Drools

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Agenda

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  - KIE’s projects
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»

Introduction

BRMS
KIE’s projects
The rules Engine Drools
IDE setup

The problem

Today, the main challenge for business applications is agility

Applications must be able to adapt quickly and react to:

- Functional evolutions
- Changes in legislation
- Changes in organisation
- ...

In other words : Changing business rules

Where to implement business rules?

Stored as configuration properties in files or database ?

=> Not suited for such a rule

If the customer lives in Paris, is over 55 years old and has been a customer for more than 2 years, give a 10% discount

Implemented in source code

- Low maintenability
- Spaghetti code which may be unefficient

BRMS

A **business rule management system (BRMS)** identifies the notion of business rule as an asset that can be managed independently of the application code

- Rules can be edited, versionned monitored by a business expert
- Independently tested
- Independently documented, audited
- Independently deployed

Rule’s engine

A BRMS include a **rule’s engine**

- Which evaluates IF-THEN instructions based upon the business rules
- When the conditions of the rules are satisfied (IF), it executes the associated actions (THEN) which generally modify the model

=> Programming becomes declarative

=> Business logic is no longer distributed in the code but centralized in the rules repository.

Execution model

Rule’s engine :

– Parses and compile the set of rules. (Once at the startup of the application for instance)

Client (final application) :

– Get a reference to the rule’s engine

– Insert facts

– Ask the engine to trigger rules

– Retreive the objetcs updated by the rule’s engine

Required steps

Adopting a rule-based solution requires:

- Identification of business rules: ***Business Expert***
- Implements the rule in a rule language: **Business / technical expert**
- Integrating the Rules Service into the Application as Librairies or External service: **Technical**
- Provision of a rules management interface (BRMS Tool): Business / **Technical**
- Deployment of new rules procedure (Automation of tests / Deployment): **Technical**

Considerations

- A rule engine is based on complex technologies
- It's hard to rely on a black box
- How the rules are triggered is not very intuitive
- Rules extraction is not always easy

Benefits

- **Declarative programmation** : Rule engines allow you to specify "What to do" and not "How to do it". They are able to solve difficult problems and in addition to providing explanations!
- **Separation of concern** : data are the domain objects, the logic centralized in a rules file (different from the OO approach that encapsulates attributes and methods). The business logic is no longer dispersed
- **Centralization of knowledge** : Everything is centralized in the knowledge base, relatively readable and can be used as documentation
- **Understandable rules** : By defining language specific to the domain or the trade, the rules are expressed in quasi-natural language and become accessible to the business experts

When to use a rules engine ?

The problem is too complex for the classical code (optimization problems for example, expert system)

The problem is not complex but there is no simple robust solution.

The logic often changes, in this case buisness rules can be changed quickly without too much risk.

The business experts exist but are not technical. The rules syntax then make it possible to express the business logic in their own terms.

When not to use rules engine?

A rule engine is just a part of a complex application, you do not have to implement everything as rules

A good indicator is the degree of coupling between the rules.

- If triggering a rule ***invariably*** triggers a rule chain, then the implementation of this rule-based logic may not be appropriate, a decision tree may be sufficient

Classical domains and use cases

Domains

- Finance and Insurance
- Regulation, government rules
- Ecommerce
- Risk management

Use cases

- Authorization of access based on several criteria (role, ownership of the entity, organization, location, etc.)
- Application customization (eg management of a personalized homepage of an e-commerce site)
- Diagnostic
- Complex validation
- Workflow / Orchestration
- Problem of routing, Optimization of planning, storage, ...

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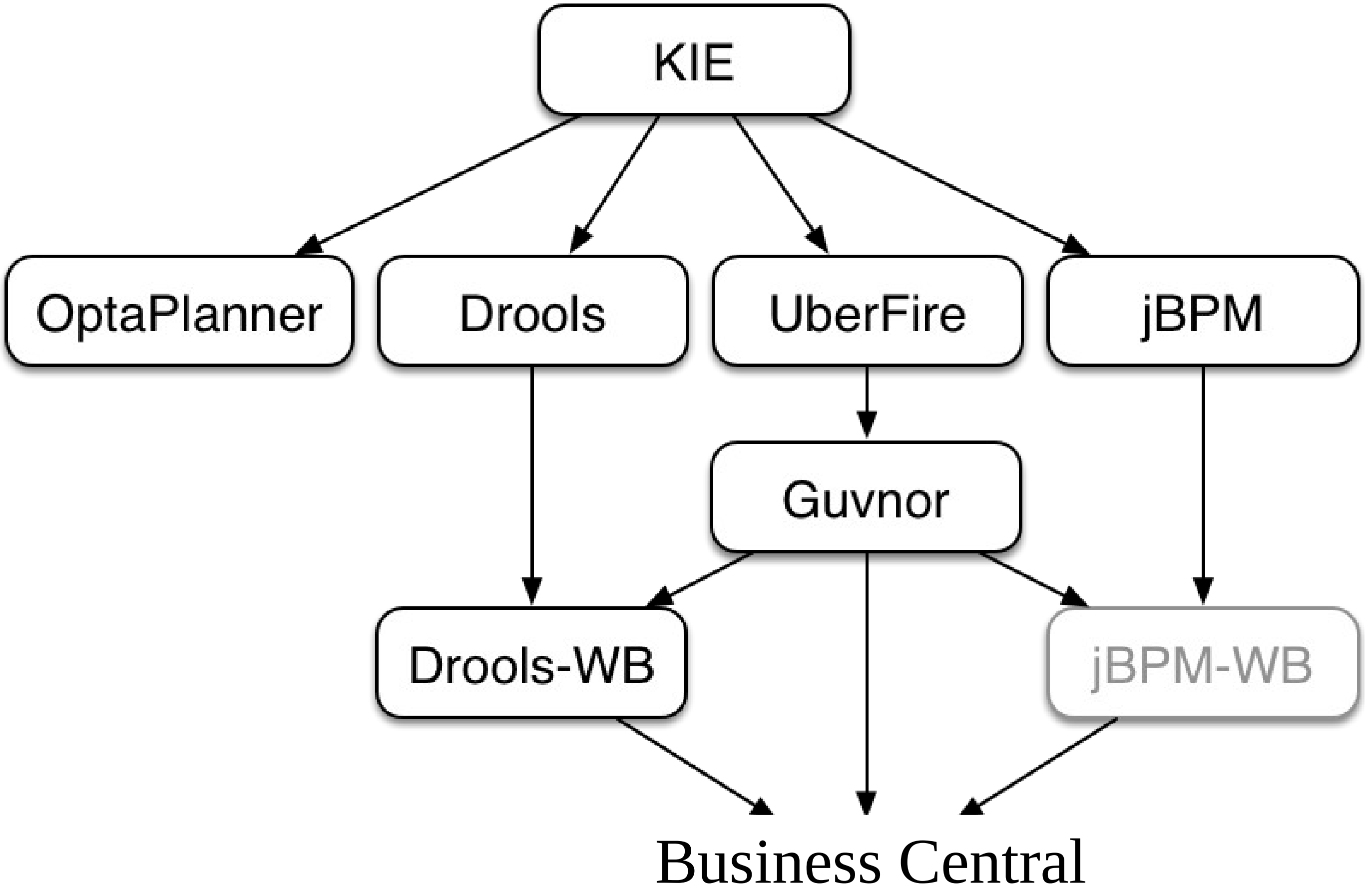
Projets KIE

KIE (Knowledge Is Everything) wraps several projects that share the same API and the same building and deployment techniques (based on Maven and Git)

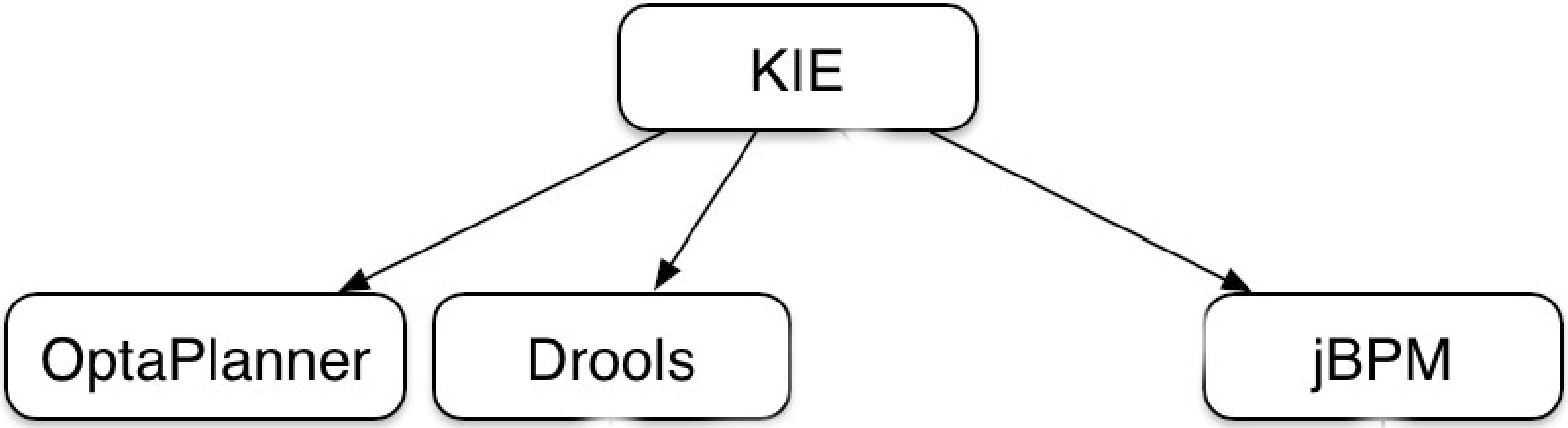
- **Drools** : Rules engine and Complex Event Processing
- **jBPM** : Workflow engine
- **OptaPlanner** optimize complex problems subject to constraints (planning, vehicle routing, etc.)
- **Business Central** : Web application for managing business rules and processes.
- **UberFire** : A framework to easily build web interfaces: workbenches

With release 8, the Kogito product (equivalent to Business Central in native cloud version) is also offered

KIE's projects



KIE's projects



Kogito

Business Central Project Lifecycle

Authoring : Creation of knowledge using a specific language: DRL, BPMN2, DMN, Decision Table, ...

Build : Build a Deployable Artifact containting Knowledge (***.jar***)

Test : Test rules, processes

Deployment: Deployment in a repository (Typically Maven)

Client Integration : kjar is exposed as a KieContainer. Client application create KieSession to interact with the engine (embedeed or REST API)

Usage : User interface or CLI for end users:

Operation : Monitoring of session, Reporting

Alternatives

Authoring / Development

- Business Central and several KieServer to deploy knowledge base for testing or production
- VSCode, IntelijIDEA, Eclipse plugin and Java test classes. Pipeline CI/CD to deploy on KieServer, Kubernetes/Kogito or custom

Packaging :

- Embedeed Drools libraries and rules in a regular Java application
- Kjar deployed separately from client applications in a Maven repository

Client integration

- Direct Java Call
- Remote Java Call (Drools Client Library)
- Regular RestFul

Writing rules

Drools supports different assets to specify rules:

- **Decision Model and Notation (DMN)** : Standard OMG : XML-based decision diagram
- **Decision tables** : Excel or guided decision tables of Business Central
- **Guided rules** : Wizard from Business Central
- **DRL** : The most powerful
- **Predictive Model Markup Language (PMML)** : Predictive data analysis models in XML

Storage and build options for rules

Versionning of business resources :

