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Index
Preface

This Preface contains these topics:

- Audience
- Documentation Accessibility
- Related Documents
- Conventions

Audience

Oracle Fusion Middleware Language Reference Guide for Oracle Business Rules is intended for application developers and Oracle Application Server administrators who perform the following tasks:

- Develop rule enabled applications
- Debug rule enabled applications
- Deploy and Administer rule enabled applications.
- Develop rulesets for those who prefer a technical language environment instead of the Oracle Business Rules Rule Author graphical environment for rule authoring.
- Need to use Oracle Business Rules RL Language advanced features that are not available in the Oracle Business Rules Rule Author environment.

To use this document, you need to be familiar with the Java programming language.

Documentation Accessibility

Our goal is to make Oracle products, services, and supporting documentation accessible to all users, including users that are disabled. To that end, our documentation includes features that make information available to users of assistive technology. This documentation is available in HTML format, and contains markup to facilitate access by the disabled community. Accessibility standards will continue to evolve over time, and Oracle is actively engaged with other market-leading technology vendors to address technical obstacles so that our documentation can be accessible to all of our customers. For more information, visit the Oracle Accessibility Program Web site at http://www.oracle.com/accessibility/.

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Screen readers may not always correctly read the code examples in this document. The conventions for writing code require that closing braces should appear on an
otherwise empty line; however, some screen readers may not always read a line of text that consists solely of a bracket or brace.

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**Related Documents**

Printed documentation is available for sale in the Oracle Store at [http://oraclestore.oracle.com/](http://oraclestore.oracle.com/)

To download free release notes, installation documentation, white papers, or other collateral, please visit the Oracle Technology Network (OTN). You must register online before using OTN; registration is free and can be done at [http://www.oracle.com/technology/membership/index.html](http://www.oracle.com/technology/membership/index.html)

If you already have a username and password for OTN, then you can go directly to the documentation section of the OTN Web site at [http://www.oracle.com/technology/documentation/index.html](http://www.oracle.com/technology/documentation/index.html)

**Conventions**

This section describes the conventions used in the text and code examples of this documentation set. It describes:

- **Conventions in Text**
- **RL Language Backus-Naur Form Grammar Rules**

**Conventions in Text**

<table>
<thead>
<tr>
<th>Convention</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>boldface</strong></td>
<td>Boldface type indicates graphical user interface elements associated with an action, or terms defined in text or the glossary.</td>
</tr>
<tr>
<td><strong>italic</strong></td>
<td>Italic type indicates book titles, emphasis, or placeholder variables for which you supply particular values.</td>
</tr>
<tr>
<td><strong>monospace</strong></td>
<td>Monospace type indicates commands within a paragraph, URLs, code in examples, text that appears on the screen, or text that you enter.</td>
</tr>
</tbody>
</table>

**RL Language Backus-Naur Form Grammar Rules**

Each RL Language command in the guide is shown in a format description that consists of a variant of Backus-Naur Form (BNF) that includes the symbols and conventions in the following table.
<table>
<thead>
<tr>
<th>Symbol or Convention</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ ]</td>
<td>Brackets enclose optional items.</td>
</tr>
<tr>
<td>{ }</td>
<td>Braces enclose items only one of which is required.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>*</td>
<td>A star indicates that an element can be repeated.</td>
</tr>
<tr>
<td>delimiters</td>
<td>Delimiters other than brackets, braces, vertical bars, stars, and ellipses must be entered as shown.</td>
</tr>
<tr>
<td><strong>boldface</strong></td>
<td>Words appearing in boldface are keywords. They must be typed as shown.</td>
</tr>
<tr>
<td><strong>underline</strong></td>
<td>When on the left side of a production ( ::= ) indicates a definition for a non-terminal symbol.</td>
</tr>
<tr>
<td><strong>underline</strong></td>
<td>When found on the right side of a production, ::=, a link, which is a non-terminal symbol, links to the definition for the non-terminal symbol.</td>
</tr>
<tr>
<td><em>italic text</em></td>
<td>Semantic information about non-terminals, such as the required data type for an expression or a descriptive tag used in following discussion, is in italics.</td>
</tr>
</tbody>
</table>
This chapter introduces Oracle Business Rules RL Language (RL Language) concepts. This chapter includes the following sections:

- Section 1.1, "Starting the Oracle Business Rules RL Language Command-Line"
- Section 1.2, "Introducing Rules and Rulesets"
- Section 1.3, "Introducing Facts and RL Language Classes"
- Section 1.4, "Understanding and Controlling Rule Firing"
- Section 1.5, "Using Effective Dates"
- Section 1.6, "Integrating RL Language Programs with Java Programs"
- Section 1.7, "Using Decision Tracing"
- Section 1.8, "Building a Coin Counter Rules Program"
1.1 Starting the Oracle Business Rules RL Language Command-Line

The Oracle Business Rules environment is implemented in a JVM or in a J2EE container by the classes supplied with \texttt{rl.jar}. Start the RL Language command-line interface using the following command:

\begin{verbatim}
java -jar $ORACLE_HOME/soa/modules/oracle.rules_11.1.1/rl.jar -p "RL> 
\end{verbatim}

Where \texttt{ORACLE_HOME} is where SOA modules are installed (for example, \texttt{c:/Oracle/Middleware}). The \texttt{-p} option specifies the prompt.

The RL Language command-line interface provides access to an Oracle Business Rules \textit{RuleSession}. The RuleSession is the API that allows Java programmers to access the RL Language in a Java application (the command-line interface uses a RuleSession internally).

You can run the program in Example 1–1 using the command-line interface by entering the text shown at the \texttt{RL>} prompt.

\begin{example}
\texttt{Example 1–1 Using the Command-Line Interface}
\begin{verbatim}
RL> println(1 + 2);
3
RL> final int low = -10;
RL> final int high = 10;
RL> println(low + high * high);
90
RL> exit;
\end{verbatim}
\end{example}

\begin{itemize}
\item See Also:
\begin{itemize}
\item Chapter 3, "Using the Command-line Interface" for more details and for a list of command-line options
\item Chapter 4, "Using a RuleSession" for details on Oracle Business Rules RuleSession API
\end{itemize}
\end{itemize}

1.2 Introducing Rules and Rulesets

An RL Language \textit{ruleset} provides a namespace, similar to a Java package, for RL classes, functions, and rules. In addition, you can use rulesets to partially order rule firing. A ruleset may contain executable actions, may include or contain other rulesets, and may import Java classes and packages.

An RL Language \textit{rule} consists of \textit{rule conditions}, also called \textit{fact-set-conditions}, and an \textit{action-block} or list of actions. Rules follow an if-then structure with rule conditions followed by rule actions.

\textbf{Example 1–2} shows a program that prints, "Hello World." This example demonstrates a program that contains a single top-level action in the default ruleset (named \texttt{main}). \textbf{Example 1–2} contains only an action, and does not define a rule, so the action executes immediately at the command-line.

\begin{example}
\texttt{Example 1–2 Hello World Programming Example}
\begin{verbatim}
RL> println("Hello World");
Hello World
RL>
\end{verbatim}
\end{example}
1.2.1 Rule Conditions

A rule condition is a component of a rule that is composed of conditional expressions that refer to facts.

In the following example the conditional expression refers to a fact (Driver instance d1), followed by a test that the fact’s data member, age, is less than 16.

```
if (fact Driver d1 && d1.age < 16)
```

Example 1–3 shows the complete rule, written in RL Language (the rule includes a rule condition and a rule action).

The Oracle Rules Engine activates a rule whenever there is a combination of facts that makes the rule’s conditional expression true. In some respects, a rule condition is like a query over the available facts in the Oracle Rules Engine, and for every row that returns from the query, the rule activates.

---

**Note:** Rule activation is different from rule firing. For more information, see Section 1.4, "Understanding and Controlling Rule Firing".

---

**Example 1–3  Defining a Driver Age Rule**

```
RL> rule driverAge{
   if (fact Driver d1 && d1.age < 16)
   {
      println("Invalid Driver");
   }
}
```

1.2.2 Rule Actions

A rule action is activated if all of the rule conditions are satisfied. There are several kinds of actions that a rule’s action-block might perform. For example, an action in the rule’s action-block can add new facts by calling the assert function or remove facts by calling the retract function. An action can also execute a Java method or perform an RL Language function (Example 1–3 uses the println function). Using actions, you can call functions that perform a desired task associated with a pattern match.

1.3 Introducing Facts and RL Language Classes

This section describes Oracle Business Rules facts and includes the following sections:

- What Are Facts?
- Adding Facts to Working Memory with Assert
- Using RL Language Classes as Facts
- Using Java Classes as Facts
1.3.1 What Are Facts?

Oracle Business Rules facts are asserted objects. For Java objects, a fact is a shallow copy of the object, meaning that each property is cloned, if possible, and if not, then the fact is a copy of the Java object reference.

In RL Language, a Java object is an instance of a Java class and an RL Object is an instance of an RL Language class. You can use Java classes in the classpath or you can define and use RL Language classes in a ruleset. You can also declare additional properties that are associated with the existing properties or methods of a Java class using a fact class declaration. You can hide properties of a Java class that are not needed in facts using a fact class declaration.

An RL Language class is similar to a Java Bean without methods. An RL class contains set of named properties. Each property has a type that is either an RL class, a Java object, or a primitive type.

Using Oracle Business Rules, you typically use Java classes, including JAXB generated classes that support the use of XML, to create rules that examine the business objects in a rule enabled application, or to return results to the application. You typically use RL classes to create intermediate facts that can trigger other rules in the Oracle Rules Engine.

1.3.2 Adding Facts to Working Memory with Assert

Oracle Business Rules uses working memory to contain facts (facts do not exist outside of working memory). A RuleSession contains the working memory.

A fact in RL Language is an asserted instance of a class. Example 1–4 shows the assert function that adds an instance of the RL class `enterRoom` as a fact to working memory. A class that is the basis for asserted facts may be defined in Java or in RL Language.

In Example 1–4 the `sayHello` rule matches facts of type `enterRoom`, and for each such fact, prints a message. The action new, shown in the assert function, creates an instance of the `enterRoom` class.

In Example 1–4 the run function fires the `sayHello` rule.

---

**Note:** The RL Language new keyword extends the Java new functionality with the capability to specify initial values for properties.

---

**Example 1–4 Matching a Fact Defined by an RL Language Class**

```
RL> class enterRoom { String who; }
RL> assert(new enterRoom(who: "Bob"));
RL> rule sayHello {
   if ( fact enterRoom ) {
      println("Hello ' + enterRoom.who;
   }
}
RL> run();
Hello Bob
RL>
```

**See Also:** "Understanding and Controlling Rule Firing" on page 1-6
1.3.3 Using RL Language Classes as Facts

You can use RL Language classes in a rules program to supplement a Java application's object model, without having to change the application code for the Java application that supplies Java Objects.

Example 1–5 shows the goldCust rule uses a Java class containing customer data, cust; the rule's action asserts an instance of the GoldCustomer RL class, representing a customer that spends more than 500 dollars in a three month period. The Java Customer class includes a method SpentInLastMonths that is supplied an integer representing a number of months of customer data to add.

Example 1–5  goldCust Rule

```java
rule goldCust {
  if (fact Customer cust && cust.SpentInLastMonths(3) > 500 ){
    assert (new GoldCustomer(cust: cust));
  }
}
```

Example 1–6 shows the goldDiscount rule uses the RL fact GoldCustomer to infer that if a customer spent $500 within the past 3 months, then the customer is eligible for a 10% discount.

Example 1–6  goldDiscount Rule

```java
rule goldDiscount {
  if (fact Order ord & fact GoldCustomer(cust: ord.customer) )
  {
    ord.discount = 0.1;
    assert(ord);
  }
}
```

Example 1–7 shows the declaration for the GoldCustomer RL class (this assumes that you also have the Customer class available in the classpath).

Example 1–7  Declaring an RL Language Class

```java
class GoldCustomer {
  Customer cust;
}
```

See Also:  "Adding Facts to Working Memory with Assert" on page 1-4

1.3.4 Using Java Classes as Facts

You can use asserted Java objects as facts in an RL Language program. You are not required to explicitly define or declare the Java classes. However, you must include the Java classes in the classpath when you run the program. This lets you use the Java classes in rules, and allows a rules program to access and use the public attributes, public methods, and bean properties defined in the Java class (bean properties are preferable for some applications because the Oracle Rules Engine can detect that a Java object supports PropertyChangeListener; in this case it uses that mechanism to be notified when the object changes).

In addition, Fact class declarations can fine tune the properties available to use in an RL program, and may be required for certain multiple inheritance situations.
When you work with Java classes, using the import statement lets you omit the package name (see Example 1–8).

**Example 1–8  Sample Java Fact with Import**

```
ruleset main
{
    import example.Person;
    import java.util.*;
    rule hasNickNames
    {
        if (fact Person p && ! p.nicknames.isEmpty() )
        {
            // accessing properties as fields:
            println(p.firstName + " " + p.lastName + " has nicknames: ");
            Iterator i = p.nicknames.iterator();
            while (i.hasNext())
            {
                println(i.next());
            }
        }
    }
}
```

See Also:
- "Fact Class Declarations" on page 2-21
- "Import Statement" on page 2-25

### 1.4 Understanding and Controlling Rule Firing

This section covers the following topics:

- Rule Activation and the Agenda
- Watching Facts, Rules, and Rule Activations
- Ordering Rule Firing

#### 1.4.1 Rule Activation and the Agenda

The Oracle Rules Engine matches facts against the rule conditions (fact-set-conditions) of all rules as the state of working memory changes. The Oracle Rules Engine only checks for matches when the state of working memory changes, typically when a fact is asserted or retracted. A group of facts that makes a given rule condition true is called a fact set row. A fact set is a collection of all the fact set rows for a given rule. Thus a fact set consists of the facts that match the rule conditions for a rule. For each fact set row in a fact set, an activation, consisting of a fact set row and a reference to the rule is added to the agenda (the agenda contains the complete list of activations).

Figure 1–1 shows a RuleSession with an agenda containing activations in working memory.
The `run`, `runUntilHalt`, and `step` functions execute the activations on the agenda, that is, these commands *fire* the rules (use the `step` command to fire a specified number of activations).

Rules fire when the Oracle Rules Engine removes activations, by popping the activations off the agenda and performing the rule’s actions.

The Oracle Rules Engine may remove activations without firing a rule if the rule conditions are no longer satisfied. For example, if the facts change or the rule is cleared then activations may be removed without firing. Further, the Oracle Rules Engine removes activations from the agenda when the facts referenced in a fact set row are modified or the facts are retracted, such that they no longer match a rule condition (and this can also happen in cases where new facts are asserted, when the ! operator applies).

Note the following concerning rule activations:

1. Activations are created, and thus rules fire only when facts are asserted, modified, or retracted (otherwise, the rules would fire continuously).
2. If a rule asserts a fact that is mentioned in the rule condition, and the rule condition is still true, then a new activation is added back to the agenda and the rule fires again (in this case the rule would fire continuously). This behavior is often a bug.
3. The actions associated with a rule firing can change the set of activations on the agenda, by modifying facts, asserting facts, or retracting facts, and this can change the next rule to fire.
4. Rules fire sequentially, not in parallel.

See Also: Ordering Rule Firing on page 1-9

### 1.4.2 Watching Facts, Rules, and Rule Activations

You can use the functions `watchActivations`, `watchFacts`, `watchRules`, and `showFacts` to help write and debug RL Language programs.

This section covers the following topics:

- Watching and Showing Facts in Working Memory
- Watching Activations and Rule Firing
1.4.2.1 Watching and Showing Facts in Working Memory

Example 1–9 shows the watchFacts function that prints information about facts entering and leaving working memory.

As shown in Example 1–9, the watchFacts function prints \(==\) when a fact is asserted. Each fact is assigned a short identifier, beginning with \(f-\), so that the fact may be referenced. For example, activations include a reference to the facts that are passed to the rule actions.

In Example 1–9, notice that the program uses the default ruleset main. This ruleset contains the enterRoom class.

**Example 1–9 Using watchFacts with enterRoom Facts**

```plaintext
RL> watchFacts();
RL> class enterRoom (String who;)
RL> assert(new enterRoom(who: "Rahul"));
   ==> f-1 main.enterRoom(who : "Rahul")
RL> assert(new enterRoom(who: "Kathy"));
   ==> f-2 main.enterRoom(who : "Kathy")
RL> assert(new enterRoom(who: "Tom"));
   ==> f-3 main.enterRoom(who : "Tom")
RL>
```

You can use showFacts to show the current facts in working memory. Example 1–10 shows that the Oracle Rules Engine asserts the initial-fact, \(f-0\) (the Oracle Rules Engine uses this fact internally).

**Example 1–10 Show Facts in Working Memory**

```plaintext
RL> showFacts();
f-0   initial-fact()
f-1   main.enterRoom(who : 'Rahul')
f-2   main.enterRoom(who : 'Kathy')
f-3   main.enterRoom(who : 'Tom')
For a total of 4 facts.
```

Use retract to remove facts from working memory, as shown in Example 1–11. When watchFacts is enabled, the Oracle Rules Engine prints \(<==\) when a fact is retracted.

**Example 1–11 Retracting Facts from Working Memory**

```plaintext
RL> watchFacts();
RL> retract(object(2));
   <== f-2 main.enterRoom(who : 'Kathy')
RL> showFacts();
f-0   initial-fact()
f-1   main.enterRoom(who : 'Rahul')
f-3   main.enterRoom(who : 'Tom')
For a total of 3 facts.
```

1.4.2.2 Watching Activations and Rule Firing

The watchActivations function monitors the Oracle Rules Engine and prints information about rule activations entering and leaving the agenda. The watchRules function prints information about rules firing.

Example 1–12 shows how run causes the activations to fire. Notice that Rahul is greeted last even though he entered the room first (this is due to the firing order).
Example 1–12 Using WatchActivations and WatchRules

RL> clear;
RL> class enterRoom {String who;}
RL> assert(new enterRoom(who: "Rahul"));
RL> assert(new enterRoom(who: "Kathy"));
RL> assert(new enterRoom(who: "Tom"));
RL> watchActivations();
RL> rule sayHello {
  if (fact enterRoom) {
    println("Hello " + enterRoom.who);
  }
}

==>
Activation: main.sayHello :  f-1
Activation: main.sayHello :  f-2
Activation: main.sayHello :  f-3

RL> watchRules();
RL> run();
Fire 1 main.sayHello f-3
Hello Tom
Fire 2 main.sayHello f-2
Hello Kathy
Fire 3 main.sayHello f-1
Hello Rahul
RL>

1.4.3 Ordering Rule Firing

To understand the ordering algorithm for firing rule activations on the agenda, we introduce the ruleset stack. Each RuleSession includes one ruleset stack. The RuleSession’s ruleset stack contains the top of the stack, called the focus ruleset, and any non focus rulesets that are also on the ruleset stack. You place additional rulesets on the ruleset stack using either the pushRuleset or setRulesetStack built-in functions. You can manage the rulesets on the ruleset stack with the clearRulesetStack, popRuleset, and setRulesetStack functions. In this case, the focus of the ruleset stack is the current top ruleset in the ruleset stack (see Example 1–13).

Example 1–13 Ruleset Stack - Picture

RuleSet Stack

```
Focus Ruleset --> Top_Ruleset
               Next_down_Ruleset
               Lower_Ruleset
               Bottom_Ruleset
```

When activations are on the agenda, the Oracle Rules Engine fires rules when run, runUntilHalt, or step executes. The Oracle Rules Engine sequentially selects a rule activation from all of the activations on the agenda, using the following ordering algorithm:

1. The Oracle Rules Engine selects all the rule activations for the focus ruleset, that is the ruleset at the top of the ruleset stack (see the pushRuleset and setRulesetStack built-in functions).
Understanding and Controlling Rule Firing

2. Within the set of activations associated with the focus ruleset, rule priority specifies the firing order, with the higher priority rule activations selected to be fired ahead of lower priority rule activations (the default priority level is 0).

