array function with examples. For more information on array functions, see Appendix B: Functions Used in OpenL Tablets.

The **Length** array function returns the number of elements in the array as a result value. An example is as follows.

Rules String InsuranceProcedure (Policy policy)	
C1	RET1
vehicles.length	res
	String res
Car park	**Insurance procedure**
2	Senior Auto Driver
1	Standart Auto Driver

Figure 118: Rule table with the length function

In this example, the **Insure** procedure depends on the number of vehicles. The policy includes vehicles field represented as array.

	Test InsuranceProcedure InsuranceProcedureTest	
	policy	_res_
	> policyProfile2	
	Name of Policy	**Insurance procedure**
1	Policy2	Senior Auto Driver

ID	Name of Policy	Insurance procedure
1	Policy (Policy2)	Senior Auto Driver

Figure 119: Test table for rule table with length function

Policy2 contains two vehicles as illustrated in the following data table.

Data Policy policyProfile2			
name		**Policy**	Policy2
drivers	>driverProfiles1	**Drivers**	Sara Spencer, Sara's Son
vehicles	>autoProfiles2	**Vehicles**	2004 Honda Odyssey 2001 Toyota Camry
clientTier		**Client Tier**	Preferred
clientTerm		**Client Term**	

Figure 120: Data table for a test table

Rules Applied to Array

OpenL Tablets allows applying a rule intended for work with one value to an array of values. The following example demonstrates this feature in a very simple way.

Spreadsheet SpreadsheetResult PolicyCalculation (Policy policy)	
	Value
Policy : Policy	= policy
Vehicles : SpreadsheetResult[]	= VehicleCalculation (vehicles)
Premium	= sum (GetPremium ($Vehicles)) - ClientDiscount (clientTier)

Spreadsheet SpreadsheetResult VehicleCalculation (Vehicle vehicle)	
	Value
Age	= CurrentYear() - year
BasePremium	= BasePremium (carType)
Surcharge	= AgeSurcharge ($Age)
VehicleDiscount	= VehicleDiscount (airbagType, hasAlarm)
Premium	= ($BasePremium + $Surcharge) * (1 - $VehicleDiscount)

Figure 121: Applying a rule to an array of values

The **VehicleCalculation** rule is designed for working with one vehicle as an input parameter and returns one spreadsheet as a result. In the example, this rule is applied to an array of vehicles, which means that it is executed for each vehicle and returns an array of spreadsheet results.

4.2 Working with Data Types

Data in OpenL Tablets must have a type of data defined. A data type indicates the meaning of the data, their possible values, and instructs OpenL Tablets how to process operations, which rules can be performed, and how these rules and operations affect data.

All data types used in OpenL Tablets can be divided into the following groups:

Data types in OpenL Tablets	
Type	**Description**
Predefined data types	Types that exist in OpenL Tablets, can be used, but cannot be modified.
Custom data types	Types created by a user as described in the Datatype Table section.

This section describes predefined data types that include the following ones:

- Simple Data Types
- Value Data Types
- Range Data Types

Simple Data Types

The following table lists simple data types that can be used in user's business rules in OpenL Tablets:

Simple Data Types				
Data Type	**Description**	**Examples**	**Usage in OpenL Tablets**	**Notes**
Integer	Used to work with whole numbers without fraction points.	8; 45; 12; 356; 2011	Common for representing a variety of numbers, such as driver's age, a year, a number of points, and mileage.	Not exceeding 2,147,483,647.
Double	Used for operations with fractional numbers. Can hold very large or very small numbers.	8.4; 10.5; 12.8; 12,000.00; 44.416666666666664	Commonly used for calculating balances or discount values for representing exchange rates, a monthly income, and so on.	
BigInteger	Used to operate with whole numbers that exceed the values allowed by the Integer data type. The maximum Integer value is 2147483647.	7,832,991,657,779;20,000,000,013	Only used for operations on very big values over two billion, for example, dollar deposit in Bulgarian Leva equivalent.	
BigDecimal	Represents decimal numbers with a very high precision. Can be used to work with decimal values that have more than 16 significant digits, especially when precise rounding is required.	0,6666666666666666667	Often used for currency calculations or in financial reports that require exact mathematical calculations, for example, a year bank deposit premium calculation.	

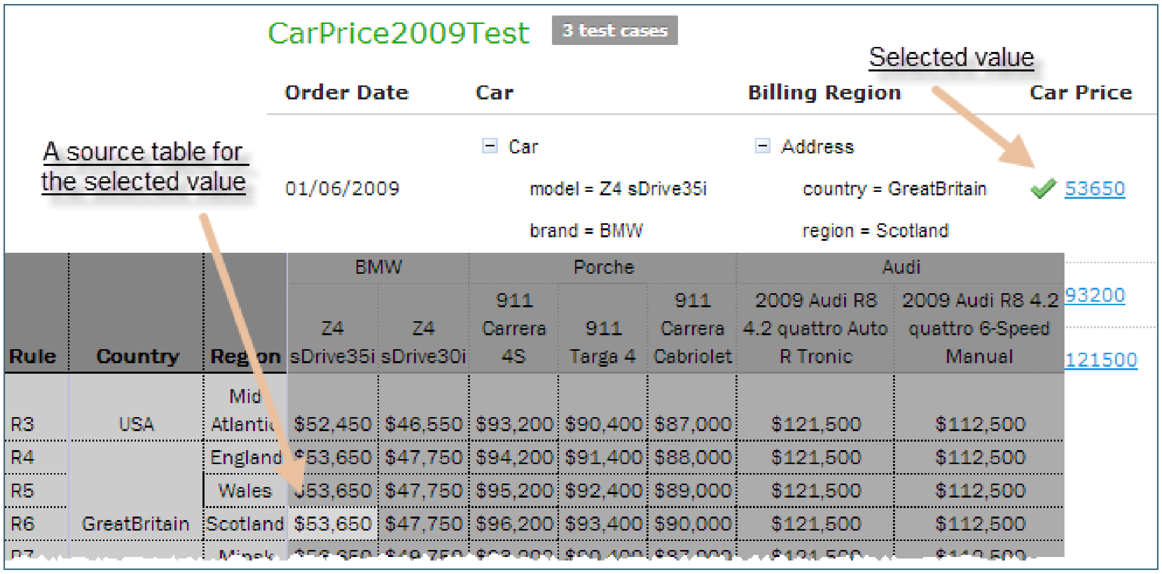
Simple Data Types				
Data Type	**Description**	**Examples**	**Usage in OpenL Tablets**	**Notes**
String	Represents text rather than numbers. String values are comprised of a set of characters that can contain spaces and numbers. For example, the word **Chrysler** and the phrase **The Chrysler factory warranty is valid for 3 years** are both Strings.	John Smith, London, Alaska, BMW; Driver is too young.	Represents cities, states, people names, car models, genders, marital statuses, as well as messages, such as warnings, reasons, notes, diagnosis, and other similar data.	
Boolean	Represents only two possible values: `true` and `false`. For example, if a driver is trained, the condition is `true`, and the insurance premium coefficient is 1.5. If the driver is not trained, the condition is false, and the coefficient is 0.25.	true; yes; y; false; no; n	Handles conditions in OpenL Tablets.	The synonym for 'true' is 'yes', 'y'; for 'false' – 'no', 'n'.
Date	Used to operate with dates.	06/05/2010; 01/22/2014; 11/07/95; 1/1/1991.	Represents any dates, such as policy effective date, date of birth, and report date. If the date is defined as a text cell value, it is expected in the `<month>/<date>/<year>` format.	

Byte, Character, Short, Long, and Float data types are rarely used in OpenL Tablets, therefore, ranges of values are only provided in the following table. For more information about values, see the appropriate Java documentation.

Ranges of values		
Data Type	**Min**	**Max**
Byte	-128	127
Character	0	65535
Short	-32768	32767
Long	-9223372036854775808	9223372036854775807
Float	$1.5*10^{-45}$	3.4810^{38}

Value Data Types

In OpenL Tablets, **value data types** are exactly the same as simple data types described in Simple Data Types, except for an **explanation**, a clickable field displayed in the test results table in OpenL Tablets WebStudio. Value data types provide detailed information on results of rules testing and are useful for working with calculated values to have better debugging capabilities. By clicking the linked value, users can view the source table for that value and get information on how the value is calculated.



Rule	Country	Region	BMW Z4 sDrive35i	BMW Z4 sDrive30i	Porche 911 Carrera 4S	Porche 911 Targa 4	Porche 911 Carrera Cabriolet	Audi 2009 Audi R8 4.2 quattro Auto R Tronic	Audi 2009 Audi R8 4.2 quattro 6-Speed Manual
R3	USA	Mid Atlantic	$52,450	$46,550	$93,200	$90,400	$87,000	$121,500	$112,500
R4		England	$53,650	$47,750	$94,200	$91,400	$88,000	$121,500	$112,500
R5		Wales	$53,650	$47,750	$95,200	$92,400	$89,000	$121,500	$112,500
R6	GreatBritain	Scotland	$53,650	$47,750	$96,200	$93,400	$90,000	$121,500	$112,500

Figure 122: Usage of value data type

OpenL Tablets supports the following value data types:

- ByteValue
- ShortValue
- IntValue
- LongValue
- FloatValue
- DoubleValue
- BigIntegerValue
- BigDecimalValue

Range Data Types

Range Data Types can be used when a business rule must be applied to a group of values. For example, a driver's insurance premium coefficient is usually the same for all drivers from within a particular age group. So a range of ages can be defined, and one rule for all drivers from within that range can be created. The way to inform OpenL Tablets that the rule must be applied to a group of drivers is to declare driver's age as the range data type.

