

Oracle® Business Rules

Language Reference

10g Release 3 (10.1.3)

B15985-01

January 2006

Oracle Business Rules Language Reference 10g Release 3 (10.1.3)

B15985-01

Copyright © 2006, Oracle. All rights reserved.

Primary Author: Thomas Van Raalte

Contributors: Qun Chen, Ching Chung, David Clay, Kathryn Gruenefeldt, Gary Hallmark, Phil Varner, Neal Wyse, Lance Zaklan

The Programs (which include both the software and documentation) contain proprietary information; they are provided under a license agreement containing restrictions on use and disclosure and are also protected by copyright, patent, and other intellectual and industrial property laws. Reverse engineering, disassembly, or decompilation of the Programs, except to the extent required to obtain interoperability with other independently created software or as specified by law, is prohibited.

The information contained in this document is subject to change without notice. If you find any problems in the documentation, please report them to us in writing. This document is not warranted to be error-free. Except as may be expressly permitted in your license agreement for these Programs, no part of these Programs may be reproduced or transmitted in any form or by any means, electronic or mechanical, for any purpose.

If the Programs are delivered to the United States Government or anyone licensing or using the Programs on behalf of the United States Government, the following notice is applicable:

U.S. GOVERNMENT RIGHTS Programs, software, databases, and related documentation and technical data delivered to U.S. Government customers are "commercial computer software" or "commercial technical data" pursuant to the applicable Federal Acquisition Regulation and agency-specific supplemental regulations. As such, use, duplication, disclosure, modification, and adaptation of the Programs, including documentation and technical data, shall be subject to the licensing restrictions set forth in the applicable Oracle license agreement, and, to the extent applicable, the additional rights set forth in FAR 52.227-19, Commercial Computer Software—Restricted Rights (June 1987). Oracle Corporation, 500 Oracle Parkway, Redwood City, CA 94065

The Programs are not intended for use in any nuclear, aviation, mass transit, medical, or other inherently dangerous applications. It shall be the licensee's responsibility to take all appropriate fail-safe, backup, redundancy and other measures to ensure the safe use of such applications if the Programs are used for such purposes, and we disclaim liability for any damages caused by such use of the Programs.

Oracle, JD Edwards, and PeopleSoft are registered trademarks of Oracle Corporation and/or its affiliates. Other names may be trademarks of their respective owners.

The Programs may provide links to Web sites and access to content, products, and services from third parties. Oracle is not responsible for the availability of, or any content provided on, third-party Web sites. You bear all risks associated with the use of such content. If you choose to purchase any products or services from a third party, the relationship is directly between you and the third party. Oracle is not responsible for: (a) the quality of third-party products or services; or (b) fulfilling any of the terms of the agreement with the third party, including delivery of products or services and warranty obligations related to purchased products or services. Oracle is not responsible for any loss or damage of any sort that you may incur from dealing with any third party.

Contents

Preface	xi
Audience	xi
Documentation Accessibility	xi
Related Documents	xii
Conventions	xii
1 Rules Programming Concepts	
1.1 Starting the Oracle Business Rules RL Language Command-Line	1-2
1.2 Introducing Rules and Rulesets	1-2
1.2.1 Rule Conditions	1-3
1.2.2 Rule Actions.....	1-3
1.3 Introducing Facts and RL Language Classes	1-3
1.3.1 What Are Facts?	1-3
1.3.2 Adding Facts to Working Memory with Assert.....	1-4
1.3.3 Using RL Language Classes as Facts	1-4
1.3.4 Using Java Classes as Facts	1-5
1.4 Understanding and Controlling Rule Firing.....	1-6
1.4.1 Rule Activation and the Agenda	1-6
1.4.2 Watching Facts, Rules, and Rule Activations	1-7
1.4.3 Ordering Rule Firing	1-9
1.5 Integrating RL Language Programs with Java Programs	1-11
1.5.1 Using Java Beans Asserted as Facts	1-12
1.5.2 Using RuleSession Objects in Java Applications.....	1-14
1.6 Building a Coin Counter Rules Program.....	1-14
2 Rule Language Reference	
Ruleset	2-2
Types.....	2-4
Identifiers	2-7
Literals	2-9
Definitions.....	2-10
Variable Definitions.....	2-11
Rule Definitions	2-13
Class Definitions	2-16

Function Definitions	2-21
Fact Class Declarations.....	2-22
Import Statement	2-26
Include Statement	2-27
Using Expressions.....	2-28
Boolean Expressions	2-29
Numeric Expressions	2-31
String Expressions	2-32
Array Expressions.....	2-33
Fact Set Expressions	2-34
Object Expressions.....	2-39
Primary expressions	2-40
Actions and Action Blocks.....	2-44
If Else Action Block.....	2-45
While Action Block	2-46
For Action Block.....	2-47
Try Catch Finally Action Block.....	2-48
Synchronized Action Block	2-49
Return Action	2-50
Throw Action.....	2-51
Assign Action	2-52
Increment or Decrement Expressions	2-53
Primary Actions	2-54
Built-in Functions.....	2-55
assert	2-56
assertXPath	2-58
clearRule.....	2-59
clearRulesetStack	2-60
clearWatchRules, clearWatchActivations, clearWatchFacts, clearWatchFocus, clear- WatchCompilations, clearWatchAll	2-61
getRulesetStack	2-62
getRuleSession.....	2-63
getStrategy	2-64
halt	2-65
id.....	2-66
object.....	2-67
println	2-68
popRuleset	2-69
pushRuleset	2-70
retract.....	2-71
reset.....	2-72
run.....	2-73

runUntilHalt	2-74
setRulesetStack	2-75
setStrategy	2-76
showActivations	2-77
showFacts	2-78
step	2-79
watchRules, watchActivations, watchFacts, watchFocus, watchCompilations	2-80

3 Using the Command-line Interface

3.1 Starting and Using the Command-Line Interface	3-1
3.2 RL Command-Line Options	3-3
3.3 RL Command-Line Built-in Commands	3-3
3.3.1 Clear Command	3-3
3.3.2 Exit Command	3-4

4 Using a RuleSession

4.1 RuleSession Constructor Properties	4-2
4.2 RuleSession Methods	4-2
4.3 RL to Java Type Conversion	4-3
4.4 RL Exceptions	4-3
4.5 Error Handling	4-4
4.6 RL Class Reflection	4-4
4.7 XML Navigation	4-5
4.8 Obtaining Results from a Rule Enabled Program	4-5
4.8.1 Overview of Results Examples	4-5
4.8.2 Using External Resources to Obtain Results	4-6