3. Within the set of rule activations of the same priority, within the focus ruleset, the most recently added rule activation is the next rule to fire. However, note that in some cases multiple activations may be added to the agenda at the same time, the ordering for such activations is not defined.

4. When all of the rule activations in the current focus fire, the Oracle Rules Engine pops the ruleset stack, and the process returns to Step 1, with the current focus.

If a set of rules named R1 must all fire before any rule in a second set of rules named R2, then you have two choices:

- Use a single ruleset and set the priority of the rules in R1 higher than the priority of rules in R2.
- Use two rulesets R1 and R2, and push R2 and then R1 on the ruleset stack.

Generally, using two rulesets with the ruleset stack is more flexible than using a single ruleset and setting the priority to control when rules fire. For example if some rule R in R1 must trigger a rule in R2 before all rules in R1 fire, a return in R pops the ruleset stack and allows rules in R2 to fire.

If execution must alternate between two sets of rules, for example, rules to produce facts and rules to consume facts, it is easier to alternate flow with different rulesets than by using different priorities.

Example 1–14 shows that the priority of the keepGaryOut rule is set to high, this is higher than the priority of the sayHello rule (the default priority is 0). If the activations of both rules are on the agenda, the higher priority rule fires first. Notice that just before calling run, sayHello has two activations on the agenda. Because keepGaryOut fires first, it retracts the enterRoom(who: "Gary") fact, which removes the corresponding sayHello activation, resulting in only one sayHello firing.

The rule shown in Example 1–14 illustrates two additional RL Language features.

1. The fact operator, also known as a fact set pattern, uses the optional var keyword to define a variable, in this case the variable g, that is bound to the matching facts.

2. You can remove facts in working memory using the retract function.

Example 1–14 Using Rule Priority with keepGaryOut Rule

```
RL> final int low = -10;
RL> final int high = 10;
RL> rule keepGaryOut {
    priority = high;
    if (fact enterRoom(who: "Gary") var g) {
        retract(g);
    }
}
RL> assert(new enterRoom(who: "Gary"));
===> f-4 main.enterRoom(who: "Gary")
===> Activation: main.sayHello : f-4
===> Activation: main.keepGaryOut : f-4
RL> assert(new enterRoom(who: "Mary"));
===> f-5 main.enterRoom(who: "Mary")
===> Activation: main.sayHello : f-5
```
Example 1–15 shows the `sayHello` rule that includes a condition that matches the asserted `enterRoom` fact; this match adds an activation to the agenda. Example 1–15 demonstrates the following RL Language programming features.

1. The Oracle Rules Engine matches facts against the rule conditions (fact-set-conditions) of all rules as the state of working memory changes. Thus, it does not matter whether facts are asserted before the rule is defined, or after.

2. The `run` function processes any activations on the agenda. No activations on the agenda are processed before calling `run`.

Example 1–15  enterRoom Class with sayHello Rule

```
RL> class enterRoom { String who; }
RL> rule sayHello { 
  if ( fact enterRoom ) { 
    println('Hello ' + enterRoom.who); 
  }
}
RL> assert(new enterRoom(who: "Bob"));
RL> run();
Hello Bob
RL>
```

Notes for ordering rule firing.

1. When you use the `return` action, this changes the behavior for firing rules. A `return` action in a rule pops the ruleset stack, so that execution continues with the activations on the agenda that are from the ruleset that is currently at the top of the ruleset stack.

   If rule execution was initiated with either the run or step functions, and a return action pops the last ruleset from the ruleset stack, then control returns to the caller of the run or step function.

   If rule execution was initiated with the `runUntilHalt` function, then a return action does not pop the last ruleset from the ruleset stack. The last ruleset is popped with `runUntilHalt` when there are not any activations left. The Oracle Rules Engine then waits for more activations to appear. When they do, it places the last ruleset on the ruleset stack before resuming ruleset firing.

2. Rule priority is only applicable within rules in a given ruleset. Thus, the priority of rules in different rulesets are not comparable.

1.5 Using Effective Dates

By default, the value of the effective date is managed implicitly by the rules engine. In this case, when a run family of built-in functions is invoked, the effective date is updated to the current system date. This is done before any rules fire so that the new effective date is applied before rules begin to fire. In the case of `runUntilHalt`, this update occurs each time there is a transition from 0 rules on the agenda to > 0 rules on the agenda.
In Oracle Business Rules RL Language, the effective start and end dates and the active property are only applied to rules (and do not apply for rulesets). The effective start and end date properties of a rule can be specified in the rule.

For example,

```java
rule myrule2 {
    active = true;
    effectiveDateForm = Rule.EDFORM_DATETIME:
    effectiveStartDate = JavaDate.fromDateTimeString("2008-11-01");
    effectiveEndDate = JavaDate.fromDateTimeString("2008-11-16");

    if (fact Foo)
    {
        .
        .
    }
}
```

If you use the RuleSession Java API, you can access the effective start and end date.

Setting a property from RL Language requires a long expression or several statements.

For example, given a ruleset:

```java
ruleset MyRules {
    rule myRule { if fact foo { }}
}
```

To set the active property, use the following:

```java
Rule r = getRuleSession().getRuleset("MyRules").getRule("myRule");
r.setActive(false);
```

1.6 Integrating RL Language Programs with Java Programs

This section describes integrating RL Language programs with Java programs. This section covers the following topics:

- Using Java Beans Asserted as Facts
- Using RuleSession Objects in Java Applications

See Also: "Working with Rules SDK Decision Point API" in the Oracle Business Rules User’s Guide

1.6.1 Using Java Beans Asserted as Facts

Example 1–16 shows the Java source for a simple bean. Use the javac command to compile the bean, example.Person shown in Example 1–16 into a directory tree.

The following shows how an RL Language command-line can be started that can access this Java bean:

```bash
java -classpath $ORACLE_HOME/soa/modules/oracle.rules_11.1.1/rl.jar;BeanPath
oracle.rules.rl.session.CommandLine -p 'RL' *
```
Integrating RL Language Programs with Java Programs

**Example 1–16  Java Source for Person Bean Class**

```java
package example;
import java.util.*;
public class Person
{
    private String firstName;
    private String lastName;
    private Set nicknames = new HashSet();

    public Person(String first, String last, String[] nick) {
        firstName = first; lastName = last;
        for (int i = 0; i < nick.length; ++i)
            nicknames.add(nick[i]);
    }
    public Person() {}
    public String getFirstName() {return firstName;}
    public void setFirstName(String first) {firstName = first;}
    public String getLastName() {return lastName;}
    public void setLastName(String last) {lastName = last;}
    public Set getNicknames() {return nicknames;}
}
```

Example 1–17 shows how the RL Language command-line can execute an RL Language program that uses `example.Person`. The `import` statement, as in Java, allows a reference to the `Person` class using "Person" instead of "example.Person". Rules reference the `Person` bean class and its properties and methods. In order to create a Person fact you must assert a Java Person bean.

Example 1–17 uses the `new` operator to create an array of `Person` objects, named `people`. The `people` array is declared final so that `reset` does not create more people. The `numPeople` variable is not declared final so that `reset` re-invokes the `assertPeople` function and re-asserts the Person facts using the existing `Person` objects.

**Example 1–17  Ruleset Using Person Bean Class**

```java
ruleset main
{
    import example.Person;
    import java.util.*;
    rule hasNickNames
    {
        if (fact Person(nicknames: var nns) p && !nns.isEmpty())
        {
            // accessing properties as fields:
            println(p.firstName + " " + p.lastName + " has nicknames: ");
            Iterator i = nns.iterator();
            while (i.hasNext())
            {
                println(i.next());
            }
        }
    }
    rule noNickNames
    {
        if fact Person(nicknames: var nns) p && nns.isEmpty()
        {
```
// accessing properties with getters:
println(p.getFirstName() + " " + p.getLastName() + " does not have nicknames");

final Person[] people = new Person[] {
    new Person("Robert", "Smith", new String[] { "Bob", "Rob" }), // using constructor
    new Person(firstName: "Joe", lastName: "Schmoe") // using attribute value pairs
};

function assertPeople(Person[] people) returns int
{
    for (int i = 0; i < people.length; ++i) {
        assert(people[i]);
    }
    return people.length;
}

int numPeople = assertPeople(people);
run();

Note the following when working with Java beans as facts:

1. The fact operator can include a pattern that matches or retrieves the bean properties. The properties are defined by getter and setter methods in the bean class.

2. The new operator can include a pattern that sets property values after invoking the default no-argument constructor, or can pass arguments to a user-defined constructor.

3. Outside of the fact and new operators, the bean properties may be referenced or updated using getter and setter methods, or using the property name as if it were a field.

4. If a bean has both a property and a field with the same name, then the field cannot be referenced in RL Language.

If Example 1–18 executes using the same RuleSession following the execution of Example 1–17, the output is identical to the Example 1–17 results (both person facts are reasserted).

1.6.2 Using RuleSession Objects in Java Applications

Java programs can use the RuleSession interface to execute rulesets, invoke RL Language functions passing Java objects as arguments, and redirect RL Language watch and println output. Example 1–19 and Example 1–20 each contain a Java program fragment that uses a RuleSession that prints "hello world". Like many Java program fragments, these examples are also legal RL Language programs.

Example 1–18 Using Reset with a RuleSession
reset();
run();
The RL Language environment provides multiple rule sessions. Each rule session can be used by multiple threads, but rules are fired by a single thread at a time.

Each rule RuleSession has its own copy of facts and rules. To create a fact from a Java Object, use a call such as:

```java
r.s.callFunctionWithArgument("assert", Object);
```

To create a rule, a function, or an RL Language class, define a string containing a ruleset, and use the `executeRuleset` method.

**Example 1–19 Using a RuleSession Object with callFunctionWithArgument**

```java
import oracle.rules.rl.*;
try {
    RuleSession rs = new RuleSession();
    rs.callFunctionWithArgument("println", "hello world");
} catch (RLException rle) {
    System.out.println(rle);
}
```

**Example 1–20 Using a RuleSession with ExecuteRuleset**

```java
import oracle.rules.rl.*;
try {
    RuleSession rs = new RuleSession();
    String rset =
        "ruleset main {" +
        " function myPrintln(String s) {" +
        " println(s);" +
        " }" +
        "}";
    rs.executeRuleset(rset);
    rs.callFunctionWithArgument("myPrintln", "hello world");
} catch (RLException rle) {
    System.out.println(rle);
}
```

### 1.7 Using Decision Tracing

Using Oracle Business Rules, a decision trace is a trace of rule engine execution that includes information on the state of the rule engine, including the state of facts when rule fire. The Oracle Business Rules rule engine constructs and returns a decision trace using JAXB generated Java classes generated from the decision trace XML schema.

#### 1.7.1 Introduction to Rule Engine Level Decision Tracing

To provide a business analyst friendly presentation of a decision trace requires that the associated rule dictionary is available. Using the rule dictionary associated with a trace allows for a more flexible and efficient approach, as the trace output does not need to include all of the related dictionary content information in the trace.

The XML schema is in the file `decisiontrace.xsd` and it is part of the Jar file `rl.jar` as: `oracle/rules/r1/trace/decisiontrace.xsd`. The packages of interest are `oracle.rules.r1.trace`, `oracle.rules.r1.extensions.trace`, and `oracle.rules.sdk2.decisiontrace`. The Java classes packages generated from the `decisiontrace` XML schema are in the package `oracle.rules.r1.trace` and are...
1.7.2 Using Rule Engine Level Decision Tracing

A decision trace is a set of XML elements showing rule engine events that occur during rule evaluation. The types of events that are added to a decision trace depend on the trace level selected, and can include:

- Fact operations (assert, retract, modify)
- Rules fired
- Rule activations added or removed from the agenda
- Ruleset stack changes
- Rule compilation
- Reset (which is needed for maintaining state for decision trace analysis)

Each trace contains information about a particular event. For example, a fact operation event entry consists of:

- The operation type (assert, modify, retract)
- The ID of the fact in working memory
- Fact type name (fact classed in RL)
- Runtime object type name
- The fact object data, including the property name and value for zero or more fact properties
- Name of rule, RL name, if the operation was the result of a rule action
- Millisecond timestamp

In a fact operation event trace, the fact object content reflects the structure of the object as a Java Bean. If the bean properties are references to other beans the related bean content is included in the trace. The value of a bean property can be one of the following alternatives.

- A string representation of the property. This is the case for primitive types and classes in the java.* and javax.* packages.
- A nested bean object with its property values.
- A fact ID. This occurs when the property value is an object which has itself been asserted as a fact. The data for the fact at the time of the trace can be retrieved from the RuleEngineState using the fact ID when analyzing the trace.
- A collection of values accessed as a List in the trace.
- An array of values accessed as a List in the trace.

At runtime, to determine which alternative is included in the trace you can test for null; only the correct alternative has a non-null value.

Table 1–1 shows the RL functions that provide control over decision tracing in the rule engine and provide access to a decision trace.
The decision trace level may be set by invoking the `setDecisionTraceLevel` function. You can also configure the initial trace level in a RuleSession or in a RuleSessionPool by including the `RuleSession.CFG_DECISION_TRACE_LEVEL` initialization parameter and specifying a level in the configuration Map passed to the RuleSession or RuleSessionPool constructor. This sets the decision trace level at the time a RuleSession is created.

You can invoke the `setDecisionTraceLevel` function on a RuleSession or a RuleSessionPool object after initialization. When you invoke `reset()`, this function returns the decision trace level to the configured value (if the level was changed during rule execution). Thus, the `reset()` function resets the decision trace limit to the value set during initialization of a RuleSession or a RuleSessionPool. In these cases, `reset()` restores the values established using the initialization parameters.

Note: These `reset()` semantics for a RuleSession are only valid for a RuleSession initialized with either or both of the `CFG_DECISION_TRACE_LIMIT` and the `CFG_DECISION_TRACE_LEVEL` initialization parameters (or that is obtained from a RuleSessionPool when the pool is created with either or both of the `CFG_DECISION_TRACE_LIMIT` and the `CFG_DECISION_TRACE_LEVEL` initialization parameters).

The size of a trace is limited by limiting the number of entries in a decision trace. This necessary to avoid infinite rule fire loops, due to a possible bug in the rules, from creating a trace that consumes all available heap in the JVM. Set the trace limit with the `setDecisionTraceLimit` function. The limit may also be configured in a RuleSession (or RuleSessionPool) by including the `RuleSession.CFG_DECISION_TRACE_LIMIT` initialization parameter with the desired limit in the configuration Map passed to the RuleSession or RuleSessionPool constructor.

For rules applications that use `runUntilHalt`, it is the responsibility of the application to invoke `getDecisionTrace` before the trace limit is hit.

The decision trace provides structure to the trace data so that it can be manipulated programmatically. However, the trace by itself can be cumbersome to analyze. A trace analysis class (oracle.rules.rl.extensions.trace.TraceAnalysis) analyzes a decision trace and facilitates exploration of the trace. Use this class to construct the state of working memory, the agenda, and the ruleset stack from the trace.

The `TraceAnalysis` API supports the following:

- Obtain a list of fact types that appear in the trace.
- Obtain a list of names of the rules that fired in the trace.

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>getDecisionTrace</code></td>
<td>Returns the current trace and starts a new trace.</td>
</tr>
<tr>
<td><code>getDecisionTraceLevel</code></td>
<td>Gets the current decision trace level.</td>
</tr>
<tr>
<td><code>getDecisionTraceLimit</code></td>
<td>Returns the current limit on the number of events in a trace.</td>
</tr>
<tr>
<td><code>setDecisionTraceLevel</code></td>
<td>Sets the decision trace level to the specified level.</td>
</tr>
<tr>
<td><code>setDecisionTraceLimit</code></td>
<td>Sets the limit on the number of events in a trace.</td>
</tr>
</tbody>
</table>

Default limit value is 10000.
Using Decision Tracing

- Obtain a list of the last fact traces for each instance of a specific fact type.
- Obtain the last fact trace for a specific fact identified by its fact ID.
- Obtain all of the fact traces for a fact identified by its fact ID.
- For a fact trace, if the fact trace was created by a rule action, get the rule trace that
  rule firing in which the action executed.
- For a rule trace, get the list of fact traces for each fact that matched and resulted in
  the rule firing.
- Get the next or previous trace. Exploration of the trace is typically not an iteration
  over the trace. For example, obtaining a rule trace from a fact trace is essentially
  jumping to that rule trace. The traces near the rule trace can be explored directly.
- Obtain a list of rule traces for a rule identified by its name.
- Obtain the rule engine state for a trace entry. The rule engine state reflects the state
  of the rule engine after the activity that generated the trace. This API enables
  inspecting the rule engine state at the time of each trace. This API is most useful
  with development level tracing. With production level tracing, only the facts in
  working memory can be tracked and they will not include any fact contents.

Example 1–21 shows a code sample that uses the decision trace analysis API.

**Example 1–21  Decision Trace Analysis API Usage**

```java
DecisionTrace trace;
...
TraceAnalysis ta = new TraceAnalysis(trace);
// Get all of the last fact traces for a fact type.
List<FactTrace> factTraces = ta.getLastFactTraces("com.example.MyFactType");
// From a particular fact trace, how it was arrived at may be explored, first by
// obtaining the rule that asserted or modified the fact.
// From the FactRecord, the rule that resulted in the record can be obtained.
FactTrace factTrace = factTraces.get(0);  // assumes there is one
RuleTrace ruleTrace = ta.whichRule(factTrace);
// The ruleTrace will be null if the fact operation was not part of a rule
action.
System.out.print("Fact " + factTrace.getFactId() + ", a " +
factTrace.getFactType() + " " + factRecord.getFactOp());
if (ruleTrace != null)
  System.out.println(" by rule " + ruleTrace.getRuleName());
else
  System.out.println("");
// The analysis can continue by obtaining the list of FactRecords that matched the
rule and
// proceeding to analyze the trace back in time.
List<FactTrace> matchingFacts = ta.getRuleMatchedFacts(ruleTrace);
```

1.7.3 Decision Trace Samples for Production and Development Level Tracing

Example 1–22 shows a sample production level trace document.