OpenL Tablets supports the following range data types:

Range data types in OpenL Tablets	
Type	**Description**
IntRange	Intended for processing whole numbers within an interval, for example, vehicle or driver age for calculation of insurance compensations, or years of service when calculating the annual bonus.
DoubleRange	Used for operations on fractional numbers within a certain interval. For instance, annual percentage rate in banks depends on amount of deposit which is expressed as intervals: 500 – 9,999.99; 10,000 – 24,999.99.

The following illustration provides a very simple example of how to use a range data type. The value of discount percentage depends on the number of orders and is the same for 4 to 5 orders and 7 to 8 orders. An amount of cars per order is defined as IntRange data type. For a number of orders from, for example, 6 to 8, the rule for calculating the discount percentage is the same: the discount percentage is 10.00% for BMW, 4.00% for Porsche, and 6.00% for Audi.

Rules DoubleValue getDiscountPercentage(Car car, int numberOfCars)				
properties	category	Rules - Discounts		
C1	//Description	HC1	RET1	
numberOfCars		brand	discountPercentage	
IntRange amountPerOrder		CarBrand carBrand	DoubleValue discountPercentage	
Number of Orders	**Discount Description**	**BMW**	**Porche**	**Audi**
1	No discount for any brand	0,00%	0,00%	0,00%
2	Min discount applied	1,00%	1,00%	1,00%
3	+1% discount	2,00%	2,00%	2,00%
4 - 5	Depends on car brand	5,00%	3,00%	4,00%
6 - 8	Depends on car brand	10,00%	4,00%	6,00%
> 8	Depends on car brand	15,00%	5,00%	8,00%

Figure 123: Usage of the range data type

Supported range formats are as follows:

Range formats				
#	**Format**	**Interval**	**Example**	**Values for IntRange**
1	[<min_number>; <max_number>) Mathematic definition for ranges using square brackets for included borders and round brackets for excluded borders.	[min; max] (min; max) [min; max) (min; max]	[1; 4] (1; 4) [1; 4) (1; 4]	1, 2, 3, 4 2, 3 1, 2, 3 2, 3, 4
2	[<min_number> .. <max_number>) Mathematic definition for ranges with two dots used instead of semicolon.	[min; max] (min; max) [min; max) (min; max]	[1 .. 4] (1 .. 4) [1 .. 4) (1 .. 4]	1, 2, 3, 4 2, 3 1, 2, 3 2, 3, 4
3	<min_number> – <max_number>	[min; max]	1 - 4 -2 - 2 -4 - -2	[1; 4] [-2; 2] [-4; -2]
4	<min_number> .. <max_number>	[min; max]	1 .. 4	1, 2, 3, 4
5	<min_number> … <max_number>	(min; max)	1 … 4	2, 3
6	<<max_number>	[-∞; max)	<2	-∞ …, -1, 0, 1
7	<=<max_number>	[-∞; max]	<=2	-∞ …, -1, 0, 1, 2
8	><min_number>	(min; +∞]	>2	3, 4, 5, … +∞
9	>=<min_number>	[min; +∞]	>=2	2, 3, 4, 5, … +∞
10	><min_number> <<max_number> <<max_number> ><min_number>	(min; max)	>1 <4 <4 >1	2, 3 2, 3
11	>=<min_number> <<max_number> <<max_number> >=<min_number>	[min; max)	>=1 <4 <4 >=1	1, 2, 3 1, 2, 3
12	><min_number> <=<max_number> <=<max_number> ><min_number>	(min; max]	>1 <=4 <=4 >1	2, 3, 4 2, 3, 4
13	>=<min_number> <=<max_number> <=<max_number> >=<min_number>	[min; max]	>=1 <=4 <=4 >=1	1, 2, 3, 4 1, 2, 3, 4
14	<min_number>+	[min; +∞]	2+	2, 3, 4, 5, … +∞

Range formats				
#	**Format**	**Interval**	**Example**	**Values for IntRange**
15	`<min_number> and more`	`[min; +∞]`	2 and more	2, 3, 4, 5, ... +∞
16	`more than <min_number>`	`(min; +∞]`	more than 2	3, 4, 5, ... +∞
17	`less than <max_number>`	`[-∞; max)`	less than 2	-∞ ..., -1, 0, 1

The following rules apply:

- Infinities in IntRange are represented as `Integer.MIN_VALUE` for -∞ `and` `Integer.MAX_VALUE` for +∞.
- Using of ".." and "..." requires spaces between numbers and dots.
- Numbers can be enhanced with the `$` sign as a prefix and `K`, `M`, `B` as a postfix, for example, `$1K = 1000`.
- For negative values, use the '–' (minus) sign before the number, for example, `-<number>`.

4.3 Working with Functions

Data types are used to represent user data in the system. Business logic in rules is implemented using **functions.** Examples of functions are the **Sum** function used to calculate a sum of values and **Min/Max** functions used to find the minimum or maximum values in a set of values.

This section describes OpenL Tablets functions and provides simple usage examples. All functions can be divided into the following groups:

- math functions
- array processing functions
- date functions
- String functions
- error handling functions

The following topics are included in this section:

- Understanding OpenL Tablets Function Syntax
- Math Functions
- Date Functions
- ROUND Function
- ERROR Function
- Null Elements Usage in Calculations

Understanding OpenL Tablets Function Syntax

This section briefly describes how functions work in OpenL Tablets.

Any function is represented by the following elements:

- function name or identifier, such as **sum, sort, median**
- function parameters
- value or values that the function returns

For example, in the `max(value1, value2)` expression, **max** is the rule or function name, **(value1, value2)** are function parameters, that is, values that take part in the action. When determining **value1** and **value2** as 50 and 41, the given function looks as `max(50, 41)` and returns **50** in result as the biggest number in the couple.

If an action is performed in a rule, use the corresponding function in the rules table. For example, to calculate the best result for a gamer in the following example, use the **max** function and enter *max(score1, score2, score3)* in the **C1** column. This expression instructs OpenL Tablets to select the maximum value in the set. The **contains** function can be used to determine the gamer level.

Subsequent sections provide description for mostly often used OpenL Tablets functions. For a full list of functions, see Appendix B: Functions Used in OpenL Tablets.

Math Functions

Math functions serve for performing math operations on numeric data. These functions support all numeric data types described in Working with Data Types.

The following example illustrates how to use functions in OpenL Tablets. The rule in the diagram defines a gamer level depending on the best result in three attempts.

Rules String GamerLevelEvaluation(Integer score1, Integer score2, Integer score3)	
C1	RET1
max(score1,score2,score3)	
IntRange	
BestResultEvaluation	**GamerLevel**
0-3	novice
4-6	medium
7-10	senior

Figure 124: An example of using the 'max' function

Math functions used in OpenL Tablets	
Function	**Description**
min/max	Returns the smallest or biggest number in a set of numbers for array or multiple values. The function result is a number. **`min/max(number1, number2, …)`** `min/max(array[])` is the array that must be previously defined in the given rule table or in a different table. In the previous example, the `max(score1,score2,score3)` expression is used to define the highest result for a player. For example, `max(1, 5, 3)` gives **5** as the result so the player level is **medium** as defined in the `RET1` column.
Sum	Adds all numbers in the provided array and returns the result as a number. **`sum (number1, number2, …)`** **`sum(array[])`**

avg	Returns the arithmetic average of array elements. The function result is a number.
	`avg(number1, number2, …)`
	`avg(array[])`

product	Multiplies numbers from the provided array and returns the product as a number.
	`product(number1, number2, …)`
	`product(array[])`

mod	Returns the remainder after a number is divided by a divisor. The result is a numeric value and has the same sign as the devisor. **`mod(number, divisor)`** `number` is a numeric value which's remainder must be found. `divisor` is the number used to divide the `number`. If the divisor is **0**, the **mod** function returns an error.

Math functions used in OpenL Tablets	
Function	**Description**
sort	Returns values from the provided array in ascending sort. The result is an array. `sort(array[])`

Date Functions

OpenL Tablets supports a wide range of date functions that can be applied in the rule tables. The following date functions return an int data type:

Date functions used in OpenL Tablets that return an int data type	
Function	**Description**
absMonth	Returns the number of months since AD. `absMonth(Date)`
absQuarter	Returns the number of quarters since AD as an integer value. `absQuarter(Date)`
dayOfWeek	Takes a date as input and returns the day of the week on which that date falls. Days in a week are numbered from 1 to 7 as follows: 1=Sunday, 2=Monday, 3 = Tuesday, and so on. `dayOfWeek(Date d)`
dayOfMonth	Takes a date as input and returns the day of the month on which that date falls. Days in a month are numbered from 1 to 31. `dayOfMonth(Date d)`
dayOfYear	Takes a date as input and returns the day of the year on which that date falls. Days in a year are numbered from 1 to 365. `dayOfYear(Date d)`
weekOfMonth	Takes a date as input and returns the week of the month within which that date is. Weeks in a month are numbered from 1 to 5. `weekOfMonth(Date d)`
weekOfYear	Takes a date as input and returns the week of the year on which that date falls. Weeks in a year are numbered from 1 to 54. `weekOfYear(Date d)`
second	Returns a second (0 to 59) for an input date. `second(Date d)`
minute	Returns a minute (0 to 59) for an input date. `minute(Date d)`
hour	Returns the hour of the day in 12 hour format for an input date. `hour(Date d)`
hourOfDay	Returns the hour of the day in 24 hour format for an input date. `hourOfDay(Date d)`

The following date function returns a String data type:

Date function used in OpenL Tablets that returns a String data type	
Function	**Description**
amPm(Date d)	Returns `Am` or `Pm` value for an input date. `amPm(Date d)`

The following figure displays values returned by date functions for a particular input date specified in the **MyDate** field.