A Summary of Java and RL Differences

A.1 RL Differences from Java	A-1
------------------------------------	-----

B Oracle Business Rules DMS Instrumentation

B.1 Enabling Oracle Business Rules DMS Instrumentation	B-2
B.2 Oracle Business Rules Metrics	B-2
B.2.1 Oracle Business Rules Rule Metrics	B-2
B.2.2 Oracle Business Rules Ruleset Metrics	B-3
B.2.3 Oracle Business Rules Working Memory Metrics	B-3
B.2.4 Oracle Business Rules RuleSession Metrics	B-3

Index

List of Examples

1-1	Using the Command-Line Interface.....	1-2
1-2	Hello World Programming Example.....	1-2
1-3	Defining a Driver Age Rule.....	1-3
1-4	Matching a Fact Defined by an RL Language Class.....	1-4
1-5	goldCust Rule.....	1-5
1-6	goldDiscount Rule.....	1-5
1-7	Declaring an RL Language Class.....	1-5
1-8	Sample Java Fact with Import.....	1-6
1-9	Using watchFacts with enterRoom Facts.....	1-8
1-10	Show Facts in Working Memory.....	1-8
1-11	Retracting Facts from Working Memory.....	1-8
1-12	Using WatchActivations and WatchRules.....	1-9
1-13	Ruleset Stack - Picture.....	1-9
1-14	Using Rule Priority with keepGaryOut Rule.....	1-10
1-15	enterRoom Class with sayHello Rule.....	1-11
1-16	Java Source for Person Bean Class.....	1-12
1-17	Ruleset Using Person Bean Class.....	1-12
1-18	Using Reset with a RuleSession.....	1-14
1-19	Using a RuleSession Object with callFunctionWithArgument.....	1-14
1-20	Using a RuleSession with ExecuteRuleset.....	1-14
1-21	Using Debugging Functions with Coins Example.....	1-15
1-22	Count Coins Program Source.....	1-16
2-1	Using a Named Ruleset.....	2-2
2-2	Using a Nested Ruleset.....	2-3
2-3	Sample Mapping for XML Identifiers Using Back Quotes.....	2-7
2-4	Using an XML Identifier in a String with assertXPath.....	2-7
2-5	Using Java Identifiers with assertXPath.....	2-8
2-6	Class Definition Within a Named Ruleset.....	2-10
2-7	Non-Final Global Variable Initialization After Reset Function.....	2-11
2-8	Initializing a Global Variable with Side Effects with Reset.....	2-12
2-9	Initializing a Final Global Variable to Avoid Side Effects with Reset.....	2-12
2-10	Defining and Using Rule allMenAreMortal.....	2-14
2-11	Asserting Facts Unconditionally.....	2-14
2-12	Class Definition with Type of Property with Name of Containing Class.....	2-16
2-13	Class Definitions with Forward References are Not Allowed.....	2-16
2-14	Sample Family Tree Rule Using supports xpath.....	2-18
2-15	Output from Run of Family Tree Example.....	2-19
2-16	Retract the Family Tree.....	2-20
2-17	Print Ancestor Pairs with Class Ancestor.....	2-20
2-18	Output from Run of Ancestor Example.....	2-20
2-19	Valid Function Definition Containing Recursive Reference.....	2-21
2-20	Invalid Function Definition Containing Reference to Undefined Function.....	2-21
2-21	matchVehicle Rule with Subclasses Referenced Before the Superclass.....	2-23
2-22	matchVehicle Rule with References to Superclass First.....	2-23
2-23	matchVehicle Rule with Fact Class Declaration with Reference to Superclass First.....	2-23
2-24	Java Classes and Sample Multiple Inheritance.....	2-24
2-25	MultipleInheritance Exception for Facts.....	2-24
2-26	RLRuntimeException wraps MultipleInheritanceException.....	2-24
2-27	FactClassException Possible Cause.....	2-24
2-28	RL Boolean Expression.....	2-30
2-29	RL String Expression.....	2-32
2-30	Fact Set Express for Counter.value.....	2-36
2-31	Using a Fact Set Constraint.....	2-37
2-32	Illegal Use of Fact Set.....	2-37

2-33	Using a Fact Set with &&Operator for Counter Fact.....	2-37
2-34	Using a Fact Set with && Operator	2-37
2-35	Use of Literals	2-42
2-36	Overloading.....	2-42
2-37	Initialization Using the New Operator	2-42
2-38	Action Block Sample.....	2-44
2-39	Sample If Else Action.....	2-45
2-40	Illegal If Action Without an Action Block	2-45
2-41	Sample While Action.....	2-46
2-42	Illegal While Action Without an Action Block	2-46
2-43	For Action.....	2-47
2-44	Try Catch and Finally Action Blocks.....	2-48
2-45	Synchronized Action	2-49
2-46	Assignment Expression.....	2-52
2-47	Decrement Action	2-53
2-48	Using Assert Function in the highestSalary Rule.....	2-56
2-49	Using Assert Function in the emptyDept Rule.....	2-57
2-50	Using popRuleSet and Throwing RLRuntimeException	2-69
2-51	Using pushRuleSet - Throws RLIllegalArgumentException.....	2-70
2-52	Using pushRuleSet - Throws RLIllegalArgumentException.....	2-70
2-53	Using popRuleSet - Throws RLRuntimeException.....	2-70
3-1	Sample RL Command-Line Input Processing	3-2
3-2	Sample Command-Line Input Processing - Waiting for End of Line	3-2
4-1	Obtaining Results Using External Resources.....	4-6
4-2	Sample Showing Results with External Resources	4-6

List of Figures

1-1	RuleSession with Working Memory and the Agenda Containing Activations.....	1-7
-----	--	-----

List of Tables

2-1	Implicit Type Conversions	2-4
2-2	Explicit Type Conversions.....	2-5
2-3	RL Language Literals.....	2-9
2-4	xpath Selection Strings	2-18
2-5	Expression Operator Precedence.....	2-31
2-6	Strategy Values for setStrategy and getStrategy Functions.....	2-76
2-7	Watch Functions Event Descriptions	2-80
3-1	RL Command-Line Options	3-3
4-1	RuleSession Properties	4-2
4-2	RL to Java Object Conversion.....	4-3
B-1	Oracle Business RulesRule Metrics (RLRuleType)	B-2
B-2	Oracle Business Rules Ruleset Metrics (RLRulesetType).....	B-3
B-3	Oracle Business Rules Working Memory Metrics (RLWorkingMemoryType).....	B-3
B-4	Oracle Business Rules RuleSession Metrics (RLRuleSessionType)	B-3

Preface

This Preface contains these topics:

- [Audience](#)
- [Documentation Accessibility](#)
- [Related Documents](#)
- [Conventions](#)

Audience

Oracle Business Rules Language Reference 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, with good usability, to the disabled community. 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/>

Accessibility of Code Examples in Documentation

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.

Accessibility of Links to External Web Sites in Documentation

This documentation may contain links to Web sites of other companies or organizations that Oracle does not own or control. Oracle neither evaluates nor makes any representations regarding the accessibility of these Web sites.