**Example 1–22  Sample Production Level Decision Trace**

```xml
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<decision-trace xmlns="http://xmlns.oracle.com/rules/decisiontrace">
  <trace-entries xsi:type="rule-trace" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
```

Example 1–23  Sample Development Level DecisionTrace

<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<decision-trace xmlns="http://xmlns.oracle.com/rules/decisiontrace">
  <trace-entries xsi:type="fact-trace" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
    <timestamp>1248975491008</timestamp>
    <fact-id>1</fact-id>
    <operation>assert</operation>
    <fact-type>com.example.Customer</fact-type>
    <object-type>com.example.Customer</object-type>
    <fact-object>
      <properties>
        <name>YTDOrderAmount</name>
        <value>
          <string>2000.0</string>
        </value>
      </properties>
      <properties>
        <name>level</name>
        <value>
          <string>null</string>
        </value>
      </properties>
      <properties>
        <name>name</name>
        <value>
          <string>OneLtd</string>
        </value>
      </properties>
      <properties>
        <name>pastDue</name>
        <value>
          <string>false</string>
        </value>
      </properties>
    </fact-object>
  </trace-entries>
  <trace-entries xsi:type="activation-trace" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
    <timestamp>1248975491024</timestamp>
    <rule-name>OrderDiscount.goldCustomer</rule-name>
    <token-time>0</token-time>
    <sequence-number>1</sequence-number>
  </trace-entries>
  <trace-entries xsi:type="rule-trace" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
    <timestamp>1248975549893</timestamp>
    <rule-name>OrderDiscount.goldCustomerDiscount</rule-name>
    <token-time>0</token-time>
    <sequence-number>2</sequence-number>
  </trace-entries>
  <trace-entries xsi:type="rule-trace" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
    <timestamp>1248975549894</timestamp>
    <rule-name>OrderDiscount.applyDiscount</rule-name>
    <token-time>0</token-time>
    <sequence-number>3</sequence-number>
  </trace-entries>
</decision-trace>
<rule-name>OrderDiscount.goldCustomer</rule-name>
<token-time>2</token-time>
<fact-ids>1</fact-ids>
<operation>add</operation>
</trace-entries>
<trace-entries xsi:type="fact-trace" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
<timestamp>1248975491025</timestamp>
<fact-id>2</fact-id>
<operation>assert</operation>
<fact-type>com.example.Order</fact-type>
<object-type>com.example.Order</object-type>
<fact-object>
  <properties>
    <name>customerName</name>
    <value>
      <string>OneLtd</string>
    </value>
  </properties>
  <properties>
    <name>discount</name>
    <value>
      <string>0.0</string>
    </value>
  </properties>
  <properties>
    <name>grossAmount</name>
    <value>
      <string>400.0</string>
    </value>
  </properties>
  <properties>
    <name>netAmount</name>
    <value>
      <string>0.0</string>
    </value>
  </properties>
  <properties>
    <name>number</name>
    <value>
      <string>1001</string>
    </value>
  </properties>
</fact-object>
</trace-entries>
<trace-entries xsi:type="activation-trace" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
<timestamp>1248975491035</timestamp>
<rule-name>OrderDiscount.goldCustomerDiscount</rule-name>
<token-time>5</token-time>
<fact-ids>2</fact-ids>
<fact-ids>1</fact-ids>
<operation>add</operation>
</trace-entries>
<trace-entries xsi:type="rule-trace" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
<timestamp>1248975491036</timestamp>
<rule-name>OrderDiscount.goldCustomerDiscount</rule-name>
<token-time>5</token-time>
<fact-ids>2</fact-ids>
<fact-ids>1</fact-ids>
<sequence-number>2</sequence-number>
</trace-entries>
1.8 Building a Coin Counter Rules Program

This section shows a sample that uses RL Language to solve a puzzle:

How many ways can 50 coins add up to $1.50?

The rules program that solves this puzzle illustrates an important point for rule-based programming: knowledge representation, that is, the fact classes that you select, can be the key design issue. It is often worthwhile to write procedural code to shape your data into a convenient format for the rules to match and process.

To use this example, first copy the RL Language program shown in Example 1–25 to a file named coins.rl. You can include this from the RL Language command-line using the include command. Before you include the coins program, use the clear; command to erase everything in the current rule session, as follows:

```
RL> clear;
RL> include file:coins.rl;
RL>
```

Example 1–24 shows the debugging functions that show the count coins sample facts, activations, and rules for the coin counter. All facts are asserted, and activations for all solutions are placed on the agenda. Notice that the facts are matched to the rule condition as they are generated by populate_facts, and that find_solution prints the matches.

```
Example 1–24 Using Debugging Functions with Coins Example
```

In Example 1–25, the keyword final in front of a global variable definition such as coinCount and totalAmount marks that variable as a constant, as in Java. You can
reference constants in rule conditions, but you cannot reference variables in rule conditions.

In RL Language, you must initialize all variables. The initialization expression for a final variable is evaluated once when the variable is defined. The initialization expression for a non-final variable is evaluated when the variable is defined, and again each time the reset function is called. Because the reset function retracts all facts from working memory, it is good practice to assert initial facts in a global variable initialization expression, so that the facts are re-asserted when reset is called.

Example 1–25 illustrates how to use global variable initialization expressions. The initialized global variable is initialized with the populate_facts function. This function is re-executed whenever reset is called. The populate_facts function has a while loop nested within a for loop. The for loop iterates over an array of coin denomination Strings. For each denomination, the while loop asserts a fact that expresses a count and a total that does not exceed the total amount of $1.50. For example, for half dollars:

\[
\begin{align*}
&\text{coin(denomination "half-dollar", count:0, amount:0)} \\
&\text{coin(denomination "half-dollar", count:1, amount:50)} \\
&\text{coin(denomination "half-dollar", count:2, amount:100)} \\
&\text{coin(denomination "half-dollar", count:3, amount:150)}
\end{align*}
\]

With such facts in working memory, the rule find_solution matches against each denomination with a condition that requires that the counts sum to coinCount and the amounts sum to totalAmt. The run function fires the find_solutions activations.

**Example 1–25 Count Coins Program Source**

```java
final int coinCount = 50;
final int totalAmt = 150;
final String[] denominations = new String[]
{"half-dollar", "quarter", "dime", "nickel", "penny"};
class coin {
    String denomination;
    int count;
    int amount;
}
function populate_facts() returns boolean {
    for (int i = 0; i < denominations.length; ++i) {
        String denom = denominations[i];
        int count = 0;
        int total = 0;
        int amount = 0;
        if (denom == "half-dollar") { amount = 50; }
        else if (denom == "quarter") { amount = 25; }
        else if (denom == "dime") { amount = 10; }
        else if (denom == "nickel") { amount = 5; }
        else { amount = 1; }
        while (total <= totalAmt && count <= coinCount) {
            assert(new coin(denomination: denom,
                            count : count,
                            amount : total));
            total += amount;
            count ++;
        }
    }
}
```
boolean initialized = populate_facts();
rule find_solution
{
    if(fact coin(denomination: "penny") p 
        && fact coin(denomination: "nickel") n 
        && fact coin(denomination: "dime") d 
        && fact coin(denomination: "quarter") q 
        && fact coin(denomination: "half-dollar") h 
        && p.count + n.count + d.count + q.count + h.count == coinCount 
        && p.amount + n.amount + d.amount + q.amount + h.amount == totalAmt)
    {
        println("Solution:"
            + " pennies=" + p.count
            + " nickels=" + n.count
            + " dimes=" + d.count
            + " quarters=" + q.count
            + " half-dollars=" + h.count
        );
    }
}
run();
This chapter contains a detailed and complete reference to the Oracle Business Rules RL Language (RL Language) syntax, semantics, and built-in functions.

Grammar rules define the RL Language. Each grammar rule defines a non-terminal symbol on the left of the ::= symbol in terms of one or more non-terminal and terminal symbols on the right of the ::= symbol.

Reserved Words
aggregate, boolean, break, byte, catch, char, class, constant, continue, double, else, exists, extends, fact, factpath, false, final, finally, float, for, function, hide, if, import, include, instanceof, int, long, modify, new, null, property, public, query, return, returns, rule, rulegroup, ruleset, short, supports, synchronized, throw, true, try, while, var

Note: Reserved words in bold apply to the current release. Reserved words that are not shown in bold typeface are planned for a future RL Language release, and include the words: break, continue, and query.
A ruleset groups a set of definitions. A ruleset is a collection of rules and other definitions that are all intended to be evaluated at the same time. A ruleset may also contain executable actions, may include or contain other rulesets, and may import Java classes and packages.

*Format*

```
ruleset ::= named-ruleset | unnamed-ruleset

named-ruleset ::= ruleset ruleset-name { unnamed-ruleset }

unnamed-ruleset ::= ( import | include | named-ruleset | definition | action | fact-class | rulegroup )*

ruleset-name ::= identifier
```

*Usage Notes*

A named-ruleset creates or adds definitions to the specified ruleset named ruleset-name.

An unnamed-ruleset adds definitions to the default ruleset named main.

Rulesets may be nested, that is they may contain or include other rulesets. Nesting does not affect ruleset naming, but it does affect ruleset visibility in a way similar to Java import’s affect on package visibility.

You can execute a ruleset using the RL Language command-line, or using the Java RuleSession API.

A named-ruleset ruleset-name must be unique within a RuleSession.

*Examples*

Example 2–1 contains two definitions, enterRoom and sayHello, and two actions (assert and run).

The rule shown in Example 2–1 will not fire until:

1. An enterRoom fact is asserted.
2. The run function executes, which pushes the rule's containing ruleset, hello onto the ruleset stack.

**Example 2–1 Using a Named Ruleset**

```
ruleset hello {
    class enterRoom { String who; }
    rule sayHello {
        if (fact enterRoom) {
            println("Hello " + enterRoom.who);
        }
    }
    assert(new enterRoom(who: "Bob"));
    run("hello");
}
```

In Example 2–2, if ruleset R2 is nested in ruleset R1, the name R2 must be unique within the rule session. R2 is not named relative to R1. For example, the class C2 defined in R2 is globally named R2.C2, not R1.R2.C2. If R2 is nested in R1, a public
class C1 defined in R1 may be referenced in R2 using either the full name R1.C1 or the short name C1 (assuming R2 does not also define C1).

**Example 2–2  Using a Nested Ruleset**

ruleset R1 {
    public class C1 {
        public String s;
    }
    C1 apple = new C1(s: "apple");
}

ruleset R2 {
    public class C2 {
        public String s;
    }
    C1 c1 = apple;  // finds C1 and apple in containing ruleset R1
    c1.s = "delicious";
    C2 c2 = new C2(s: "pear");
}

R2.C2 pear = R2.c2; // finds R2.C2 and R2.c2 because they are fully qualified
println(apple.s + " " + pear.s); // prints "delicious pear"

    pear = c2;  // UndefinedException: c2 not in R1 or a containing ruleset
Types

RL Language is a strongly typed language. Each variable and value has a specified type.

Format

\[
\text{type} \ ::= \text{simple-type} \ [\ [ ]]
\]
\[
\text{simple-type} \ ::= \text{primitive} \mid \text{object-type}
\]
\[
\text{primitive} \ ::= \text{boolean} \mid \text{numeric}
\]
\[
\text{numeric} \ ::= \text{int} \mid \text{double} \mid \text{float} \mid \text{long} \mid \text{short} \mid \text{byte} \mid \text{char}
\]
\[
\text{object-type} \ ::= \text{class-definition-name} \mid \text{Java-class-name}
\]
\[
\text{class-definition-name} \ ::= \text{qname}
\]
\[
\text{Java-class-name} \ ::= \text{qname}
\]

Type Conversion

There are several ways that a value can be converted from one type to another:

1. Conversion from any type to String using the String concatenation operator + .
2. Implicitly from context. For example, by adding an int to a double first converts the int to a double and then adds the 2 doubles.
3. Casting between 2 numeric types.
4. Casting between 2 classes related by inheritance.
5. Invoking a function or method that performs the conversion. For example, toString.

Table 2–1 summarizes the implicit conversions for various types. Rows indicate how the type in the From column may be implicitly converted, as shown in the list of types shown in the To column.

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
</tr>
</thead>
<tbody>
<tr>
<td>int</td>
<td>double, float, long</td>
</tr>
<tr>
<td>float</td>
<td>double</td>
</tr>
<tr>
<td>long</td>
<td>double, float</td>
</tr>
<tr>
<td>short</td>
<td>int, double, float, long</td>
</tr>
<tr>
<td>byte</td>
<td>int, double, float, long, short</td>
</tr>
<tr>
<td>char</td>
<td>int, double, float, long</td>
</tr>
<tr>
<td>String</td>
<td>Object</td>
</tr>
<tr>
<td>Object</td>
<td>Object (if the From Object is a subclass of the To Object)</td>
</tr>
<tr>
<td>fact set</td>
<td>boolean</td>
</tr>
<tr>
<td>array</td>
<td>Object</td>
</tr>
</tbody>
</table>
Table 2–2 summarizes the allowed cast conversions for various types where a cast can be used to convert a primitive with more bits to a primitive with fewer bits, without throwing an exception.

The type conversions shown in Table 2–2 require an explicit cast operator. For example,

```java
int i = 1;
short s = (short)i;
```

When you use a cast to convert a primitive with more bits, to a primitive with fewer bits, the RL Language discards extra, high order, bits without throwing an exception.

For example,

```java
short s = -134;
byte b = (byte)s;
println('s = ' + s + ', b = ' + b);
prints: s = -134, b = 122
```

### Table 2–2  Explicit Type Conversions

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
</tr>
</thead>
<tbody>
<tr>
<td>double</td>
<td>float, long, int, short, byte, char</td>
</tr>
<tr>
<td>float</td>
<td>long, int, short, byte, char</td>
</tr>
<tr>
<td>long</td>
<td>int, short, byte, char</td>
</tr>
<tr>
<td>short</td>
<td>byte, char</td>
</tr>
<tr>
<td>byte</td>
<td>char</td>
</tr>
<tr>
<td>char</td>
<td>byte</td>
</tr>
</tbody>
</table>

When you use a cast to convert a primitive with more bits, to a primitive with fewer bits, the RL Language discards extra, high order, bits without throwing an exception.

### Primitive Types

A primitive type may be any of the following

- An `int`, which is a 32 bit integer. Literal values are scanned by `java.lang.Integer.parseInt`
- A `long`. Literal values are scanned by `java.lang.Long.parseLong`
- A `short`. Literal values are scanned by `java.lang.Short.parseShort`
- A `byte`. Literal values are scanned by `java.lang.Byte.parseByte`
- A `char`
- A `double`. Literal values are scanned by `java.lang.Double.parseDouble`
• A float. Literal values are scanned by `java.lang.Float.parseFloat`.
• A boolean `true` or `false`.

**Object Types**

An object type may be:

• A `java Object`, identified by the qualified name, `qname`, of its class. For example, `java.lang.String`.
• An RL Language `Object`, identified by the qualified name, `qname` of its class. For example, `ruleset1.Class1`.

**String Types**

RL Language uses Java strings, where:

• Strings are instances of the class `java.lang.String`.
• A string literal is delimited by double quotes ("string"). Use `\"` to include the double quote character in a string.
• Strings may be concatenated using the `+` operator as follows:
  - If any operand of a `+` operator is a String then the remaining operands are converted to String and the operands are concatenated.
  - An Object is converted to a String using its `toString` method.
  - An instance of an RL Language class is converted to a String using a built-in conversion.

**Array Types**

Square brackets `[]` denote arrays. An array in RL Language has the same syntax and semantics as a Java 1-dimensional array.

---

**Note:** RL Language does not support multi-dimensional arrays.
Identifiers

RL Language supports both the Java and the XML variant of identifiers and namespace packages. To use the XML variant, the identifier must be enclosed in back quotes.

Format

\[\text{identifier ::= java-identifier | xml-identifier}\\]
\[\text{java-identifier ::= valid-Java-identifier}\\]
\[\text{xml-identifier ::= `valid-xml-identifier or URI`}\\]

Where:

- valid-Java-identifier is: a legal Java identifier, for example, JLd_0.
- valid-xml-identifier is: a legal XML identifier, for example x-1.
- URI is: a legal Uniform Resource Identifier, for example, http://www.oracle.com/rules

Usage Notes

An xml-identifier can contain characters that are illegal Java identifier characters, for example, `:` and `-`. The JAXB specification defines a standard mapping of XML identifiers to Java identifiers, and includes preserving the Java conventions of capitalization. The JAXB specification also defines a standard mapping from the schema target namespace URI to a Java package name, and a mapping from anonymous types to Java static nested classes.

Examples

RL Language supports both the Java and the XML variant of identifiers and namespaces or packages. Enclose an identifier in back quotes to use the XML variant, as shown in Example 2–3.

You can use the back quote notation anywhere an identifier or package name is legal in RL Language. To use the XML variant of identifiers in `String` arguments to `assertXPath`, back quotes are not needed.

Example 2–3  Sample Mapping for XML Identifiers Using Back Quotes

`http://www.mycompany.com/po.xsd` -> com.mycompany.po
`my-attribute` -> myAttribute
`Items/item` -> Items$ItemType
Literals

Table 2–3 summarizes the RL Language literals. The literals are the same as Java literals.

<table>
<thead>
<tr>
<th>A literal such as</th>
<th>Can be assigned to variables of these types</th>
</tr>
</thead>
<tbody>
<tr>
<td>An integer in range 0..127 or a char with UCS2 encoding in range 0..127</td>
<td>byte, char, short, int, long, float, double</td>
</tr>
<tr>
<td>An integer in range 0..65535 or a char</td>
<td>char, int, long, float, double</td>
</tr>
<tr>
<td>An integer in range -128..127</td>
<td>byte, short, int, long, float, double</td>
</tr>
<tr>
<td>An integer in range -32768..32767</td>
<td>short, int, long, float, double</td>
</tr>
<tr>
<td>An integer</td>
<td>int, long, float, double</td>
</tr>
<tr>
<td>An integer with L suffix</td>
<td>long, float, double</td>
</tr>
<tr>
<td>A floating point constant</td>
<td>double</td>
</tr>
<tr>
<td>A floating point constant with F suffix</td>
<td>float, double</td>
</tr>
<tr>
<td>A String enclosed in &quot;&quot;</td>
<td>String, Object</td>
</tr>
</tbody>
</table>
Definitions

When a definition within a ruleset is executed, it is checked for correctness and then saved for use later in the rule session.

Format

```
definition ::= variable | rule | rl-class-definition | function
definition ::= variable | rule | rl-class-definition | function
definition ::= variable | rule | rl-class-definition | function
definition ::= variable | rule | rl-class-definition | function

name ::= identifier
name ::= identifier
name ::= identifier
name ::= identifier

qname ::= [ ruleset-or-packagename. ]name
qname ::= [ ruleset-or-packagename. ]name
qname ::= [ ruleset-or-packagename. ]name
qname ::= [ ruleset-or-packagename. ]name

ruleset-or-packagename ::= qname
ruleset-or-packagename ::= qname
ruleset-or-packagename ::= qname
ruleset-or-packagename ::= qname
```

Usage Notes

Every definition has a unique name within its containing ruleset, and thus a unique qualified name, qname, within the rule session.

Variables defined at the ruleset level are global. Global variables are visible to all expressions contained in the ruleset using the name of the variable and visible to expressions in other rulesets using the variable qname. Functions and public classes may also be referenced from other rulesets using the respective qname.

Java classes and their methods and properties also have qnames.

Example

The qname of the class definition in Example 2–4 is hello.enterRoom.

**Example 2–4  Class Definition Within a Named Ruleset**

```
ruleset hello {
    class enterRoom { String who; }
    rule sayHello {
        if (fact enterRoom) {
            println('Hello * + enterRoom.who);
        }
    }
    assert(new enterRoom(who: "Bob"));
    run('hello');
}
```
Variable Definitions

Variables are declared as in Java, but initialization is always required.

Format

\[
\text{variable} ::= [\text{final}] \ (\text{numeric name} = \text{numeric-expression} \\
| \ \text{boolean name} = \text{boolean-expression} \\
| \ \text{type \ [\ ] name} = \text{array-expression} | \text{null} \\
| \ \text{object-type name} = \text{object-expression} | \text{null}) \\
\]

Usage Notes

The type of the array initialized with the array-expression must be the same as the type specified for the array elements.

A variable can have a primitive type, a Java class name, or an RL Language class name, and may be an array of elements of the same type.

The type of the object-expression must be the same as the object-type of the variable being declared. A class instance or array may be initialized to null.

Variables may be local or global in scope. The initialization expression is required. Local variables may not be final.

Global Variables

Variables immediately enclosed in a ruleset, that is, in a definition, are global to a rule session in scope. The initialization expression for a final global variable is executed when the global variable is defined.

The initialization expression for a non-final global variable is executed both:

- When the global variable is defined.
- Each time the reset function is called.

Global variables declared as final may not be modified after they are initialized. Global variables referenced in a rule condition (fact-set-condition) must be final.

Examples

Example 2–5 shows that the reset function performs initialization for the non-final global variable i. Thus, this example prints 0, not 1.

Example 2–5 Non-Final Global Variable Initialization After Reset Function

RL> int i = 0;
RL> i++;
RL> reset();
RL> println(i);

Be careful when initializing global variables with functions that have side effects. If you do not want the side effects repeated when calling reset, you should declare the
variable `final`. For example, Example 2–6 prints "once" twice and Example 2–7 prints "once" once.