Spreadsheet SpreadsheetResult testDateFunctions(Date MyDate)	
Step	Value
Day of week	=dayOfWeek(MyDate)
Day of month	=dayOfMonth(MyDate)
Day of year	=dayOfYear(MyDate)
Week of year	=weekOfYear(MyDate)
Hour of day	=hourOfDay(MyDate)

MyDate	Result
12/19/2012 07:13	

Step	Value
Day of week	4.0
Day of month	19.0
Day of year	354.0
Week of year	52.0
Hour of day	19.0

Figure 125: Date functions in OpenL Tablets

The following decision table provides a very simple example of how the `dayOfWeek` function can be used when the returned value, **Risk Factor,** depends on the day of the week.

Rules DoubleValue RiskFactor3 (Date MyDate)		
C1 dayOfWeek(MyDate) IntRange	RET1	
Day of Week	Risk Factor (%)	Comments
[2 .. 5]	75%	Monday-to-Wednesday RF
6	85%	Friday RF
	100%	Week-end RF

RiskFactor3Test 3 test cases

Date	Expected	Result
12/21/2012	0.85	✔ 0.85
12/22/2012	1	✔ 1
12/19/2012	0.75	✔ 0.75

Figure 126: A risk factor depending on a day of the week

ROUND Function

The **ROUND function** is used to round a value to a specified number of digits. For example, in financial operations, users may want to calculate insurance premium with accuracy up to two decimals. Usually a number of digits in long data types such as DoubleValue or BigDecimal must be limited. The ROUND function allows rounding a value to an integer number or to a fractional number with limited signs after point.

The ROUND function syntax is as follows:

ROUND function syntax	
Syntax	**Description**
`round(DoubleValue)`	Rounds to the integer number.
`round(DoubleValue, int)`	Rounds to the fractional number. `int` is a number of digits after point.
`round(DoubleValue, int, int)`	Rounds to the fractional number and enables to get results different from usual mathematical rules. In this variant of syntax, the following rules apply: • The first `int` stands for a number of digits after point. • The second `int` stands for a rounding mode represented by a constant, for example, `1- ROUND_DOWN`, `4- ROUND_HALF_UP`.

The following topics are included in this section:

- round(DoubleValue)
- round(DoubleValue,int)
- round(DoubleValue,int,int)

round(DoubleValue)

This syntax is used to round to an integer number. The following illustration provides an example of the syntax usage.

Rules DoubleValue **roundToInteger** (DoubleValue value2)	
C1	RET1
true	
Boolean condition	
Condition	**Rate**
	=round(value)

Figure 127: Rounding to integer

Testmethod **roundToInteger** roundToInteger Test		
description	value2	_res_
Test ID	**TestType**	**Test Result**
Test1	32.285	32
Test2	42.285	42
Test3	52.285	52
Test4	62.285	62
Test5	72.285	72
Test6	82.285	82
Test7	92.285	92
Test8	102.285	102
Test9	112.285	112

Figure 128: Test table for rounding to integer

round(DoubleValue,int)

This syntax is used to round to a fractional number. int stands for a number of digits after point.

Rules DoubleValue **round** (DoubleValue value)	
C1	RET1
true	
Boolean condition	
Condition	**Rate**
	=round(value,2)

Figure 129: Rounding to a fractional number

Testmethod **round** roundTest		
description	value	_res_
Test ID	**TestType**	**Test Result**
Test1	32.285	32.29
Test2	42.285	42.29
Test3	52.285	52.29
Test4	62.285	62.29
Test5	72.285	72.29
Test6	82.285	82.29
Test7	92.285	92.29
Test8	102.285	102.29
Test9	112.285	112.29

Figure 130: Test table for rounding to a fractional number

round(DoubleValue,int,int)

This syntax enables rounding to a fractional number and get results different from usual mathematical rules. In this variant of syntax, the following rules apply:

- The first `int` stands for a number of digits after point
- The second `int` stands for a rounding mode represented by a constant, for example, `1- ROUND_DOWN, 4- ROUND_HALF_UP`.

The following table contains a list of the constants and their descriptions:

Constants list		
Constant	**Name**	**Description**
0	ROUND_UP	Rounding mode to round away from zero.
1	ROUND_DOWN	Rounding mode to round towards zero.
2	ROUND_CEILING	Rounding mode to round towards positive infinity.
3	ROUND_FLOOR	Rounding mode to round towards negative infinity.
4	ROUND_HALF_UP	Rounding mode to round towards the nearest neighbor unless both neighbors are equidistant, in which case round up.
5	ROUND_HALF_DOWN	Rounding mode to round towards the nearest neighbor unless both neighbors are equidistant, in which case round down.
6	ROUND_HALF_EVEN	Rounding mode to round towards the nearest neighbor unless both neighbors are equidistant, in which case, round towards the even neighbor.
7	ROUND_UNNECESSARY	Rounding mode to assert that the requested operation has an exact result, hence no rounding is necessary.

For more information on the constants representing rounding modes, see http://docs.oracle.com/javase/6/docs/api/constant-values.html#java.math.BigDecimal.ROUND_HALF_DOWN.

For detailed information on the constants with examples, see http://docs.oracle.com/javase/6/docs/api/java/math/RoundingMode.html, *Enum Constant Details* section.

The following examples display how the rounding works with the `ROUND_DOWN` constant.

Rules DoubleValue **round** (DoubleValue value)	
C1	RET1
true	
Boolean condition	
Condition	**Rate**
	=round(value,2,1)

Figure 131: Usage of the `ROUND_DOWN` constant

Testmethod **round** roundTest		
description	value	_res_
Test ID	**TestType**	**Test Result**
Test1	32.285	32.28
Test2	42.287	42.28
Test3	52.283	52.28
Test4	62.289	62.28

Figure 132: Test table for rounding to fractional number using the `ROUND_DOWN` *constant*

ERROR Function

The **ERROR** function is used to handle exceptional cases in a rule when an appropriate valid returned result cannot be defined. The function returns a message containing problem description instead and stops processing. The message text is specified as the error function parameter.

In the following example, if the value for a coverage limit of an insurance policy exceeds 1000$, a rule notifies a user about wrong limit value and stops further processing:

SimpleRules Double **CoveragePremium** (Integer limit)	
Coverage Limit	**Premium**
<= 100	$0
101 - 500	$15
501 - 900	$45
901 - 1000	$60
> 1000	= error ("coverage limit can't be more then 1000$"); 0

Figure 133: Usage of ERROR function

Using this function requires any arbitrary value of the expected return value data type to be defined right after the error function. This value does not impact any calculation and is not returned as a result. Only the error is returned.

Null Elements Usage in Calculations

This section describes how null elements represented as value data types are processed in calculations. For more information on value data types, see Value Data Types.

In some calculations, for example, **a+b** or **a*b,** values **a** and **b** can be **null** elements. If one of the calculated values is **null**, it is recognized as **0** for sum operations or as **1** for multiply operations.

The following diagrams demonstrate this rule.

Rules DoubleValue Operations (String testType, DoubleValue a, DoubleValue b)		
properties	modifiedOn	27.6.2012
	modifiedBy	LOCAL
C1	RET1	
testType		
String		
Checked operations	**Return**	
SUBTRACT	=a - b	
ADD	=a + b	
DIVIDE	=a / b	
MULTIPLY	=a * b	
POW	=a ** b	

Figure 134: Rules for null elements usage in calculations

The next test table provides examples of calculations with null values.

Testmethod Operations OperationsTest			
properties	modifiedOn	27.6.2012	
	modifiedBy	LOCAL	
testType	a	b	_res_
TestType	**Val1**	**Val2**	**Test Result**
SUBTRACT	5.0	3.0	2.0
SUBTRACT	5.0		5.0
SUBTRACT		3.0	-3.0
SUBTRACT			
ADD	5.0	3.0	8.0
ADD	5.0		5.0
ADD		3.0	3.0
ADD			
DIVIDE	8.0	4.0	2.0
DIVIDE	8.0		8.0
DIVIDE		4.0	0.25
DIVIDE			
MULTIPLY	8.0	4.0	32.0
MULTIPLY	8.0		8.0
MULTIPLY		4.0	4.0
MULTIPLY			
POW	2.0	3.0	8.0
POW		3.0	0.0
POW	2.0		2.0
POW			

Figure 135: Test table for null elements usage in calculations

If all values are **null**, the result is also **null**.

5 OpenL Tablets Business Expression Language

The OpenL Tablets language framework has been designed from the ground up to allow flexible combination of grammar and semantics. OpenL Tablets Business Expression (BEX) language proves this statement on practice by extending existing OpenL Tablets Java grammar and semantics presented in `org.openl.j` configuration by new grammar and semantic concepts that allow users to write "natural language" expressions.