- Business Central Git VFS
- External git repository

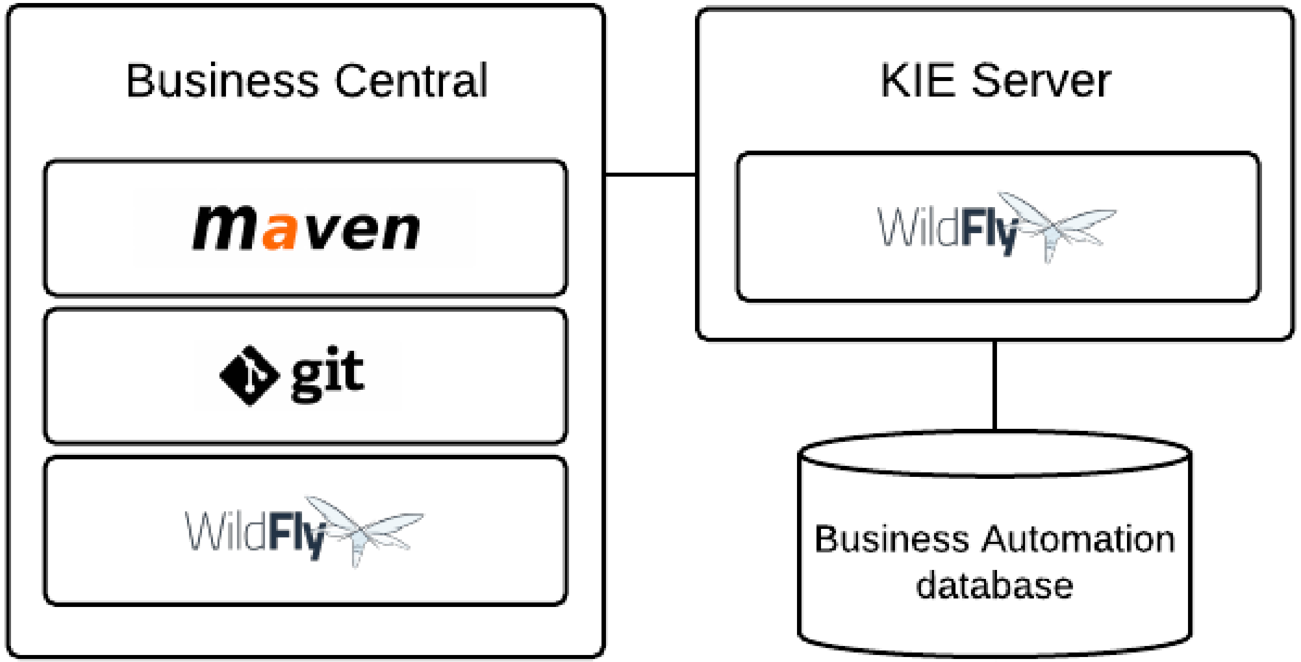
Artifact repository

- Business Central Maven repository
- External Maven repository

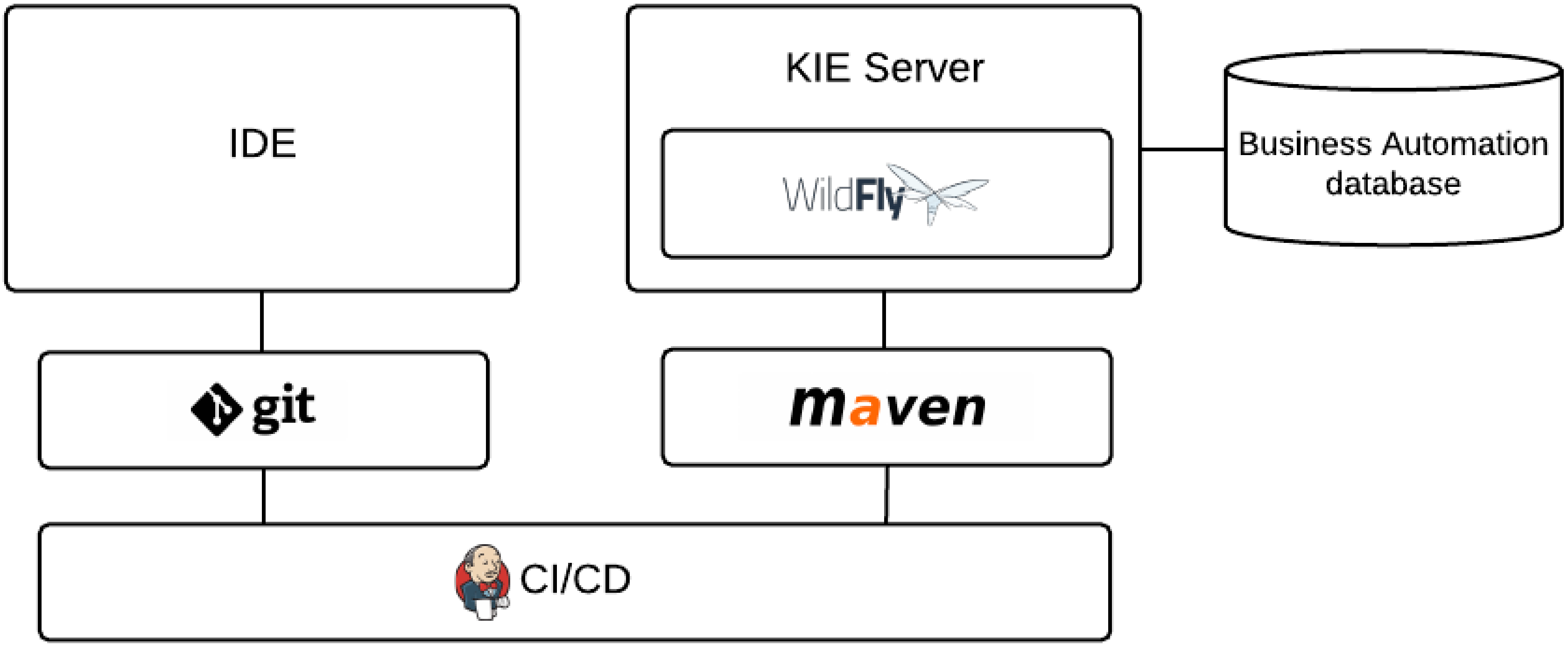
Build

- Business Central
- Independent Maven project
- Embedeed with the final application

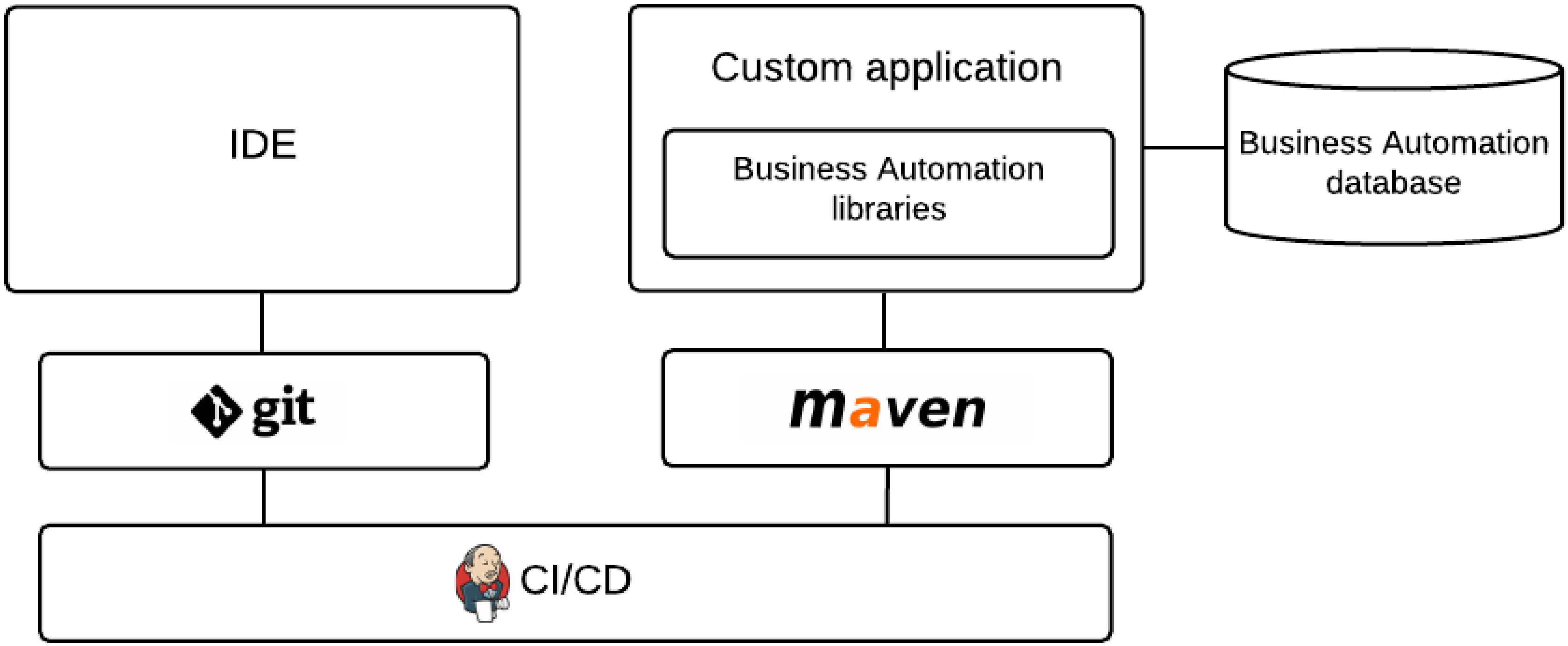
Business Central Architecture



IDE + KieServer/Kogito



IDE and embedeed



Packaging KJAR

- Whatever the architecture chosen, artifact produced is a JAR named KJAR which contains :
  - The module descriptor *META-INF/kmodule.xml*
  - Ressources which contains business rules
  - Domain Model classes : the facts.
- The tool used for packaging is generally Maven ; a plugin allows to validate the rules files
- The *kjar* may or may not contains the client application

kmodule.xml

META-INF/kmodule.xml

- Configures one or more knowledge bases by specifying the resources (rules files or processes)
- For each knowledge base, configure one or more types of sessions that can be created.

An empty descriptor applies a default configuration:

- all resource files found in the classpath are added to the same knowledge base.
- 2 types of sessions (stateless and stateful) are associated with the single knowledge base

Example *kmodule.xml*

```xml
<kmodule xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns="http://www.drools.org/xsd/kmodule">

  <kbase name="KBase1" default="true" eventProcessingMode="cloud" equalsBehavior="equality"
 declarativeAgenda="enabled" packages="org.domain.pkg1">
    <ksession name="KSession2_1" type="stateful" default="true"/>
    <ksession name="KSession2_2" type="stateless" default="false" beliefSystem="jtms"/>
  </kbase>
  <kbase name="KBase2" default="false" eventProcessingMode="stream" equalsBehavior="equality"
 declarativeAgenda="enabled" packages="org.domain.pkg2, org.domain.pkg3" includes="KBase1">
    <ksession name="KSession3_1" type="stateful" default="false" clockType="realtime">
      <fileLogger file="drools.log" threaded="true" interval="10"/>
      <workItemHandlers>
        <workItemHandler name="name" type="org.domain.WorkItemHandler"/>
      </workItemHandlers>
      <calendars>
        <calendar name="monday" type="org.domain.Monday"/>
      </calendars>
      <listeners>
        <ruleRuntimeEventListener type="org.domain.RuleRuntimeListener"/>
        <agendaEventListener type="org.domain.FirstAgendaListener"/>
        <agendaEventListener type="org.domain.SecondAgendaListener"/>
        <processEventListener type="org.domain.ProcessListener"/>
      </listeners>
    </ksession>
  </kbase>
</kmodule>
```

Example : Independent rules project

- kie-maven-plugin-example
  - src
    - main
      - java
        - org
          - kie
            - sample
              - model
                - Fire.java
                - Room.java
                - Sprinkler.java
      - resources
        - FireAlarmKBase
          - alarm.drl
          - rules.drl
          - rules2.drl
        - KBase1
          - decA.drl
          - decB.drl
          - rule.drl
        - META-INF
          - kmodule.xml
    - test
  - .gitignore
  - pom.xml

```xml
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://maven.apache.org/maven-v4_0_0.xsd">

  <modelVersion>4.0.0</modelVersion>
  <parent>
    <groupId>org.drools</groupId>
    <artifactId>droolsjbpm-integration</artifactId>
    <version>7.0.0-SNAPSHOT</version>
  </parent>

  <groupId>org.kie</groupId>
  <artifactId>kie-maven-plugin-example</artifactId>

  <packaging>kjar</packaging>

  <dependencies>
    <dependency>
      <groupId>org.drools</groupId>
      <artifactId>drools-compiler</artifactId>
    </dependency>
  </dependencies>

  <build>
    <plugins>
      <plugin>
        <groupId>org.kie</groupId>
        <artifactId>kie-maven-plugin</artifactId>
        <version>${project.version}</version>
        <extensions>true</extensions>
      </plugin>
    </plugins>
  </build>
</project>
```

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Rule's engine

A rule's engine is composed of a knowledge base, an inference engine and a working memory

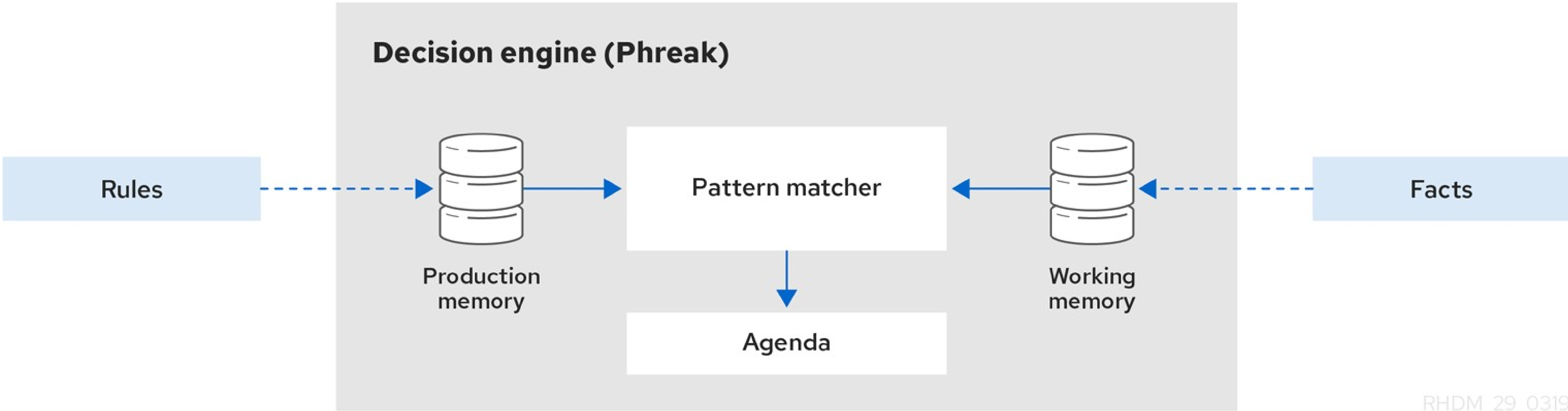
- The knowledge base agregates the **compiled rules**
- The client application inserts facts (domain model objects) in the **working memory**
- The inference engine, able to handle large volume of rules and facts, has the role of comparing the facts to the conditions of the rules,
  if the conditions of the rules are satisfied the corresponding actions are performed.
  => actions **modify** the facts of the working memory, which can trigger the activation of other rules.

Agenda

When matching the rules, it is possible that several rules are active simultaneously, it is said that they are in conflict.

The **Agenda** component is responsible for managing the execution order of the conflicting rules byusing a conflict resolution strategy. (priority or other)

Components of the engine



Pattern matching, ReteOO and PHREAK

The treatment of comparing the facts to the rules is called the ***Pattern Matching***. There are many pattern matching algorithms: Linear, Rete, Treat, Leaps.

Drools started to implement and optimize the Rete algorithm in an object technology. (***ReteOO***)

- Eager algorithm
- Poor performance when inserting lot of facts in working memory

Since Drools6 : the new algorithm is **PHREAK** :

- Based on Rete Graph
- Lazy algorithm
- Much better performance when inserting facts

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Eclipse plugins

- Drools provides Eclipse plugins which unfortunately will be discontinued, the current version is buggy!
- It offers
  – A Drools Perspective
  – Project, .drl file, decision table and DSL creation wizards
  – A drl file editor and validator
  – Views for debugging

Drool's views

For debugging, the plugin offers several views to inspect the rules engine.
These views are available when the execution reaches a breakpoint

1. The **Working Memory View** allow to inspect the facts in memory
2. The **Agenda View** allow to see the activated rules in the agenda. For each rule, the associated variables are displayed. (Does not work with PHREAK)
3. The **Global Data View** allow to see all the global variables available in the session.