**Example 2–6  Initializing a Global Variable with Side Effects with Reset**

```plaintext
RL> clear;
RL> function once() returns int
{   
println('once');
   
return 1;
}
RL> int i = once();
once
RL> reset();
once
```

**Example 2–7  Initializing a Final Global Variable to Avoid Side Effects with Reset**

```plaintext
RL> clear;
RL> function once() returns int
{   
println('once');
   
return 1;
}
RL> final int i = once();
once
RL> reset();
```


Rule Definitions

The Oracle Rules Engine matches facts against the fact-set-conditions of all rules in the rule session to build the agenda of rules to execute. A fact set row is a combination of facts that makes the conditions of a rule true. An activation is a fact set row paired with a reference to the action-block of the rule. The agenda is the list of all activations in the rules session. The Oracle Rules Engine matches facts and rules when the state of working memory changes, typically when a fact is asserted or retracted.

The run, runUntilHalt, and step functions execute activations. Activations are removed from the agenda after they are executed, or if the facts referenced in their fact set row are modified or retracted such that they no longer match the rule’s condition.

Activations are executed in order of the ruleset stack. You can manage the ruleset stack with the getRulesetStack, clearRulesetStack, pushRuleset, and popRuleset functions.

In order for a rule to fire, three things must occur:

1. An activation of that rule must be on the agenda.
2. The containing ruleset must be at the top of the ruleset stack.
3. You must invoke run, runUntilHalt, or step.

The fact set produced in a fact-set-condition is available to the rule actions. For each row in the fact set, the action-block is activated as follows:

- The rule’s action-block is scheduled for execution at the specified rule priority.
- References from the action-block to the matched facts are bound to the current row.
- If a matched fact is retracted before the action-block is executed, the dependent activations are destroyed (removed from the agenda).

Format

\[
\text{rule} ::= \text{rule } \text{rule-name } \{ \text{property}^* \text{ fact-set-condition } \text{ action-block} \}
\]

\[
\text{rule-name} ::= \text{name}
\]

\[
\text{property} ::= \text{priority} \mid \text{autofocus} \mid \text{logical} \mid \text{active}
\]

\[
\text{priority} ::= \text{priority} = \text{numeric-expression}
\]

\[
\text{autofocus} ::= \text{autofocus} = \text{boolean-literal}
\]

\[
\text{logical} ::= \text{logical} = ( \text{boolean-literal} \mid \text{positive-integer-literal} )
\]

\[
\text{active} ::= \text{active} = \text{boolean-literal}
\]

\[
\text{effectiveDateForm} ::= \text{effectiveDateForm} = \text{an int restricted to one of values defined in oracle.rules.rl.Rule: EDFORM_DATE, EDFORM_DATETIME, or EDFORM_TIME}
\]

\[
\text{effectiveStartDate} ::= \text{effectiveStartDate} = \text{expression of type java.util.Calendar}
\]

\[
\text{effectiveEndDate} ::= \text{effectiveEndDate} = \text{expression of type java.util.Calendar}
\]

Where:

- positive-integer-literal is: an integer literal that is > 0
Usage Notes

The **priority** property specifies the priority for a rule. Within a set of activations of rules from the same ruleset, activations are executed in priority order (see “Ordering Rule Firing” on page 1-9). When rules have different priorities, the rules with a higher priority are activated before those with a lower priority. The default priority is 0. Within a set of activations of rules of the same priority, the most recently added activations are executed first, but this behavior can be changed (see the **getStrategy** and **setStrategy** functions).

A rule with the **autofocus** property equal to `true` automatically pushes its containing ruleset onto the ruleset stack whenever it is activated.

A rule with the **logical** property makes all facts asserted by the rule’s action block dependent on some or all facts matched by the rule’s condition. An integer value of `n` for the **logical** property makes the dependency on the first `n` top-level `&&` ed fact set expressions in the rule’s condition. A boolean value of `true` for the **logical** property makes the dependency on the fact set expression of the condition. Anytime a fact referenced in a row of the fact set changes such that the rule’s logical conditions no longer apply, the facts asserted by the activation associated with that fact set row are automatically retracted. A rule with the logical property enabled makes all facts that are asserted by an action block in the rule dependent on facts matched in the rule condition. Anytime a fact referenced in the rule condition changes, such that the rule’s conditions no longer apply, the facts asserted by the rule condition are automatically retracted.

The **active** property defaults to `true`.

**effectiveStartDate** date defaults to null.

**effectiveEndDate** date default to null.

**effectiveDateForm** defaults to `Rule.EDFORM_DATETIME`

Examples

**Example 2–8** shows a rule with the inference, Socrates is mortal, which depends on the fact, Socrates is a man.

**Example 2–8  Defining and Using Rule allMenAreMortal**

```glare
RL> clear;
RL> class Man    {String name;}
RL> class Mortal {String name;}
RL> Mortal lastMortal = null;
RL> rule allMenAreMortal {
    logical = true;
    if (fact Man)
    {
        assert(lastMortal = new Mortal(name: Man.name));
    }
}
RL> watchAll();
RL> Man socrates = new Man(name: "Socrates");
RL> assert(socrates);
==> f-1 main.Man (name : "Socrates")
==> Activation: main.allMenAreMortal :  f-1
RL> run();
Fire 1 main.allMenAreMortal f-1
==> f-2 main.Mortal (name : "Socrates")
<== Focus main, Ruleset stack: {}```
Example 2-9 shows that it is possible for the same fact to be asserted by multiple rules, or to be asserted by a top-level ruleset action or function. Such a fact will not be automatically retracted unless all asserters have logical clauses that call for automatic retraction. A fact that is asserted by a top level action or function will never be automatically retracted.

Note that the fact that Socrates is mortal is not retracted, because it was asserted by a top level action that is not dependent on the fact that Socrates is a man.

Example 2-9  Asserting Facts Unconditionally

```
RL> assert(socrates);
  === f-3 main.Man(name : 'Socrates')
  === Activation: main.allMenAreMortal : f-3
RL> run();
Fire 1 main.allMenAreMortal f-3
  === f-4 main.Mortal(name : 'Socrates')
  === Focus main, Ruleset stack: {}
RL> assert(lastMortal);
  === f-4 main.Mortal(name : 'Socrates')
RL> retract(socrates);
  === f-3 main.Man(name: 'Socrates')
RL> showFacts();
  f-0 initial-fact()
  f-2 main.Mortal(name: 'Socrates')
```
Class Definitions

All referenced classes must be defined with an RL Language class definition or must be on the Java classpath (Java classes must be imported).

Both RL Language classes and Java classes can support xpath using the `supports` keyword, with a supplied xpath.

Format

```
rl-class-definition ::= [ public ] [ final ] class name [ extends ] [ supports ] { type-property* }

type-property ::= [ public ] type name [ = expression ] ;

extends ::= extends qname extended-class-name

extended-class-name ::= qname
```

Usage Notes

The type of the optional initialization expression must be the same as the type of the property or implicitly convertible to that type.

A public class is visible from all rulesets. A non-public class is visible only in the containing ruleset.

A final class cannot be extended.

The extended class must be a defined RL Language class not an imported Java class.

Each property may have an optional initializer. The initializer is evaluated when the class is instantiated by new. If an initial value is also passed to new, the value passed to new overwrites the value computed by the initializer in the class definition.

A public property is visible from all rulesets. A non-public property is visible only within its containing ruleset.

Examples

In RL Language, the type of an property may be the name of the containing class definition (see Example 2–10). RL Language, unlike Java, does not support forward references to class definitions (see Example 2–11).

**Example 2–10  Class Definition with Type of Property with Name of Containing Class**

```java
class C0 {
  C0 next;
}
```

**Example 2–11  Class Definitions with Forward References are Not Allowed**

```java
class C1 {
  C2 c2;  // causes an UndefinedException
}
class C2 {
  C1 c1;
}
```
xpath Support

Note: xpath support has been deprecated. For more information, see assertTree.

Both RL Language classes and Java classes support xpath.

An xml identifier does not need to be surrounded by back quotes within an xpath.

The built-in assertXPath function supports a simple xpath-like syntax to assert a tree of objects as facts. The nodes in the tree are objects from classes in the same package or ruleset that support xpath. The links between parent and child nodes are instances of the XLink class. All of the properties in a class that supports xpath may be used in the xpath expression.

Format

supports ::= supports xpath
xpath ::= first-step next-step*
first-step ::= ( . | * | [ ] ) ( identifier | * ) predicate*
predicate ::= [ identifier xrelop literal ]
next-step ::= ( / | // ) ( identifier | * ) predicate*
xrelop ::= eq | lt | gt | le | ge | == | < | <= | >= | !=
literal ::= integer-literal | decimal-literal | double-literal | string-literal | true | false | dateTime-literal | date-literal | time-literal
integer-literal ::= [-] d+
d ::= 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9
decimal-literal ::= [-] [. d+ | d+ . d]*
double-literal ::= [-] (. d+ | d+ [. d*] ) ( e | E ) [ + | - ] d+
string-literal ::= " char* " | ' char* '
dateTime-literal ::= local-date T time-literal
date-literal ::= local-date [ time-zone ]
time-zone ::= Z | (+ | - ) d d : d d
date-time ::= d d d d - d d - d d
time-literal ::= d d : d d [ , d+ ] [ time-zone ]

Usage Notes

RL Language xpath support was designed to work with classes that conform to the Java XML Binding (JAXB) 1.0 standard. All JAXB elements from the given root to the elements selected by the xpath, inclusive, are asserted. Additional XLink facts are asserted to aid in writing rules about the parent-child relationships among the asserted elements.

If a JAXB element is retracted or re-asserted, using assert, then all of its children, and XLinks, are retracted. Instead of re-asserting, use assertXPath again.

Note that RL Language Xpath is not a proper subset of W3C Xpath 2.0. Note the following differences:
Definitions

- The `lt` and `<`, `gt` and `>`, are synonymous in RL Language but different in W3C.
- Date literals must use `xs:date()` and other constructors in W3C.
- Constructors are not supported in RL Language, and literals, other than string literals, must not be quoted in RL Language.

Examples

Table 2–4 shows the xpath selection options for use with the built-in `assertXPath` function. In the descriptions, select means that the element is asserted as a fact, and the selected property of the XLink whose element property refers to the asserted element is `true`. The ancestors of a selected element, up to and including the root element, are always asserted, but not necessarily selected.

<table>
<thead>
<tr>
<th>xpath Select String</th>
<th>Description of Selection</th>
</tr>
</thead>
<tbody>
<tr>
<td>///*</td>
<td>Select all elements including the root</td>
</tr>
<tr>
<td>.//*</td>
<td>Select all but the root</td>
</tr>
<tr>
<td>.</td>
<td>Select only the root</td>
</tr>
<tr>
<td>//foo</td>
<td>Select all objects that are the value of a property named <code>foo</code>.</td>
</tr>
<tr>
<td>.[x==1]/y</td>
<td>Select children or attributes of root named <code>y</code> only if the root has a child element or attribute named <code>x</code> and equal to <code>1</code></td>
</tr>
</tbody>
</table>

Example 2–12 instantiates an RL Language class called Person to build a family tree, as follows:

First Generation   Second Generation     Third Generation
Ida                 Mary                  Fred
                      John                  Rachel
                      Sally                Evan

Example 2–12 uses the `assertXPath` function twice, with two xpaths:

```
//kids[male==true]
//kids[male==false]
```

Example 2–12 defines two rules:

- `sibling`: prints all pairs of siblings.
- `brotherSister`: prints all pairs of brothers and all pairs of sisters.

Example 2–13 shows the output from running Example 2–12.

Example 2–12 Sample Family Tree Rule Using supports xpath

```java
import java.util.*;
ruleset xp {
  public class Person supports xpath {
    public String name;
    ```
public boolean male;
    public List kids;
}

// Build the Family Tree
Person p = new Person(name: 'Fred', male: true);
List k = new ArrayList();
k.add(p);
p = new Person(name: 'John', male: true);
k.add(p);
p = new Person(name: 'Mary', male: false, kids: k);
Person gramma = new Person(name: 'Ida', male: false, kids: new ArrayList());
gramma.kids.add(p);
p = new Person(name: 'Sally', male: false);
k = new ArrayList();
k.add(p);
p = new Person(name: 'Evan', male: true);
k.add(p);
p = new Person(name: 'Rachel', male: false, kids: k);
gramma.kids.add(p);

// test for siblings.
// Note the test id(p1) < id(p2) halves the Cartesian product p1 X p2.
rule sibling {
    if (fact Person p1 && fact Person p2 && id(p1) < id(p2) &&
        exists(fact XLink(element: p1) x &&
            fact XLink(element: p2, parent: x.parent))) {
        println(p1.name + ' is sibling of ' + p2.name);
    }
}

// test for brothers and sisters, given the following 2 assertXPath() calls
rule brotherSister {
    if (fact Person p1 && fact Person p2 && id(p1) < id(p2) &&
        exists(fact XLink(element: p1, selected: true) x &&
            fact XLink(element: p2, selected: true, parent: x.parent) y &&
            x.samePath(y))) {
        println(p1.name + ' and ' + p2.name + ' are ' +
            (p1.male ? 'brothers' : 'sisters'));
    }
}
assertXPath("xp", gramma, "/kids[male==true]");
assertXPath("xp", gramma, "/kids[male==false]");
run("xp");

---

Example 2–13  Output from Run of Family Tree Example

Mary and Rachel are sisters
Evan is sibling of Sally
Fred and John are brothers
Fred is sibling of John
Mary is sibling of Rachel

Example 2–14 shows that when you retract an element that was asserted with assertXPath, all its descendents are retracted as well.

The result is:
```plaintext
f-0 initial-fact()
```
For a total of 1 fact.
Example 2–14 Retract the Family Tree

retract(xp.gramma);
showFacts();

Example 2–15 prints all pairs of ancestors. First, the family tree is asserted. Example 2–16 shows the output of a run of the code from Example 2–15.

Example 2–15 Print Ancestor Pairs with Class Ancestor

assertXPath('xp', xp.gramma, "/**");
class Ancestor { Object element; Object ancestor; }
rule parents {
    if (fact XLink x) {
        assert(new Ancestor(element: x.element, ancestor: x.parent));
    }
}
rule ancestors {
    if (fact XLink x && fact Ancestor(ancestor: x.element) a) {
        assert(new Ancestor(element: a.element, ancestor: x.parent));
    }
}
rule printAncestor {
    if (fact xp.Person p && fact xp.Person a &&
        fact Ancestor(element: p, ancestor: a)) {
        println(a.name + " is an ancestor of " p.name);
    }
}
run();

Example 2–16 Output from Run of Ancestor Example

Mary is an ancestor of John
Ida is an ancestor of John
Mary is an ancestor of Fred
Ida is an ancestor of Fred
Ida is an ancestor of Mary
Rachel is an ancestor of Evan
Ida is an ancestor of Evan
Rachel is an ancestor of Sally
Ida is an ancestor of Sally
Ida is an ancestor of Rachel
Function Definitions

A function is similar to a Java static method.

Format

\[
\text{function} ::= \text{function} \ \text{name} \ \text{parameters} \ [ \ \text{returns} \ \text{type} ] \ \text{action-block}
\]

\[
\text{parameters} ::= ( [ \ \text{type} \ \text{identifier} (, \ \text{type} \ \text{identifier})* ] )
\]

Usage Notes

The action-block may invoke the function being defined. However, the action-block may not contain a forward reference to a function that has not already been defined (see Example 2–17 and Example 2–18).

Functions may be overloaded. For example, the built-in println function is overloaded.

Examples

**Example 2–17  Valid Function Definition Containing Recursive Reference**

```java
function factorial(long x) returns long {
    if (x <= 1) { return 1; }
    else { return x * factorial(x - 1); }
}
```

**Example 2–18  Invalid Function Definition Containing Reference to Undefined Function**

```java
function f1() {
    f2(); // causes an UndefinedException
}
function f2() {
}
```
Fact Class Declarations

Any Java class can be used as an RL Language fact in a fact context. A fact context is one of:

- The class of a fact-class declaration.
- The class of a fact-set-pattern.
- The declared class of an argument to the assert function.
- The declared class of an argument to the retract function.
- The declared class of an element argument to the assertXPath function.

If a class or interface $B$ implements or extends class or interface $A$, and both $A$ and $B$ appear in fact contexts, then $A$ must appear before $B$. Failure to follow this rule will result in a FactClassException.

Fact class definitions are not required when using RL Language classes. For xpath support, use the supports xpath clause of the RL Language class definition.

Format

```
fact-class ::= fact class class-name [ supports ] ( fact-class-body | ; )
class-name ::= qname
fact-class-body ::= { [ hidden-properties | properties ]}
hidden-properties ::= hide property * ; | ( hide property ( ( name , )* name | * ) ; )*
properties ::= property * ; | ( property ( ( name , )* name | * ) ; )*
```

Usage Notes

The fact-class-body is optional in a fact-class declaration. The default fact-class-body is:

```
( property * ; )
```

Either the property or hide property keywords can be used in a body, but not both.

If hide property is used with a list of property names, then those property names are hidden and not available for use in RL Language.

If hide property is used with the wildcard "*", then no properties other than those exposed by a superclass or superinterface are available for use in RL Language.

If property is used with a list of property names, then those properties are exposed and available for use in RL Language. If property is used with the wildcard *, then all properties other than those hidden by a superclass or superinterface are available for use in RL Language.

A HiddenPropertyException will be thrown if a superclass exposes a property that its subclass hides or if a subclass exposes a property that its superclass hides.
Examples

Suppose a Java class Vehicle has subclasses Car and Truck. The rule shown in Example 2–19, matchVehicle, generates a TypeCheckException wrapping a FactClassException because the subclasses are referenced before the superclass. Wrapping is used instead of subclassing for both FactClassException and MultipleInheritanceException because in some fact contexts, these exceptions are not thrown until runtime and then are wrapped by a RLRuntimeException.

Example 2–19  matchVehicle Rule with Subclasses Referenced Before the Superclass

assert(new Car());    // fact context for Car
assert(new Truck());   // fact context for Truck
rule matchVehicle {
  if (fact Vehicle v) { // fact context for Vehicle - too late!
    if (v instanceof Car) {
      println("car");
    } else {
      println("truck");
    }
  }
}  // generates a TypeCheckException wrapping a FactClassException

In Example 2–20, the matchVehicle rule is the first reference to the superclass, so no exception is thrown.

Example 2–20  matchVehicle Rule with References to Superclass First

clear;
rule matchVehicle {
  if (fact Vehicle v) {
    if (v instanceof Car) {
      println("car");
    } else {
      println("truck");
    }
  }
}
assert(new Car());
assert(new Truck());
run();  // prints "truck" then "car"

In Example 2–21, a fact class declaration is the first reference to the superclass, so no exception is thrown.

Example 2–21  matchVehicle Rule with Fact Class Declaration with Reference to Superclass First

clear;
fact class Vehicle;
assert(new Car());
assert(new Truck());
rule matchVehicle {
  if (fact Vehicle v) {
    if (v instanceof Car) {
      println("car");
    } else {
      println("truck");
    }
  }
}
Facts do not support multiple inheritance. Consider the Java classes and interfaces shown in Example 2–22.

Example 2–22 Java Classes and Sample Multiple Inheritance

```java
package example;
public class Car {}
public interface Sporty {}
public class SportsCar extends Car implements Sporty {}
```

Example 2–23 entered at the command-line results in a TypeCheckException that wraps a MultipleInheritanceException. Use the getCause method on the TypeCheckException to retrieve the wrapped MultipleInheritanceException exception.

Example 2–23 MultipleInheritance Exception for Facts

```java
import example.*;
fact class Sporty;
fact class Car;
fact class SportsCar; // throws TypeCheckException wrapping a MultipleInheritanceException
```

Example 2–24 illustrates an exception that occurs at runtime when the Oracle Rules Engine attempts to assert the `rx8` object and discovers its true type is `SportsCar`, not `Object`. To avoid the MultipleInheritanceException, you must choose whether to use `Sporty` or `Car` in a fact class context. You cannot use both.