The following topics are included in this chapter:

- Java Business Object Model as a Basis for OpenL Tablets Business Vocabulary
- New Keywords and Avoiding Possible Naming Conflicts
- Simplifying Expressions with Explanatory Variables
- Simplifying Expressions by the Using Unique in Scope Concept
- OpenL Tablets Vocabulary and OpenL Tablets BEX
- Future Developments, Compatibility, and Other Considerations
- OpenL Tablets Programming Language Framework

5.1 Java Business Object Model as a Basis for OpenL Tablets Business Vocabulary

OpenL Tablets minimizes the effort required to build a business vocabulary. Using BEX does not require any special mapping, and the existing Java BOM automatically becomes the basis for OpenL Tablets business vocabulary (OBV). For example, the following expressions are equivalent:

`driver.age`

and

`Age of the Driver`

Another example:

`policy.effectiveDate`

and

`Effective Date of the Policy`

In these examples, if the Java model correctly reflects business vocabulary, no further action is needed. If the Java model is not satisfactory, users can still apply custom type-safe mapping, or renaming, which is a part of OpenL Tablets framework.

5.2 New Keywords and Avoiding Possible Naming Conflicts

In the previous chapter, a new **of the** keyword was introduced. There are other, self-explanatory, keywords in BEX language:

- is less than
- is more than
- is less or equal
- is no more than

- is more or equal
- is no less than

When adding new keywords to OpenL Tablets BEX language, there is a chance of a name clash with business vocabulary. The easiest way to avoid this clash is to use upper case notation when referring to the model attributes because BEX grammar is case-sensitive and all new keywords appear in the lower case. For example, there is an attribute called `isLessThanCoverageLimit`. When referring to it as `is less than coverage limit`, there is going to be a name clash with the keyword, but if `Is Less Than Coverage Limit` is written, no clash appears. Possible direction in extending keywords is to add numeric, measurement units, measure sensitive comparisons, such as `is longer than` or `is colder than`, or use any other similar approach.

5.3 Simplifying Expressions with Explanatory Variables

Consider a rather simple expression in Java:

```
(vehicle.agreedValue - vehicle.marketValue) / vehicle.marketValue > limitDefinedByUser
```

In BEX language, the same expression can be rewritten in a business-friendly way:

```
(Agreed Value of the vehicle - Market Value of the vehicle) / Market Value of the vehicle is
more than Limit Defined By User
```

Unfortunately, the more complex is the expression, the less comprehensible the "natural language" expression becomes. OpenL Tablets BEX offers an elegant solution for this problem:

```
(A - M) / M > X, where
  A - Agreed Value of the vehicle,
  M - Market Value of the vehicle,
  X - Limit Defined By User
```

The syntax resembles the one used in scientific publications and is easy to understand for anybody. It is believed that the syntax provides the best mix of mathematical clarity and business readability.

5.4 Simplifying Expressions by Using the Unique in Scope Concept

Humans differ from computers, in particular, by their ability to understand the scope of a language expression. For example, when discussing an insurance policy and the effective date is mentioned, there is no need to say the fully qualifying expression **the effective date of the policy** every time, because the context of the effective date is clearly understood. On the other hand, when discussing two policies, for example, the old and the new ones, one needs to say **the effective date of the new policy**, or **the effective date of the old policy,** to differentiate between two policies.

Similarly, when humans write so-called business documents, that is, files that serve as a reference point to a rule developer, they also often use an implied context in mind. Therefore in documentation, they often use business terms, such as **effective date**, **driver**, and **account**, with the implied scope in mind. Scope resolution is left to a so-called rules engineer, who has to do it by manually analyzing BOM and setting appropriate paths from root objects.

OpenL Tablets BEX tries to close this semantic gap or at least make it a bit narrower by using attributes unique in scope. For example, if there is only one policy in the scope, user can write **effective date** instead of **effective date of the policy**. OpenL Tablets BEX automatically determines the uniqueness of the attribute and either produces a correct path, or emits an error message in case of an ambiguous statement. The level of the resolution can be modified programmatically and by default equals to **1**.

5.5 OpenL Tablets Vocabulary and OpenL Tablets BEX

OpenL Tablets supports augmenting the existing Java BOM with different kind of meta-information through OpenL Tablets vocabulary accessible to business users through Java API and as Excel tables.

While the vocabulary can be used for many other important activities, it has one feature significant in the context of OpenL Tablets BEX, **business object attribute aliasing,** which stands for ability to name attribute with alternative names. Thus a user can adopt existing Java model names to business terminology if the Java model does not reflect it properly. For more information, see OpenL Tablets vocabulary.

5.6 Future Developments, Compatibility, and Other Considerations

OpenL Tablets BEX is a fairly new development, which evolves to provide users with new convenient features. In particular, right now there is no other way to call methods in OpenL Tablets except for the old-fashioned Java/C++ style. Nevertheless, it must be said that the existing syntax will remain compatible with all future modifications.

Also, the ability to use Java style constructs together with natural-language extensions will be kept supported in the language.

It is important to mention that BEX is not a natural-language tool. BEX is a syntax extension of the standard Java grammar that allows user's expressions look like regular English phrases. The result will be as good as Java BOM is; nevertheless remember that BEX is not able to fix bad design or naming conventions.

It is strongly recommended to at least try out using BEX as it is a standard part of OpenL Tablets and does not require any additional effort. Users can use BEX in any place where Java expressions were previously used.

5.7 OpenL Tablets Programming Language Framework

Business rules consist of rules, where each rule has a condition and action. A condition is a Boolean expression, the one that returns `true` or `false`. An action can be any sequence, usually simple, of programming statements.

Consider an expression **`driver.age < 25`**.

From semantic perspective, the expression defines the relationship between a value defined by the **driver.age** expression and literal **25**. This can be interpreted as **age of the driver is less than 25 years** or **select drivers who are younger than 25 years old,** or any other similar phrase.

From the programming language perspective, the semantic part is irrelevant due to the following reasons:

- A statement must be valid in the language grammar.
- A statement must be correct from the type-checking point of view.
- If the language is compiled, the results of compiling, such as valid binary code, or bytecode, or code in another target language, can be considered as possible results of compiling and must be produced from the statement.

- A runtime system, interpreter, or virtual machine must be able to execute, or interpret, this statement's compiled code and produce a resulting object.

The following topics are included in this section:

OpenL Tablets Grammars

When the OpenL Tablets parser parses an OpenL Tablets expression, it produces a syntax tree. Each tree node has a node type, a literal value, a reference to the source code for displaying errors and debugging, and also may contain child nodes. This is similar to what other parsers do, with one notable exception – the OpenL Tablets Grammar is not hard-coded, it can be configured, and a different one can be used. For all practical purposes, as of today, only the following grammars implemented in OpenL Tablets are distributed:

OpenL Tablets grammar	
Grammar	**Description**
org.openl.j	Based on the classic Java 1.3 grammar. No templates and exception handling are supported.
org.openl.bex	org.openl.j grammar with business natural language extensions.

By default, **org.openl.bex** is used in the OpenL Tablets business rules product.

An experimental **org.openl.n3 grammar** is available, and **org.openl.sql** grammar is targeted to be added in the future.

The syntax tree produced by the **org.openl.j** grammar for the expression mentioned previously in this chapter is as follows:

```
        <
       / \
      .   25
     / \
driver  age
```

Types of nodes are as follows:

- **op.binary.lt** for '<'
- **literal.integer** for '25'
- **chain** for '.'
- **identifier** for 'driver'
- **identifier** for 'age'

Node type names are significant. More information on the type names is available further in this chapter.

The grammar used in `org.openl.j` is similar not only to Java but to any other language in the C/C++/Java/C# family. This makes OpenL Tablets easily to learn and apply by the huge pool of available Java/Cxx programmers and adds to its strength. Proliferation of new languages like Ruby and Groovy, multiple proprietary languages used in different business rules engines, CEP engines and so on, introduce new semantics to the programming community and make usage of new technologies much harder.

OpenL Tablets team makes their best to stay as close to the Java syntax as possible to make sure that the "entities would not be multiplied beyond necessity".

Context, Variables and Types

After the syntax tree is created, syntax nodes must be bound to their semantic definitions. At this stage, OpenL Tablets uses specific binders for each node type. The modular structure of OpenL Tablets allows definition of custom binders for each node type. Once a syntax node is bound into the bound node, it is assigned a type, thus making the process type-safe.

Most of the time, the standard Java approach is used to assign type to the variable, so it must be defined in the context of the OpenL Tablets framework. Typical examples include the following components:

- method parameter
- local variable
- member of surrounding class

  For OpenL Tablets, it is usually the implementation of IOpenClass called **module**.
- external types accessed as static, which are mostly Java classes imported into OpenL Tablets

Fields and methods used in binding context do not exist in Java; OpenL Tablets allows programmatically adding custom types, fields, and methods into binding context. For different examples of how it can be done, see the source code of the OpenLBuilder classes in different packages. For example, `org.openl.j` automatically imports all classes from the `java.util` in addition to the standard `java.lang` package. Since version 5.1.1, `java.math` is imported automatically.

OpenL Tablets Type System

Java is a type-safe language. However, its type-safety ends when Java has to deal with types that lie outside of the Java type system, such as database tables, http requests, or XML files.

There are two approaches to deal with those external types:

Approaches to deal with types outside the Java type system	
Approach	**Specifics**
using API	• API approach is inherently not type-safe, it treats attribute as literal strings; therefore, even spelling errors become visible only in runtime. • Unless the standard API exists, user’s program becomes dependent on the particular API.
using code generation	• Code generation requires an extra building step and is dependent on particular generator, especially the part where names and name spaces are converted into Java names and packages. • Often, generators introduce dependencies with runtime libraries that affect portability of the code. • Generators usually require full conversion from external data into Java objects that may incur an unnecessary performance penalty when only a few attributes must be accessed.