The audit view

The **audit view** allow to display a log which can be generated with the following code :

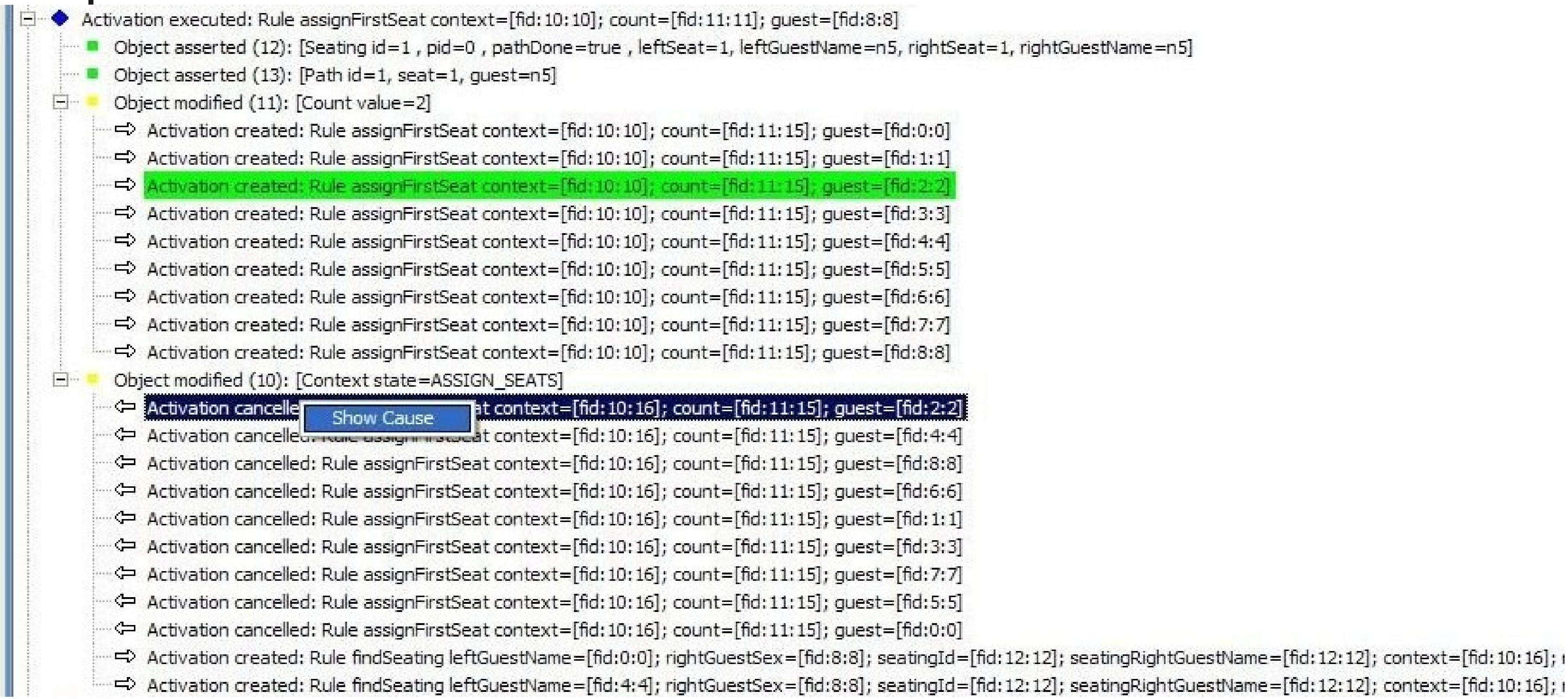
```
KieRuntimeLogger logger =
  KieServices.Factory.get().getLoggers().newFileLogger
  (ksession, "logdir/mylogfile");

ksession.insert(...);

ksession.fireAllRules();

// stop logging

logger.close();
```

Or which has been configured via *kmodule.xml*

Events of the logfile

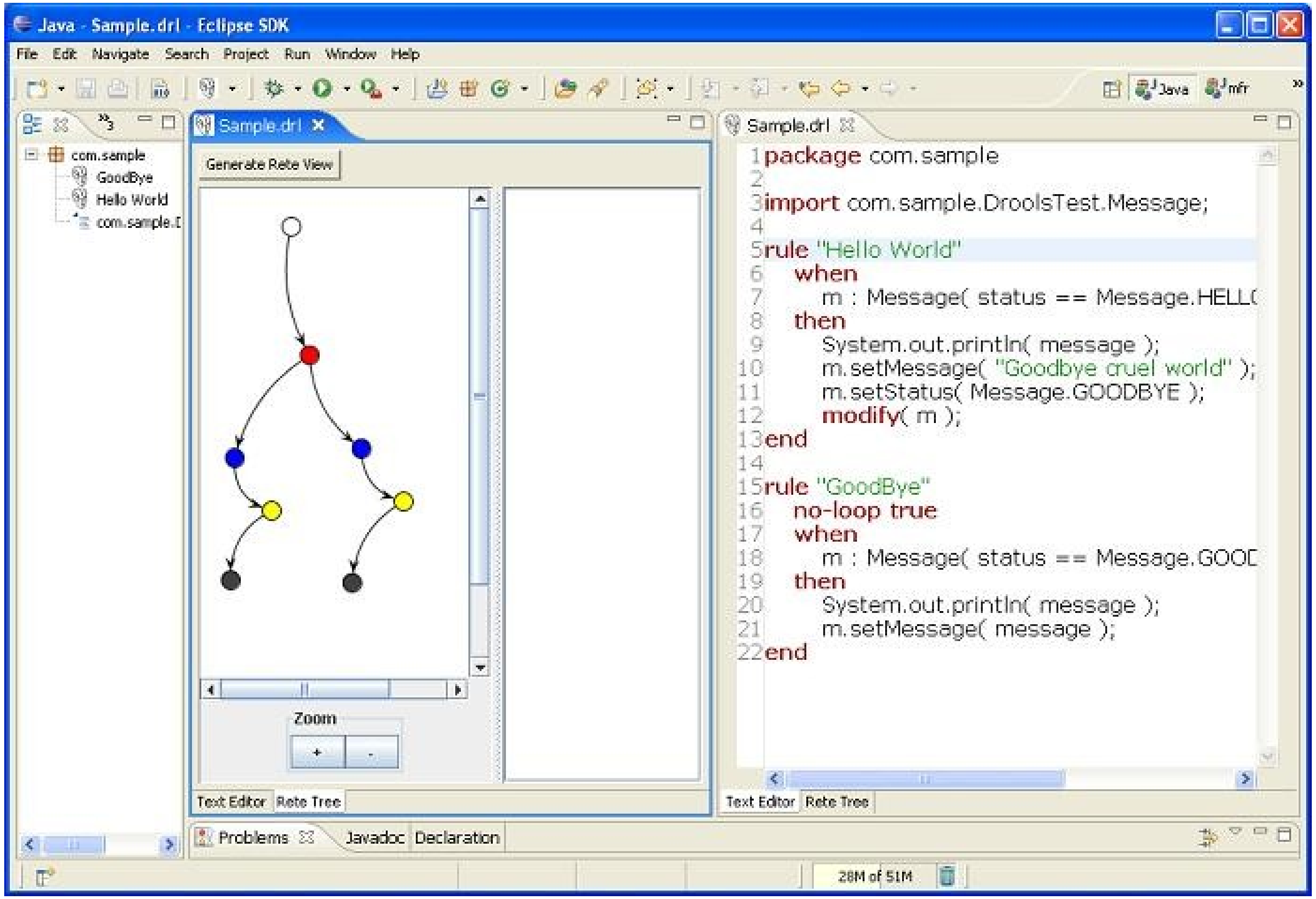
1. Object inserted
2. Object updated:
3. Object removed
4. Activation created
5. Activation canceled :
6. Activation executed :
7. Sequence of starting or ending of a rule :
8. Activation/desactivation of a rules’s group:
9. Add/remove a rule’s package:
10. Add/remove a rule :

Example



Activation executed: Rule assignFirstSeat context=[fid:10:10]; count=[fid:11:11]; guest=[fid:8:8]
Object asserted (12): [Seating id=1 , pid=0 , pathDone=true , leftSeat=1, leftGuestName=n5, rightSeat=1, rightGuestName=n5]
Object asserted (13): [Path id=1, seat=1, guest=n5]
Object modified (11): [Count value=2]
Activation created: Rule assignFirstSeat context=[fid:10:10]; count=[fid:11:15]; guest=[fid:0:0]
Activation created: Rule assignFirstSeat context=[fid:10:10]; count=[fid:11:15]; guest=[fid:1:1]
Activation created: Rule assignFirstSeat context=[fid:10:10]; count=[fid:11:15]; guest=[fid:2:2]
Activation created: Rule assignFirstSeat context=[fid:10:10]; count=[fid:11:15]; guest=[fid:3:3]
Activation created: Rule assignFirstSeat context=[fid:10:10]; count=[fid:11:15]; guest=[fid:4:4]
Activation created: Rule assignFirstSeat context=[fid:10:10]; count=[fid:11:15]; guest=[fid:5:5]
Activation created: Rule assignFirstSeat context=[fid:10:10]; count=[fid:11:15]; guest=[fid:6:6]
Activation created: Rule assignFirstSeat context=[fid:10:10]; count=[fid:11:15]; guest=[fid:7:7]
Activation created: Rule assignFirstSeat context=[fid:10:10]; count=[fid:11:15]; guest=[fid:8:8]
Object modified (10): [Context state=ASSIGN_SEATS]
Activation cancelle
Show Cause
at context=[fid:10:16]; count=[fid:11:15]; guest=[fid:2:2]
Activation cancelled
t context=[fid:10:16]; count=[fid:11:15]; guest=[fid:4:4]
Activation cancelled: Rule assignFirstSeat context=[fid:10:16]; count=[fid:11:15]; guest=[fid:8:8]
Activation cancelled: Rule assignFirstSeat context=[fid:10:16]; count=[fid:11:15]; guest=[fid:6:6]
Activation cancelled: Rule assignFirstSeat context=[fid:10:16]; count=[fid:11:15]; guest=[fid:1:1]
Activation cancelled: Rule assignFirstSeat context=[fid:10:16]; count=[fid:11:15]; guest=[fid:3:3]
Activation cancelled: Rule assignFirstSeat context=[fid:10:16]; count=[fid:11:15]; guest=[fid:7:7]
Activation cancelled: Rule assignFirstSeat context=[fid:10:16]; count=[fid:11:15]; guest=[fid:5:5]
Activation cancelled: Rule assignFirstSeat context=[fid:10:16]; count=[fid:11:15]; guest=[fid:0:0]
Activation created: Rule findSeating leftGuestName=[fid:0:0]; rightGuestSex=[fid:8:8]; seatingId=[fid:12:12]; seatingRightGuestName=[fid:12:12]; context=[fid:10:16];
Activation created: Rule findSeating leftGuestName=[fid:4:4]; rightGuestSex=[fid:8:8]; seatingId=[fid:12:12]; seatingRightGuestName=[fid:12:12]; context=[fid:10:16];

Rete View



Java - Sample.drl - Eclipse SDK
File Edit Navigate Search Project Run Window Help
com.sample
GoodBye
Hello World
Sample.drl
Generate Rete View
Zoom
Text Editor
Rete Tree
package com.sample
import com.sample.DroolsTest.Message;
rule "Hello World"
when
m : Message(status == Message.HELL(
then
System.out.println(message);
m.setMessage("Goodbye cruel world");
m.setStatus(Message.GOODBYE);
modify(m);
end
rule "GoodBye"
no-loop true
when
m : Message(status == Message.GOOD
then
System.out.println(message);
m.setMessage(message);
end
Problems
Javadoc
Declaration
28M of 51M

Rete view legend

- Green : Input point
- Red : *ObjectTypeNode*
- Blue : *AlphaNode*
- Yellow: Adaptateur de l'entrée gauche
- Green : *BetaNode*
- Black : Rule node

Selection of a node update the properties view

Other IDES

RedHat offers also a VSCode Extension which allows :

- Syntax coloration on drl files
- View and design BPMN models,
- View and design of DMN models and test scenario files .

You can aloso find support in InteliJIDEA : *https://plugins.jetbrains.com/plugin/16871-drools*

Archetype Maven

- An alternative to using the project creation wizard, it is possible to use a Maven archetype: **`org.kie:kie-drools-archetype`**

Getting started

KIE API

Stateless Session

Stateful Session and inference

Agenda and conflicts

Listeners, Channels, Entry-points

Main classes

KieServices : Singleton giving access to other Kie services (Container, Loggers, persistence, Serializer, ...)

KieModule : Wraps Knowledged base(s), and their sessions. Generally configured via *kmodule.xml*

KieContainer: The container responsible for loading the *KieModule*.

KieBase : A compiled knowledge base.

KieSession : API with the working memory.

KieContainer / KieModule

- Differents ***KieContainer*** can be created depending the way to load the *KieModule*
  - From the classpath
  - From a maven repository
  - From a REST API
- From *KieContainer*, we can instantiate :
  - *KieBases* and *KieSessions* defined in the module

Example

```
// Retreive the singleton KieServices
KieServices kieServices = KieServices.Factory.get();

// Instanciate a container which loads ressources
// from classpath
KieContainer container = KieServices.getKieClasspathContainer()


// Retrieve KnowledgeBase from the module
KieBase kBase1 = kContainer.getKieBase("KBase1");

// Retrieve different sessions
KieSession kieSession1 = kContainer.newKieSession("KSession2_1");

StatelessKieSession kieSession2 =
   kContainer.newStatelessKieSession("KSession2_2");
```

ReleaseId

- A Kie project is a Maven project
- The ***groupId***, ***artifactId***, and ***version*** declared in the *pom.xml* file are used to generate a ***ReleaseId***.
- A *KieContainer* can also be constructed with a *ReleaseId*.
- Then, it will load resources from the Maven repository.

```
KieServices kieServices = KieServices.Factory.get();
ReleaseId rId = kieServices.newReleaseId( "org.acme", "myartifact", "1.0" );
KieContainer kieContainer = kieServices.newKieContainer( rId );
```

Types of sessions

Two types of Drools session are possible

- ***stateless*** : ***StatelessKieSession.*** which does not use inference
- ***stateful*** : ***KieSession***

Getting started

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Stateless Knowledge Session

Stateless sessions are the simplest case because they do not use the inference engine.