TTY Access to Oracle Support Services

Oracle provides dedicated Text Telephone (TTY) access to Oracle Support Services within the United States of America 24 hours a day, seven days a week. For TTY support, call 800.446.2398.

Related Documents

For more information, see the following documents:

- *Oracle Business Rules User's Guide*
- *Oracle Containers for J2EE Deployment Guide*

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

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

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.

Symbol or Convention	Meaning
[]	Brackets enclose optional items.
{ }	Braces enclose items only one of which is required.
	A vertical bar separates alternatives within brackets or braces.
*	A star indicates that an element can be repeated.

Symbol or Convention	Meaning
delimiters	Delimiters other than brackets, braces, vertical bars, stars, and ellipses must be entered as shown.
boldface	Words appearing in boldface are keywords. They must be typed as shown. (Keywords are case-sensitive in some, but not all, operating systems.) Words that are not in boldface are placeholders for which you must substitute a name or value
<u>underline</u>	When on the left side of a production ($::= $) indicates a definition for a non-terminal symbol.
<u>underline</u>	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.
<i>italic text</i>	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.

Rules Programming Concepts

This chapter introduces Oracle Business Rules RL Language (RL Language) concepts, and includes the following sections:

- [Starting the Oracle Business Rules RL Language Command-Line](#)
- [Introducing Rules and Rulesets](#)
- [Introducing Facts and RL Language Classes](#)
- [Understanding and Controlling Rule Firing](#)
- [Integrating RL Language Programs with Java Programs](#)
- [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 `rl.jar`. Start the RL Language command-line interface using the following command:

```
java -jar RuleDir/lib/rl.jar -p "RL> "
```

Where *RuleDir* is the path for the Oracle Business Rules installation. The `-p` option specifies the prompt.

The RL Language command-line interface provides access to an Oracle Business Rules *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 `RL>` prompt.

Example 1–1 Using the Command-Line Interface

```
RL> println(1 + 2);  
3  
RL> final int low = -10;  
RL> final int high = 10;  
RL> println(low + high * high);  
90  
RL> exit;
```

See Also:

- [Chapter 3, "Using the Command-line Interface"](#) for more details and for a list of command-line options
- [Chapter 4, "Using a RuleSession"](#) for details on Oracle Business Rules *RuleSession* API

1.2 Introducing Rules and Rulesets

An RL Language *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 *rule* consists of *rule conditions*, also called [fact-set-conditions](#), and an [action-block](#) or list of actions. Rules follow an if-then structure with rule conditions followed by rule actions.

[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 `main`). [Example 1–2](#) contains only an action, and does not define a rule, so the action executes immediately at the command-line.

Example 1–2 Hello World Programming Example

```
RL> println("Hello World");  
Hello World  
RL>
```


See Also: [Understanding and Controlling Rule Firing](#) on page 1-6 for details on rule firing

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 not the same as 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

```
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

```
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`

```
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 2-22
- ["Import Statement"](#) on page 2-26

1.4 Understanding and Controlling Rule Firing

This section covers the following topics:

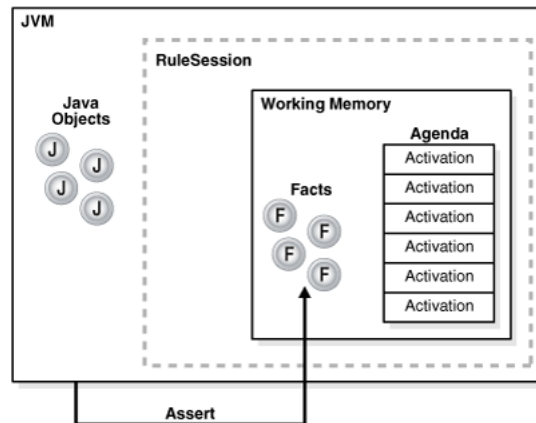
- [Rule Activation and the Agenda](#)
- [Watching Facts, Rules, and Rule Activations](#)
- [Ordering Rule Firing](#)

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.

Figure 1–1 RuleSession with Working Memory and the Agenda Containing Activations



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. Avoid this by adding additional limiting details in the rule condition.
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

```
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

```
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

```
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).

Note: Activations may be removed from the agenda before they are fired if their associated facts no longer make the condition true.

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).

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

```



```

RL> run();
Fire 1 main.keepGaryOut f-4
<== f-4 main.enterRoom(who: "Gary")
<== Activation: main.sayHello : f-4
Fire 2 main.sayHello f-5
Hello Mary
RL>

```

[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 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: "Invoking Rules" in Chapter 3 in the *Oracle Business Rules User's Guide*

1.5.1 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:

```
java -classpath RuleDir/lib/rl.jar;BeanPath oracle.rules.rl.session.CommandLine -p
"RL> "
```

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

Example 1–16 Java Source for Person Bean Class

```
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

```
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).

Note: The RL Language command-line interpreter internally creates a `RuleSession` when it starts up (and when you use the `clear` command).

Example 1–18 Using Reset with a RuleSession

```
reset();
run();
```

1.5.2 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.

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:

```
rs.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

```
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

```
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);
}
```

1.6 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 1–22](#) 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 1–21](#) 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` merely prints the matches.

Example 1–21 Using Debugging Functions with Coins Example

```
RL> watchFacts();
RL> watchActivations();
RL> watchRules();
RL> reset();
RL> showActivations();
RL> run();
The rule is fired for each activation, printing out the solutions
RL>
```

In [Example 1–22](#), 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 1–22](#) 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:

```
coin(denomination "half-dollar", count:0, amount:0)
coin(denomination "half-dollar", count:1, amount:50)
coin(denomination "half-dollar", count:2, amount:100)
coin(denomination "half-dollar", count:3, amount:150)
```

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 1–22 Count Coins Program Source

```

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 ++;
        }
    }
}
return true;
}
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();

```

Rule Language Reference

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

autofocus, boolean, break, catch, char, class, constant, continue, double, else, exists, extends, fact, false, final, finally, float, for, function, if, import, include, instanceof, int, logical, long, new, null, priority, property, public, query, return, returns, rule, ruleset, short, synchronized, throw, true, try, while, var

Note: Reserved words not shown in **bold** are planned for a future RL Language release, and include the words: break, continue, and query.

Ruleset

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)*`

`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

```

type           ::= simple-type [[]]
simple-type    ::= primitive | object-type
primitive     ::= boolean | numeric
numeric       ::= int | double | float | long | short | byte | char
object-type   ::= class-definition-name | Java-class-name
class-definition-name ::= qname
Java-class-name ::= 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 2–1 *Implicit Type Conversions*

From	To
<code>int</code>	<code>double</code> , <code>float</code> , <code>long</code>
<code>float</code>	<code>double</code>
<code>long</code>	<code>double</code> , <code>float</code>
<code>short</code>	<code>int</code> , <code>double</code> , <code>float</code> , <code>long</code>
<code>byte</code>	<code>int</code> , <code>double</code> , <code>float</code> , <code>long</code> , <code>short</code>
<code>char</code>	<code>int</code> , <code>double</code> , <code>float</code> , <code>long</code>
<code>String</code>	<code>Object</code>
<code>Object</code>	<code>Object</code> (if the From <code>Object</code> is a subclass of the To <code>Object</code>)
<code>fact set</code>	<code>boolean</code>
<code>array</code>	<code>Object</code>

Note: An Object is an instance of a Java or RL Language class or array. Type conversion is possible only if the classes are related by inheritance (implements or extends).