The **OpenL Tablets open type** system provides a simple way of adding new types into the OpenL Tablets language. It only requires defining a class object that implements the OpenClass interface and adding it to the

OpenL Tablets type system. Implementations can vary, but access to object attributes and methods has the same syntax and provides the same type-checking in all OpenL Tablets code throughout the user application.

OpenL Tablets as OpenL Tablets Type Extension

OpenL Tablets is built on top of the OpenL Tablets type system, thus enabling natural integration into any Java or OpenL Tablets environment. Using the OpenL Tablets methodology, **decision tables** become **methods**, and **data tables** become **fields**. Similar conversion happens to all project artifacts. As a result, any project component can be easily modularly accessed through Java or OpenL Tablets code. An OpenL Tablets project itself becomes a **class** and easy Java access to it is provided through a generated JavaWrapper class.

Operators

Operators are methods with priorities defined by grammar. OpenL Tablets has two major types of operators, unary and binary. In addition, there are operator types used in special cases. A complete list of OpenL Tablets operators used in **org.openl.j** grammar is available at List of org.openl.j Operators.

OpenL Tablets has a modular structure, so OpenL Tablets has configurable, high-level separate components like **parser** and **binder,** and each node type can have its own NodeBinder. At the same time, the single NodeBinder can be assigned to a group of operators, as in the case of the **op.binary** prefix.

op.binary.or || and **op.binary.and &&** have separate NodeBinders to provide short-circuiting for boolean operands. For all other binary operators, OpenL Tablets uses a simple algorithm based on the operator's node type name. For example, if the node type is **op.binary.add**, the algorithm looks for the **add()** method named in the following order:

- **Tx add(T1 p1, T2 p2)** in the **org.openl.operators** namespace in **BindingContext**
- **public Tx T1.add(T2 p2)** in **T1**
- **static public Tx T1.add(T1 p1, T2 p2)** in **T1**
- **static public Tx T2.add(T1 p1, T2 p2)** in **T2**

The found method is executed in runtime. So, to override binary operator **t1 OP t2**, where **t1**, **t2** are objects of classes **T1**, T2**,** perform the following steps:

1. Check operators and find the operator's type name.

   The last part of the type name is the name of the method to be implemented.
2. Use one of the following options available for implementing operators:
   - Put it into the YourCustomOperators class as a static method and register the class as a library in the org.openl.operators namespace

     For more information on how to do that, see OpenLBuilder code.
   - Implement **public Tx name(T2 p2)** as method in T1.
   - Implement **Tx name(T1 p1,T2 p2) as**method in T1.
   - Implement **static public Tx name(T1 p1,T2 p2)** as method in T2.
3. If **T1** and **T2** are different, define both **OP(T1, T2)** and **OP(T2, T1**), unless **autocast()** operator can be relied on or binary operators semantic **map. Autocast** can help skipping implementation when there is already an operator implemented for the autocasted type.

   For example, when having **OP(T1, double),** there is no need to implement **OP(T1, int)** because **int** is autocasted to double. Some performance penalty can be incurred by doing this though. For more information on binary operators semantic map, see Binary Operators Semantic Map.

Binary Operators Semantic Map

There is a convenient feature called *operator semantic map*. It makes implementing some of the operators easier by describing symmetrical and inverse properties for some operators as described in List of opg.openl.j Operator Properties.

Unary Operators

For unary operators, the same method resolution algorithm is being applied, with difference that there is only one parameter to deal with.

Cast Operators

Cast operators in general correspond to Java guidelines and come in two types, **cast** and **autocast. T2 autocast (T1 from, T2 to)** methods are used to overload implicit cast operators, as from int to long, so that actually no cast operators are required in code, T2 cast(T1 from, T2 to) methods are used with explicit cast operators.

Note: It is important to remember that while both **cast()** and **autocast()** methods require two parameters, only T1 from parameter is actually used. The second parameter is used to avoid ambiguity in Java method resolution.

Strict Equality and Relation Operators

Strict operators are the same as their original prototypes used for strict comparison of float point values. Float point numbers are used in JVM as value with an inaccuracy. The original relation and equality operators are used with inaccuracy of float point operations. An example is as follows:

```
1.0 == 1.0000000000000002 – returns true value,
1.0 ==== 1.0000000000000002 (1.0 + ulp(1.0)) – returns false value,
```

where `1.0000000000000002 = 1.0 + ulp(1.0)`.

List of org.openl.j Operators

The `org.openl.j` operators in order of priority are as follows:

org.openl.j operators	
Operator	**org.openl.j operator**
Assignment	
=	op.assign
+=	op.assign.add
-=	op.assign.subtract
*=	op.assign.multiply
/=	op.assign.divide
%=	op.assign.rem
&=	op.assign.bitand
|=	op.assign.bitor
^=	op.assign.bitxor
Conditional Ternary	
? :	op.ternary.qmark

org.openl.j operators	
Operator	**org.openl.j operator**
Implication	
->	op.binary.impl (*)
Boolean OR	
|| or "or"	op.binary.or
Boolean AND	
&& or "and"	op.binary.and
Bitwise OR	
|	op.binary.bitor
Bitwise XOR	
^	op.binary.bitxor
Bitwise AND	
&	op.binary.bitand
Equality	
==	op.binary.eq
!=	op.binary.ne
====	op.binary.strict_eq (*)
!===	op.binary.strict_ne (*)
Relational	
<	op.binary.lt
>	op.binary.gt
<=	op.binary.le
>=	op.binary.ge
<==	op.binary.strict_lt (*)
>==	op.binary.strict_gt (*)
<===	op.binary.strict_le (*)
>===	op.binary.strict_ge (*)
Bitwise Shift	
<<	op.binary.lshift
>>	op.binary.rshift
>>>	op.binary.rshiftu
Additive	
+	op.binary.add
-	op.binary.subtract
Multiplicative	
*	op.binary.multiply
/	op.binary.divide

org.openl.j operators	
Operator	**org.openl.j operator**
%	op.binary.rem
Power	
**	op.binary.pow (*)
Unary	
+	op.unary.positive
-	op.unary.negative
++x	op.prefix.inc
--x	op.prefix.dec
x++	op.suffix.inc
x--	op.suffix.dec
!	op.unary.not
~	op.unary.bitnot
(cast)	type.cast
|x|	op.unary.abs (*)

Note: (*) Operators do not exist in Java standard and exist only in org.openl.j. They can be used and overloaded if necessary.

List of opg.openl.j Operator Properties

opg.openl.j operator properties	
Operator group	**Operators**
Symmetrical	`eq(T1,T2) <=> eq(T2, T1)` `add(T1,T2) <=> add(T2, T1)`

Inverse	`le(T1,T2) <=> gt(T2, T1)`
	`lt(T1,T2) <=> ge(T2, T1)`
	`ge(T1,T2) <=> lt(T2, T1)`
	`gt(T1,T2) <=> le(T2, T1)`

6 Working with Projects

This chapter describes creating an OpenL Tablets project. For more information on projects, see Projects.

The following topics are included in this chapter:

- Project Structure
- Rules Runtime Context
- Project and Module Dependencies

6.1 Project Structure

The best way to use the OpenL Tablets rule technology in a solution is to create an OpenL Tablets project in OpenL Tablets WebStudio. A typical OpenL Tablets project contains Excel files which are physical storage of rules and data in the form of tables. On the logical structure level, Excel files represent modules of the project. Additionally, a project can contain `rules.xml`, Java classes, JAR files, according to developer's needs, and other related documents, such as guides and instructions.

Thereby, the structure can be adjusted according to the developer's preferences, for example, to comply with the Maven structure.

Note for experienced users: The `rules.xml` project file is a rules project descriptor that contains project and configuration details. For instance, a user may redefine a module name there that is the same as a name of the corresponding Excel file by default. When updating project details via OpenL Tablets WebStudio, the `rules.xml` file is automatically created or updated accordingly. For more information on configuring `rules.xml`, see ***[OpenL Tablets Developer's Guide],*** *Rules Project Descriptor* section.

The following topics are included in this section:

- Multi Module Project
- Creating a Project
- Project Sources

Multi Module Project

All modules inside one project have mutual access to each other's tables. It means that a rule or table of a module of a project is accessible and can be referenced and used from any rule of any module of the same project. Projects with several rule modules are called **multi module projects**.

To define compilation order of modules in a project, **module dependencies** are used. When a rule table must be run from another project, project dependencies must be used. For more information on using dependencies, see Project and Module Dependencies.

Creating a Project

The simplest way to create an OpenL Tablets project is to create a project from template in the installed OpenL Tablets WebStudio.

A new project is created containing simple template files that developers can use as the basis for a custom rule solution.

Project Sources

Project sources can be added from developer created artifacts, such as jars and Java classes, which contain a reference to the folder with additional compiled classes to be imported by the module. For that, a rules project must contain the `rules.xml` file created in the project root folder.

Saved classpath is automatically added to the `rules.xml` file. After that, classpath can be used in rules.

```
<classpath>
 <entry path="."/>
 <entry path="auto-rating-model.jar"/>
 <entry path="target/classes"/>
 <entry path="lib"/>
</classpath>
```

Figure 136: Classpath description in the rules.xml

To use a classpath in dependent projects, place a common classpath inside the main dependency project and then reuse it in all dependent projects.

6.2 Rules Runtime Context

OpenL Tablets supports rules overloading by metadata, or business dimension properties.