You can think about a *function* that we would pass arguments and that would cause a result.

Use cases of stateless sessions :

- Validation : Is a person eligible for a loan?
- Computation : Calculate a discount
- Routing or filtering: Filter emails, forward messages to destinations
- ...

Sample : The domain model (facts)

```
public class Applicant {
    private String name;
    private int age;
    // getter and setter methods here
}


public class Application {
    private Date dateApplied;
    private boolean valid;
    // getter and setter methods here
}
```

Sample - Rules

```
package com.company.license

rule "Is of valid age"
when
    Applicant( age < 18 )
    $a : Application()
then
    $a.setValid( false );
end

rule "Application was made this year"
when
    $a : Application( dateApplied > "01-jan-2014" )
then
    $a.setValid( false );
end
```

Pattern matching (Rete)

When rules are evaluated, if there is fact of type *Applicant* in the working memory. The fact is evaluated against the constraints of the rules.

- In this case, the 2 constraints of the first rule (constraint on the type and the age field).
- A constraint on an object type plus one or more constraints on its fields is called a **pattern**.

If a fact matches the pattern, the consequence of the rule is executed.

The notation **$a** represents a variable[1]. It reference the object which has matched and therefore its properties can be updated in the consequence part.

1. The ('$') character is optional but makes the expression of the rule more readable.

Execution

```
// Statless session creation

StatelessKieSession ksession = kContainer.newStatelessKieSession();

Applicant applicant = new Applicant( "Mr John Smith", 16 );

Application application = new Application();

assertTrue( application.isValid() );

// Execution of the rules for this 2 facts

ksession.execute(
  Arrays.asList( new Object[] { application, applicant } ) );

assertFalse( application.isValid() );
```

BatchExecutor and *CommandFactory*

The methods *execute(Object object)* and *execute(Iterable objects)* are shortcuts for : ***execute(Command command)*** of the BatchExecutor interface

For instance, the second method is equivalent to :

```
ksession.execute(
  CommandFactory.newInsertIterable( new Object[]
  { application, applicant } ) ) ;
```

BatchExecutor and *CommandFactory*

BatchExecutor are *CommandFactory* are particularly useful for working with several commands and results :

```
List<Command> cmds = new ArrayList<Command>();

cmds.add(CommandFactory.newInsert( new Person( "Mr John Smith" ), "mrSmith" );

cmds.add(CommandFactory.newInsert( new Person( "Mr John Doe" ), "mrDoe" );

BatchExecutionResults results =
   ksession.execute( CommandFactory.newBatchExecution( cmds ) );

assertEquals( new Person( "Mr John Smith" ), results.getValue( "mrSmith" ) );
```

Getting started

KIE API
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Agenda and conflicts
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Stateful Session

Stateful session have a longer life cycle and allow iterative update of the facts .

Use cases are:

- Monitoring : Stock market monitoring and semi-automatic purchasing
- Diagnosis: Discovery of fault, medical diagnosis
- Logistics: Delivery tracking, provisionning
- Compliance: Validation of legislation

Stateful versus stateless

- Unlike a Stateless Session, the ***dispose()*** method must be called to avoid memory leaks[1]
- A Stateful Knowledge Session is simply called ***KieSession***.
- *KieSession* implements also the interface *BatchExecutor*
  – But, the method *fireAllRules()* is not triggered automatically.

1. *KieBase contains references to Stateful Sessions*

Sample – Domain model

```
public class Room {
    private String name
    // getter and setter methods here
}
public class Sprinkler {
    private Room room;
    private boolean on;
    // getter and setter methods here
}
public class Fire {
    private Room room;
    // getter and setter methods here
}
public class Alarm { }
```

Sample – Rule

```
rule "When there is a fire turn on the sprinkler"
when
    Fire($room : room)
    $sprinkler : Sprinkler( room == $room, on == false )
then
    modify( $sprinkler ) { setOn( true ) };
    System.out.println( "Turn on the sprinkler for room " + $room.getName() );
end
```

Inference and modify

Unlike the *StatelessSession* example, which used the standard Java syntax to modify the attribute of a fact, using the ***modify*** statement can warn the engine of changes of the facts and thus allow it to make other pattern matching.

This is called ***inference***

not operator

The ***not*** operator is used to match when no instance of the object exists in the working memory:

```
rule "When the fire is gone turn off the sprinkler"
when
    $room : Room( )
    $sprinkler : Sprinkler( room == $room, on == true )
    not Fire( room == $room )
then
    modify( $sprinkler ) { setOn( false ) };
    System.out.println( "Turn off the sprinkler for room " +
  $room.getName() );
end
```

exists operator

- The operator ***exist*** test the existence of a fact :

```
rule "Raise the alarm when we have one or more fires"
when
    exists Fire()
then
    insert( new Alarm() );
    System.out.println( "Raise the alarm" );
end
```

delete/retract instruction

The instruction ***delete*** allows to remove a fact from working memory

```
rule "Cancel the alarm when all the fires have gone"
  when
    not Fire()
    $alarm : Alarm()
  then
    delete( $alarm );
    System.out.println( "Cancel the alarm" );
end
```

1. retract is also supported

Inference and maintenabilty

The insertion of a new fact from a previous knowledge may lead to more maintenability

```
rule "Infer Adult"
when
  $p : Person( age >= 18 )
then
  insert( new IsAdult( $p ) )
end
```

The other rules can be based on being an adult rather than the value 18.
=> Adaptation to other specification will be facilitated

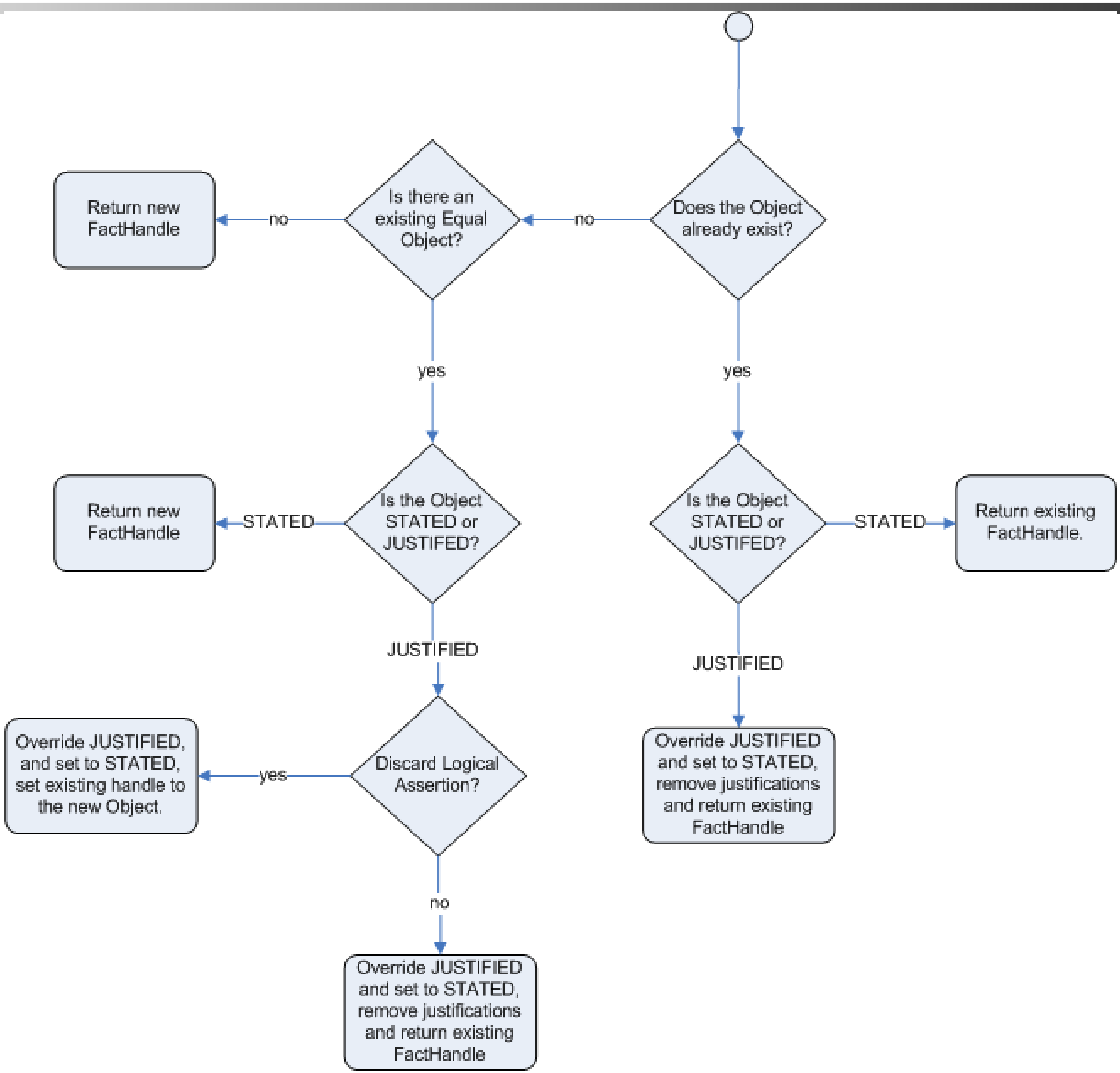
insertLogical

insertLogical retract the fact as soon as the when clause becomes false again :

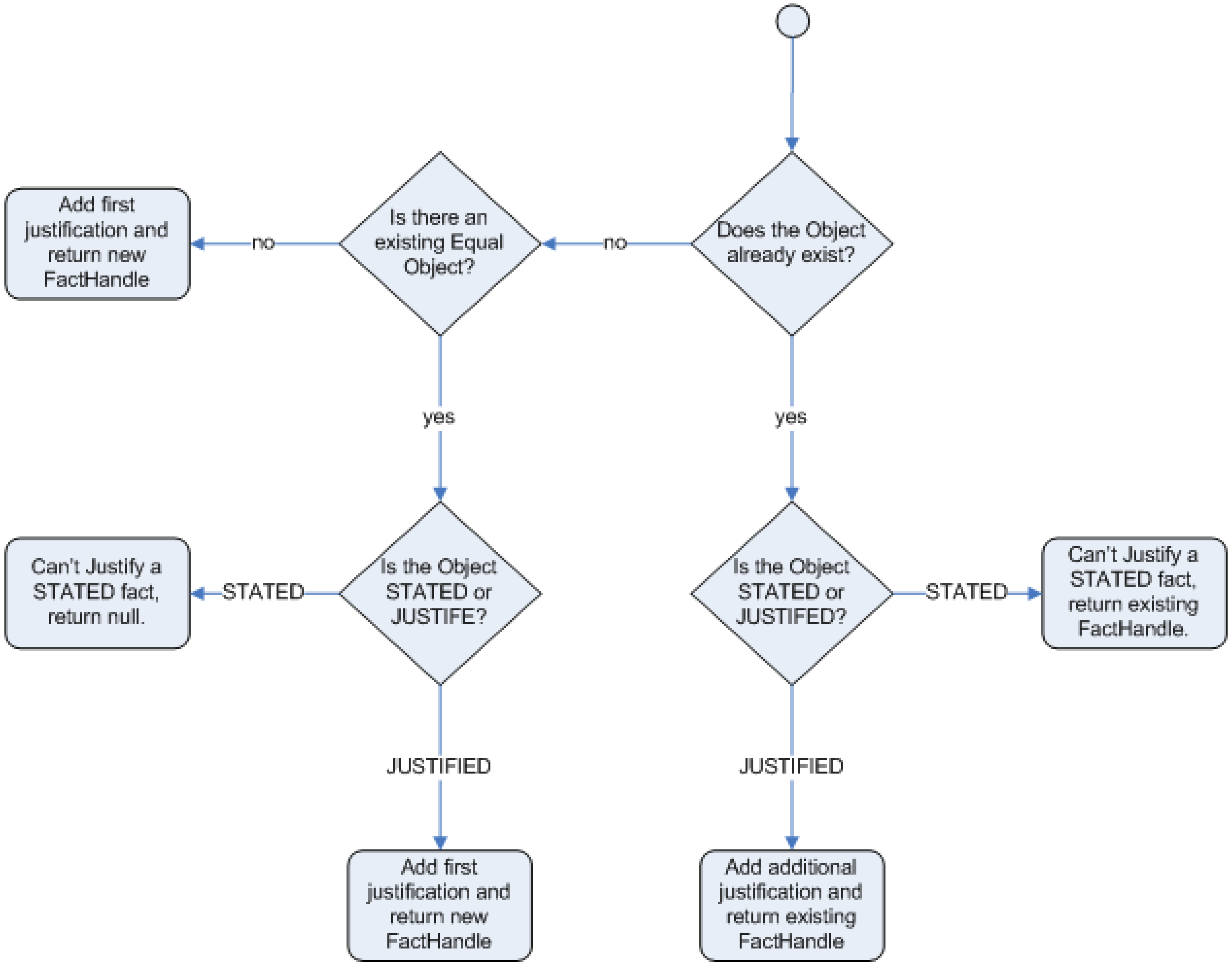
```
rule "Infer Child"

when

$p : Person( age < 16 )

then

insertLogical( new IsChild( $p ) )

end
```

The fact *IsChild ($ p)* is automatically retracted as soon as the person reaches 16

Insertion simple (STATED)



Logical insertion (JUSTIFIED)



Equality of facts

Determine when 2 facts are the same.