[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,

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

Note: Type conversions such as those shown in [Table 2–2](#) that involve numeric types may lose high order bits, and such conversions involving Objects may throw a `RLClassCastException`.

Table 2–2 *Explicit Type Conversions*

From	To
double	float, long, int, short, byte, char
float	long, int, short, byte, char
long	int, short, byte, char
short	byte, char
byte	char
char	byte

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,

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

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

`identifier ::= java-identifier | xml-identifier`

`java-identifier ::= valid-Java-identifier`

`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 2-4](#) and [Example 2-5](#) are equivalent.

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
```

Example 2-4 Using an XML Identifier in a String with assertXPath

```
import `http://www.mycompany.com/po.xsd`.*;
fact class `purchaseOrder` supports xpath;
fact class `Items/item` supports xpath;
assertXPath("http://www.mycompany.com/po.xsd", root,
    "`.`item[ship-date > 20-jul-2004]");
rule r {
    if (fact `a-global-element-name`(`my-attribute`: 0)) {
```

```
        println("my-attribute is zero");
    }
}
```

Example 2-5 Using Java Identifiers with assertXPath

```
import com.mycompany.po.*;
fact class PurchaseOrder supports xpath;
fact class Items$ItemType supports xpath;
assertXPath("com.mycompany.po",
            root,
            "//*[item[shipDate > 20-jul-2004]");
rule r {
    if (fact AGlobalElementName (myAttribute: 0)) {
        println("my-attribute is zero");
    }
}
```

Literals

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

Table 2–3 *RL Language Literals*

A literal such as	Can be assigned to variables of these types
An integer in range 0..127 or a char with UCS2 encoding in range 0...127	byte, char, short, int, long, float, double
An integer in range 0..65535 or a char	char, int, long, float, double
An integer in range -128..127	byte, short, int, long, float, double
An integer in range -32768..32767	short, int, long, float, double
An integer	int, long, float, double
An integer with L suffix	long, float, double
A floating point constant	double
A floating point constant with F suffix	float, double
A String enclosed in ""	String, Object

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](#)

`name` ::= [identifier](#)

`qname` ::= [[ruleset-or-packagename](#).]`name`

[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 2–6](#) is `hello.enterRoom`.

Example 2–6 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

```
variable ::= [ final ] ( numeric name = numeric-expression
|   boolean name = boolean-expression
|   type [] name = array-expression | null
|   object-type name = object-expression | 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 2–7](#) shows that the `reset` function performs initialization for the non-final global variable `i`. Thus, this example prints 0, not 1.

Example 2–7 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 2-8](#) prints "once" twice and [Example 2-9](#) prints "once" once.

Example 2-8 Initializing a Global Variable with Side Effects with Reset

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

Example 2-9 Initializing a Final Global Variable to Avoid Side Effects with Reset

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

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

```

rule          ::= rule rule-name { property* fact-set-condition action-block }
rule-name    ::= name
property     ::= priority | autofocus | logical
priority     ::= priority = numeric-expression
autofocus    ::= autofocus = boolean-literal
logical      ::= logical = ( boolean-literal | positive-integer-literal )

```

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.

Examples

[Example 2–10](#) shows a rule with the inference, Socrates is mortal, which depends on the fact, Socrates is a man.

Example 2–10 Defining and Using Rule `allMenAreMortal`

```
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: {}
RL> retract(socrates);
<== f-1 main.Man (name : "Socrates")
<== f-2 main.Mortal (name : "Socrates")
RL> showFacts();
f-0  initial-fact()
```

[Example 2–11](#) shows that it is possible for the same fact to be asserted by more than one rule, 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 2–11 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 2–12](#)). RL Language, unlike Java, does not support forward references to class definitions (see [Example 2–13](#)).

Example 2–12 Class Definition with Type of Property with Name of Containing Class

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

Example 2–13 Class Definitions with Forward References are Not Allowed

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

xpath Support

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 | ne | == | < | > | <= | >= | !=`

`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`

`local-date ::= d d d d - d d - d d`

`time-literal ::= d d : 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:

- 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 2–4 *xpath Selection Strings*

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

Example 2–14 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 2–14 uses the `assertXPath` function twice, with two xpaths:

```

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

```

Example 2–14 defines two rules:

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

Example 2–15 shows the output from running Example 2–14.

Example 2–14 Sample Family Tree Rule Using supports xpath

```

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 2–15 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 2–16](#) shows that when you retract an element that was asserted with `assertXPath`, all its descendants are retracted as well.

The result is:

```
f-0 initial-fact()
```

For a total of 1 fact.

Example 2–16 Retract the Family Tree

```
retract(xp.gramma);
showFacts();
```

[Example 2–17](#) prints all pairs of ancestors. First, the family tree is asserted. [Example 2–18](#) shows the output of a run of the code from [Example 2–17](#).

Example 2–17 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 2–18 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

`function` ::= `function name parameters [returns type] action-block`

`parameters` ::= `([type identifier (, type 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 2–19](#) and [Example 2–20](#)).

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

Examples

Example 2–19 Valid Function Definition Containing Recursive Reference

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

Example 2–20 Invalid Function Definition Containing Reference to Undefined Function

```
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 2-21](#), `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 2-21 *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 2-22](#), the `matchVehicle` rule is the first reference to the superclass, so no exception is thrown.

Example 2-22 *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 2-23](#), a fact class declaration is the first reference to the superclass, so no exception is thrown.