Sometimes a user needs business rules that work differently but have the same input.
Consider provided vehicle insurance and a premium calculation rule defined for it as follows:

```
PREMIUM = RISK_PREMIUM + VEHICLE_PREMIUM + DRIVER_PREMIUM - BONUS
```

For different US states, there are different bonus calculation policies. In a simple way, for all states there must be different calculations:

```
PREMIUM_1 = RISK_PREMIUM + VEHICLE_PREMIUM + DRIVER_PREMIUM - BONUS_1, for state #1
PREMIUM_2 = RISK_PREMIUM + VEHICLE_PREMIUM + DRIVER_PREMIUM - BONUS_2, for state #2
...
PREMIUM_N = RISK_PREMIUM + VEHICLE_PREMIUM + DRIVER_PREMIUM - BONUS_N, for state #N
```

OpenL Tablets provides a more elegant solution for this case:

```
PREMIUM = RISK_PREMIUM + VEHICLE_PREMIUM + DRIVER_PREMIUM - BONUS*, where
BONUS* = BONUS_1, for state #1
BONUS* = BONUS_2, for state #2
...
BONUS* = BONUS_N, for state #N
```

So a user has one common premium calculation rule and several different rules for bonus calculation. When running premium calculation rule, provide the current state as an additional input for OpenL Tablets to choose the appropriate rule. Using this information OpenL Tablets makes decision which bonus method must be invoked. This kind of information is called **runtime data** and must be set into runtime context before running the calculations.

The following OpenL Tablets table snippets illustrate this sample in action.

SimpleRules DoubleValue **Bonus**()		
properties	state	STATE #1
Bonus Premium		
$100		

SimpleRules DoubleValue **Bonus**()		
properties	state	STATE #2
Bonus Premium		
$150		

SimpleRules DoubleValue **Bonus**()		
properties	state	STATE #N
Bonus Premium		
$200		

Figure 137: The group of Decision Tables overloaded by properties

All tables for bonus calculation have the same header but a different **state** property value.

OpenL Tablets has predefined runtime context which already has several properties.

Managing Rules Runtime Context from Rules

The following additional internal methods for modification, retrieving, and restoring runtime context support work with runtime context from OpenL Tablets rules:

<table>
<tr><th colspan="2">Internal methods for work with runtime context</th></tr>
<tr><th>Method</th><th>Description</th></tr>
<tr><td>getContext()</td><td>Returns a copy of the current runtime context.

Method DoubleValue calcRateForDate (Policy policy, Date date)
IRulesRuntimeContext context = getContext();
context.currentDate = date;
setContext(context);
return calcRate(policy);

Figure 138: Using the getContext function in a method</td></tr>
<tr><td>emptyContext()</td><td>Returns new empty runtime context.</td></tr>
<tr><td>setContext(IRulesRuntimeContext context)</td><td>Replaces the current runtime context with the specified one.</td></tr>
</table>

<table>
<tr><th colspan="2">Internal methods for work with runtime context</th></tr>
<tr><th>Method</th><th>Description</th></tr>
<tr><td>modifyContext(String propertyName, Object propertyValue)</td><td>Modifies the current context by one property: adds a new one or replaces by specified if property with such a name already exists in the current context.
<table>
<tr><th colspan="2">Rules DoubleValue calcRateForState(int homeIndex, Policy policy)</th></tr>
<tr><td>A1</td><td>RET1</td></tr>
<tr><td>modifyContext("usState",stateToSet)</td><td>result</td></tr>
<tr><td>UsStatesEnum stateToSet</td><td>DoubleValue result</td></tr>
<tr><td>State</td><td>Check</td></tr>
<tr><td>=policy.home[homeIndex].state</td><td>=calc(policy)</td></tr>
</table>
Figure 139: Using modifyContext in a rules table
Note: All properties from the current context remain available after modification, so it is only one property update.</td></tr>
<tr><td>restoreContext()</td><td>Discharges the last changes in runtime context. The context is rolled back to the state before the last setContext or modifyContext.
<table>
<tr><th>Method DoubleValue calcAutoRateForMO (Policy policy)</th></tr>
<tr><td>IRulesRuntimeContext context = emptyContext();</td></tr>
<tr><td>context.lob = "auto";</td></tr>
<tr><td>context.usState = UsStatesEnum.MO;</td></tr>
<tr><td>setContext(context);</td></tr>
<tr><td>DoubleValue res = calcRate(policy);</td></tr>
<tr><td>restoreContext();</td></tr>
<tr><td>return res;</td></tr>
</table>
Figure 140: Using restoreContext in a method table</td></tr>
</table>

ATTENTION: All changes and rollbacks must be controlled manually: all changes applied to runtime context will remain after rule execution. Make sure that the changed context is restored after the rule is executed to prevent unexpected behavior of rules caused by unrestored context.

6.3 Project and Module Dependencies

Dependencies provide more flexibility and convenience. They may divide rules into different modules and structure them in a project or add other related projects to the current one. For example, if a user has several projects with different modules, all user projects share the same domain model or use similar helpers rules, and to avoid rules duplication, put the common rules and data to a separate module and add this module as dependency for all required modules.

Dependencies glossary	
Term	**Description**
Dependency module	Module that is used as a dependency.
Dependency project	Project that is used as a dependency.
Root module	Module that has dependency declaration, explicit via environment or implicit via project dependency, to other module.
Root project	Project that has dependency declaration to other project.

The following topics are included in this section:

- Dependencies Description
- Dependencies Configuration
- Import Configuration
- Components Behavior

Dependencies Description

The **module dependency** feature allows making a hierarchy of modules when rules of one module depend on rules of another module. As mentioned before, all modules of one project have mutual access to each other's tables. Therefore, module dependencies are intended to order them in the project if it is required for compilation purposes. Module dependencies are commonly established among modules of the same project. An exception is as follows.

The following diagram illustrates a project in which the content of **Module_1** and **Module_2** depends on the content of **Module_3,** where thin black arrows are module dependencies:

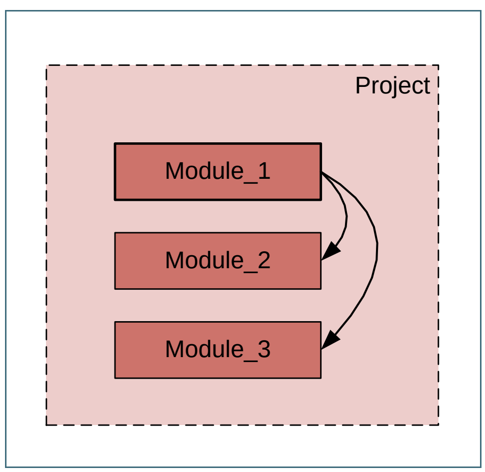


Figure 141: Example of a project with modules hierarchy

In addition, **project dependency** enables accessing modules of other projects from the current one:

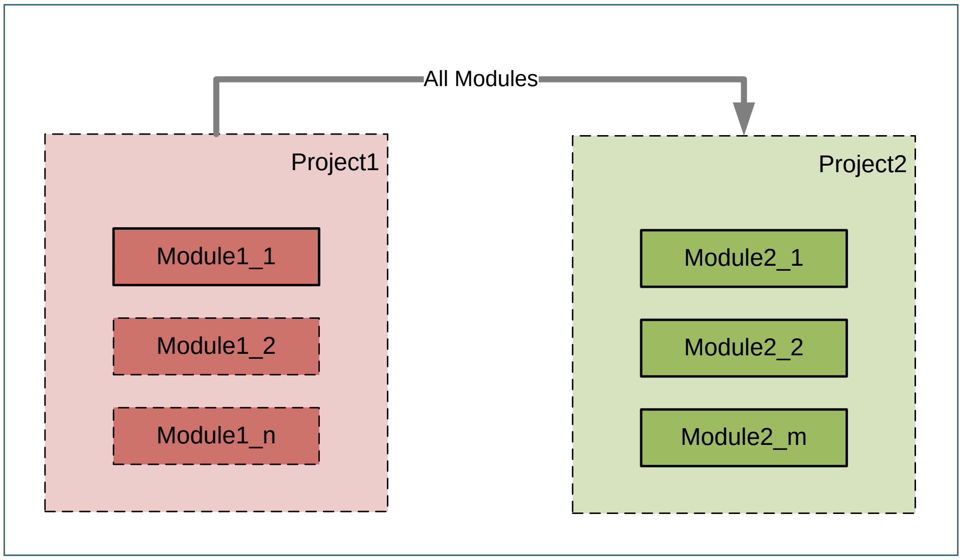


Figure 142: Example of a project dependency with all modules

The previous diagram displays that any module of **Project1** can execute any table of any module of **Project2***:* thick gray arrow with the **All Modules** label is a project dependency with all dependency project modules included. This is equivalent to the following schema when each module of **Project1** has implicit dependency declaration to each module of **Project2**:

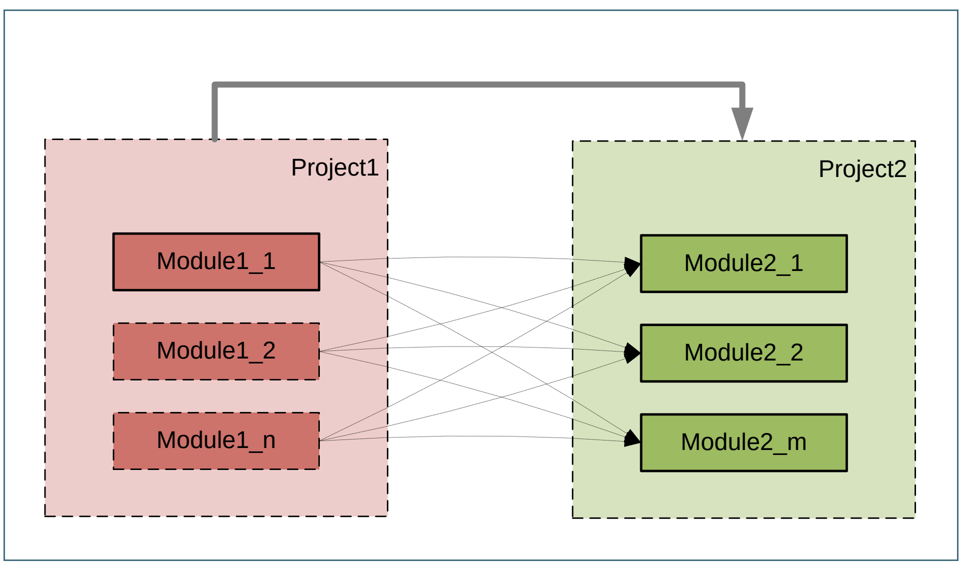


Figure 143: Interpretation of a project dependency (with all modules)

The project dependency with the **All Modules** setting switched on provides access to any module of a dependency project from the current root project.