The rule engine handle 2 behaviours :

- ***identity***: (Default) Equality based on identity (== in Java)
- ***equality*** : Equality based on method *equals()*

```
<kbase name="KBase2" default="false"
equalsBehavior="equality"
packages="org.domain.pkg2, org.domain.pkg3"
includes="KBase1">
```

Creation of a stateful session

```
// Creation of the stateful session
KieSession ksession = kContainer.newKieSession();

String[] names = new String[]{"kitchen", "bedroom", "office",
   "livingroom"};
Map<String,Room> name2room = new HashMap<String,Room>();
for( String name: names ){
    Room room = new Room( name );
    name2room.put( name, room );
    ksession.insert( room );
    Sprinkler sprinkler = new Sprinkler( room );
    ksession.insert( sprinkler );
}

ksession.fireAllRules() ;

> Everything is ok
```

FactHandle

A FactHandle allow to obtain a reference to an inserted fact in the working memory.

```
Fire kitchenFire = new Fire( name2room.get( "kitchen" ) );
Fire officeFire = new Fire( name2room.get( "office" ) );
FactHandle kitchenFireHandle = ksession.insert( kitchenFire );
FactHandle officeFireHandle = ksession.insert( officeFire );
ksession.fireAllRules() ;


> Raise the alarm
> Turn on the sprinkler for room kitchen
> Turn on the sprinkler for room office
```

This reference allow to remove the fact later :

```
ksession.retract( kitchenFireHandle );
ksession.retract( officeFireHandle );
ksession.fireAllRules() ;


> Turn on the sprinkler for room office
> Turn on the sprinkler for room kitchen
> Cancel the alarm
> Everything is ok
```

Getting started

KIE API
Stateless Session
Stateful Session and inference
Agenda and conflicts
Listeners, Channels, Entry-points

Methods versus Rules

<u>Methods</u>:

- They are explicitly called
- Specific instances are passed as arguments
- A call causes a single run

<u>Rules</u> :

- They are never explicitly called
- Specific instances can not be passed as an argument
- A rule can fire once, several times, or no time.

Activations, Agenda and conflicts **(Drools6)**

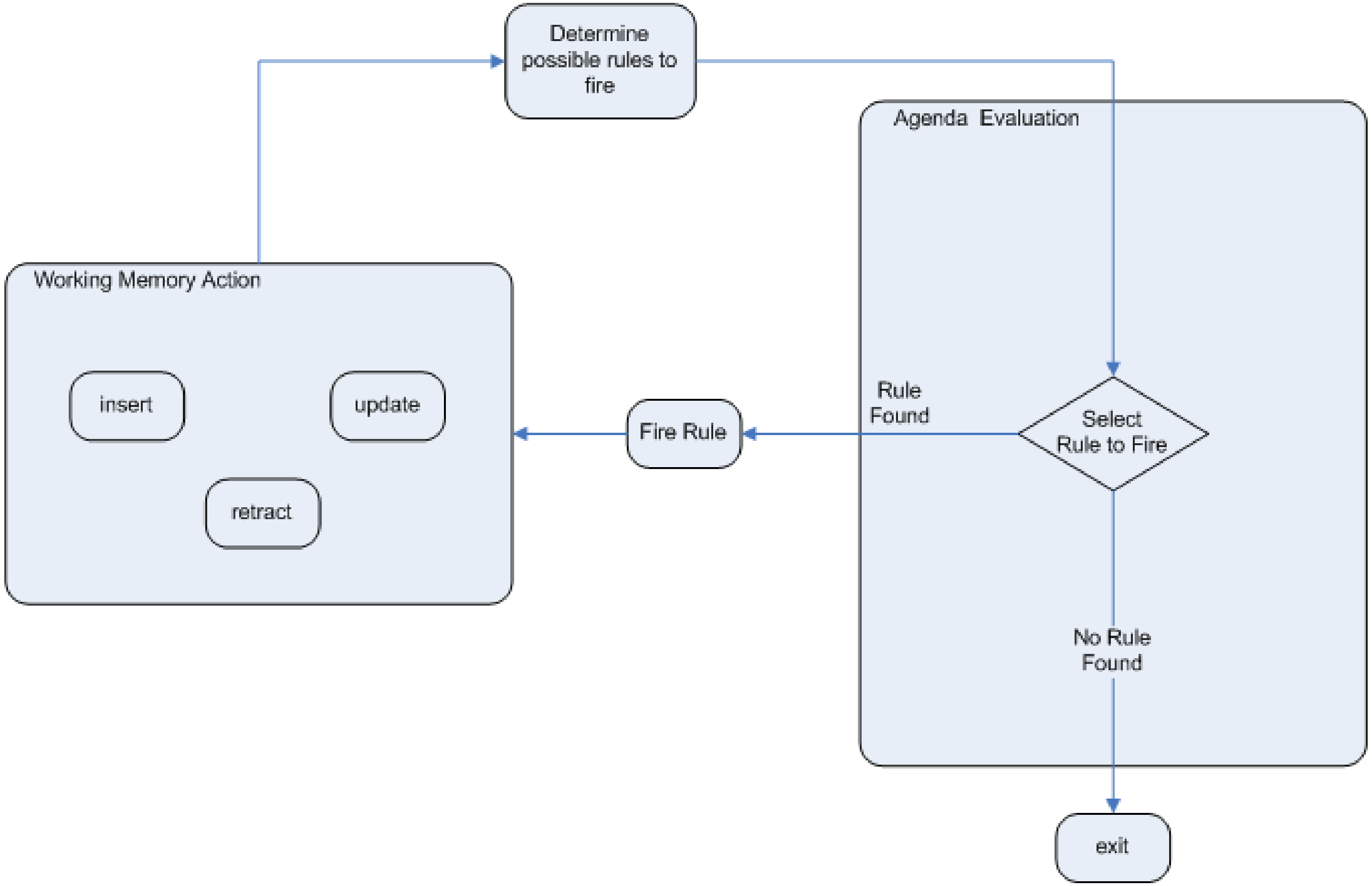
When calling *fireAllRules()*, the rules are evaluated independently of each other

The agenda chooses the first rule based on the active activation group and the salience attributes of the rule.
If 2 rules have the same precedence, the declaration’s order is taken in account

If the conditions of a rule are met, it is triggered immediately.

If the consequence of the rule updates the working memory, the inference occurs

Life cycle of the Agenda



Agenda groups

- **Agenda groups** allow to partition rules in groups that are themselves placed in an execution stack
- The agenda executes the rules of the group placed on the top of the stack
- When all the rules have been executed, the agenda pops another group from the stack.

Execution model

Drools supports 2 rule execution modes :

- **Passive mode** (default) : Rules are triggered by *fireAllRules()*
- **Active mode** : When *fireUntilHalt()* is called.
  Drools continuously evaluates rules until the *halt()* method is called.
  => Application which reacts to facts insertion events, or when timers are configured

Agenda filter

When executing the rules, Drools allows you to set an ***AgendaFilter*** to filter the rules that the Agenda can activate.

```
ksession.fireAllRules( new RuleNameEndsWithAgendaFilter( "Test" ) );
```

Getting started

KIE API
Stateless Session
Stateful Session and inference
Agenda and conflicts
Listeners, Channels, Entry-points

Event Model

- Kie provides an event model that allows listeners to be aware of engine events such as triggering a rule, inserting a fact, and so on.
  - This allows separation of trace or audit activities
- 3 interfaces are provided:
  - *AgendaListener*
  - *RuleRuntimeEventListener*
  - *ProcessEventListener* (for jBPM).

Debug listeners

Drools provides 2 listeners for debugging. They display debug messages on the console :

- *DebugRuleRuntimeEventListener* and *DebugAgendaEventListener*

KieRuntimeLogger also uses events to generate a trace file visible by the Audit view of Eclipse

```
KieRuntimeLogger logger =

KieServices.Factory.get().getLoggers().newFileLogger(ksession,
  "logdir/mylogfile");

...

logger.close();
```

Example of a customized listener

```
ksession.addEventListener(
   new DefaultAgendaEventListener() {
     public void afterMatchFired(AfterMatchFiredEvent event) {
      super.afterMatchFired( event );
      System.out.println( event );
}
});


ksession.addEventListener( new
   DebugRuleRuntimeEventListener() );
```

Configuration via *kmodule.xml*

```
<kmodule xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xmlns="http://jboss.org/kie/6.0.0/kmodule">
  <kbase name="KBase1" default="true" eventProcessingMode="cloud" equalsBehavior="equality">
    <ksession name="KSession2_1" type="stateful" default="true/">
    <ksession name="KSession2_1" type="stateless" default="false" beliefSystem="jtms"/>
</kbase>
<kbase name=""KBase2" default="false" eventProcessingMode="stream" equalsBehavior="equality"
  declarativeAgenda="enabled"
packages="org.domain.pkg2,org.domain.pkg3" includes="KBase1">
<ksession name="KSession2_1" type="stateful" default="false" clockType="realtime">
  <fileLogger file="drools.log" threaded="true" interval="10"/>
  <listeners>
    <ruleRuntimeEventListener type="org.domain.RuleRuntimeListener"/>
    <agendaEventListener type="org.domain.FirstAgendaListener"/>
    <agendaEventListener type="org.domain.SecondAgendaListener"/>
  </listeners>
</ksession>
</kbase>
</kmodule>
```

Channels

A **channel** is a standardized way to transmit data from within a session to the external world.

- Alternative to globals. (see further)

Technically, *channel* is a Java interface with a single method :
void send(Object object)

Channels can only be used in the RHS of our rules as a way to send data to outside

Registration

Channels must be registered : :

```
ksession.registerChannel("audit-channel",auditChannel);
```

Then, they can be used in rules :

```
rule "Send Suspicious Operation to Audit Channel"
  when
    $so: SuspiciousOperation()
  then
    channels["audit-channel"].send($so);
end
```

Entry points

Entry points are a way to partition working memory. The rules can then apply to certain entry points

```
// Reasoning from an entry point
rule "Routing transactions from small resellers"
when
  t: TransactionEvent()
     from entry-point "small resellers"
```

On insertion, the entry point can be specified:

```
ksession.getEntryPoint("myEntryPoint").insert(new Object());
```

Lab 2.2 : Session stateful

Rule syntax : DRL

Main elements

Rule’s attributes

LHS

RHS

Query, aggregation

.drl files

A rules file is a simple text file with the extension .drl

It has the following structure :

- **package** : Namespace
- **imports :** Java types used
- **declare :** Internal declaration of new types
- **globals :** Globals variables which can accessed from outside the session
- **functions :** Reuse of logic
- **queries :** Fact queries
- **rules :** Rules

It is also possible to distribute the rules over several files which then usually have the *.rule* extension

Structure of a rule

```
rule "name"
    attributs
    when
        LHS
    then
        RHS
end
```

- Punctuation ", line breaks are optional
- Attributes are optional
- LHS is the conditional part of the rule
- RHS is a block that allows to specify in different dialects a code to execute.

Keywords

Keywords :

– Hard (*true, false, accumulate, collect, from, null, over, then, when*). Can not be used as variable

– Soft : only recognized in their context (*package, import, attributes, rule, ...)*

The escape character is ` (backquote) :

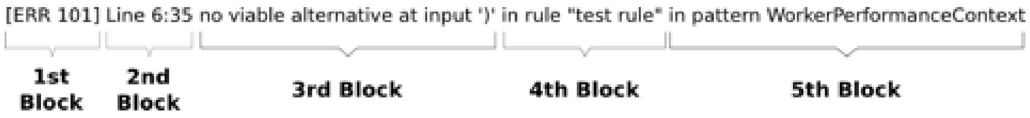
```
Holiday( `when` == "july" )
```

Comments:

– line : **#** or **//**

– multi-lines : ***/* .... */***

Error message



- ✓1st block : Error code
- ✓2nd block : Information on the column and the row.
- ✓3rd block : Description of the error.
- ✓4th block (optional) : First context of the error. Generally, the rule, the function, the query where the error occured.
- ✓5th bloc (optional) : Identify the **pattern** where the error occured

Package

A ***package*** groups together a set of *rules*, *imports*, and *globals* that are related.

- A package represents a namespace and must be unique in the knowledge base. It follows the naming conventions of Java packages
- If the rules of the same package are distributed over several files. Only one file contains the package configuration.
- Items declared in a package can be in any order, except for the package statement.
- The ';' is optional.

Import

import instructions are similar to java imports

The full name of the Java types must be specified.

Drools automatically imports :

- the Java classes from the package of the same name
- the package *java.lang.*

Global

global defines global variables

- Global variables can be used in the consequences of the rules. (RHS)
- They are not inserted into working memory and therefore should not be used as conditions in the rules except as a constant
- The engine is not warned when the value of a global variable changes

Example

```
global java.util.List myGlobalList;

rule "Using a global"
when
eval( true )
then
myGlobalList.add( "Hello World" );
end

-----

List list = new ArrayList();
WorkingMemory wm = rulebase.newStatefulSession();
wm.setGlobal( "myGlobalList", list );
```

Functions

functions allow to insert code in rule's files.

- They are just like Helper classes.
  With functions, the logic is centralized in one place.
- They are used to invoke actions in the consequence part of the rules.

```
function String hello(String name) {
  return "Hello "+name+"!";
}
rule "using a static function"
when
  eval( true )
then
  System.out.println( hello( "Bob" ) );
end
```

Declarations

2 kinds of declarations :

- **Declaration of new types** : Drools works directly with POJOs as facts.
  It is therefore possible to define the business model directly in the rules or to create model objects that are useful only in reasoning.
  Drools, at compile-time, generates the Java bytecode that implements the new type
- **Declaration of meta-data or annotations**: The facts or their attributes can be annotated.
  Annotations can be used to filter rules or facts.

Declaration of new types

```
declare Address
   number : int
   streetName : String
   city : String
end


declare Person
    name : String
    dateOfBirth : java.util.Date
    address : Address
end
```

Access to the declared types

We can access to the internal declared types via the interface ***org.drools.definition.type.FactType***

```
// Get the data type
FactType personType = kbase.getFactType( "org.drools.examples",
                                          "Person" );
// Instanciate it
Object bob = personType.newInstance();


// Set attributes
personType.set( bob, "name", "Bob" );
personType.set( bob, "age", 42 );
```

Meta-data declaration

The character **@** is used

The metadata can concern a new or existing type or one of its attributes.

```
declare Person
    @author( Bob )
    @dateOfCreation( 01-Feb-2009 )

    name : String @key @maxLength( 30 )
    dateOfBirth : Date
    address : Address
end
```

Or on a existing type

```
declare Person
    @author( Bob )
    @dateOfCreation( 01-Feb-2009 )
end
```

Usage of meta-data

Drools allows the declaration of arbitrary meta-data.