Example 2-23 *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");
    }
  }
}
```

```
}  
run(); // prints "truck" then "car"
```

Facts do not support multiple inheritance. Consider the Java classes and interfaces shown in [Example 2–24](#).

Example 2–24 Java Classes and Sample Multiple Inheritance

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

[Example 2–25](#) 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 2–25 MultipleInheritance Exception for Facts

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

[Example 2–26](#) 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 2–26 RLRuntime Exception wraps MultipleInheritanceException

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

Example 2–27 FactClassException Possible Cause

```
oracle.rules.rl.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:

```
<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

```
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 that ruleset, but the import actually applies globally. The following code demonstrates this behavior, if imports were scoped, then the `PrintWriter` reference in `r2` would fail compilation.

```
class X { }
ruleset r1 {
  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) * (b - 2)
```

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

Format

```
expression ::=   boolean-expression  
                  |   numeric-expression  
                  |   string-expression  
                  |   array-expression  
                  |   fact-set-expression  
                  |   object-expression
```

Boolean Expressions

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

Format

```

boolean-expression ::=  boolean-assignment
                    |  boolean-expression ? boolean-expression : boolean-expression
                    |  boolean-expression || boolean-expression
                    |  boolean-expression && boolean-expression
                    |  numeric-expression equal-op numeric-expression
                    |  object-expression equal-op object-expression
                    |  boolean-expression equal-op boolean-expression
                    |  object-expression instanceof type-name
                    |  numeric-expression relop numeric-expression
                    |  string-expression relop string-expression
                    |  ! boolean-expression
                    |  boolean-primary-expression

```

```

boolean-assignment ::= boolean-target-expression = boolean-expression

```

```

equal-op ::= == | !=

```

```

relop ::= < | > | <= | >=

```

```

type-name ::= 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:

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

Is equivalent to the statement:

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

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

Example

[Example 2–28](#) shows use of a boolean expression in RL Language.

Example 2–28 RL Boolean Expression

```
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

```

numeric-expression ::=  numeric-assignment
                    |  boolean-expression ? numeric-expression : numeric-expression
                    |  numeric-expression( + | - ) numeric-expression
                    |  numeric-expression ( * | / | % ) numeric-expression
                    |  numeric-expression ** numeric-expression
                    |  ( numeric-cast ) numeric-expression
                    |  ( + | - ) numeric-expression
                    |  ( ++ | -- ) numeric-primary-expression
                    |  numeric-primary-expression [ ++ | -- ]

```

```

numeric-assignment ::=  numeric-target-expression ( = | += | -= | *= | /= | %= ) numeric-expression

```

```

numeric-cast ::= numeric

```

Usage Notes

[Table 2–5](#) shows the precedence order, from highest to lowest, for a `numeric-expression`.

Table 2–5 *Expression Operator Precedence*

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

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

```
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 2–29](#) shows use of a string expression in RL Language. The example prints "1 2.0 true {1,2}"

Example 2–29 *RL String Expression*

```
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)

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

fsp-class ::= qname
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
```

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`
- `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 2-33](#)).

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:

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

If both an X and a W are both asserted, this rule fires twice, once 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:

```
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.

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

Examples

[Example 2-30](#) shows the action is placed on the agenda for all Counter facts with a value of 1.

Example 2-30 Fact Set Express for Counter.value

```
class Counter { int id; int value; }  
rule ex1a {  
    if (fact Counter c && c.value == 1)  
    { println("counter id " + c.id + " is 1"); }  
}
```

[Example 2–31](#) shows an equivalent way to express the rule from [Example 2–30](#), using a constraint.

Example 2–31 Using a Fact Set Constraint

```
rule ex1b {
  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 2–32](#) shows an illegal use of a fact set, because `c` is used before it is defined.

Example 2–32 Illegal Use of Fact Set

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

[Example 2–33](#) shows an action is placed on the agenda for all `AttFact`s with the property `a2==0` and without a matching, equal first elements, `Counter`.

Example 2–33 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 2–34](#) 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 2–34 Using a Fact Set with && Operator

```
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
```


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 2-9)
- | 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*

- | [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 2–35](#) shows the RL Language literal syntax (which is the same as Java).

Example 2–35 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 2–36](#) shows an example of example of overloading

Example 2–36 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 2–37 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  
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 semi-colon terminated action.

Format

```
action ::= action-block | if | while | for | try | synchronized | return | throw  
          | assign | incr-decr-expression | primary-action  
action-block ::= { ( variable | 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 2–38 Action Block Sample

```
RL> {  
    int i = 2;  
    while (i-- > 0) { println("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 semi-colon terminated action.

Format

```
if ::= if if-test action-block [ else if | action-block ]
```

```
if-test ::= boolean-expression
```

Examples

[Example 2-39](#) shows an RL Language if else action block. [Example 2-40](#) shows that an action block is required.

Example 2-39 Sample If Else Action

```
String s = "b";

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

Example 2-40 Illegal If Action Without an Action Block

```
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 semi-colon terminated action.

Examples

[Example 2-41](#) prints "bye" twice.

Example 2-41 Sample While Action

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

Example 2-42 Illegal While Action Without an Action Block

```
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 2-43](#) shows RL Language code that converts an `int[]` to a `double[]`.

Example 2-43 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 or not 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 one of the `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 2-44](#) 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 2-44 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 allows you to 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 2-45](#) 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 2-14](#) details on the `Person` bean).

Example 2-45 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 Wuver"});
println(person.nicknames.toArray());
changeName(person, "Bugs", "Bunny");
println(person.nicknames.toArray());
```

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 2–46](#) shows the use of the RL Language assignment expression. This prints "6 5".

Example 2–46 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

`incr-decr ::= incr-decr-expression ;`

`incr-decr-expression ::= (++ | --) numeric-target-expression | numeric-target-expression (++ | --)`

Examples

[Example 2-47](#) shows the use of the RL Language decrement action. This example prints "0".

Example 2-47 *Decrement Action*

```
clear;
int i = 1;
--i;
println(i);
```

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

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

Built-in Functions

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

`assert`, `assertXPath`, `clearRule`, `clearRulesetStack`, `clearWatchRules`,
`clearWatchActivations`, `clearWatchFacts`, `clearWatchFocus`, `clearWatchCompilations`,
`clearWatchAll`, `getRulesetStack`, `getRuleSession`, `getStrategy`, `halt`, `id`, `object`, `println`,
`popRuleset`, `pushRuleset`, `retract`, `reset`, `run`, `runUntilHalt`, `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 *obj*. If the supplied object *obj* is a Java instance, then properties are Java bean properties defined by an associated `BeanInfo` class or by the existence of getter and setter methods. If *obj* is an RL Language class instance, then the properties are the fields of the class.

Format

```
function assert(Object obj);
```

Usage Notes

The fact in working memory is a shadow of the supplied object *obj*, and this shadow contains a copy, clone, or reference to each property *prop*. If *prop* is a primitive type, then *prop* is copied to the shadow. If *prop* implements the Java `Cloneable` interface, then a clone, shallow copy, of *prop* is shadowed. Otherwise, only the reference to *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 `Object` in RL Language always invokes the `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 `!`, 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 *obj*'s state has been updated that could possibly have an effect on a rule condition, unless the *obj* is a Java bean that supports registering property change listeners, and all that is changed is the value of a bean property.

Examples

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

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();
```

Example 2–49 Using Assert Function in the emptyDept Rule

```
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

[assertXPath](#), [id](#), [object](#), [retract](#)

assertXPath

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](#)

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 2–6](#) 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 *obj*. If *obj* is not associated with a fact, returns -1.

Format

function id(Object *obj*) returns int;

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 ob);
```

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 2-52](#) shows the RL Language using the `pushRuleset` and `popRuleset` functions.