Users may combine module and project dependencies if only a particular module of another project must be used. An example is as follows:

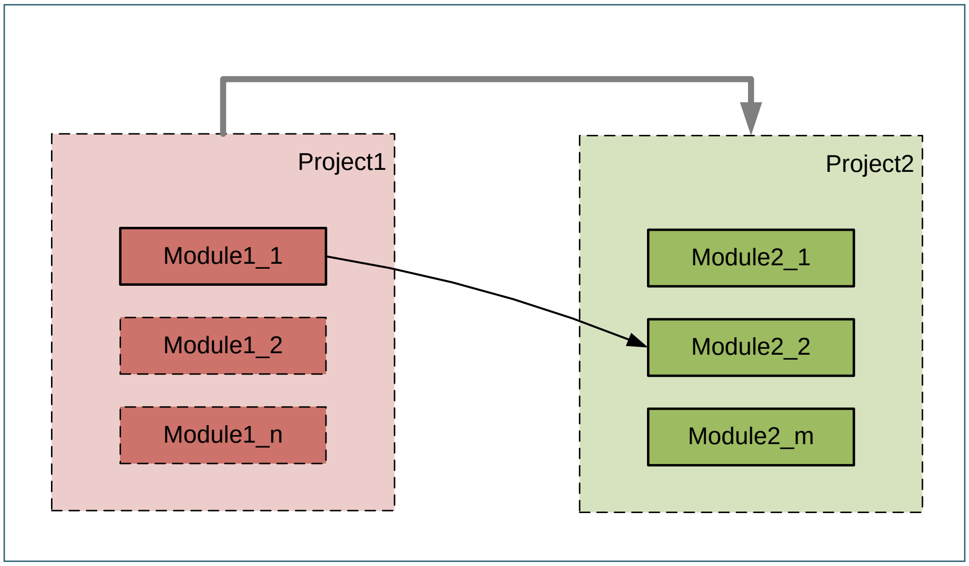


Figure 144: Example of a project and module dependencies combined

In the example, for defined external **Project2**, only the content of **Module2_2** is accessible from **Project1**: thick gray arrow without label is a project dependency which defines other projects where dependency module can be located.

If the project dependency does not have the **All Modules** setting enabled, dependencies are determined on the module level, and such project dependencies serve the isolation purpose thus enabling getting a dependency module from particular external projects.

After adding a dependency, all its rules, data fields, and datatypes are accessible from the root module. The root module can call dependency rules.

Dependencies Configuration

This section describes dependencies configuration.

1. To add a dependency to a module, add the instruction to a configuration table as described in Configuration Table using the **dependency** command and the name of the module to be added.

   A module can contain any number of dependencies. Dependency modules can also have dependencies. Avoid using cyclic dependencies.

Environment	
dependency	Module2_2

Figure 145: Example of configuring module dependencies

2. To configure a project dependency, in a rules project descriptor, in the `rules.xml` file created in the project root folder, in the **Dependency** section, for the **name** tag used for defining the dependency project name, set the **autoIncluded** tag to **true** or **false**.

```
<dependencies>
  <dependency>
    <name>Project Name</name>
    <autoIncluded>false</autoIncluded>
  </dependency>
</dependencies>
<properties-file-name-processor>
```

Figure 146: Example of configuring project dependencies – fragment of rules.xml

For more information on configuring `rules.xml`, see ***[OpenL Tablets Developer's Guide]***, *Rules Project Descriptor* section.

By a business user, project dependencies are easily set and updated in OpenL Tablets WebStudio as described in ***[OpenL Tablets WebStudio User Guide]***, *Defining Project Dependencies* section.

A project can contain any number of dependencies. Dependency projects may also have dependencies. Avoid cyclic dependencies. Module names of the root and dependency projects must be unique.

When OpenL Tablets is processing a module, if there is any dependency declaration, it is loaded and compiled before the root module. When all required dependencies are successfully compiled, OpenL Tablets compiles the root module with awareness about rules and data from dependencies.

Import Configuration

Using import instructions allows adding external rules and datatypes from developer created artifacts, such as jars and Java classes, located outside the Excel based rule tables. In the import instruction, list all Java packages holding datatypes and Java classes that must become accessible in the module.

Import configuration is defined using the **Environment** table. Configuration can be made for any user mode, single-user mode or multi-user mode. For proper import configuration, classpath must be registered in project sources as described in Project Sources.

In the following example, the **Environment** table contains an import section with reference to the corresponding Java package:

Environment	
import	com.generated.rating.auto

Figure 147: Example of configuring module import

Common Java imports can be placed only into the main, or dependency, project or module. When working with a dependent project, there is no need to specify **Import** in this project. Import data is retrieved directly from the dependency project. Dependency instruction makes all import instructions applied to the dependent module.

Components Behavior

All OpenL Tablets components can be divided into three types:

- Rules in rule tables as described in Decision Table, Spreadsheet Table, Method Table, TBasic Table.
- Data in data tables as described in Data table.
- Data types in data type tables as described in Datatype Table.

The following table describes behavior of different OpenL Tablets components in dependency infrastructure:

OpenL Tablets components behavior in dependency infrastructure			
Operations or components	**Rules**	**Datatypes**	**Data**
Can access components in a root module from dependency.	Yes.	Yes.	Yes.
Both root and dependency modules contain a similar component.	1. Rules with the same signature and without dimension properties: duplicate exception. 2. Methods with the same signature and with a number of dimension properties: they are wrapped by Method Dispatcher. At runtime, a method that matches the runtime context properties is executed. 3. Methods with the same signature and with property active: only one table can be set to true. Appropriate validation checks this case at compilation time.	Duplicate exception.	Duplicate exception.
None of root and dependency modules contain the component.	**There is no such method** exception during compilation.	There is no such datatype exception during compilation.	**There is no such field** exception during compilation.

7 Appendix A: BEX Language Overview

This chapter provides a general overview of the BEX language that can be used in OpenL Tablets expressions.

The following topics are included in this chapter:

7.1 Introduction to BEX

BEX language provides a flexible combination of grammar and semantics by extending the existing Java grammar and semantics presented in the `org.openl.j` configuration using new grammar and semantic concepts. It enables users to write expressions similar to natural human language.

BEX does not require any special mapping; the existing Java business object model automatically becomes the basis for open business vocabulary used by BEX. For example, the **policy.effectiveDate** Java expression is equivalent to the **Effective Date of the Policy** BEX expression.

If the Java model correctly reflects business vocabulary, no further action is required. Otherwise, custom type-safe mapping or renaming can be applied.

7.2 Keywords

The following table represents BEX keyword equivalents to Java expressions:

BEX keywords equivalent to Java expressions	
Java expression	**BEX equivalents**
`==`	• `equals to` • `same as`
`!=`	• `does not equal to` • `different from`
`a.b`	`b of the a`
`<`	`is less than`
`>`	`is more than`
`<=`	• `is less or equal` • `is in`
`!>`	`is no more than`
`>=`	`is more or equal`
`!<`	`is no less than`

Because of these keywords, name clashes with business vocabulary can occur. The easiest way to avoid clashes is to use upper case notation when referring to model attributes because BEX grammar is case sensitive and all keywords are in lower case.

For example, assume there is an attribute called `isLessThanCoverageLimit`. If it is referred to as **is less than coverage limit**, a name clash with keywords **is less than** occurs. The workaround is to refer to the attribute as **Is Less Than Coverage Limit**.

7.3 Simplifying Expressions

Unfortunately, the more complex an expression is, the less comprehensible the natural language expression becomes in BEX. For this purpose, BEX provides the following methods for simplifying expressions:

- Notation of Explanatory Variables
- Uniqueness of Scope

Notation of Explanatory Variables

BEX supports a notation where an expression is written using simple variables followed by the attributes they represent. For example, assume that the following expression is used in Java:

```
(Agreed Value of the vehicle - Market Value of the vehicle) / Market Value of the vehicle is
more than Limit Defined By User
```

The expression is hard to read. However, it becomes much simpler if written according to the notion of explanatory variables as follows:

```
(A - M) / M > X, where
  A - Agreed Value of the vehicle,
  M - Market Value of the vehicle,
  X - Limit Defined By User
```

This syntax is similar to the one used in scientific publications and is much easier to read for complex expressions. It provides a good mix of mathematical clarity and business readability.