Metadata can be used by queries.

Some meta-data are predefined and have a meaning for the engine. They are especially useful for Drools-CEP:

@role, @timestamp, @duration, ...

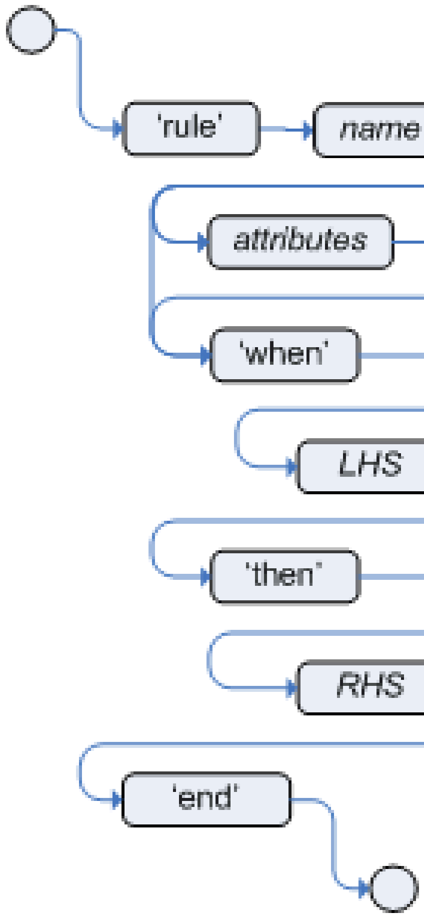
Example

```
StatefulKnowledgeSession ksession= createKSession();

ksession.fireAllRules(new AgendaFilter() {
  public boolean accept(Activation activation) {
    Map<String, Object> metaData =
   activation.getRule().getMetaData();
    if (metaData.containsKey("LegalRequirement")) {
      return true;
    }
    return false;
  }
});
```

Rule syntax : DRL

Main elements
Rule’s attributes
LHS
RHS
Query, aggregation

Rule



Rule

- A ***rule*** must have a unique name inside the package.
- The name can contain spaces if it is delimited by ".
- The left side of the rule (LHS) or condition follows the keyword ***when***
- The Right Hand Side (RHS) or Consequence follows the keyword ***then***
- The rule ends with the keyword ***end***.
- Rules can not be nested.

Attributes (1)

no-loop (boolean, false) : When the consequence of the rule changes a fact, it can cause the rule to be activated again. Recursion can be avoided with the no-loop attribute set to true.

salience (integer, 0) : Each rule has an salience attribute that determines the priority of the rule in the agenda.

dialect (String, "java" or "mvel") : The dialect is usually specified at the package level. This attribute overrides the package-level definition.

Attributes (2)

agenda-group (String, MAIN) : This attribute allows to partition the Agenda and control the execution. Only the rules of the agenda group that has the focus are allowed to fire.

activation-group (String) : Rules belonging to the same activation group are exclusive. The first rule that fires cancels the others.

ruleflow-group (String) : Group several rules. The rules in this group will only be enabled when the process is in a particular node of an associated jBPM process.

Attributes (3)

auto-focus (boolean, false) : When a rule is enabled with the auto-focus attribute set, the group indicated by one of its attributes (agenda-group or activation-group) gains the focus.

lock-on-active (boolean, false) : When a group (ruleflow or agenda) becomes active, all the rules in this group that have the lock-on-active attribute set will no longer be activated in the future whatever the origin of the update. They can be reactivated when their group is reactivated. (gain the focus again)

date-effective (date as String) : A rule can only be activated if the current date is greater than the effective date.

date-expires (date as String) : A rule can only be activated if the current date is greater than the expiration date.

Timer

Drools supports ***timers*** based on intervals or expressed by cron expressions.

```
timer ( int: <initial delay> <repeat interval>? )
```

```
timer ( cron: <cron expression> )
```

Exemple

```
rule "Send SMS every 15 minutes"
    timer (cron:* 0/15 * * * ?)
when
    $a : Alarm( on == true )
then
    channels[ "sms" ].insert( new Sms( $a.mobileNumber, "The alarm is still on" );
end
```

fireUntilHalt()

In order for rules using timers to be triggered, the engine must be active.

In this case, do not call *fireAllRules()* but ***fireUntilHalt()*** which evaluates the rules until it receives a halt signal

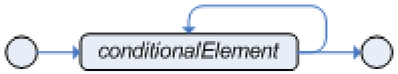
In this case, stopping the engine can be done:

- Inside the RHS of a rule : ***drools.halt()***
- Inside Java client : ***ksession.halt()***
  fireUntilHalt() method is usually started in an independent thread so that the Java code can stop it.

Rule syntax : DRL

Main elements
Rule’s attributes
LHS
RHS
Query, aggregation

LHS

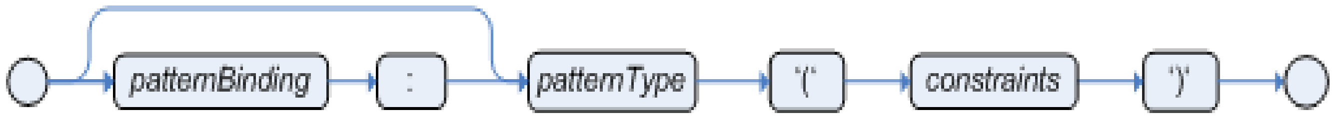


The LHS part is the conditional part of the rule.

It consists of zero or more conditions elements

- If no condition element, the LHS is set to true and will be activated when the working memory is created
- Conditional elements consist of **patterns** that are implicitly connected by **and**

Pattern



A pattern consists of:

- A binding pattern to create a variable used in the rule
  (the $ character is optional but recommended)
- A restriction on the type (A fact, an interface, an abstract class)
- A set of constraints linked by operators

Ex : `$c : Cheese()`

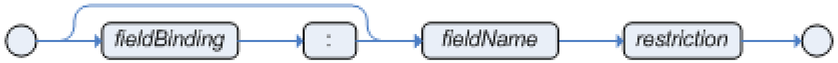
Constraint's syntax

2 syntaxes can be used:

- **Field's constraints**
  - Concern only ONE attribute
  - Combined with && , || and ()
- <u>Ex:</u> `Cheese( quantity == 5 && quantity < 10 )`
- **Group 's constraints**
  - Concern SEVERAL attributes of the same fact
  - Combined with '**,**' (which means && with a lower precedence)

<u>Ex:</u> `Person( age > 50, weight > 80, height > 2 )`

Field’s constraints



A field constraint expresses a restriction on a property of the object accessible by getter / setter, it is possible to bind the field on a variable

3 types of restriction are possible:

- **Unique value**: the field is compared to a single value
- **Multiple values**: the field is compared to several values
- **Multi-constraints**: Several constraints are specified on the field

The value of the field can be String, numeric, date (format "*dd-mmm-yyyy*" by default), boolean or Enum

Constraints on null value or return value of a method can also be used

Single value constraint

Available operators : <, <=, >, >=, ==, *!=, contains, not contains, memberof, not memberof, matches (regexp), not matches*

```
Cheese( quantity == 5 )

Cheese( bestBefore < "27-Oct-2009" )

Cheese( type == "camembert" )

Cheese( from == Enum.COW)

Cheese( type matches "(Buffalo)?\S*Mozarella" )

CheeseCounter( cheeses contains "stilton" )

CheeseCounter( cheese memberOf $matureCheeses )

Person( likes : favouriteCheese ) Cheese( type == likes )

Person( girlAge : age, sex == "F" ) Person( age == ( girlAge + 2), sex ==
   'M' )
```

Multiple values constraint

- Operators *in* and *not in*, allow to specify multiple values separated by ","

```
Person( $cheese : favouriteCheese )
Cheese( type in ( "stilton", "cheddar", $cheese ))
```

Multiples constraints

Multiple constraints allow you to specify several restrictions on the field related by the operators '&&' or '||' and parentheses

```
Person( age > 30 && < 40 )

Person( age ( (> 30 && < 40) ||
              (> 20 && < 25) ) )

Person( age > 30 && < 40 || location == "london" )
```

Group’s constraint

The comma, allows to separate the constraints of groups and is equivalent to an AND (with less priority):

```
Person( age > 50, weight > 80, height > 2 )
```

The comma operator can not be nested in a composite expression:

```
Person( ( age > 50, weight > 80 ) || height > 2 )
  // => compilation ERROR
```

Other operators

not : There is no fact in the working memory corresponding to these restrictions

exists : There is at least one fact in the working memory corresponding to these restrictions

forall : All the facts of the working memory corresponding to the first restriction satisfy the other restrictions

from : Used to compare data other than the entire working memory (For example a query, a channel)

collect : Lets reason on a collection of facts

accumulate : Allows to perform an aggregate function on a collection of objects

Examples

```
#There is no red bus in the memory
not Bus(color == "red")

#There is at least one bus 42 of red color in the memory
exists ( Bus(color == "red", number == 42) )

#All English buses are red
forall( $bus : Bus( type == 'english')  Bus( this == $bus, color =
   'red' ) )

# Addresses with the correct postal code
# which are associated with a Person from memory
Person( $personAddress : address )
Address( zipcode == "23920W") from $personAddress
```

Examples

```
# Build a mothers list
# Any woman with a child
$mothers : LinkedList()
from collect( Person( gender == 'F', children > 0 ) )

# All orders with a total greater than 100
$order : Order()
$total : Number( doubleValue > 100 )
from accumulate( OrderItem( order == $order, $value : value ),
   sum( $value ) )
```

Rule syntax : DRL

Main elements
Rule's attributes
LHS
RHS
Query, aggregation

RHS

- The right part contains a list of actions to perform.
- In general, no conditional code because the rule must be "atomic" (if not separate into several rules)
- The operations can act on the working memory and thus trigger the inference:
  - Inserting new facts
  - Deleting facts
  - Updating facts

Macro-methods

Drools supports several macro-methods that avoid retrieving the references of the facts that you want to update:

- ***set : set<field> (<value>)***

  Used to update a field

  ```
  $application.setApproved ( false );
  $application.setExplanation( "has been bankrupt" );
  ```

- **modify : modify (<fact-expression>) {**
  <expression>,
  <expression>,
  ... }

  Used to specify the fields to modify and notify Drools of the change

  ```
  modify( LoanApplication ) {
    setAmount( 100 ),
    setApproved ( true )
  }
  ```

Macro-methods (2)

- **update :**
  update (<object, <handle>)
  update (<object>) // => Find the corresponding fact
  Used to specify the fact to update and to notify Drools of the change.
  ```
  LoanApplication.setAmount( 100 );
  update( LoanApplication );
  ```

- **insert: insert(new <object>);**
  Used to insert a new fact
  ```
  insert( new Applicant() );
  ```

- **insertLogical** : ***insertLogical(new Something())***
  the object is automatically deleted if the rule is no longer valid.
  ```
  insertLogical( new Applicant() );
  ```

Macro-methods (3)

- **delete : delete(<object>)**
  Used to remove an object from working memory. The retract keyword is also supported
  `delete( Applicant )`

Context variables

2 context variables can be used in the RHS :

- ***drools*** *(RuleContext)* expose
  - useful methods to retreive information about the rule
    - *drools.getRule().getName()*: The name of the activated rule
    - *drools.getMatch()* : Information on why the rule was activated

- ***kcontext*** is also available and it can retreive a reference of *KieRuntime*

KieRuntime API

With a *KieRuntime* reference, you can call

- ***halt() :*** Stop the engine in active mode
- ***getAgenda():*** return a reference on the agenda of the session
  Ex : getAgenda().getAgendaGroup("CleanUp").setFocus();
- ***getQueryResults(String query)*** returns the result of a queries
- ***addEventListener, removeEventListener :*** (Un)Register listeners.
- ***getKnowledgeBase()*** Access to KnowledgeBase .
- Managing global variables with ***setGlobal(...), getGlobal(…)*** and ***getGlobals().***
- ***getEnvironment() :*** Access to the environment configuration properties of the engine

Rule syntax : DRL

Main elements
Rule's attributes
LHS
RHS
Query, aggregation

Introduction

A ***query***, in Drools, can be considered as a rule without its RHS section.

However, a major difference is that a query can take arguments

Query definition

A query can search for facts in the knowledge base

A request can be parameterized.

The names of the queries are global to the knowledge base

=> No identical name even in different packages

Its definition is similar to the left part of a rule:

```
// One parameter : x
query "people over the age of x"  (int x)
    person : Person( age > x )
end
```

Query on demand

The result of a query is obtained by :
ksession.getQueryResults("name")

It is then possible to iterate on the resulting rows

```
QueryResults results = ksession.getQueryResults( "people over the age of x" ,30 );
System.out.println( "we have " + results.size() + " people over the age  of 30" );

System.out.println( "These people are are over 30:" );
for ( QueryResultsRow row : results ) {
    Person person = ( Person ) row.get( "person" );
    System.out.println( person.getName() + "\n" );
}
```

Live queries

Drools also allows you to attach a listener to a query in order to be informed of the change of a results as soon as they are available

These are the live requests, they are executed via the method ***openLiveQuery()***

```
public LiveQuery openLiveQuery(String query,
                               Object[] arguments,
                ViewChangedEventListener listener);
```

Interface *ViewChangedListener*

ViewChangedListener has 3 methods:

```
public interface ViewChangedEventListener {
  public void rowInserted(Row row);
  public void rowDeleted(Row row);
  public void rowUpdated(Row row);
}
```

The interface therefore allows you to be warned when inserting, updating and deleting facts respecting the query

Other ways to express rules

Decision tables

Rule's templates

DMN

Presentation

- ***Decision tables*** are an efficient and compact way to represent conditional logic, they are tailored to business experts
- The data entered in a spreadsheet makes it possible to generate the rules.
- => the business expert then benefits from his favorite tool: ***Excel***
- For each line of the decision table, the data is combined with a template to generate a rule.
- Decision tables allow you to encapsulate rules and isolate the object model. Only the parameters of the rules that can be modified are exposed.