Example 2-51 Using pushRuleSet - Throws RLIllegalArgumentException

```
clearRulesetStack();
pushRuleset("main");           // focus is "main"
pushRuleset("main");           // RLIllegalArgumentException
```

Example 2-52 Using pushRuleSet - Throws RLIllegalArgumentException

```
clearRulesetStack();
pushRuleset("main");           // focus is "main"
pushRuleset("main");           // RLIllegalArgumentException
```

Example 2-53 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 re-evaluates 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 [halt](#) directly or indirectly. For example, when [halt](#) is called by a function called by a rule action.
- The agenda is empty.
- The ruleset stack is empty.

Format

function run() returns int;

function run(String *rulesetName*) returns int;

Usage Notes

If the argument, *rulesetName* is supplied, the named ruleset is pushed on the top of the ruleset stack before firing any rules.

If a null *rulesetName* is supplied, the ruleset stack is not modified before firing rules.

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

Returns: `int`, the number of rules fired.

See Also

[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](#)

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 2-6](#) shows the valid strategy values.

Table 2-6 Strategy Values for setStrategy and getStrategy Functions

Strategy	Description
queue	Activations are fired in order from oldest to newest.
stack	Activations are fired in order from newest to oldest.

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, *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

```
function step(int numRulesToFire) returns int;
```

```
function step(int numRulesToFire, String rulesetName) returns int;
```

Usage Notes

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

If a ruleset named, *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 2-7](#) describes the available debugging information.

Table 2-7 Watch Functions Event Descriptions

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

Format

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

See Also

[clearWatchRules](#), [clearWatchActivations](#), [clearWatchFacts](#), [clearWatchFocus](#), [clearWatchCompilations](#), [clearWatchAll](#), [showActivations](#), [showFacts](#)

Using the Command-line Interface

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 covers the following topics:

- [Starting and Using the Command-Line Interface](#)
- [RL Command-Line Options](#)
- [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 -jar RuleDir/lib/rl.jar -p "RL> "
```

Example with Java Beans:

```
java -classpath RuleDir/lib/rl.jar;BeanPath oracle.rules.rl.session.CommandLine -p "RL> "
```

Where *RuleDir* is the top level installation directory and *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 semi-colon 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 3–1 *RL Command-Line Options*

Flag	Description
-i	<p>Read rulesets from the file named by the next argument, instead of from the default, <code>System.in</code>.</p> <p>For example,</p> <pre>-i myInput.rl</pre> <p>Note: the command-line segments its input into blocks and then feeds each block to the interpreter. If the file <code>myInput.rl</code> 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 <code>-i</code> option could run and execute the valid part of the code from the file <code>myInput.rl</code>, and exit, while still waiting for command line input.</p>
-c	<p>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.</p> <p>For example,</p> <pre>-c "include file:debugSettings.rl;"</pre> <p>If you do not want to read from the input after executing the command, include <code>"exit;"</code> at the end of the command.</p> <p>For example,</p> <pre>-c "include file:script.rl; exit;"</pre>
-p	<p>Sets the next argument as the prompt string.</p> <p>For example,</p> <pre>-p "RL> "</pre>
-o	<p>Specifies where to write output from <code>println</code>, <code>watch</code>, and <code>show</code> to the file named by the next argument, instead of to <code>System.out</code>.</p> <p>For example:</p> <pre>-o debug.log</pre>
-v	<p>Print version information.</p>

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.

Using a RuleSession

This chapter includes the following sections:

- [RuleSession Constructor Properties](#)
- [RuleSession Methods](#)
- [RL to Java Type Conversion](#)
- [RL Exceptions](#)
- [Error Handling](#)
- [RL Class Reflection](#)
- [XML Navigation](#)
- [Obtaining Results from a Rule Enabled Program](#)

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, logging, and DMS options set.

Table 4–1 shows the `RuleSession` constructor properties.

Table 4–1 RuleSession Properties

Property Name	Property Value
<code>oracle.rules.rl.configLocale</code>	A Locale object for the desired Locale. If not present in the map, the default Locale is used. Default Value: the JVM default Locale.
<code>oracle.rules.rl.configSessionName</code>	A name to associate with the <code>RuleSession</code> . Default Value: the default is a generated name that should be unique.
<code>oracle.rules.rl.configLogging</code>	A Boolean value. If this property is present and the value is <code>true</code> , logging is enabled. Default Value: <code>false</code>
<code>oracle.rules.rl.configDMS</code>	A Boolean value. If this property is present and the value is <code>true</code> , DMS is enabled. Default Value: <code>false</code>
<code>oracle.rules.rl.configAppName</code>	A String with the name of the application or component that is instantiating this session. This is only used for DMS metrics. Within OC4J, a component name may be obtained using <code>MBeanServerFactory.createMBeanServer().getDefaultDomain()</code> . Default Value: there is no default value. If this is missing, then that component is missing from the DMS metric hierarchy.

4.2 RuleSession Methods

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

The `rulesetName` property sets the ruleset in the event that 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 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 4–2 *RL to Java Object Conversion*

Java Class	RL Type
<code>java.lang.Integer</code>	<code>int</code>
<code>java.lang.Character</code>	<code>char</code>
<code>java.lang.Byte</code>	<code>byte</code>
<code>java.lang.Short</code>	<code>short</code>
<code>java.lang.Long</code>	<code>long</code>
<code>java.lang.Double</code>	<code>double</code>
<code>java.lang.Float</code>	<code>float</code>
<code>java.lang.Boolean</code>	<code>boolean</code>
<code>Object</code>	<code>Object</code>
<code>int[]</code>	<code>int[]</code>
<code>char[]</code>	<code>char[]</code>
<code>byte[]</code>	<code>byte[]</code>
<code>short[]</code>	<code>short[]</code>
<code>long[]</code>	<code>long[]</code>
<code>double[]</code>	<code>double[]</code>
<code>float[]</code>	<code>float[]</code>
<code>boolean[]</code>	<code>boolean[]</code>
<code>Object[]</code>	<code>Object[]</code>

4.4 RL Exceptions

The `RuleSession` parse and execute methods may throw an `RLException`. The `getMessage` method returns a formatted error message containing the description of the error, the RL source ("main" or included URL), line number, and column number. Each of these error components can also be accessed separately. Sometimes an `RLException` is caused by another error (in general, a `Throwable` object). This underlying cause, if any, can also be accessed.

The package `oracle.rules.rl.exceptions` contains the exceptions. The `RLException` class has many subclasses that further categorize the nature of the exception, as shown in the following hierarchy:

`RLException`

`ParseException` - a syntax error

`TypeCheckException` - a semantic error

`ArrayException` - array expected

`AssignmentException` - invalid assignment target

`ConstructorException` - can't find constructor for Java class

`ContextException` - construct invalid in given context

`ConversionException` - can't convert between given types

`FinalClassException` - attempt to extend a final fact class
`InvocationException` - illegal function or method invocation
`HiddenPropertyException` - fact class for subclass attempted to expose a hidden property or vice versa
`MemberException` - property or method not a member of class
`MultipleDefinitionException` - symbol defined more than once
`OperationException` - operator applied to wrong types. For example, `String * String`
`UndefinedException` - symbol is not defined
`VisibilityException` - class or member referenced outside of defining ruleset or package is not public

`RLRuntimeException` - runtime error

`RLXPathException` - error in `assertXPath` function

`RLXmlNameException` - error in xml identifier syntax

`EngineException` - internal rule engine error

`JavaException` - an invoked Java method threw an exception, call `getCause()` to access the exception

`RLArithmeticException` - an RL arithmetic operation resulted in a divide by zero.

`RLArrayIndexOutOfBoundsException` - an attempt was made to index into an array with an index outside the allocated array

`RLArrayStoreException` - an attempt has been made to store the wrong type of object into an RL array of objects

`RLClassCastException` - in an RL expression, an attempt has been made to cast an object to a subclass of which it is not an instance

`RLCloneNotSupportedException` - a property of an object asserted as a fact appeared to be cloneable but did not implement the clone method

`RLIllegalArgumentException` - an attempt was made to pass an illegal argument to a builtin RL function or to a rule engine Java method

`RLNegativeArraySizeException` - an attempt was made to allocate an array with a negative size

`RLNullPointerException` - an RL expression attempted to dereference a null object or null array reference

The following exceptions are always wrapped with either a `RLRuntimeException` or `TypeCheckException`:

- `FactClassException`: the fact class is defined too late (subclasses have already been seen in a fact context).
- `MultipleInheritanceException`: fact class declarations support single inheritance only.

4.5 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.

4.6 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`.

4.7 XML Navigation

XLink objects are created and asserted as facts by the `assertXPath` function. An RL rule can use XLinks to reason about the hierarchy of elements asserted by `assertXPath`.

See Also: ["xpath Support"](#) on page 2-17

4.8 Obtaining Results from a Rule Enabled Program

When you create a 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: 3.11 Invoking Rules, in *Oracle Business Rules User's Guide*

4.8.1 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.

See Also: For documentation see the Javadoc for the `RLClass`, `RLObj`, `RLProperty` and `RLArray` classes in the `oracle.rules.rl` package. Thus, RL objects, or instances of RL classes, can be used to hold rule engine results as well as Java objects.

4.8.2 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 to 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