Uniqueness of Scope

BEX provides another way for simplifying expressions using the concept of unique scope. For example, if there is only one policy in the scope of expression, a user can write **effective date** instead of **effective date of the policy**. BEX automatically determines uniqueness of the attribute and either produces a correct path or emits an error message in case of ambiguous statement. The level of the resolution can be modified programmatically and by default equals 1.

8 Appendix B: Functions Used in OpenL Tablets

This chapter provides a complete list of functions available in OpenL Tablets and includes the following sections:

- Math Functions
- Array Functions
- Date Functions
- String Functions
- Special Functions

8.1 Math Functions

Math functions	
Function	**Description**
abs(a)	Returns the absolute value of a number.
acos(double a)	Returns the arc cosine of a value. The returned angle is in the range 0.0 through pi.
asin(double a)	Returns the arc sine of a value. The returned angle is in the range -pi/2 through pi/2.
atan(double a)	Returns the arc tangent of a value; the returned angle is in the range -pi/2 through pi/2.
atan2(double y, double x)	Returns the angle theta from the conversion of rectangular coordinates (x, y) to polar coordinates (r, theta).
cbrt(double a)	Returns the cube root of a double value.
ceil(double a)	Returns the smallest (closest to negative infinity) double value that is greater than or equal to the argument and is equal to a mathematical integer.
copySign(magnitude, sign)	Returns the first floating-point argument with the sign of the second floating-point argument.
cos(double a)	Returns the trigonometric cosine of an angle.
cosh(double x)	Returns the hyperbolic cosine of a double value.
cosh(double x)	Returns the hyperbolic cosine of a double value.
exp(double a)	Returns Euler's number e raised to the power of a double value.
expm1(double x)	Returns ex -1.
floor(double a)	Returns the largest (closest to positive infinity) double value that is less than or equal to the argument and is equal to a mathematical integer.
format(double d)	Formats double value.
format(double d, String fmt)	Formats double value according to Format fmt.
getExponent(a)	Returns the unbiased exponent used in the representation of a.
getExponent(double x, double y)	Returns sqrt(x2 +y2) without intermediate overflow or underflow.
IEEEremainder(double f1, double f2)	Computes the remainder operation on two arguments as prescribed by the IEEE 754 standard.
log(double a)	Returns the natural logarithm (base e) of a double value.
log10(double a)	Returns the base 10 logarithm of a double value.

Math functions	
Function	**Description**
log1p(double x)	Returns the natural logarithm of the sum of the argument and 1.
mod(number, divisor)	Returns the remainder after a number is divided by a divisor.
nextAfter(start, direction)	Returns the floating-point number adjacent to the first argument in the direction of the second argument.
pow(double a, double b)	Returns the value of the first argument raised to the power of the second argument.
quotient(number, divisor)	Returns the quotient from division number by divisor.
random()	Returns a double value with a positive sign, greater than or equal to 0.0 and less than 1.0.
rint(double a)	Returns the double value that is closest in value to the argument and is equal to a mathematical integer.
round(value)	Returns the closest value to the argument, with ties rounding up.
round(value, int scale, int roundingMethod)	Returns a BigDecimal which scale is the specified value, and which unscaled value is determined by multiplying or dividing this BigDecimal's unscaled value by the appropriate power of ten to maintain its overall value.
scalb(a, int scaleFactor)	Return a × 2scaleFactor rounded as if performed by a single correctly rounded floating-point multiply to a member of the double value set.
signum(double d) / (float f)	Returns the signum function of the argument; zero if the argument is zero, 1.0 if the argument is greater than zero, -1.0 if the argument is less than zero.
sin(double a)	Returns the trigonometric sine of an angle.
sinh(double x)	Returns the hyperbolic sine of a double value.
sqrt(double a)	Returns the correctly rounded positive square root of a double value.
tan(double a)	Returns the trigonometric tangent of an angle.
tanh(double x)	Returns the hyperbolic tangent of a double value.
toDegrees(double angrad)	Converts an angle measured in radians to an approximately equivalent angle measured in degrees.
toRadians(double angdeg)	Converts an angle measured in degrees to an approximately equivalent angle measured in radians.
ulp(value)	Returns the size of an ulp of the argument.

8.2 Array Functions

Array functions	
Function	**Description**
add(array[],element)	Copies the given array and adds the given element at the end of the new array.
add(array[],index, element)	Inserts the specified element at the specified position in the array.
addAll(array1[], array2[])	Adds all elements of the given arrays into a new array.
addIgnoreNull(array[], element)	Copies the given array and adds the given element at the end of the new array.
addIgnoreNull(array[], int index, element)	Inserts the specified element at the specified position in the array.

Array functions	
Function	**Description**
allTrue(Boolean[] values)	Returns true if all array elements are true.
anyTrue(Boolean[] values)	Returns true if any array element is true.
avg(array[])	Returns the arithmetic average of the array of number elements.
big(array[], int position)	Removes null values from array, sorts an array in descending order and returns the value at position '*position*'.
contains(array, elem)	Checks if the value is in the given array.
indexOf(array[], elem)	Finds the index of the given value in the array.
intersection(String[] array1, String[] array2)	Returns a new array containing elements common to the two arrays.
isEmpty(array[])	Checks if an array is empty or null.
flatten(arrayN)	Returns a flatten array with values from arrayN. Returns Object[] of arrayN fields.
max(array[])	Returns the maximal value in the array of numbers.
min(array[])	Returns the minimal value in the array of numbers.
noNulls(array[])	Checks if the array is non-empty and has only non-empty elements.
product(array [] values)	Multiplies the numbers from the provided array and returns the product as a number.
remove(array [] , int index)	Removes the element at the specified position from the specified array.
removeElement(array [], element)	Removes the first occurrence of the specified element from the specified array.
removeNulls(T[] array)	Returns a new array without null elements.
slice(Array[], int startIndexInclusive, int endIndexExclusive)	Returns a part of array from startIndexInclusive to endIndexExclusive.
small(Array[], int position)	Removes null values from array, sorts an array in ascending order and returns the value at position 'position'.
sort(Array[])	Sorts the specified array of values into ascending order, according to the natural ordering of its elements.
sum(array[])	Returns the sum of numbers in the array.

8.3 Date Functions

Date functions	
Function	**Description**
absMonth(Date)	Returns the number of months since AD.
absQuarter(Dat)	Returns the number of quarters since AD as an integer value.
amPm(Date d)	Returns `Am` or `Pm` value for an input Date as a String.
dateToString(Date date)	Converts a date to the String.

Date functions	
Function	**Description**
dateToString(Date date, dateFormat)	Converts a date to the String according dateFormat.
dayDiff(Date d1, Date d2)	Returns the difference in days between endDate and startDate.
dayOfMonth(Date d)	Returns the day of month.
dayOfWeek(Date d)	Returns the day of week.
dayOfYear(Date d)	Returns the day of year.
firstDateOfQuarter(int absQuarter)	Returns the first date of quarter.
hour(Date d)	Returns the hour.
hourOfDay(Date d)	Returns the hour of day.
lastDateOfQuarter(int absQuarter)	Returns the last date of the quarter.
lastDayOfMonth(Date d)	Returns the last date of the month.
minute(Date d)	Returns the minute.
month(Date d)	Returns the month (0 to 11) of an input date.
monthDiff(Date d1, Date d2)	Return the difference in months before d1 and d2.
quarter(Date d)	Returns the quarter (0 to 3) of an input date.
second(Date d)	Returns the second of an input date.
weekDiff(Date d1, Date d2)	Returns the difference in weeks between endDate and startDate.
weekOfMonth(Date d)	Returns the week of the month within which that date is.
weekOfYear(Date d)	Returns the week of the year on which that date falls.
yearDiff(Date d1, Date d2)	Returns the difference in years between endDate and startDate.
year(Date d)	Returns the year (0 to 59) for an input Date.

8.4 String Functions

String functions		
Function	**Description**	**Comment**
contains(String str, char searchChar)	Checks if String contains a search character, handling null.	
contains(String str, String searchStr)	Checks if String contains a search String, handling null.	
containsAny(String str, char[] chars)	Checks if the String contains any character in the given set of characters.	
containsAny(String str, String searchChars)	Checks if the String contains any character in the given set of characters.	
endsWith(String str, String suffix)	Check if a String ends with a specified suffix.	
isEmpty(String str)	Checks if a String is empty ("") or null.	
lowerCase(String str)	Converts a String to lower case.	

String functions		
Function	**Description**	**Comment**
removeEnd(String str, String remove)	Removes a substring only if it is at the end of a source string, otherwise returns the source string.	
removeStart(String str, String remove)	Removes a substring only if it is at the beginning of a source string, otherwise returns the source string.	
replace(String str, String searchString, String replacement)	Replaces all occurrences of a String within another String.	
replace(String str, String searchString, String replacement, int max)	Replaces a String with another String inside a larger String, for the first max values of the search String.	
startsWith(String str, String prefix)	Check if a String starts with a specified prefix.	
substring(String str, int beginIndex)	Gets a substring from the specified String.	A negative start position can be used to start n characters from the end of the String.
substring(String str, int beginIndex, int endIndex)	Gets a substring from the specified String.	A negative start position can be used to start or end n characters from the end of the String.
upperCase(String str)	Converts a String to upper case.	

8.5 Special Functions

Special functions		
Function	**Description**	**Comment**
error(String msg)	Shows the error message.	
getValues(MyAliasDatatype)	Returns arrays of values from the MyAliasDatatype alias.	Returns Object[] of MyAliasDatatype fields.

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