Example

	B	C	D	E
7				
8				
9		RuleSet	Some business rules	
10		Import	org.drools.decisiontable.Cheese, org.drools.deci	
11		Sequential	true	
12				
13		RuleTable Cheese fans		
14		CONDITION	CONDITION	ACTION
15		Person	Cheese	list
16	(descriptions)	age	type	add("$param")
17	Case	Persons age	Cheese type	Log
18	Old guy	42	stilton	Old man stilton
19	Young guy	21	cheddar	Young man cheddar
20				
21		Variables	java.util.List list	

Template syntax

Decision tables have 2 types of columns:

- **Condition columns** <=> LHS, the constraint syntax must be used
- **Action columns** <=> RHS, the code syntax must be used

$param is used to indicate where cell data will be inserted (*$1* can be used)

If the cell contains a value list separated by commas, the symbols $1, $2, and so on can be used.

The *forall (DELIMITER) {SNIPPET}* function can be used to loop through all available values.

Condition columns

The rendering of a condition depends on the presence of a declaration of an object type in a line above.

If the type is specified, a type constraint is created.

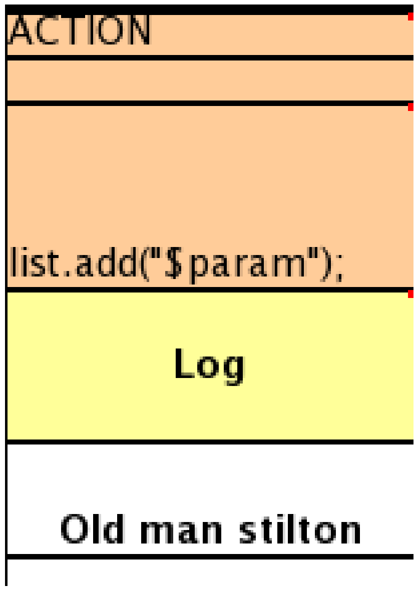
If the cell contains just one attribute, the constraint will be an equality constraint, otherwise the cell will include an operator.

13	RuleTable Cheese fans	
14	CONDITION	CONDITION
15	Person	
16	age	type
17	Persons age	Cheese type
18	42	stilton

Consequences

The result of an action cell depends on the presence of an entry on the line immediately above.

- If there is nothing, the cell is interpreted as it is
- If there is a variable, the contents of the cell are added to the variable (Method Call)



Keywords

Before the keyword *RuleTable*, the following keywords may be present and condition their cell immediately to the right:

- ***RuleSet*** : Specifying the name of the rule group, if empty it is the default group
- ***Sequential*** : The cell on the right contains true or false. If true, the salience property is used to guarantee order
- ***Import*** : List of java classes to import
- ***Functions*** : Functions declaration
- ***Variables*** : Global variables declaration
- ***Queries*** : Queries declaration

Example

RuleSet	Control Cajas[1]
Import	foo.Bar, bar.Baz
Variables	Parameters parametros, RulesResult resultado, EvalDate fecha

Functions	function boolean isRango(int iValor, int iRangoInicio, int iRangoFinal) {
	 if (iRangoInicio <= iValor && iValor <= iRangoFinal)
	  return true;
	 return false;
	}
	
	function boolean isIgualTipo(TipoVO tipoVO, int p_tipo, boolean isNull) {
	 if (tipoVO == null)
	  return isNull;
	 return tipoVO.getSecuencia().intValue() == p_tipo;
	}

RuleTable

A cell with ***RuleTable*** indicates the beginning of the definition of a rule table.

The table starts with the next line.

It is read from left to right and from bottom to top to a white line.

Keywords in the rules table

CONDITION : Indicates a condition column

ACTION : Indicates an action column

PRIORITY : Indicates a column used for the salience attribute

DURATION : Indicates the duration attribute of the rule

NAME : The name of the rule (optional)

NO-LOOP : Attribute no-loop (true or false)

ACTIVATION-GROUP : Attribute activation-group

AGENDA-GROUP : Attribute agenda-group of the rule

RULEFLOW-GROUP : Attribute ruleflow-group of the rule

Integration

- The integration of a decision table requires the library
- ***drools-decisiontables.jar***
- The main class ***SpreadsheetCompiler*** takes as input a csv or excel file and generates the rules in DRL
- The rules can then be manipulated independently

Example : usage of SpreadSheet Compiler

```java
@SuppressWarnings("restriction")
public static void main(String[] args) {

String fileName="/org/formation/dtables/assurance.xls";
if ( args.length  > 0 )
  fileName = args[0];

SpreadsheetCompiler spc = new SpreadsheetCompiler();
String drl = spc.compile(fileName, InputType.XLS);
System.out.println("DRL\n"+drl);
}
```

Steps

1. The business expert starts from a decision table template
2. It informs the parameters of the rules and actions with business descriptions
3. They enter the lines corresponding to the rules
4. The decision table is taken over by a technician who maps the business language to scripts
5. The business expert and the technician review together the changes made.
6. The business expert can edit the rules according to his needs.
7. The technical espert can write test cases that check the rules

Other ways to express rules

Decision tables

Rule’s templates

DMN

Rules template

Rules templates use tabular data sources (Spreadsheets, CSV, or others) to generate many rules.

This is a technique that is ultimately more powerful than the decision tables:

- Data can be stored in a database
- Rule generation can be conditioned by data
- The data can be used in any part of the rules (operator, name of a class, name of a property)
- Several templates can be run on the same data

Structure of a template

The text file :

- starts with ***template header***.
- Then it list of columns of tabular data
- A blank line to mark the end of the column definitions
- The standard DRL headers (*package, import, global, functions*)
- The ***template*** keyword marks the beginning of a rule template ; several templates can be defined in the same file.
- The template uses the syntax ***@{token_name}*** for substitutions (ex: @ {row.rowNumber})
- The keyword ***end template*** marks the end of the template.

Example

```
template header
age
type
Log

package org.drools.examples.templates;

global java.util.List list;

template "cheesefans"

rule "Cheese fans_@{row.rowNumber}"
when
Person(age == @{age})
Cheese(type == "@{type}")
then
list.add("@{log}");
end
end template
```

kmodule

The template must then be included with the associated data file in the *kmodule* definition

```
<?xml version="1.0" encoding="UTF-8"?>
<kmodule xmlns="http://drools.org/xsd/kmodule">
<kbase name="TemplatesKB" packages="org.drools.examples.templates">
<ruleTemplate
  dtable="org/drools/examples/templates/ExampleCheese.xls"
template="org/drools/examples/templates/Cheese.drt"
row="2" col="2"/>
<ksession name="TemplatesKS"/>
</kbase>
</kmodule>
```

Sample with a database

```
// Get results from your DB query...
resultSet = preparedStmt.executeQuery();
// Generate the DRL...
resultSetGenerator = new ResultSetGenerator();
String drl = resultSetGenerator.compile(resultSet,
         new
  FileInputStream("path/to/template.drt"));
```

Other ways to express rules

Decision tables

Rule's templates

DMN

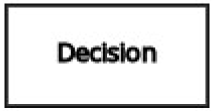
Introduction

- ***Decision Model Notation*** is a standard published by OMG (like BPMN2)
- It is supported in Drools since latest 7.x
- The primary goal is to provide a standard notation that is readily understandable by :
  - **Business Analysts** : They can define the initial decision requirements
  - ***Developers*** : They can create complex decision logic and automate the decisions;
  - ***Business Stakeholders*** : They can manage and monitor the decisions.

DMN support in Drools

- Drools engine provides runtime support for DMN 1.1, 1.2, 1.3, and 1.4 models at conformance level 3.
- ***KIE DMN Editor*** provides design support for DMN 1.2 models at conformance level 3.
- DMN models can be integrated by :
  - Design your DMN models using the KIE DMN Editor online.
  - Design your DMN models using the KIE DMN Editor in VSCode.
  - Import DMN files into your project by opening them in KIE DMN Editor.
  - Package DMN files as part of your project knowledge JAR (KJAR) file without KIE DMN Editor

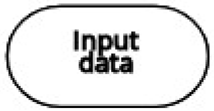
Main components



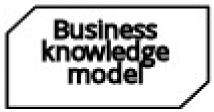
Decisions determine an output value depending on:

– their input data (input nodes or the output value from other decisions)

– their decision logic - boxed expressions that may reference functions from BKM nodes



Input data : Information used in decision nodes. When enclosed within a Business Knowledge Model (BKM), they indicate parameters for the BKM node.



BKMs encapsulate business knowledge as reusable functions.

A knowledge source denotes an authority which regulates a BKM or a decision node.

Connectors

The connectors connecting the different elements must also respect the notation

Information Requirement

Connection from an input data node or decision node to another decision node that requires the information

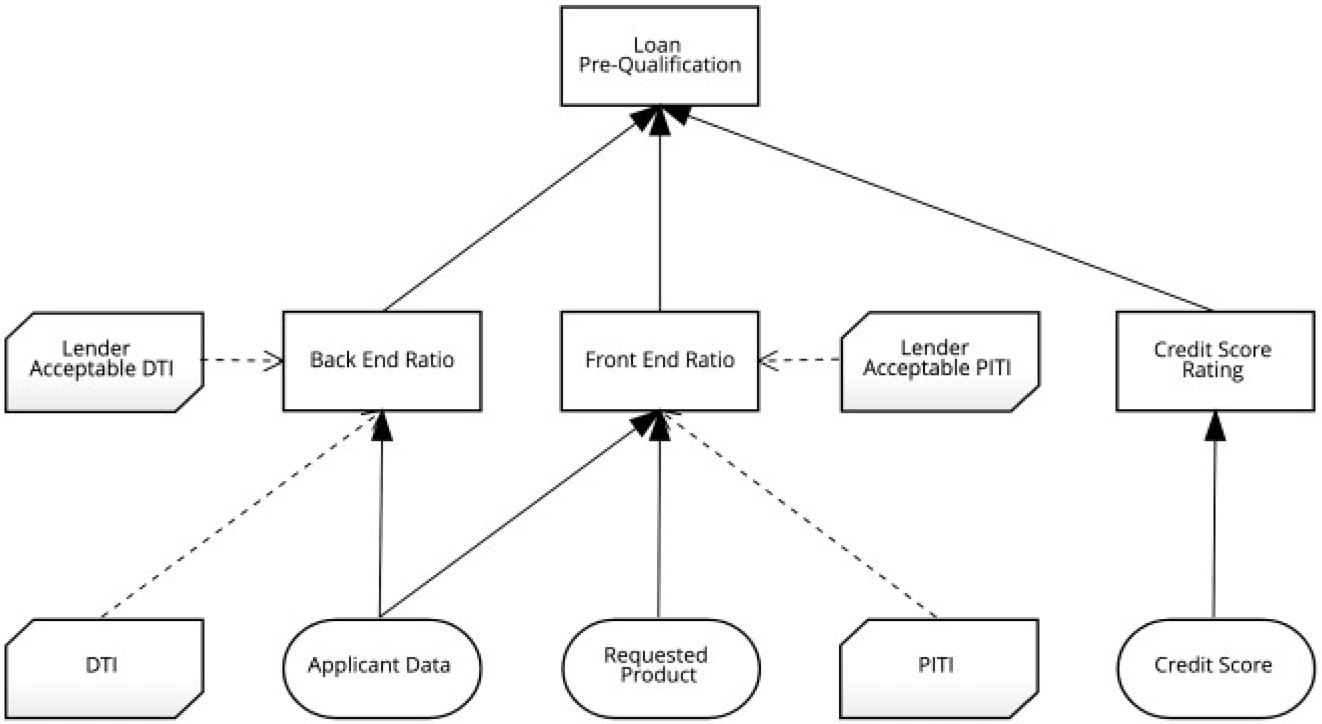
Knowledge requirement

from a business knowledge model to a decision node or to another business knowledge model that invokes the decision logic.

Authority requirement

from an input data node or a decision node to a dependent knowledge source or from a knowledge source to a decision node, business knowledge model, or another knowledge source.

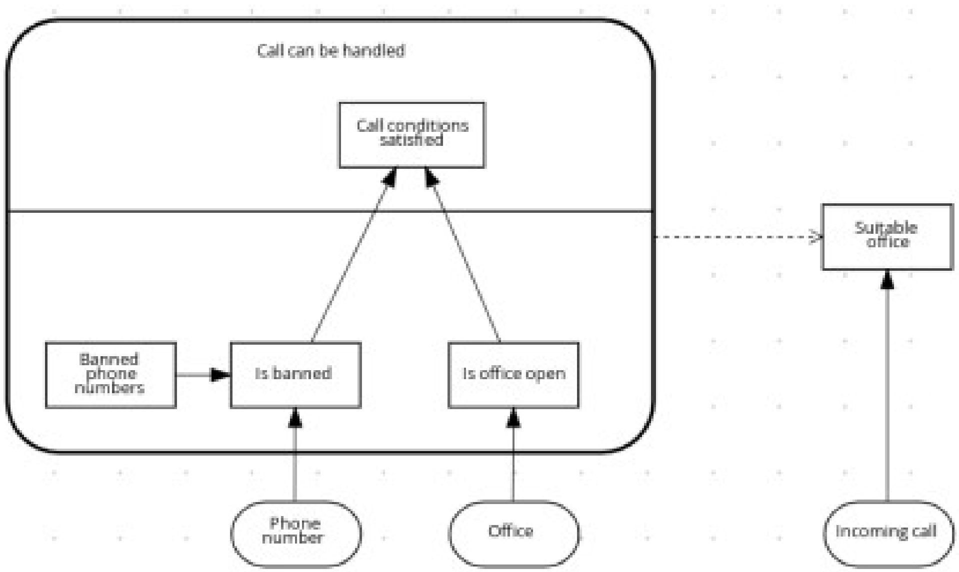
Example



Loan Pre-Qualification
Lender Acceptable DTI
Back End Ratio
Front End Ratio
Lender Acceptable PITI
Credit Score Rating
DTI
Applicant Data
Requested Product
PITI
Credit Score

Decision service

Some parts of the graph can be externalized in a ***Decision Service***



Decision node

Decision nodes may express their logic by a variety of boxed expressions

- ***FEEL*** expression that produces the output value
- ***Contexts*** represent a collection of one or more key-value pairs where the value is a decision logic, and the key is the respective identifier
- ***Decision tables***
  - Input columns
  - Output columns
  - Hit policy (unique, ...)
- ***Relations*** encapsulate lists of expressions
- ***Functions*** define reusable operations into your model. They are generally associated to BKM
- ***Invocation*** : map the invocation for business knowledge model nodes
- ***List*** represent a group of FEEL expressions.