```
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

```
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");
```

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 or not 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:

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

Is equivalent to the statement:

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

- Forward references to classes or functions is not allowed.

Oracle Business Rules DMS Instrumentation

Oracle Rules Engine runs as a library that an application or application component uses to work with rules. The application or component can include an application name in the configuration passed to a `RuleSession` constructor. With a name present, the name becomes the top level in a DMS hierarchy. This facilitates analysis of Oracle Rules Engine runtime.

In order to keep metrics for a `RuleSession` instance, the instance must have a name. A name for the `RuleSession` may be included in the configuration that is passed to the `RuleSession` constructor. If no name is specified and DMS is configured, then the Oracle Rules Engine generates a name.

This appendix includes the following sections:

- [Enabling Oracle Business Rules DMS Instrumentation](#)
- [Oracle Business Rules Metrics](#)

B.1 Enabling Oracle Business Rules DMS Instrumentation

Support for DMS instrumentation is encapsulated so that the Oracle Rules Engine uses a set of interfaces defined in `oracle.rules.rl.dms`. If a `RuleSession` is created with DMS enabled, then `rl_dms.jar` must be in the classpath otherwise `RuleSession` construction fails.

B.2 Oracle Business Rules Metrics

Oracle Business RulesDMS metrics are organized in a hierarchy that reflects the key components in a `RuleSession`. The path in the hierarchy to the metrics for a `RuleSession` is (application specified portions are in italics):

/appName/rules/rl/rule_session_name/

Under each `RuleSession`, there is:

`workingMemory`

ruleset/ruleset_name/rule/rule_name

where there are 1 or more rule sets. The ruleset named `main` is always present and 0 or more rules are shown for each ruleset.

DMS Nouns are defined for rules, rule sets, working memory, rule sessions, and `rl`. DMS Noun Types contain DMS Sensors which contain the metrics.

B.2.1 Oracle Business Rules Rule Metrics

Table B-1 shows the Oracle Business Rules Rule metrics.

Table B-1 Oracle Business Rules Rule Metrics (RLRuleType)

Metric	Description	Unit
<code>addActivation</code>	the number of activations of this rule that were added to the agenda	ops
<code>removeActivation</code>	the number of activations of this rule that were removed from the agenda.	ops
<code>clearActivations</code>	The number of activations removed by <code>reset()</code> or <code>clearRule()</code>	ops
<code>activations</code>	The number of activations of this rule currently on the agenda	ops
<code>fire</code>	The number of activations of this rule that fired	ops

The behavior of adding and removing activations from the agenda is that when a fact is updated, re-asserted, and the activation remains a valid match, the activation is removed and then added back. Thus, each sensor is incremented. This occurs because an update of fact results in two tokens flowing through the Rete network, a remove token and an add token.

If a rule is removed using the `clearRule` built in function, the `RLRuleType` instance for that rule is destroyed and any data is lost.

B.2.2 Oracle Business Rules Ruleset Metrics

Table B–2 shows the Oracle Business Rules Ruleset metrics.

Table B–2 Oracle Business Rules Ruleset Metrics (RLRulesetType)

Metric	Description	Unit
rules	The number of rules that are defined in this ruleset. The metrics from the RLRuleType instances for each rule in this ruleset are aggregated at the ruleset level.	ops

B.2.3 Oracle Business Rules Working Memory Metrics

Table B–3 shows the Oracle Business Rules Working Memory metrics.

Table B–3 Oracle Business Rules Working Memory Metrics (RLWorkingMemoryType)

Metric	Description	Unit
facts	The number of facts in working memory	ops
assert	The number of new fact asserts	ops
re-assert	The number of asserts of modified facts	ops
retract	The number of fact retract	ops
resetRetracts	The number of facts retracted by reset invocations	ops

B.2.4 Oracle Business Rules RuleSession Metrics

Table B–4 shows the Oracle Business Rules RuleSession metrics.

Table B–4 Oracle Business Rules RuleSession Metrics (RLRuleSessionType)

Metric	Description	Unit
rulesets	the number of rulesets that are defined in this rule session	ops
reset	the number of reset invocations	ops

During initialization of a RuleSession, a reset is invoked so the number of reset invocations will always be one more than invoked by the RuleSession client.