Example 2–24 RLRuntimeException wraps MultipleInheritanceException

```java
import example.*;
fact class Sporty;
fact class Car;
Object rx8 = new SportsCar();
assert(rx8); // throws RLRuntimeException wrapping a MultipleInheritanceException
```

Example 2–25 FactClassException Possible Cause

```
oracle.rules.r1.FactClassException: fact class for 'X' should be declared earlier in rule session
```

Note the fact context rule is:

If X is a subclass or subinterface, of Y, then Y must appear in a fact context before X. A fact context is a fact-class declaration, a rule fact pattern, or the argument of assert, assertXPath, or retract.

In some cases you need to consider the fact context. For example, with an XML schema such as the following:

```xml
<schema>
  <element name=A type=T/>
  <complexType name=T>
    <sequence>
      <element name=B type=T/>
    </sequence>
  </complexType>
</schema>
```
JAXB generates:

interface T {
    List getB(); // List has TImpl objects
}
interface A extends T;
class AImpl implements A extends TImpl;
class TImpl implements T;

In an example with the following order of appearance in fact contexts:

1. fact class T
2. assertXPath AImpl
3. assert TImpl (performed internally by the assertXPath implementation)

The, AImpl precedes TImpl in the ordering, yet AImpl extends TImpl, which would give the exception. The fix for this fact context is to explicitly issue fact class TImpl; anywhere before Step 2.
Import Statement

An import statement makes it possible to omit the package name qualification when referencing Java classes.

Format

```plaintext
import ::= import (Java-class-name | Java-package-name.*);  
Java-package-name ::= qname
```

Usage Notes

Import commands can be placed inside a ruleset, implying that the scope of the import is the ruleset where the import is located, but the import actually applies globally. For example, in the following code if the imports were scoped to the rulesets, then the PrintWriter reference in r2 would not compile.

```java
class X { }

ruleset rl {
  import java.io.*;
  rule A {
    if ( fact X ) {
      @ PrintWriter pw = null;
    }
  }
}

ruleset r2 {
  rule B {
    if ( fact X ) {
      @ PrintWriter pw = null;
    }
  }
}
```
Include Statement

Include the ruleset at the location specified by the URL.

Format

include := include URL;

Where:

URL is: A legal Uniform Resource Locator.

Usage Notes

The file: and http: schemes are supported.

Example

include file:example.rl;
Using Expressions

Expressions in RL Language use familiar Java syntax (with minor variations as noted). For example,

\[(a + 1) \ast (b - 2)\]

Use expressions in a condition or in an action, with some restrictions. Expressions are strongly typed.

Format

\[
\text{expression ::= boolean-expression} \\
| \text{numeric-expression} \\
| \text{string-expression} \\
| \text{array-expression} \\
| \text{fact-set-expression} \\
| \text{object-expression} \\
| \text{comparable-expression}
\]
Boolean Expressions

Boolean expressions, as in Java, may be either true or false.

Format

\[
\text{boolean-expression} ::= \text{boolean-assignment} \\
| \text{boolean-expression} ? \text{boolean-expression} : \text{boolean-expression} \\
| \text{boolean-expression} \text{||} \text{boolean-expression} \\
| \text{boolean-expression} \text{&&} \text{boolean-expression} \\
| \text{numeric-expression} \text{equal-op} \text{numeric-expression} \\
| \text{object-expression} \text{equal-op} \text{object-expression} \\
| \text{boolean-expression} \text{equal-op} \text{boolean-expression} \\
| \text{object-expression} \text{instanceof} \text{type-name} \\
| \text{numeric-expression} \text{relop} \text{numeric-expression} \\
| \text{string-expression} \text{relop} \text{string-expression} \\
| \text{! boolean-expression} \\
| \text{boolean-primary-expression}
\]

\[
\text{boolean-assignment} ::= \text{boolean-target-expression} = \text{boolean-expression}
\]

\[
\text{equal-op} ::= == | !=
\]

\[
\text{relop} ::= < | > | <= | >=
\]

\[
\text{type-name} ::= \text{qname}
\]

Usage Notes

For strings, < is Unicode UCS2 code point order.
For objects, != does not test for inequality of object references, but rather is the negation of the equals methods.
Thus, the statement:
\[
\text{if (object1 != object2)();}
\]

Is equivalent to the statement:
\[
\text{if (! (object1.equals(object2))();}
\]

RL Language, unlike Java, does not support testing for equality of object references.

Example

Example 2–26 shows use of a boolean expression in RL Language.
Example 2–26  RL Boolean Expression

```java
if {
    (true ? 'a' < 'b' : false)
    && (1 == 0 || 1.0 > 0)
    && "x" instanceof Object
} {
    println("all true");
};
```
Numeric Expressions

Numeric expressions, as in Java, implicitly convert integer operands to floating point if other operands are floating point. Table 2–1 shows other implicit conversions.

Format

\[
\text{numeric-expression} ::= \text{numeric-assignment} \\
| \quad \text{boolean-expression} ? \text{numeric-expression} : \text{numeric-expression} \\
| \quad \text{numeric-expression} ( + - ) \text{numeric-expression} \\
| \quad \text{numeric-expression} ( * / % ) \text{numeric-expression} \\
| \quad \text{numeric-expression} ^ {2} \text{numeric-expression} \\
| \quad ( \text{numeric-cast} ) \text{numeric-expression} \\
| \quad ( + - ) \text{numeric-expression} \\
| \quad ( ++ | -- ) \text{numeric-primary-expression} \\
| \quad \text{numeric-primary-expression} [ ++ | -- ]
\]

\[
\text{numeric-assignment} ::= \text{numeric-target-expression} ( = | += | -= | *= | /= | %= ) \text{numeric-expression}
\]

\[
\text{numeric-cast} ::= \text{numeric}
\]

Usage Notes

Table 2–5 shows the precedence order, from highest to lowest, for a numeric-expression.

<table>
<thead>
<tr>
<th>Symbols</th>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>++</td>
<td>Post-increment</td>
<td>numeric-primary-expression [ ++</td>
</tr>
<tr>
<td>--</td>
<td>Post-decrement</td>
<td></td>
</tr>
<tr>
<td>++</td>
<td>Pre-increment</td>
<td>( ++</td>
</tr>
<tr>
<td>--</td>
<td>Pre-decrement</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>Unary minus</td>
<td>( +</td>
</tr>
<tr>
<td>+</td>
<td>Unary plus</td>
<td></td>
</tr>
<tr>
<td>(type)</td>
<td>Type cast</td>
<td>( numeric cast ) numeric-expression</td>
</tr>
<tr>
<td>**</td>
<td>Exponentiation</td>
<td>numeric-expression ** numeric-expression</td>
</tr>
<tr>
<td>*, /, %</td>
<td>Multiply or Divide or Remainder</td>
<td>numeric-expression ( * / % ) numeric-expression</td>
</tr>
<tr>
<td>+, -</td>
<td>Addition or Subtraction</td>
<td>numeric-expression( + - ) numeric-expression</td>
</tr>
<tr>
<td></td>
<td>Conditional</td>
<td>boolean-expression ? numeric-expression : numeric-expression</td>
</tr>
<tr>
<td>=</td>
<td>Assignment Operators</td>
<td>numeric-target-expression ( =</td>
</tr>
</tbody>
</table>
String Expressions

As in Java, any expression can be converted to a string using the concatenation + operator. In RL Language, unlike Java, when an array is converted to a string, the array contents are converted to a string, with array elements separated by commas and surrounded with curly braces. When an instance of an RL Language class is converted to a string, the class name appears followed by property value pairs separated by commas and surrounded with parentheses. This RL Language feature is useful for logging, tracing, and debugging.

When + operator is applied to an operand that is a String, then all operands are converted to Strings and the operands are concatenated.

Format

```plaintext
string-expression ::= string-assignment
| boolean-expression ? string-expression : string-expression
| string-expression + expression
| expression + string-expression
| string-primary-expression

string-assignment ::= string-target-expression ( = | += ) string-expression
```

Example

Example 2–27 shows use of a string expression in RL Language. The example prints "1 2.0 true {1,2}"

**Example 2–27  RL String Expression**

```plaintext
int i = 1;
double f = 2.0;
boolean b = true;
int[] v = new int[]{i, 2};
println(i + " " + f + " " + b + " " + v);
```
Array Expressions

RL Language arrays behave just like Java arrays, but are limited to one dimension. The base type of an array is the type of the members of the array. All members must be of the same type. An array element may contain an array but only if the containing array is of type `Object[]`.

**Note:** RL Language does not directly support multi-dimensional arrays.

### Format

```
array-expression ::= array-assignment
                   | boolean-expression ? array-expression : array-expression
                   | ( array-cast ) ( array-expression | object-expression )
                   | array-primary-expression

array-assignment ::= array-target-expression = array-expression

array-cast ::= type
```

### Usage Notes

The type of an `array-cast` must be an array type.
Fact Set Expressions

A fact-set-expression matches, filters, and returns facts from working memory. A fact-set-expression is legal only in a rule fact-set-condition. The if keyword indicates a fact-set-condition; however, a fact-set-condition is different from an if action. A rule’s fact-set-condition iterates through all the rows in a fact set that match the fact-set-condition. The if action tests a boolean expression.

**Format**

```
fact-set-condition ::= if fact-set-expression

fact-set-expression ::= fact-set-expression || fact-set-expression
                      | fact-set-expression && fact-set-expression
                      | fact-set-expression && boolean-expression
                      | ! fact-set-expression
                      | exists fact-set-expression
                      | fact-set-pattern
                      | (fact-set-expression)
                      | aggregate

fact-set-pattern ::= fact [ (property-pattern (, property-pattern)*) ]
                   [ var ] local-object-variable

local-object-variable ::= identifier

property-pattern ::= property-name : field-pattern

field-pattern ::= var local-property-variable | constraint

local-property-variable ::= identifier

simple-expression ::= string literal
                      | object-target-expression
                      | numeric literal
                      | numeric-target-expression
                      | boolean-literal
                      | boolean-target-expression

constraint ::= simple-expression

property-name ::= name

aggregate ::= aggregate fact-set-expression : aggregate-spec (, aggregate-spec) *

aggregate-spec ::= aggregate-function [ var ] identifier

aggregate-function ::= average (numeric-expression)
                      | sum (numeric-expression)
```
Fact Set Expressions

| minimum (comparable-expression) |
| maximum (comparable-expression) |
| count () |
| collection (object-expression) |
| user-defined (expression type Tin) |

user-defined ::= qname

Usage Notes

A fact-set-expression can limit the facts it returns using either a simple-expression as a constraint in a fact-set-pattern or using a supported operator with the fact-set-expression.

A fact-set-expression may not contain any of the following:
- assert
- modify
- new
- References to non-final global variables.

Operator precedence is as in Java. Use parentheses to force desired precedence. For example,

```
fact person var p && (p.age < 21 || p.age > 65)
```

Without the parentheses, the p in p.age is undefined (see Table 2–5 for more details on operator precedence).

A local-object-variable or local-property-variable is in scope for all expressions following the pattern that are following the pattern and connected with the \&\& operator. If the pattern is not contained in an exists, | |, or ! expression, the variable is also in scope in the rule’s action-block. The \&\&’ed expressions may filter the returned facts, so that only the facts surviving the filter are returned.

Fact Set Pattern - Fetch From Working Memory

The most primitive fact-set-expression is the fact-set-pattern that returns some or all facts of the given class that have been asserted into working memory. A fact-set-pattern searches working memory for facts of the given class and with the optional constraint on the property values. The returned fact set contains a row for each matching fact. A local row variable can be defined to refer to each row, or local field variables can be defined to refer to fields within a row. If no local row variable is supplied, the name part of the class qname can be used to refer to each row (see Example 2–31).

Join Operator

The \&\& operator defines the cross product or join of two fact-set-expression operands. The left-hand-side of a fact-set-expression \&\& operator must be a fact set. The right-hand-side of a join operator is another fact-set-expression. The result of applying the \&\& operator to two fact sets is the joined fact set.

Filter Operator

The \&\& operator defines a filter operator that rejects facts in its left-hand-side fact-set-expression that do not match the right-hand-side boolean-expression. The
left-hand-side of filter must be a fact-set-expression. The right-hand-side of a filter is a boolean-expression.

A filter right-hand-side may include references to variables defined, using the var keyword, in the left-hand-side.

**Union Operator**

The || operator defines the union of two fact-set-expression operands. When the || operator is applied to fact-set-expressions, the following is true:

- The expression’s vars cannot be referenced outside the containing expression.
- The || returns the concatenation of its input fact sets, but the contents of the produced fact set are not accessible. Thus, || is typically used in a ! or exists expression. Rather than a top-level || in a condition, it is usually better to use two or more rules with top-level && operators so that vars defined in the condition can be referenced in the action-block.

---

**Note:** In the following construction:

```plaintext
if (fact X || fact W) {}
```

If both an X and a W are asserted, this rule fires twice, one time for each fact.

---

**Empty Operator**

The ! operator tests if the fact-set-expression is empty. When the ! is applied to the fact-set-expression, the following is true:

- The expression’s vars cannot be referenced outside the containing ! expression.
- The ! operator returns a single row if the fact-set-expression is empty, else the ! operator returns an empty fact set.

**Exists (Not Empty) Operator**

The exists operator tests if the fact-set-expression is not empty.

When the exists operator is applied to the fact-set-expression, the following is true:

- The expression’s vars cannot be referenced outside the containing exists expression.
- The exists returns a single row if the expression is not empty, else exists returns an empty fact set.

**Var Keyword**

Note that when you use var, the fact is only visible using the var defined variable (and not using the original name). Thus, the following example works, assuming action.kind is defined:

```plaintext
if (fact action) {
    println(action.kind);
}
```

However, for the following example, after var a is defined, the action.kind reference produces a syntax error because you need to use a.kind after the var a definition.

```plaintext
if (fact action var a) {
```
println(action.kind);
}

## Aggregate

Aggregates support the following functions:

### Table 2–6 Aggregate Functions

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>average()</td>
<td>Provides the average for matching facts. The result is double.</td>
</tr>
<tr>
<td>sum()</td>
<td>Provides the sum for the matching facts. The result is double or long.</td>
</tr>
<tr>
<td>count()</td>
<td>The result is long.</td>
</tr>
<tr>
<td>minimum()</td>
<td>Provides the minimum for the matching facts.</td>
</tr>
<tr>
<td>maximum()</td>
<td>Provides the maximum for the matching facts.</td>
</tr>
<tr>
<td>collection()</td>
<td>The result is java.util.List of Facts.</td>
</tr>
<tr>
<td>user defined</td>
<td>For a user-defined function the result is type Tout.</td>
</tr>
</tbody>
</table>

RL Language supports the aggregate pattern that applies one or more aggregate functions to a `factRowCollection`, and binds the aggregates to pattern variables. The usual SQL set of built-in aggregates is supported, and user-defined aggregates are supported when a user-supplied Java class is supplied.

If an aggregate function uses primitive wrapper types, for example Long, Double, then these will be unboxed such that the bind variable for the result has the appropriate raw primitive type.

If the fact expression in an aggregate is empty, then the rule will not fire. This ensures that if there are no matching facts for the expression, the aggregate function does not return a number that is meaningless in this context. For example, the “sum” of a property of a zero-size set is not meaningful.

For example, print the names of employees who are paid better than average:

```java
if fact Emp emp && aggregate fact Emp(salary: var sal) : average(sal) var avgSal && emp.salary > avgSal {
    println(emp.name);
}
```

Print the names of employees, who are paid better than the average of employees who make over $100,000:

```java
if fact Emp emp && aggregate fact Emp(salary: var sal) && Emp.salary > 100000 average(sal) var avgSal && emp.salary > avgSal {
    println(emp.name);
}
```

User-defined aggregates are supported by providing a public class named `user defined` with a public 0-arg constructor that implements:

```java
public interface IncrementalAggregate<Tin, Tout> extends Serializable {
    public void initialize();
    public void add(Tin value);
    public void remove(Tin value);
    public Tout getResult();
}
```
public boolean isValid();
)

Implementations must support the following invocation sequence:
new (initialize (add|remove)+ isValid getResult)*

isValid should return true when the result of the user defined aggregate is valid and false otherwise.

Examples

Example 2–28 shows the action is placed on the agenda for all Counter facts with a value of 1.

Example 2–28  Fact Set Expression for Counter.value  

class Counter { int id; int value; }
rule exla { 
  if (fact Counter c && c.value == 1)
  { println('counter id " + c.id + " is 1"); } 
}

Example 2–29 shows an equivalent way to express the rule from Example 2–28, using a constraint.

Example 2–29  Using a Fact Set Constraint  

rule exlb { 
  if (fact Counter(value: 1) c)
  { println('counter id " + c.id + " is 1"); } 
}

assert(new Counter(id: 99, value: 1)); run(); // prints twice, once for each rule

Example 2–30 shows an illegal use of a fact set, because c is used before it is defined.

Example 2–30  Illegal Use of Fact Set  

rule ex2 { 
  if (c.value == 1 && fact Counter c)
  { println('counter id " + c.id + " is 1"); } 
}

Example 2–31 shows an action is placed on the agenda for all AttFacts with the property a2==0 and without a matching, equal first elements, Counter.

Example 2–31  Using a Fact Set with && Operator for Counter Fact  

class AttFact {int a1; int a2;}
rule ex3 { 
  if (fact AttFact(a2: 0) && ! fact Counter(id: AttFact.a1))
  { println(AttFact.a1); } 
}

assert(new AttFact()); // will match because a1=a2=0
assert(new AttFact(a1: 1, a2: 0)); // will not match
run();  // rule fires once
Example 2–32 shows the condition, if (fact Ca a && fact Cb(v: a.v) b) is interpreted as follows:

- The fact Ca a returns a fact set containing a(v: 1), a(v: 2), a(v: 3)
- The && operator returns a fact set containing the two rows {a(v: 1), b(v: 1)}, {a(v: 2), b(v: 2)}

**Example 2–32 Using a Fact Set with && Operator**

```java
class Ca {int v;}
assert(new Ca(v: 1));
assert(new Ca(v: 2));
assert(new Ca(v: 3));
class Cb {int v;}
assert(new Cb(v: 0));
assert(new Cb(v: 1));
assert(new Cb(v: 2));
rule r {
    if (fact Ca a && fact Cb(v: a.v) b) {
        println("row: " + a + " * " + b);
    }
}
run(); // prints 2 rows
```
Comparable Expression

Comparable expressions allow objects that implement java.lang.Comparable to be compared using the ==, !=, <, <=, >, and >= operators. This allows dates to be easily compared. Also, BigDecimal, often used to represent money, can be compared in such expressions.

Format

comparable-expression ::= qname variable of type implementing java.lang.Comparable

| member of type implementing java.lang.Comparable
Object Expressions

The only expression operators for objects are assignment and cast.

Format

```
object-expression ::= object-assignment | ( ob-cast ) object-expression |
                      boolean-expression ? object-expression : object-expression

object-assignment ::= object-target-expression = object-primary-expression

ob-cast ::= object-type
```
Primary Expressions

Primary expressions include assignment targets such as variables, properties, array elements, class members and other tightly binding expression syntax such as literals, method and function calls, and object and fact construction. The syntax is very similar to Java except where noted.