The metrics from the RLRulesetTypes and the RLRuleTypes will be aggregated at the rule session level through the DMS roll up feature. Unlike RLRuleType, instances of RLRuleSessionType are never destroyed.

Index

A

action, 2-44
 assign, 2-52
 primary, 2-54
 return, 2-50
 throw, 2-51
action-block, 2-44
 catch, 2-48
 else, 2-45
 finally, 2-48
 for, 2-47
 if, 2-45
 synchronized, 2-49
 try, 2-48
 while, 2-46
activation, 1-6
agenda, 1-6
array-expression, 2-33
assert function, 2-56
assertXPath function, 2-58
assignment-expression, 2-52
autofocus, 2-13

B

back quote
 and xml identifiers, 2-7
boolean keyword, 2-4, 2-11
byte keyword, 2-4

C

catch keyword, 2-48
char keyword, 2-4
class-definition-name, 2-4
clear function, 2-61
clearRule function, 2-59
clearRulesetStack function, 2-60
clearWatch function, 2-61
clearWatchActivation function, 2-61
clearWatchAll function, 2-61
clearWatchCompilations function, 2-61
clearWatchFacts function, 2-61
clearWatchFocus function, 2-61
clearWatchRules function, 2-61

command line
 starting, 1-2
concatenation, 2-6
 string, 2-32

D

decrement expression, 2-53
definition, 2-10
 name, 2-10
 qname, 2-10
 variable, 2-11
double keyword, 2-4

E

else
 action-block, 2-45
 else keyword, 2-45
exception
 throw, 2-51
exists keyword, 2-34
expression
 array-expression, 2-33
 boolean-expression, 2-29
 decrement, 2-53
 definition, 2-28
 increment, 2-53
 numeric-expression, 2-31
 object-expression, 2-39
 primary-expression, 2-40
 string-expression, 2-32

F

fact set, 1-6, 2-34
fact set row, 1-6
fact-class-body, 2-22
facts
 and working memory, 1-4
 definition of, 1-3
 Java classes as, 1-5
 RL classes as, 1-5
fact-set-expression, 2-34
final keyword, 2-11
finally keyword, 2-48

- fire rule, 1-7
- float keyword, 2-4
- for
 - action-block, 2-47
 - for-init, 2-47
 - for-update, 2-47
- function
 - assert, 2-56
 - assertXPath, 2-58
 - clear, 2-61
 - clearRule, 2-59
 - clearRulesetStack, 2-60
 - definition, 2-21
 - getRuleSession, 2-63
 - getRuleSetStack, 2-62
 - getStrategy, 2-64
 - halt, 2-65
 - id, 2-66
 - keyword, 2-21
 - object, 2-67
 - popRuleset, 2-69
 - println, 2-68
 - pushRuleset, 2-70
 - recursive, 2-21
 - reset, 2-72
 - retract, 2-71
 - run, 2-73
 - runUntilHalt, 2-74
 - setRulesetStack, 2-75
 - setStrategy, 2-76
 - showActivation, 2-77
 - showFacts, 2-78
 - step, 2-79
 - watch, 2-80

G

- getRuleSession function, 2-63
- getRulesetStack function, 2-62
- getStrategy function, 2-64
- global variable, 2-11

H

- halt function, 2-65
- hide keyword, 2-22

I

- id function, 2-66
- identifier, 2-7
 - java-identifier, 2-7
 - xml-identifier, 2-7
- if action-block, 2-45
- implicit conversion, 2-4
- import keyword, 2-26
- importing
 - Java class, 2-26
- include
 - file, 2-27
 - http, 2-27

- increment expression, 2-53
- instanceof keyword, 2-29
- int keyword, 2-4

J

- Java class
 - importing, 2-26
- Java-class-name, 2-4
- java-identifier, 2-7
- java.lang.String, 2-6
- JAXB and xml support, 2-17

L

- literals, 2-9
- logical, 2-13
- logical= keyword, 2-13
- long keyword, 2-4

N

- name
 - definition, 2-10
- named-ruleset, 2-2
- nested ruleset, 2-2
- null keyword, 2-11
- numeric, 2-4
- numeric-expression, 2-31
 - precedence, 2-31

O

- object function, 2-67
- object type, 2-6
- object-expression, 2-39
- object-type, 2-4
- options
 - c command-line, 3-3
 - i command-line, 3-3
 - o command-line, 3-3
 - p command-line, 1-2, 3-3
 - v command-line, 3-3

P

- popRuleset function, 2-69
- precedence
 - numeric-expression, 2-31
- primary action, 2-54
- primary-expression, 2-40
- primitive, 2-4
- primitive type, 2-5
- println function, 2-68
- priority, 2-13
- priority= keyword, 2-13
- property, 2-13
- property keyword, 2-22
- pushRuleset function, 2-70

Q

qname
 definition, 2-10
queue strategy, 2-76

R

reserved words, 2-1
reset function, 2-72
results
 obtaining, 4-5
 using external resources, 4-6
retract function, 1-8, 2-71
return keyword, 2-50
returns keyword, 2-21
RL
 reserved words, 2-1
rule
 autofocus, 2-13
 definition, 2-13
 logical, 2-13
 priority, 2-13
rules
 fire, 1-7
 ordering, 1-9
 priority, 1-9
 rule action, 1-2, 1-3
 rule condition, 1-2, 1-3
ruleset, 2-2
 include, 2-27
 nested, 2-2
 using, 1-2
ruleset stack, 1-9
ruleset-name, 2-2
run function, 2-73
runUntilHalt function, 2-74

S

setRulesetStack function, 2-75
setStrategy
 function, 2-76
 queue strategy, 2-76
 stack strategy, 2-76
short keyword, 2-4
showActivations function, 2-77
showFacts function, 1-8, 2-78
simple-type, 2-4
stack strategy, 2-76
starting command line interface, 1-2
step function, 2-79
string
 + operator, 2-32
 concatenation, 2-6, 2-32
 literal, 2-6
 type, 2-6
string-expression, 2-32
supports keyword, 2-17
synchronized
 keyword, 2-49

T

throw keyword, 2-51
try keyword, 2-48
type, 2-4
 conversion, 2-4
 implicit conversion, 2-4
 java.lang.String, 2-6
 object, 2-6
 primitive, 2-5
 simple-type, 2-4
 string, 2-6
types
 simple-type, 2-4

U

unnamed-ruleset, 2-2

V

var keyword, 2-34
variable
 definition, 2-11
 global, 2-11

W

watchActivations function, 1-7, 2-80
watchAll function, 2-80
watchCompilations function, 2-80
watchFacts function, 1-7, 2-80
watchFocus function, 2-80
watchRules function, 1-7, 2-80
while
 action-block, 2-46
 keyword, 2-46
working memory, 1-4

X

XML
 binding, 2-17
 support, 2-17
 XLINK class, 2-17
 xpath support, 2-17
xml-identifier, 2-7