Format

```
primary-expression ::= array-primary-expression
  | string-primary-expression
  | numeric-primary-expression
  | boolean-primary-expression
  | object-primary-expression

array-primary-expression ::= array-constructor
  | function-call returning array
  | method-call* returning 1-dim Java array
  | ( array-expression )
  | array-target-expression

array-constructor ::= new simple-type [ numeric-expression integer ]
  | numeric [] { numeric-expression ( , numeric-expression )* } numeric expression must be implicitly convertible to base
  | boolean [] { boolean-expression ( , boolean-expression )* }
  | object-type [] { object-expression ( , object-expression )* }

array-target-expression ::= qname variable of type array
  | member of type array
  | array-primary-expression base type is Object [ numeric-expression int ]

string-primary-expression ::= string literal (see "Literals" on page 2-8)
  | object-primary-expression object is java.lang.String

string-target-expression ::= object-target-expression object is java.lang.String
```
numeric-primary-expression ::= 
    numeric literal
    | function-call returning numeric
    | method-call returning numeric
    | array-primary-expression . length
    | ( numeric-expression )
    | numeric-target-expression

numeric-target-expression ::= 
    qname variable of type numeric
    | member of type numeric
    | array-primary-expression base type is numeric [ numeric-expression ]

boolean-primary-expression ::= 
    boolean-literal
    | function-call returning boolean
    | method-call returning boolean
    | ( boolean-expression )
    | boolean-target-expression

boolean-literal ::= true | false

boolean-target-expression ::= 
    qname variable of type boolean
    | member of type boolean
    | array-primary-expression base type is boolean [ numeric-expression int ]

object-primary-expression ::= 
    new class-definition-name ( [ expression ( , expression )* ] argument list )
    | new class-definition-name ( [ property-pattern ( , property-pattern )* ] property-value pairs )
    | function-call returning Java object
    | method-call returning Java object
    | object-target-expression

object-target-expression ::= 
    qname variable of type object
Using Expressions

| member of type Java object |
| array-primary-expression base type is object [ numeric-expression int ] |

function-call ::= qname function name ( [ expression ( , expression )* ] argument list )

method-call ::= object-primary-expression . identifier method name ( [ expression ( , expression )* ] argument list )

member ::= object-primary-expression . identifier member name

Examples

Example 2–33 shows the RL Language literal syntax (which is the same as Java).

Example 2–33 Use of Literals

String s = "This is a string."
int i = 23;
double f = 3.14;
boolean b = false;

Methods and functions can be overloaded. However, unlike Java, RL Language uses a first fit algorithm to match an actual argument list to the overloaded functions.

Example 2–34 shows an example of overloading

Example 2–34 Overloading

function f(int i);  
function f(Object o);  
function f(String s);  // can never be called

f(1);        // calls first f
f('a'); // calls second f, because "a" is an Object

new

RL Language classes do not have user-defined constructors. The default constructor initializes properties to their default values. The RL Language new operator permits specifying some property values (this works for Java bean properties, too).

A Java bean property may have a getter but no setter. Such a property may not be modified.

Example

Example 2–35 Initialization Using the New Operator

class C { int i = 1; int j = 2; }
C c = new C();
println(c); // c.i == 1 and c.j == 2
c = new C(i: 3);
println(c); // c.i == 3 and c.j == 2

```java
C c = new C(i: 0, j: 0);
println(c); // c.i == c.j == 0
```

println(c); // c.i == 3 and c.j == 2
```java
C c = new C(i: 0, j: 0);
println(c); // c.i == c.j == 0
```
Actions and Action Blocks

RL Language, unlike Java, requires action blocks and does not allow a single semicolon terminated action.

Format

\[
\text{action} ::= \text{action-block} | \text{if} | \text{while} | \text{for} | \text{try} | \text{synchronized} | \text{return} | \text{throw} \\
\text{assign} | \text{incr-decr-expression} | \text{primary-action} \\
\text{action-block} ::= \{ \text{variable} | \text{action} \}^* 
\]

Usage Notes

An action block is any number of local variable declarations and actions. The variables are visible to subsequent variable initialization expressions and actions within the same action block.

In RL Language, unlike in Java, all local variables must be initialized when they are declared. Local variables may not be final.

To exit, you can invoke the System.exit(int) method from within an action.

Example

Example 2–36  Action Block Sample

```
RL> {
    int i = 2;
    while (i-- > 0) { println("bye"); }
}
bye
bye
bye
RL>
```
If Else Action Block

Using the if else action, if the test is true, execute the first action block, and if the test is false, execute the optional else part, which may be another if action or an action block.

RL Language, unlike Java, requires action blocks and does not allow a single semicolon terminated action.

Format

\[\text{if} ::= \text{if } \text{if-test} \text{ action-block} \quad \text{else if} \quad \text{action-block} \]

\[\text{if-test} ::= \text{boolean-expression}\]

Examples

Example 2–37 shows an RL Language if else action block. Example 2–38 shows that an action block is required.

Example 2–37  Sample If Else Action

```java
String s = "b";
if (s=="a") { println("no"); } else
  if (s=="b") { println("yes"); }
else { println("no"); }
```

Example 2–38  Illegal If Action Without an Action Block

```java
if (s=="a") println("no");
```
While Action Block

While the test is true, execute the action block. A return, throw, or halt may exit the action block.

Format

```
while ::= while  while-test  action-block
while-test ::= boolean-expression
```

Usage Notes

RL Language, unlike Java, requires action blocks and does not allow single semicolon terminated action.

Examples

Example 2–39 prints "bye" twice.

**Example 2–39  Sample While Action**

```java
int i = 2;
while (i-- > 0) {
    println("bye");
}
```

**Example 2–40  Illegal While Action Without an Action Block**

```java
while (i-- > 0) println("no");
```
For Action Block

RL Language, like Java, has a for loop. Using the for action block, the for-init portion executes, then while the boolean-expression is true, first the specified action block is executed then the for-update executes. A return, throw, or halt may exit the action block.

Format

for ::= for ( for-init ; boolean-expression ; for-update ) action-block

for-init ::= variable | for-update

for-update ::= incr-decr-expression | assign | primary-expression

Usage Notes

RL Language does not allow a comma separated list of expressions in the for init or for update clauses (Java does allow this).

Example

Example 2–41 shows RL Language code that converts an int[] to a double[].

Example 2–41 For Action

int[] is = new int[]{1,2,3};
double[] fs = is; // error!
double[] fs = new double[3];
for (int i = 0; i < is.length; ++i) {
    fs[i] = is[i];
}
println(fs);
Try Catch Finally Action Block

Execute the first action block. Catch exceptions thrown during executions that match the `Throwable` class in a catch clause. For the first match, execute the associated catch action block. Bind the `Throwable` class instance to the given identifier and make it available to the catch action block. Whether an exception is thrown in the try action block, execute the finally action block, if given.

Uncaught exceptions are printed as error messages when using the RL Language command-line and are thrown as `RLExceptions` when using a RuleSession's `executeRuleset` or `callFunction` methods. The `try`, `catch`, and `finally` in RL Language is like Java both in syntax and in semantics. There must be at least one `catch` or `finally` clause.

Format

```
try ::= try action-block
   ( catch (class-implementing-throwable identifier) action-block )* 
[ finally action-block ]
class-implementing-throwable ::= qname
```

Usage Notes

In order to fully understand how to catch exceptions in RL Language, one must understand how the stack frames are nested during rule execution. Rules do not call other rules the way that functions or methods may call functions or methods. Therefore, you cannot use a catch block in one rule's action block to catch exceptions in another rule's action block. Exceptions thrown during rule firing must either be handled by the firing rule's action block, or must be handled by a caller to the `run`, `runUntilHalt`, or `step` functions that caused the rule to fire.

Examples

Example 2–42 shows the try catch and finally actions. The output from running this example is:

```
exception in invoked Java method
this is really bad!
but at least it's over!
```

Example 2–42  Try Catch and Finally Action Blocks

```
try {
    throw new Exception("this is really bad!");
} catch (Exception e) {
    println(e.getMessage());
    println(e.getCause().getMessage());
} finally {
    println("but at least it's over!");
}
```

Note that RL Language treats the explicitly thrown `Exception"this is really bad!"` as an exception from an invoked Java method, and wraps the `Exception` in a `JavaException`. The explicitly thrown `Exception` is available as the cause of the `JavaException`. 
Synchronized Action Block

As in Java, the synchronized action is useful for synchronizing the actions of multiple threads. The synchronized action block lets you acquire the specified object's lock, then execute the action-block, then release the lock.

Format

```
synchronized ::= synchronized object-primary-expression action-block
```

Example

Example 2–43 changes the name of a Person object, adding old names to the nicknames, and synchronizes so that a concurrent reader of the Java object who is also synchronizing will see a consistent view of the Person (See Example 2–12 details on the Person bean).

```
Example 2–43  Synchronized Action
import example.Person;  // this Java bean is defined in example J1
function changeName(Person p, String first, String last) {
  synchronized(p) {
    java.util.Set s = p.getNicknames();
    s.add(p.getFirstName());
    s.add(p.getLastName());
    p.setFirstName(first);
    p.setLastName(last);
  }
  assert(p);
}
Person person = new Person("Elmer", "Fudd", new String[]{"Wabbit Wuvver"});
println(person.nicknames.toArray());
changeName(person, "Bugs", "Bunny");
println(person.nicknames.toArray());
```
Modify Action

Modify updates the named properties using the associated expressions. It also updates the associated shadow fact, if any, and causes rules whose conditions reference the updated properties and evaluate to true to be activated. Rules whose conditions do not reference the updated properties are not activated.

The object argument to modify must be an object that has already been asserted, then the values of that object are updated and network is updated with the slot-specific semantics. The result is the object and the network are consistent.

Format

\[
\text{modify} ::= \text{modify} \left( \text{object-expression} , \ \text{property-update} \ (, \ \text{property-update})^* \right)
\]

\[
\text{property-update} ::= \text{property-name} : \text{expression}.
\]

Usage Notes

It is common for a fact to have properties that are set or modified by rules. For example, a customer in an application might have a status of "", "silver", or "gold". The status may be set by rules that examine other properties of customer and related facts (such as past orders). It is also common for these computed properties to be used in further rule conditions. For example, give gold customers a 10% discount. A rule that modifies a fact and reasserts it must be careful to add an extra condition so that it does not reactive itself over and over. For example, if the following rule fires once, it will fire over and over:

```plaintext
if fact Customer c && c.pastYearSpend > 1000 {
    c.status = "gold";
    assert(c);
}
```

You can fix this looping using the following rule definition:

```plaintext
if fact Customer c && c.pastYearSpend > 1000 && c.status != "gold" {
    c.status = "gold";
    assert(c);
}
```

Example 2–44 prevents the loop but does not activate rules that are looking for gold customers.

Example 2–44  Example Showing Bad Rules Programming Practice to be Avoided

```plaintext
if fact Customer c && c.pastYearSpend > 1000 {
    c.status = "gold";
}
```

Example 2–44 demonstrates bad rules programming practice because it changes the value of the customer object but not the value of the, shadow, customer fact. The modify action lets you modify the object and fact together. Modify also activates rules that test the modified properties but does not activate rules that test non-modified properties.

```plaintext
if fact Customer c && c.pastYearSpend > 1000 {
    modify(c, status: "gold");
}
```
This rule does not loop because the tested properties and modified properties are disjoint. This rule can be used in an inference to fire subsequent rules that test for status="gold".

A second rule that illustrates infinite looping is the rule described as follows:

Give Employees earning at least $50,000 a 5% raise.

if Employee emp && emp.sal > 50000 {
    modify(emp, sal: sal * 1.05);
}

Even using modify, this rule will self-trigger because it is testing the same property (sal) that it is modifying, and the test is true after modification. To avoid looping in this case, you could also add a raise property test, as follows:

if Employee emp && emp.sal > 50000 && !emp.raise {
    modify(emp, sal: emp.sal * 1.05, raise: true);
}

Alternatively, to avoid looping in this case you could also add a fact to handle the raise. For example:

public class RaiseGiven
{
    Employee emp;  // or possibly just an employee ID
}

if Employee emp && emp.sal > 500000 && !RaiseGiven(emp: emp) {
    modify(emp, sal: sal * 1.05);
    assert(new RaiseGiven(emp: emp));
}
Return Action

The return action returns from the action block of a function or a rule.

A return action in a rule pops the ruleset stack, so that execution continues with the activations on the agenda that are from the ruleset that is currently at the top of the ruleset stack.

If rule execution was initiated with either the run or step functions, and a return action pops the last ruleset from the ruleset stack, then control returns to the caller of the run or step function.

If rule execution was initiated with the runUntilHalt function, then a return action will not pop the last ruleset from the ruleset stack. The last ruleset is popped with runUntilHalt when there are not any activations left. The Oracle Rules Engine then waits for more activations to appear. When they do, it places the last ruleset on the ruleset stack before resuming ruleset firing.

Format

```
return ::= return [ return-value ] ;
return-value ::= expression
```

If the function has a returns clause, then the return-value must be specified and it must be of the type specified by the returns clause.

Usage Notes

A return action in a rule or a function without a returns clause must not specify a return-value.
Throw Action

Throw an exception, which must be a Java object that implements `java.lang.Throwable`. A thrown exception may be caught by a `catch` in a `try` action block.

Format

```
throw ::= throw throwable ;
throwable ::= object-primary-expression
```
Assign Action

An assignment in RL Language, as in Java, is an expression that can appear as an action.

Format

assign ::= assignment-expression ;

assignment-expression ::= boolean-assignment
  | numeric-assignment
  | string-assignment
  | object-assignment
  | array-assignment

Example

Example 2–45 shows the use of the RL Language assignment expression. This prints "6 5".

Example 2–45  Assignment Expression

clear;
int i = 1;
int j = 2;
i += j += 3;
println(i + " " + j);
Increment or Decrement Expressions

Increment and decrement in RL Language, as in Java, are expressions that can appear as actions.

Format

\[
\text{incr-decr} ::= \text{incr-decr-expression} ; \\
\text{incr-decr-expression} ::= ( ++ | -- ) \text{numeric-target-expression} \mid \text{numeric-target-expression} ( ++ | -- )
\]

Examples

Example 2–46 shows the use of the RL Language decrement action. This example prints "0".

\begin{verbatim}
Example 2–46  Decrement Action
clear;
int i = 1;
--i;
println(i);
\end{verbatim}
Primary Actions

A primary action is a primary expression such as a function call, `assert`, or Java method call executed for its side-effects. For example, the `println` function is often used as a primary action.

Format

```plaintext
primary-action ::= primary-expression ;
```
Rulegroup

A rulegroup provides support for decision table overrides. This supports the following decision table features: the ability for one rule to override one or more other rules.

Format

```
rulegroup ::= rulegroup rulegroup-name { rulegroup-property* ( rule | rulegroup )* }
rulegroup-name ::= identifier
rulegroup-property ::= mutex
mutex ::= mutex = boolean-literal ;
```

Usage Notes

A rulegroup construct is a top level construct in a ruleset. A rulegroup has an optional boolean property:

- mutex: The mutex property enables mutual exclusion between rules. The common case is that the rules reside in the same rulegroup that has set mutex to true. In more complex rulegroup hierarchies, two rules mutually exclude each other if their closest common ancestor rulegroup has mutex set to true. When a rules fires, existing activations for rules which it mutually excludes are removed from the agenda preventing them from firing. Theses activations must be directly related as identified by the set of facts that resulted in the activations being placed on the agenda. This leads to the requirement that the conditions of all rules that mutually exclude each other have the same fact clauses specified in the same order. This occurs naturally for decision tables.

Example

Example 2–47 demonstrates the use of rulegroups with the mutex property. Note that r2 and r3 reference the same set of fact types in the same order in the rule condition. This is required within a mutex group. The tests in the patterns can be different. The restriction on the shape of the rule condition in a mutex group extends to its descendent groups. Thus, rules r4 and r5 also must reference the same set of fact types in the same order. Assume that one instance of A and one instance of B have been asserted and that r1, r2, r3, r4 and r5 have activations on the agenda. r3 will fire since it has a higher priority. The activation of r2 will be removed without firing since r2 is in a group with mutex=true. Since group2 is a member of group1, the activations of r4 and r5 will also be removed without firing. Rule r1 will fire. Now, assume that r2, r4, and r5 have activations on the agenda and assume that r4 fires first. The activation for r2 will be remove without firing since any rule in group2 firing mutually excludes both r2 and r3. r5 will fire. It is not mutually excluded since group2 does not have mutex=true.

Example 2–47  Ruleset with Rulegroup with Specified Fact Order of Reference

```
ruleset set1
{
  rule r1 { ... }
  rulegroup group1
  {
    mutex = true;
    rule r2 { if fact A && fact B ... ( ... )}
    rule r3 { priority = 2; if fact A && fact B ... ( ... )}
  }
```

rulegroup group2
{
  rule r4 { if fact A && fact B ... { ... }}
  rule r5 { if fact A && fact B ... { ... }}
}
}
Built-in Functions

This section covers the following RL Language built-in functions:

assert, assertTree, assertXPath, clearRule, clearRulesetStack, clearWatchRules, clearWatchActivations, clearWatchFacts, clearWatchFocus, clearWatchCompilations, clearWatchAll, contains, getCurrentDate, getDecisionTrace, getDecisionTraceLevel, getDecisionTraceLimit, getEffectiveDate, getFactsByType, getRulesetStack, getRuleSession, getStrategy, halt, id, object, println, popRuleset, pushRuleset, retract, reset, run, runUntilHalt, setCurrentDate, setDecisionTraceLevel, setDecisionTraceLimit, setEffectiveDate, setRulesetStack, setStrategy, showActivations, showFacts, step, watchRules, watchActivations, watchFacts, watchFocus, watchCompilations
assert

Adds a fact to working memory or updates a fact already in working memory based on the properties of the supplied object \textit{obj}. If the supplied object \textit{obj} is a Java instance, then properties are Java bean properties defined by an associated \texttt{BeanInfo} class or by the existence of getter and setter methods. If \textit{obj} is an RL Language class instance, then the properties are the fields of the class.

\textbf{Format}

\begin{verbatim}
function assert(Object \textit{obj});
\end{verbatim}

\textbf{Usage Notes}

The fact in working memory is a shadow of the supplied object \textit{obj}, and this shadow contains a copy, clone, or reference to each property \textit{prop}. If \textit{prop} is a primitive type, then \textit{prop} is copied to the shadow. If \textit{prop} implements the Java \texttt{Cloneable} interface, then a clone, shallow copy, of \textit{prop} is shadowed. Otherwise, only the reference to \textit{prop} is shadowed. The more a shadow can copy its object's properties, the better a rule with references to several facts can be optimized.

Note that because == and != when applied to an \texttt{Object} in RL Language always invokes the \texttt{Object equals} method, whether a shadow contains copies, clones, or references is transparent to the RL Language program.

Assert may affect the agenda. Rules whose conditions now return a fact set because of a new fact place activations on the agenda. Activations that test for non-existence of facts, using \texttt{!}, may be removed from the agenda. Updates to facts may affect the agenda. Activations whose rule conditions no longer match the changed facts are removed from the agenda. Rules whose conditions return a fact set because of the changed facts have activations placed on the agenda.

Assert should be used to update the fact in working memory if any part of the \textit{obj}'s state has been updated that could possibly have an effect on a rule condition, unless \textit{obj} is a Java bean that supports registering property change listeners, and all that is changed is the value of a bean property.

\textbf{Examples}

Example 2–48 prints, "Pavi has highest salary 65000.0" and Example 2–49 prints, "dept 10 has no employees!".

\begin{verbatim}
Example 2–48  Using Assert Function in the highestSalary Rule

class Emp { String ename; double salary; }
rule highestSalary { 
    if (fact Emp hi && !(fact Emp e && e.salary > hi.salary))
        { 
            println(hi.ename + " has highest salary " + hi.salary);
        }
    }
Emp e1 = new Emp(ename: "Pavi", salary: 55000.00);
assert(e1); // put in working memory
Emp e2 = new Emp(ename: "Fred", salary: 60000.00);
assert(e2); // put in working memory
e1.salary += 10000.00; // Pavi is now the highest paid
assert(e1); // MUST re-assert before allowing rules to fire
run();
\end{verbatim}
import java.util.*;
class Dept { int deptno; List emps = new ArrayList(); }
rule emptyDept {
    if (fact Dept d && d.emps.isEmpty()) {
        println("dept " + d.deptno + " has no employees!");
    }
}
Dept d = new Dept(deptno: 10);
d.emps.add(e1);
assert(d); // put in working memory with 1 employee
d.emps.remove(0);
assert(d); // MUST re-assert before allowing rules to fire
run();

See Also
assertTree, id, object, retract
assertTree

The assertTree built-in function asserts object in an object tree as facts.
The assertTree built-in function supports JAXB 2.0.

Format

assertTree(Object root)
assertTree(String spec, Object root)

Usage Notes

There are two assertTree() signatures:

- assertTree(Object root) is necessary with SDK2. This format traverses the object
graph and asserts objects as directed by internal metadata generated by SDK2.

- assertTree(String spec, Object root) is necessary when SDK2 is not involved. Similar
to assertXPath, spec is a package specification enhanced to allow the specification
of multiple packages separated by a colon. This format asserts objects and
traverses the bean properties of an object if the object is in one of the specified
packages. Typically, the package specification will be the same one used in
establishing the JAXBContext.

The assertTree function does the following:

- asserts objects starting with the root and every fact (object with a visible declared
  fact type) referenced from the root, recursively.

- assert JAXBElement instances it encounters, extract the value class object it
  contains and continue.

See Also

assert
The assertXPath function is deprecated. Use assertTree instead.

Add a tree of facts to working memory using the specified element as the root and an XML xpath-like expression to define the objects in the tree. The pkg is the Java package or RL Language ruleset that contains the classes of objects in the tree. All objects in the tree must be in the same package or ruleset.

In addition to asserting "element" and selected descendants, XLink facts are asserted that link parent and child objects. The classes of all objects in the tree must use the supports xpath (supports) clause of the RL class (rl-class-definition) or fact-class declaration.

**Format**

```
function assertXPath(String pkg, Object element, String xpath);
```

**See Also**

assert, id, object, retract
clearRule

Clears the named rule from the rule session. Removes all of the rule’s activations from the agenda.

Format

function clearRule(String name);

See Also

getRuleSession
clearRulesetStack

Empties the ruleset stack.

**Format**

function clearRulesetStack();

**See Also**

getRulesetStack, getStrategy, popRuleset, pushRuleset, run, setStrategy
clearWatchRules, clearWatchActivations, clearWatchFacts, clearWatchFocus, clearWatchCompilations, clearWatchAll

The clearWatch functions stop printing debug information.

Format

function clearWatchRules();
function clearWatchActivations();
function clearWatchFacts();
function clearWatchFocus();
function clearWatchCompilations();
function clearWatchAll();

See Also

watchRules, watchActivations, watchFacts, watchFocus, watchCompilations
contains

The contains() function is similar to the contains() method on Java Collection but with includes the ability to handle the presence of JAXBElement in the collection.

Format

contains(Collection c, Object o) returns boolean

Usage

When contains() encounters a JAXBElement in the collection c, it obtains the value class from the JAXBElement and compares it to the Object o.

See Also

assertTree
**getCurrentDate**

The `getCurrentDate` function returns the date associated with the CurrentDate fact.

**Format**

```
getCurrentDate() returns Calendar
```

**Usage Notes**

The effective date and the current date are two orthogonal items. The effective date is used to determine which rules are in effect according to the start and end effective date properties. The CurrentDate fact allows reasoning on a rules engine managed fact representing the "current" date.

Setting the current date does not affect the effective date semantics.

If you want to create rules to reason on the date explicitly in the rules, then use the CurrentDate fact. If you want to assign start and or end effective dates to rules and have the rules in effect determined from a date in the data, then use `setEffectiveDate()`.

**See Also**

`setCurrentDate`, `getEffectiveDate`, `setEffectiveDate`
getDecisionTrace

Returns the current trace and starts a new trace.

Format

getDecisionTrace() returns DecisionTrace

Usage Notes

See Also

getDecisionTraceLevel, getDecisionTraceLevel, watchRules, watchActivations, watchFacts, watchFocus, watchCompilations
getDecisionTraceLevel

Gets the current decision trace level.

Format

getDecisionTraceLevel() returns int

Usage Notes

Supported decision trace levels include the following levels:

- Off: decision tracing is disabled. This is defined as RuleSession.DECISION_TRACE_OFF.
- Production: rules fired are shown in trace. This is defined as RuleSession.DECISION_TRACE_PRODUCTION.
- Development: full decision tracing similar in detail to watchAll(). This is defined as RuleSession.DECISION_TRACE_DEVELOPMENT.

See Also

getDecisionTrace, getDecisionTraceLimit, watchRules, watchActivations, watchFacts, watchFocus, watchCompilations
getDecisionTraceLimit

Returns the current limit on the number of events in a trace.

Format

getDecisionTraceLimit() returns int

Usage Notes

See Also

getDecisionTrace, getDecisionTraceLevel
**getEffectiveDate**

The `getEffectiveDate` function returns the current value of the effective date.

**Format**

`getEffectiveDate()` returns Calendar

**Usage Notes**

The effective date and the current date are two orthogonal items. The effective date is used to determine which rules are in effect according to the start and end effective date properties. The `CurrentDate` fact allows reasoning on an engine managed fact representing the "current" date. Both may be set explicitly.

Setting the current date does not affect the effective date semantics. Setting the effective date does not affect the `CurrentDate` fact.

If you want to create rules to reason on the date explicitly in the rules, then use the `CurrentDate` (`setCurrentDate()`). If you want to assign start and or end effective dates to rules and have the rules in effect determined from a date in the data, then use `setEffectiveDate()`.

**See Also**

`setEffectiveDate`, `getCurrentDate`, `setCurrentDate`
getFactsByType

Returns a list of all facts in working memory that are instances of a specified class.

Format

function getFactsByType(String className) returns List

See Also

showFacts, watchRules, watchActivations, watchFacts, watchFocus, watchCompilations
getRulesetStack

Returns the ruleset stack as an array of ruleset names.

**Format**

```
function getRulesetStack() returns String[];
```

**Usage Notes**

Returns: the ruleset stack as an array of ruleset names.

Entry 0, the top of the stack, is the focus ruleset. The focus ruleset is the ruleset whose activations are fired first by a subsequent `run`, `runUntilHalt`, or `step` function execution.

**See Also**

`clearRulesetStack`, `getStrategy`, `popRuleset`, `pushRuleset`, `setRulesetStack`, `setStrategy`
getRuleSession

Returns a Java RuleSession object. An RL Language program could use this RuleSession to dynamically define new classes, rules, functions, or variables.

Format

function getRuleSession() returns RuleSession;

Example

rule learn {
    if (fact f1 && ...) {
        RuleSession rs = getRuleSession();
        rs.executeRuleset("rule newRule { if fact f1 && fact f2 && ... { ... } }");
    }
}

See Also

clearRule
getStrategy

Returns the current strategy. Table 2–7 shows the possible strategy values.

Format

function getStrategy() returns String;

See Also

clearRulesetStack, getRulesetStack, popRuleset, pushRuleset, setStrategy
halt

The halt function halts execution of the currently firing rule, and returns control to the run, runUntilHalt, or step function that caused the halted rule to run. The agenda is left intact, so that a subsequent run, runUntilHalt, or step can be executed to resume rule firings.

The halt function has no effect if it is invoked outside the context of a run, runUntilHalt, or step function.

Format

function halt();

See Also

reset, run, runUntilHalt, step
id

Return the fact id associated with the object \textit{obj}. If \textit{obj} is not associated with a fact, returns -1.

\textbf{Format}

function id(Object \textit{obj}) returns int;

\textbf{See Also}

assert, object, retract
object

Return the object associated with the given fact id. If there is no such fact id, returns null.

Format

function object(int factId) returns Object;

See Also

assert, id, retract
println

Print the given value to the RuleSession output writer.

Format

function println(char c);
function println(char[] ca);
function println(int i);
function println(long l);
function println(float f);
function println(double d);
function println(boolean b);
function println(Object obj);
popRuleset

If the stack is empty, popRuleset throws RLRuntimeException. If the stack is not empty, popRuleset pops the focus off the stack and returns it.

All entries are shifted down one position, and the new focus is the new top of stack, entry 0.

Entry 0, the top of the stack, is the focus ruleset. The focus ruleset is the ruleset whose activations are fired first by a subsequent run, runUntilHalt, or step function execution.

Format

function popRuleset() returns String;

Example 2–50  Using popRuleset and Throwing RLRuntimeException

clearRulesetStack();
popRuleset();        // RLRuntimeException

See Also

clearRulesetStack, getRulesetStack, getStrategy, pushRuleset, setStrategy
pushRuleset

Push the given ruleset onto the stack and make it the focus. It is an error to push a ruleset that is already the focus (RLIllegalArgumentException is thrown for this error).

Entry 0, the top of the stack, is the focus ruleset. The focus ruleset is the ruleset whose activations are fired first by a subsequent run, runUntilHalt, or step function execution.

Format

function pushRuleset(String focus);

Examples

Example 2–51 shows the RL Language using the pushRuleset function. Example 2–52 shows the RL Language using the popRuleset function.

Example 2–51  Using pushRuleset - Throws RLIllegalArgumentException

clearRuleSetStack();
pushRuleset("main");        // focus is "main"
pushRuleset("main");        // RLIllegalArgumentException

Example 2–52  Using popRuleset - Throws RLRuntimeException

clearRuleSetStack();
popRuleset();        // RLRuntimeException

See Also

clearRuleSetStack, getRuleSetStack, getStrategy, popRuleset, setStrategy
retract

Remove the fact associated with the object obj from working memory.

Format

function retract(Object obj);

Usage Notes

Retract may affect the agenda. Activations that depend on the retracted fact are removed from the agenda.

Note, rules that have conditions that test for non-existence of facts (using !) may place new activations on the agenda.

See Also

assert, id, object
**reset**

Clears all facts from working memory, clears all activations from the agenda, and reevaluates non-final global variable initialization expressions.

**Format**

```
function reset();
```

**See Also**

`halt, run, runUntilHalt, step`
run

Fire rule activations on the agenda until:

- A rule action calls \texttt{halt} directly or indirectly. For example, when \texttt{halt} is called by a function called by a rule action.
- The agenda is empty.
- The ruleset stack is empty.

Format

\begin{verbatim}
function run() returns int;
function run(String \texttt{rulesetName}) returns int;
\end{verbatim}

Usage Notes

If the argument, \texttt{rulesetName} is supplied, the named ruleset is pushed on the top of the ruleset stack before firing any rules.

If a null \texttt{rulesetName} is supplied, the ruleset stack is not modified before firing rules.

If no \texttt{rulesetName} is supplied and the default \texttt{main} ruleset is not on the ruleset stack, then the \texttt{main} ruleset is placed at the bottom of the ruleset stack before firing any rules.

Returns: \texttt{int}, the number of rules fired.

See Also

\texttt{halt, reset, runUntilHalt, step}
runUntilHalt

This function fires rule activations until halt is called. Unlike run and step, runUntilHalt does not return when the agenda is empty. Also, runUntilHalt does not pop the bottommost ruleset name from the ruleset stack. Instead, it waits for the agenda to contain activations.

Format

function runUntilHalt() returns int;

Usage Notes

The only way for activations to be added to the agenda while the main RuleSession thread is busy executing runUntilHalt is for a second thread to either:

1. Modify Java bean facts with PropertyChangeListeners.
2. Execute assert or retract functions.

Rules must be designed carefully when using runUntilHalt. For example, a rule that attempts to find a fact with the minimum value of a property will fire when the first instance of the fact is asserted, and then every time another instance is asserted with a lower valued property.

See Also

halt, reset, run, step
setCurrentDate

The `setCurrentDate` function sets the date for reasoning on an engine managed fact representing the "current" date (with the `CurrentDate` fact).

Format

```
setCurrentDate(Calendar newDate)
```

Usage Notes

The `RLIllegalArgumentException` exception is thrown if the `newDate` argument is null.

If you need to reason on the date explicitly in the rules, then use the `CurrentDate` fact. If you want to assign start and end effective dates to rules and have the rules in effect determined from a date in the data, then they should use `setEffectiveDate`. The `setEffectiveDate` function does not affect the `CurrentDate` fact.

By default the value of the current date is managed implicitly by the rules engine. The value of the `CurrentDate` fact is updated to the current system date and (re)asserted internally when a run family of built-in functions is invoked. This is done before any rules fire so that the new current date is evaluated in rule conditions. In the case of `runUntilHalt`, this update occurs each time there is a transition from 0 rules on the agenda to > 0 rules on the agenda.

After the user invokes the `setCurrentDate` function, it becomes the responsibility of the user to update the current date as required. The rules engine no longer manages it implicitly. This remains in effect until the reset function is invoked. After the current date is set explicitly with `setCurrentDate`, any invocation of `setCurrentDate` function that would result in time going backward, set to an earlier point in time, is an error and an `RLIllegalArgumentException` is thrown. After the reset function is invoked, the current date may be set to any value.

See Also

`getCurrentDate`, `getEffectiveDate`, `setEffectiveDate`
setDecisionTraceLevel

Sets the decision trace level to the specified level.

Format

```
setDecisionTraceLevel(int level)
```

Usage Notes

Supported decision trace levels include the following levels:

- **Off**: decision tracing is disabled. This is defined as `RuleSession.DECISION_TRACE_OFF`.
- **Production**: rules fired are shown in trace. This is defined as `RuleSession.DECISION_TRACE_PRODUCTION`.
- **Development**: full decision tracing similar in detail to `watchAll()`. This is defined as `RuleSession.DECISION_TRACE_DEVELOPMENT`.

See Also

- `getDecisionTrace`, `getDecisionTraceLevel`, `getDecisionTraceLevel`, `setDecisionTraceLimit`, `watchRules`, `watchActivations`, `watchFacts`, `watchFocus`, `watchCompilations`
setDecisionTraceLimit

Sets the limit on the number of events in a trace.

Format

setDecisionTraceLimit(int count)

Usage Notes

The default value is 10000.

See Also

getDecisionTrace, getDecisionTraceLevel, getDecisionTraceLevel, setDecisionTraceLevel
**setEffectiveDate**

The `setEffectiveDate` function updates the effective date in the rules engine.

By default, the value of the effective date is managed implicitly by the rules engine. In this case, when a run family of built-in functions is invoked the effective date is updated to the current system date. This is done before any rules fire so that the new effective date is applied before rules begin to fire. In the case of `runUntilHalt`, this update occurs each time there is a transition from 0 rule activations on the agenda to > 0 rule activations on the agenda.

**Format**

```java
setEffectiveDate(Calendar newDate)
```

**Usage Notes**

Invoking `setEffectiveDate` is the only way that you can alter the effective date. After the reset function is invoked, the effective date may be set to any value.

The `RLIllegalArgumentException` exception is thrown if the `newDate` argument is null.

After you invoke the `setEffectiveDate` function, it becomes the responsibility of the application to update the effective date as required. The rules engine no longer manages it implicitly.

This remains in effect until the reset function is invoked.

This is useful for debugging, performing rule evaluation at a “point in time”, or other use cases that require application control of the effective date.

**See Also**

`getEffectiveDate`, `getCurrentDate`, `setCurrentDate`
setRulesetStack

Sets the ruleset stack to the given array of ruleset names.

Entry 0, the top of the stack, is the focus ruleset, which is the ruleset whose activations will be fired first by a subsequent run, runUntilHalt, or step function execution.

Format

function setRulesetStack(String[] rulesetStack)

See Also

clearRulesetStack, getRulesetStack, getStrategy, popRuleSet, pushRuleSet, setStrategy
setStrategy

Strategy specifies the order in which activations from the same ruleset and with the same priority are executed. Table 2–7 shows the valid strategy values.

Table 2–7 Strategy Values for setStrategy and getStrategy Functions

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>queue</td>
<td>Activations are fired in order from oldest to newest.</td>
</tr>
<tr>
<td>stack</td>
<td>Activations are fired in order from newest to oldest.</td>
</tr>
</tbody>
</table>

Format

function setStrategy(String strategy);

See Also

clearRulesetStack, getRulesetStack, getStrategy, popRuleset, pushRuleset
showActivations

The show functions print rule session state to the output Writer. State that can be shown is: Activations all activations on the agenda

Format

function showActivations();

See Also

clearWatchRules, clearWatchActivations, clearWatchFacts, clearWatchFocus, clearWatchCompilations, clearWatchAll, showFacts, watchRules, watchActivations, watchFacts, watchFocus, watchCompilations
showFacts

The show functions print rule session state to the output Writer. State that can be shown is: all facts in working memory.

Format

function showFacts();

See Also

clearWatchRules, clearWatchActivations, clearWatchFacts, clearWatchFocus, clearWatchCompilations, clearWatchAll, showActivations, watchRules, watchActivations, watchFacts, watchFocus, watchCompilations
step

Fire rule activations on the agenda until:

- The specified number of rule activations, \textit{numRulesToFire} have been fired.
- A rule action calls halt directly or indirectly. For example, by a function called by a rule action.
- The agenda is empty.
- The ruleset stack is empty.

Format

\begin{align*}
\text{function} & \ \text{step}(\text{int numRulesToFire}) \ \text{returns int}; \\
& \text{function} \ \text{step}(\text{int numRulesToFire, String rulesetName}) \ \text{returns int};
\end{align*}

Usage Notes

If no ruleset name is supplied and the \textit{main} ruleset is not on the ruleset stack, then the \textit{main} ruleset is placed at the bottom of the ruleset stack before firing any rules.

If a ruleset named, \textit{rulesetName}, is supplied, the specified ruleset is pushed on the top of the ruleset stack before firing any rules. If a null ruleset name is supplied, the ruleset stack is not modified before firing rules.

Returns the integer number of rules fired.

See Also

halt, reset, run, runUntilHalt
### watchRules, watchActivations, watchFacts, watchFocus, watchCompilations

The watch functions turn on printing of information about important rule session events. The information is printed to the output Writer whenever the events occur. Use a clearWatch function to turn off printing.

Table 2–8 describes the available debugging information.

**Table 2–8  Watch Functions Event Descriptions**

<table>
<thead>
<tr>
<th>Debug Watch</th>
<th>Rule Session Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>watch Rules</td>
<td>Rule session event description</td>
</tr>
<tr>
<td>Rules</td>
<td>Information about rule firings (execution of activations)</td>
</tr>
<tr>
<td>Activations</td>
<td>Addition or removal of activations from the agenda</td>
</tr>
<tr>
<td>Facts</td>
<td>Assertion, retraction, or modification of facts in working memory</td>
</tr>
<tr>
<td>Focus</td>
<td>Pushing or popping of the ruleset stack. The top of the ruleset stack is called the focus ruleset, and all activations on the agenda from the focus ruleset will be fired before the focus is popped and the next ruleset on the stack becomes the focus.</td>
</tr>
<tr>
<td>Compilations</td>
<td>When a rule's conditions are added to the rete network, information about how the condition parts are shared with existing rules is printed. &quot;=&quot; indicates sharing. The order that rules are defined can affect sharing and thus can affect performance.</td>
</tr>
<tr>
<td>All</td>
<td>Includes information shown with watch Rules, watch Activations, watch Facts, watch Compilations and watch Focus.</td>
</tr>
</tbody>
</table>

**Format**

```plaintext
function watchRules();
function watchActivations();
function watchFacts();
function watchFocus();
function watchCompilations();
function watchAll();
```

**See Also**

clearWatchRules, clearWatchActivations, clearWatchFacts, clearWatchFocus, clearWatchCompilations, clearWatchAll, showActivations, showFacts
This chapter describes the RL command-line that reads rulesets from System.in and writes output from the functions println, watch, and show to System.out.

This chapter includes the following topics:

- Section 3.1, "Starting and Using the Command-Line Interface"
- Section 3.2, "RL Command-Line Options"
- Section 3.3, "RL Command-Line Built-in Commands"

### 3.1 Starting and Using the Command-Line Interface

The following invocation provides a simple command-line interface, with the prompt, RL>. Example without Java Beans:

```java
java -jar SOA_ORACLE_HOME/soa/modules/oracle.rules_11.1.1/rl.jar -p "RL> "
```

Where SOA_ORACLE_HOME is where SOA modules are installed (for example, c:/Oracle/Middleware). The -p option specifies the prompt.

The following shows how an RL Language command-line can be started that can access this Java bean:

```java
java -classpath SOA_ORACLE_HOME/soa/modules/oracle.rules_11.1.1/rl.jar;BeanPath oracle.rules.rl.session.CommandLine -p "RL> "
```

Where BeanPath is the classpath component to any supplied Java Bean classes.

To exit the command-line interface, use the special action `exit;` at the command prompt. The `exit;` action cannot be in an included ruleset. Alternatively, to exit you can invoke the `System.exit(int)` method in any action.

The RL command-line interface accumulates input line by line, and interprets the input when the input stream includes either:

- A complete named ruleset
- One or more complete `import, include, ruleset, definition, action` commands within an unnamed ruleset.
Note: The if, else and try, catch, and finally actions require lookahead to determine where they end. In order to execute an if without an else clause, or a try without a finally clause at the RL command-line, you should add a semicolon terminator.

This is not necessary if you execute RL using include, or using the RuleSession API.

Example 3–1  Sample RL Command-Line Input Processing

RL> int i = 1;
RL> if (i > 0) {println('i positive');}
// nothing happens - waiting for possible "else"
; 
i positive
RL>

Input must be complete at the end of a line. For example, if an action ends in the middle of a line, then that action is not interpreted until some following action is complete at the end of a line.

Example 3–2  Sample Command-Line Input Processing - Waiting for End of Line

RL> println('delayed'); println('hello'); println('world');
delayed
hello
world
RL>

Notes for using command-line input processing:

1. The command-line segments its input into blocks and then feeds each block to the interpreter. If you never type a closing brace or semicolon, no error is raised because the command line waits for input before it does a full parse of the block.

2. The command-line interpreter, when used interactively or with the –i option, collapses the input, for line numbering purposes, into "small" rulesets ending at a newline. Errors are reported with numbers within the ruleset.

For example, if the input consists of the following:

```
int i = 0; i = 1; // this is a ruleset
i = "i"; // this is another ruleset
```

For this example, command-line reports an error as follows:

Oracle Business Rules RL: type check error
ConversionException: cannot convert from type 'java.lang.String' to type 'int'
at line 1 column 5 in main

To avoid this behavior, you can explicitly enclose the input in a ruleset. For example,

```
ruleset main {
    int i = 0; i = 1;
i = "i";
}
```
Now, the error is on line 3 or, you can include the input file using an include.

### 3.2 RL Command-Line Options

<table>
<thead>
<tr>
<th>Flag</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>-i</td>
<td>Read rulesets from the file named by the next argument, instead of from the default, System.in. For example, -i myInput.rl</td>
</tr>
<tr>
<td></td>
<td>Note: the command-line segments its input into blocks and then feeds each block to the interpreter. If the file myInput.rl does not include a closing brace or semicolon at the end, then, no error is raised because the command line waits for additional input before it does a full parse of the block. Thus, there are cases where an incomplete input file supplied using the –i option could run and execute the valid part of the code from the file myInput.rl, and exit, while still waiting for command line input.</td>
</tr>
<tr>
<td>-c</td>
<td>Executes the next argument as the first RL command, then start reading input. This option is useful to include a file of settings and functions for debugging. For example, -c &quot;include file:debugSettings.rl;&quot;</td>
</tr>
<tr>
<td></td>
<td>If you do not want to read from the input after executing the command, include &quot;exit;&quot; after the command. For example, -c &quot;include file:script.rl; exit;&quot;</td>
</tr>
<tr>
<td>-p</td>
<td>Sets the next argument as the prompt string. For example, -p &quot;RL&gt; &quot;</td>
</tr>
<tr>
<td>-o</td>
<td>Specifies where to write output from println, watch, and show to the file named by the next argument, instead of to System.out. For example: -o debug.log</td>
</tr>
<tr>
<td>-v</td>
<td>Print version information.</td>
</tr>
</tbody>
</table>

### 3.3 RL Command-Line Built-in Commands

This section lists commands that are implemented by the RL command-line interface (these commands are not part of RL). Thus, these commands cannot appear in blocks or be included rulesets.

#### 3.3.1 Clear Command

Discard the current RuleSession object and allocate a new one. The effect is that all rules, variables, classes, and functions are discarded. Instead of using clear; to restart a command-line you can also type exit; and then reissue the Java command to start another command-line.
3.3.2 Exit Command

Exit the command-line interface. The command-line interface also exits when end-of-file is reached on its input.
This chapter includes the following sections:

- Section 4.1, "RuleSession Constructor Properties"
- Section 4.2, "RuleSession Methods"
- Section 4.3, "RL to Java Type Conversion"
- Section 4.4, "Error Handling"
- Section 4.5, "RL Class Reflection"
- Section 4.6, "XML Navigation"
- Section 4.7, "Obtaining Results from a Rule Enabled Program"
- Section 4.8, "Debugging an RL Stacktrace"
- Section 4.9, "Using RuleSession Pooling"
- Section 4.10, "Using RuleSession Options"
4.1 RuleSession Constructor Properties

This section shows you the steps for creating a rule enabled application and describes using a RuleSession object. The package oracle.rules.rl contains the RuleSession object.

The RuleSession no argument constructor returns a RuleSession with the default locale and logging options set.

Table 4-1 shows the RuleSession constructor properties.

<table>
<thead>
<tr>
<th>Property Name</th>
<th>Property Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>oracle.rules.rl.configLocale</td>
<td>A Locale object for the desired Locale. If not present in the map, the default Locale is used.</td>
</tr>
<tr>
<td></td>
<td>Default Value: the JVM default Locale.</td>
</tr>
<tr>
<td>oracle.rules.rl.configLogging</td>
<td>Logging is enabled by default (true). If this property is present and the value is false, logging is disabled.</td>
</tr>
<tr>
<td></td>
<td>Default Value: true</td>
</tr>
</tbody>
</table>

4.2 RuleSession Methods

The outputWriter property determines where println, watch, and show output goes.

The rulesetName property sets the ruleset when RL statements are executed without an explicit named ruleset. The default rulesetName is main.

The executeRuleset methods parse and execute the given ruleset text (given as a String or a java.io.Reader).

The callFunction method invokes the named RL function (which must either be a built-in RL function or must have been previously defined with no parameters using one of the executeRuleset methods) and returns its result. Functions with a single argument can be invoked with the callFunctionWithArgument method. Functions taking any number of arguments can be called using the callFunctionWithArgumentList or callFunctionWithArgumentArray methods. The argument List or array must contain a Java Object for each RL function parameter.

4.3 RL to Java Type Conversion

Table 4-2 describes how Java Object types are be converted to RL types for passing arguments to RL functions, and conversely how RL types are converted to Java types for passing the RL function return value to Java.

<table>
<thead>
<tr>
<th>Java Class</th>
<th>RL Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>java.lang.Integer</td>
<td>int</td>
</tr>
<tr>
<td>java.lang.Character</td>
<td>char</td>
</tr>
<tr>
<td>java.lang.Byte</td>
<td>byte</td>
</tr>
<tr>
<td>java.lang.Short</td>
<td>short</td>
</tr>
<tr>
<td>java.lang.Long</td>
<td>long</td>
</tr>
</tbody>
</table>
4.4 Error Handling

RuleSession method invocations that throw a ParseException or TypeCheckException do not affect the state of the RuleSession. A Java application, for example, an interactive command-line, can catch these exceptions and continue using the RuleSession.

RuleSession method invocations that throw a RLRuntimeException may have affected the state of the RuleSession and the RuleSession may not be in a usable state for the application to proceed. Robust applications should attempt to catch and recover from RLRuntimeExceptions in RL at a point near where the exception is thrown.

Other exceptions likely indicate a serious problem that the application cannot handle.

4.5 RL Class Reflection

You can use an RL class like a Java class in an RL program. The new, instanceof, and cast operators work on both kinds of class. However, when an instance of an RL class is passed to a Java program, it is actually an instance of oracle.rules.rl.RLObject. A Java program can use the following classes: RLClass, RLProperty, and RLArray to examine the RLObject in a manner similar to using the java.lang.Class, java.lang.reflect.Field, and java.lang.Array classes to reflect a java.lang.Object. The package oracle.rules.rl contains RLClass, RLProperty, and RLArray.

4.6 XML Navigation

XLink objects are created and asserted as facts by the assertTree function. An RL rule can use XLinks to reason about the hierarchy of elements asserted by assertTree.
4.7 Obtaining Results from a Rule Enabled Program

When you create a rule enabled program with Oracle Business Rules, a common question is, "How do I get the results of the evaluation?"

This section one approaches to extracting or exposing results of rule evaluation from the rule engine.

This section covers the following:

- Overview of Results Examples
- Using External Resources to Obtain Results

See Also: "Working with Rules SDK Decision Point API" in the Oracle Business Rules User’s Guide

4.7.1 Overview of Results Examples

The examples in this section show a highway incident notification system. These examples show the different approaches to access the results of rule engine evaluation.

The examples use two Java classes: traffic.TrafficIncident and traffic.IncidentSubscription.

Note: The traffic.* sample classes are not included in the Oracle Business Rules distribution.

The TrafficIncident class represents information about an incident affecting traffic and contains the following properties:

- Which highway
- Which direction
- Type of incident
- Time incident occurred
- Estimated delay in minutes

The IncidentSubscription class describes a subscription to notifications for incidents on a particular highway and contains the following properties:

- Subscriber - the name of the subscriber
- The highway
- The direction

In the example using these classes, when an incident occurs that affects traffic on a highway, a TrafficIncident object is asserted and rule evaluation determines to whom notifications are sent.

In the examples, the sess object is a RuleSession and a number of incident subscriptions are asserted. As a simplification, it is assumed that the TrafficIncident objects are short lived. They are effectively an event that gets asserted and only those subscribers registered at that time are notified.

The classes in these examples are all Java classes. However, it is possible to manipulate instances of RL classes in Java using the RL class reflection.
4.7.2 Using External Resources to Obtain Results

This approach is similar to asserting a container for results, except that instead of a container, the object is a means to affecting resources external to the rules engine. For example, this could involve queuing up or scheduling work to be done, updating a database, sending a message. Any Java method accessible in the action may be invoked to effect the results. As with the container use case, the objects used in this example to access the external resources are not re-asserted since their content is not being reasoned on.

Example 4–1 shows the IncidentDispatcher object that is asserted and then used to dispatch the notification.

**Example 4–1 Obtaining Results Using External Resources**

```java
rule incidentAlert
{
  if (fact TrafficIncident ti &&
      fact IncidentSubscription s &&
      s.highway == ti.highway &&
      s.direction == ti.direction &&
      fact IncidentDispatcher dispatcher)
  {
    dispatcher.dispatch(s.subscriber, ti);
  }
}
```

Example 4–2 shows Java code that asserts an IncidentDispatcher and a TrafficIncident, and then invokes the rule engine. This could also be accomplished using an object that is being reasoned on, but this would require a test in the rule condition to avoid an infinite loop of rule firing.

**Example 4–2 Sample Showing Results with External Resources**

```java
sess.callFunctionWithArgument("assert", new IncidentDispatcher());

// An accident has happened
TrafficIncident ti = new TrafficIncident();
ti.setHighway("I5");
ti.setDirection("south");
ti.setIncident("accident");
ti.setWhen(new GregorianCalendar(2005, 1, 25, 5, 4));
ti.setDelay(45);

sess.callFunctionWithArgument("assert", ti);
sess.callFunction("run");
```

4.8 Debugging an RL Stacktrace

The runtime provides detailed debugging information in an RL stacktrace. When possible, if there is an error, the runtime provides extra context that helps identify the
location of a problem. This extra context is useful when working with Rules SDK and Rules Designer.

The stacktrace includes the extra context showing the information for rule conditions, rule actions, functions, variables, and RL class definitions. The XPath style format consists of an RL construct and, if named, followed by the name enclosed in parentheses. If a number, $n$, appears in brackets after a construct it indicates the $n$th item following the previous construct. In combination with Rules SDK, RL generation should significantly assist in identifying a location for an error in Rules Designer.

For example, consider the ruleset shown in Example 4–3. When this ruleset executes, it gives the following report:

```
RLNullPointerException: object cannot be null
  at line 12 column 13 in stackTraceContext /Rule(porsche)/Pattern(car)/Test[1]
  at line 17 column 5 in stackTraceContext
```

**Example 4–3  Test Ruleset**

```
ruleset stackTraceContext
{
  class Car
  {
    String make;
    String model;
  }

  rule porsche
  {
    if (fact Car car &&
        car.make.startsWith("Porsche"))
    {
      println(car.make + " " + car.model);
    }
  }

  assert(new Car());
}

ruleset stackTraceContext
{
  class Car
  {
    String make;
    String model;
  }

  rule porsche
  {
    if (fact Car car &&
        car.make.startsWith("Porsche"))
    {
      println(car.make + " " + car.model);
    }
  }
```
4.9 Using RuleSession Pooling

A typical application that uses rules evaluates the same rules multiple times, with different facts corresponding to separate requests. Initializing a RuleSession typically takes a few seconds depending on the number of rules involved. In contrast, the time to execute the rules is typically much less. Therefore, better performance can be achieved by initializing a RuleSession one time and reusing it for each new request. Using RuleSession pooling, you can create a pool of RuleSession instances that supports improved performance and scalability of applications that use rules.

4.9.1 How to Create a RuleSession Pool

In order for performance to scale up with increasing load, more than one RuleSession is required. A pool of RuleSession instances supports improved performance and scalability of applications that use rules. A pool is instantiated with a list of the RL code that is used to initialize each RuleSession created by the pool. The RL code is executed in the order in which it appears in the list. The number of RuleSession instances to create initially may be specified. In general, this should be a small value and usually the default should be sufficient.

Typically, the RL code is generated from a RuleDictionary created with the Rules SDK. Example 4–4 demonstrates creating and using a RuleSessionPool with RL code from a RuleDictionary.

Example 4–4 Creating a RuleSession Pool

```java
RuleDictionary rd;
// Code to load rule dictionary not shown
List rList = new ArrayList();
rList.add(rd.dataModelRL());
List rulesetAliases = rd.getRuleSetAliases(true);
for (String alias : rulesetAliases)
{
    rList.add(rd.ruleSetRL(alias));
}
RuleSessionPool pool = new RuleSessionPool(rList);
```

If the rules in use by an application are updated, the application may need to load the new rules so that subsequent rule executions use the new rules. This is supported by the pool by invoking the refreshPool method passing it a list of the new RL. After the pool has been refreshed, RuleSessions returned by getPoolableRuleSession will have been initialized with the new RL code. When RuleSessions that were obtained before the refresh are returned using returnPoolableRuleSession, they are not placed back in the pool. The refreshed pool will only contain RuleSessions initialized with the new RL code.
4.9.2 How to Use a RuleSession Pool

To execute rules using a RuleSession, you obtain a RuleSession from the pool and then return it after execution is complete. A poolable RuleSession is acquired by invoking the getPoolableRuleSession method. The pool creates new RuleSessions as required. An invocation of getPoolableRuleSession will not block waiting for a free RuleSession.

When rule execution has been completed, the poolable RuleSession is returned to the pool by invoking the returnPoolableRuleSession method. When a RuleSession is returned to the pool it is reset by the pool by invoking the built-in RL function, reset(). This removes all facts from working memory to prepare the RuleSession for the next execution. Every RuleSession that is retrieved from the pool should be returned to the pool. If an error has occurred during rule execution that results in the RuleSession being unfit for further use, the pool detects this and discards it.

Besides clearing working memory, the reset() function re-executes the initializers of all non-final global variables. The initializer of a non-final global variable can be used to perform other initialization at reset if this is required.

Example 4–5 demonstrates using a RuleSession from the pool.

Example 4–5 Using a Rule Session Pool

```
PoolableObject po = pool.getPoolableRuleSession();
RuleSession engine = po.getPooledObject();
// use the RuleSession to execute rules as required here
pool.returnPoolableRuleSession(po);
```

A soft upper bound on the size of the pool can be specified. This allows the pool to respond to temporary increases in demand by growing the pool while allowing the pool to shrink down to this soft upper bound when demand subsides.

Using the RuleSession pooling implementation, you create RuleSession instances when the getPoolableRuleSession method is invoked and the pool is empty. If the load is heavy enough, this will result in an instance count that is greater than the soft limit.

As the load subsides, the number of RuleSession instances in the pool will automatically be decreased to the soft limit.

4.10 Using RuleSession Options

The RL runtime with a RuleSession supports the following options:

- `RuleSession.CFG_LOGGING`
- `RuleSession.CFG_DECISION_TRACE_LEVEL`
- `RuleSession.CFG_DECISION_TRACE_LIMIT`

4.10.1 Using the CFG_LOGGING System Property

RL Language runtime looks for `CFG_LOGGING` as a system property as well as a Boolean in the config Map passed to the RuleSession constructor. A value in the Map overrides the system property value.
4.10.2 Using the CFG_DECISION_TRACE_LEVEL Option

You can configure the trace level in a RuleSession or in a RuleSessionPool by including the `RuleSession.CFG_DECISION_TRACE_LEVEL` initialization parameter and specifying a level in the configuration Map passed to the RuleSession or RuleSessionPool constructor. This sets the decision trace level at the time a RuleSession is created; invoking `reset()` guarantees that the level after the `reset()` is returned to the configured value, in case it had been changed during rule execution. For more information, see Section 1.7.2, "Using Rule Engine Level Decision Tracing".

4.10.3 Using the CFG_DECISION_TRACE_LIMIT Option

The size of a trace is limited by limiting the number of entries in a decision trace. This necessary to avoid infinite rule fire loops, due to a possible bug in the rules, from creating a trace that consumes all available heap in the JVM. Set the trace limit with the `setDecisionTraceLimit` function. The limit may also be configured in a RuleSession (or RuleSessionPool) by including the `RuleSession.CFG_DECISION_TRACE_LIMIT` initialization parameter with the desired limit in the configuration Map passed to the RuleSession or RuleSessionPool constructor. For more information, see Section 1.7.2, "Using Rule Engine Level Decision Tracing".
Summary of Java and RL Differences

This appendix includes descriptions of differences between the RL Language and Java languages.

A.1 RL Differences from Java

- RL does not include interfaces or methods.
- RL global variables are similar to Java static class variables, but there is one instance for each rule session.
- RL does not have a static keyword.
- RL has rulesets instead of packages. Rulesets group definitions and actions.
- Instances of RL and Java classes can be asserted as facts in working memory.
- RL facts are not garbage collected; they must be explicitly retracted.
- RL is interpreted. There is no compilation or class loading. The include statement can be used to read and interpret a ruleset at the given URL. Classes and functions must be defined before they are used.
- RL classes may not contain constructors or methods, only data fields. The data fields behave like Java bean properties.
- Java bean properties can be accessed as fields in RL.
- The new operator can explicitly assign values to named properties, regardless of whether a constructor is defined. The fact operator can match values to named properties and retrieve, using the var keyword, values from named properties. A property is either a Java bean property, for Java objects, or a field, for RL objects.
- RL arrays are limited to one dimension.
- The if and while actions must be in a block, enclosed in curly braces ({}).
- RL does not include a switch action, continue statement, break statement, or labeled statements for breaking out of nested loops.
- An RL for loop cannot contain multiple comma separated initialization or update expressions.
- RL does not support bitwise & and | operators.
- RL supports function overloading and Java method overloading using first fit.
- RL variables must be initialized when they are defined.
For RL and Java objects, == always invokes the object equals method. RL does not allow testing for object reference equality. For objects, != does not test for inequality of object references, but rather is the negation of the equals methods.

Thus, the statement:

```java
if (object1 != object2){}
```

Is equivalent to the statement:

```java
if (! (object1.equals(object2)){};
```

Forward references to classes or functions is not allowed.

In Java the Java Bean introspector will include write only properties. RL does not include such properties as Beans, since they cannot be reasoned on in a rule. Thus, in order for Java fact type bean properties to be properly accessed in RL they must have both a getter and setter. Properties which have a setter but not a getter, that is write-only properties, are not allowed in the RL `new` syntax.

For example, if a bean `Foo` only has the method `setProp1(int i)`, then you cannot use the following in RL, `Foo f = new Foo(prop1: 0)`
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