FEEL

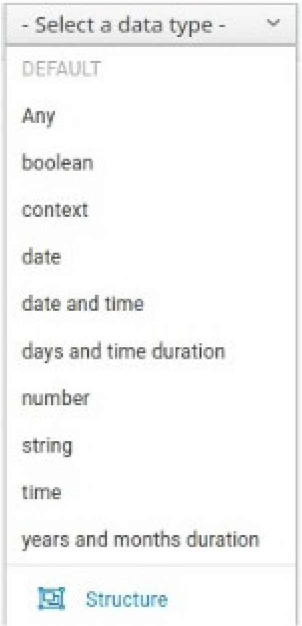
The ***FEEL (Friendly Enough Expression Language)*** is intended as a common ground between business analysts, programmers, domain experts and stakeholders.

It provides :

- Side-effect free
- Simple data model with numbers, dates, strings, lists, and contexts
- Simple syntax designed for a broad audience
- Three-valued logic (*true, false, null*)

Reference : https://kiegroup.github.io/dmn-feel-handbook/#dmn-feel-handbook

Data types



Of course complex structured data types can be defined from these basic types

Language

if expression

if 20 > 0 then "YES" else "NO"//➔ "YES"

for expression

for i in [1, 2, 3] return i * i//➔ [1, 4, 9]

some (name) in (list) satisfies (predicate)

some i in [1, 2, 3] satisfies i > 2 //➔ true

every (name) in (list) satisfies (predicate)

every i in [1, 2, 3] satisfies i > 1 //➔ false

in expression

1 in [1..10] //➔ true

Three-valued logic(and, or)

true and true //➔ true

true and false and null //➔ false

true and null and true //➔ null

true or false or null //➔ true

Built-in functions

FEEL includes a library of built-in functions which can be used in Decision nodes :

- **String** : *substring, length, upper/lower case, starts/ends with, split, string join, ...*
- **List** : *count, min, sum, median, mode, stddev, all, any, ...*
- **Numeric** : *floor/ceiling, modulo, log, exp, sqrt*
- **Range functions** : before, after, meets, overlaps, ...
- **Temporal** : *day of year, day of week, month of year, ...*

Variable and function names

FEEL supports spaces and a few special characters as part of variable and function names.

A FEEL name must start with a letter, ?, or _ element.

Valid variables names :

- Age
- Birth Date
- Flight 234 pre-check procedure

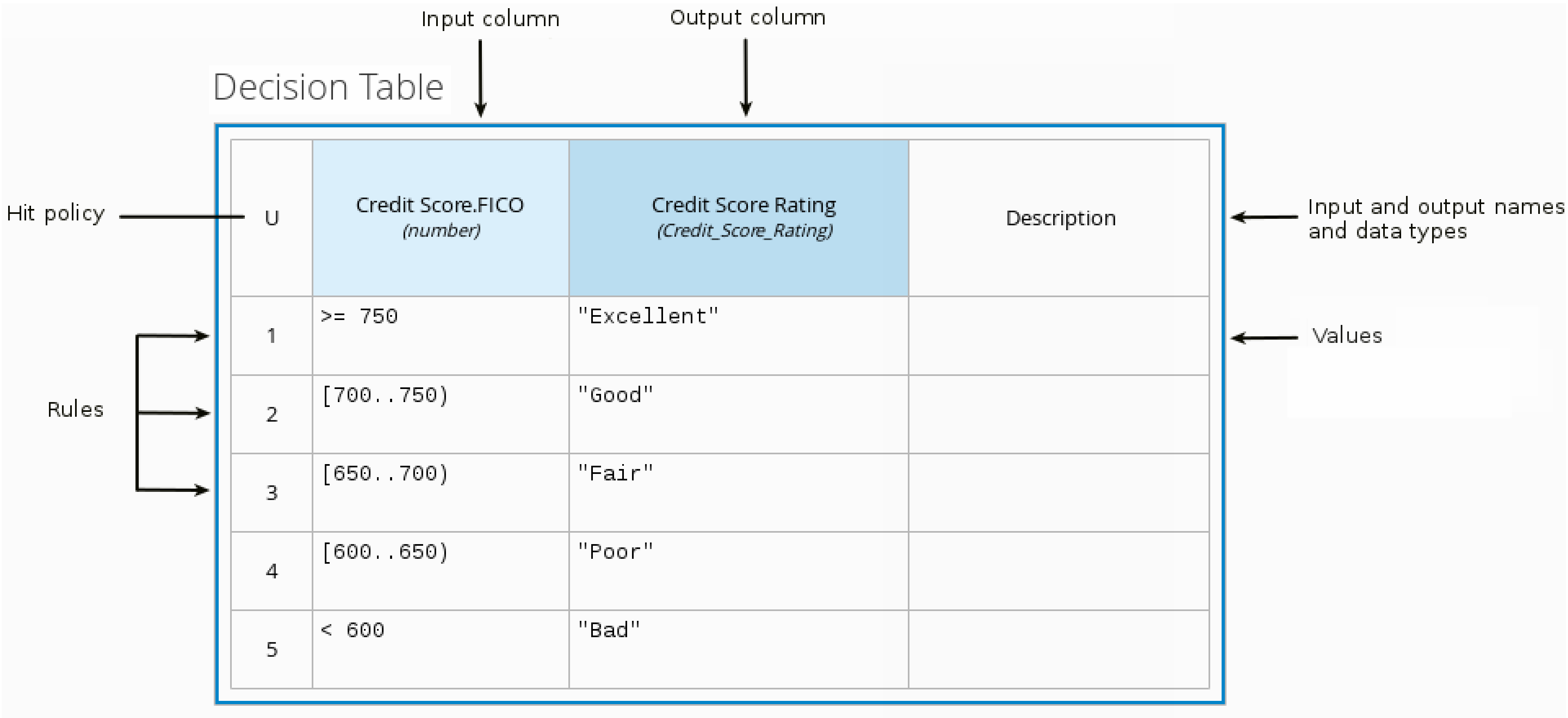
Boxed expressions

Boxed expressions in DMN are tables that you use to define the underlying logic of decision nodes in a decision requirements diagram (DRD)

Different types are available :

- Decision tables
- Literal expressions
- Contexts
- Relations
- Functions
- Invocations
- Lists

Decision Table



U	Credit Score.FICO *(number)*	Credit Score Rating *(Credit_Score_Rating)*	Description
1	>= 750	"Excellent"	
2	[700..750)	"Good"	
3	[650..700)	"Fair"	
4	[600..650)	"Poor"	
5	< 600	"Bad"	

Decision Tables

- Each rule consists of a single row in the table, and includes columns that define the conditions (input) and outcome (output) for that particular row.
- Input and output values can be FEEL expressions or defined data type values.

Hit policies

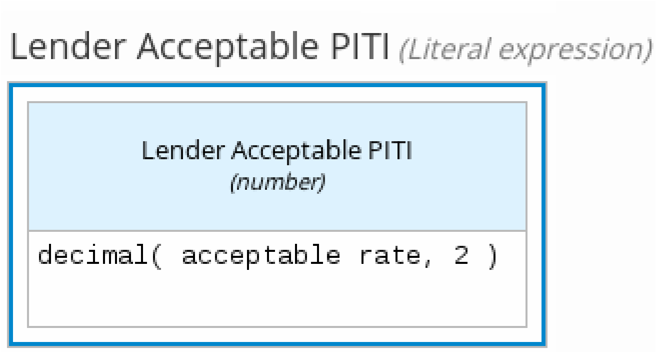
Hit policies determine what to do when several rules in the decision table match.

Possible values are :

- ***Unique (U)***: Permits only one rule to match. Any overlap raises an error.
- ***Any (A)***: Permits multiple rules to match, but they must all have the same output.
- ***Priority (P***): Permits multiple rules to match, with different outputs. The output that comes first in the output values list is selected.
- ***First (F)***: Uses the first match in rule order.
- ***Collect*** : Aggregates output from multiple rules based on an aggregation function.

Literal expressions

- Literal FEEL expression as text in a table cell



Context expression

A set of variable names and values with a result value

Prioritized Waiting List *(Context)*

#	Prioritized Waiting List *(tPassengerTable)*	
1	Cancelled Flights *(tFlightNumberList)*	`Flight List[ Status = "cancelled" ].Flight Number`
2	Waiting List *(tPassengerTable)*	`Passenger List[ list contains( Cancelled Flights, Flight Number ) ]`
	<result>	`sort( Waiting List, Passenger Priority )`

Relation expression

Traditional data table with information about given entities, listed as rows.

Used to define decision data.

Employee Information *(Relation)*

#	Name *(string)*	Dept *(string)*	Salary *(number)*
1	"John"	"Sales"	100000
2	"Mary"	"Finances"	120000

Function expressions

A parameterized expression containing a literal FEEL expression, a nested context expression of an external JAVA or PMML function, or a nested boxed expression of any type.

BKMs are defined as boxed function expressions

InstallmentCalculation *(Function)*

F	InstallmentCalculation *(number)*		
	(ProductType, Rate, Term, Amount)		
	1	MonthlyFee *(number)*	`if ProductType ="STANDARD LOAN" then 20.00 else if ProductType ="SPECIAL LOAN" then 25.00 else null`
	2	MonthlyRepayment *(number)*	`(Amount *Rate/12) / (1 - (1 + Rate/12)**-Term)`
		<result>	`MonthlyRepayment+MonthlyFee`

Invocation expression

Invokes a business knowledge model. It contains :

- the name of the business knowledge
- a list of parameter bindings
  - Name of the parameter
  - Binding expression (Value)

Rebooked Passengers *(Invocation)*

#	Rebooked Passengers *(tPassengerTable)*	
	Reassign Next Passenger	
1	Waiting List *(tPassengerTable)*	`Prioritized Waiting List`
2	Reassigned Passengers List *(tPassengerTable)*	`[]`
3	Flights *(tFlightTable)*	`Flight List`

List expression

Represents a FEEL list of items.

Used to define lists of relevant items for a particular node in a decision.

Approved credit score agencies *(List)*

1	"Acme Agency, Inc."
2	"Top Scores, Inc."
3	"Global Scoring, Inc."

DMN model execution

The model execution differs if you use embedded packaging or remote external service (Kogito)

Embeded, Get the runtime and the model

```java
// Create a KieContainer from ReleaseId
KieServices kieServices = KieServices.Factory.get();
ReleaseId releaseId = kieServices.newReleaseId( "org.acme", "my-kjar", "1.0.0" );
KieContainer kieContainer = kieServices.newKieContainer( releaseId );

// Or from the classpath
KieServices kieServices = KieServices.Factory.get();
KieContainer kieContainer = kieServices.getKieClasspathContainer();

// Obtain DMNRuntime and a reference to the DMN model to be evaluated,
// by using the model namespace and modelName
DMNRuntime dmnRuntime =
   KieRuntimeFactory.of(kieContainer.getKieBase()).get(DMNRuntime.class);
String namespace = "http://www.redhat.com/_c7328033-c355-43cd-b616-0aceef80e52a";
String modelName = "dmn-movieticket-ageclassification";
DMNModel dmnModel = dmnRuntime.getModel(namespace, modelName);
```

Execution

```
// Instantiate a new DMN Context to be the input for the model evaluation
DMNContext dmnContext = dmnRuntime.newContext();

for (Integer age : Arrays.asList(1,12,13,64,65,66)) {
// Assign input variables for the input DMN context
  dmnContext.set("Age", age);
// Evaluate all DMN decisions defined in the DMN model.
  DMNResult dmnResult = dmnRuntime.evaluateAll(dmnModel, dmnContext);
// Each evaluation may result in one or more results,
  for (DMNDecisionResult dr : dmnResult.getDecisionResults()) {
    log.info("Age: " + age + ", " + "Decision: '" + dr.getDecisionName() +
   "', " + "Result: " + dr.getResult());
  }
}
```

Related Projects

Complex Event Processing
Drools and jBPM

Introduction

Complex event processing (CEP) allow to make decisions based on temporal relationships between facts.

The main focus of CEP is to correlate small units of time-based data within an ever-changing, ever-growing data cloud in order to react to *hard-to-find* special situations

Reasonning is made on events which are facts with a time of occurrence

Features

- In general, many events need to be processed but only a small percentage are of real interest.
- Events are generally immutable (you cannot change the past!).
- Rules and queries work on event patterns
- There are strong temporal relationships between events

. Individual events are generally of little importance. The system must detect patterns of temporally related events

- The system must compose and aggregate events

Complex event

- A complex event is simply an aggregation, composition, or abstraction of other events
- Rules will be expressed via complex events using aggregation, composition or abstraction

Semantic of events

- 2 kinds of events are considered :
  - **Punctual event**
  - **Interval event**
- All events are :
  - Immuables
  - A managed life cycle : when it is too old, it is removed from the session

Declaring time-based-events

In order to create the CEP rules, we must inform the engine which types of objects must be treated as events

It is done by adding meta-data :

- ***@Role*** : *Fact* or *Event*
- ***@Timestamp*** : The attribute which gives the time of occurrence. If not present, the timestamp is the time of insertion
- ***@Duration*** : The attribute which gives the duration of the event. Optional
- ***@Expires*** : The attribute which gives the life time in the session

Example

```
@org.kie.api.definition.type.Role(Role.Type.EVENT)
@org.kie.api.definition.type.Duration("durationAttr")
@org.kie.api.definition.type.Timestamp("executionTime")
@org.kie.api.definition.type.Expires("2h30m")
public class TransactionEvent implements Serializable {
  private Date executionTime;
  private Long durationAttr;
  /* class content skipped */
}
```

Example (2)

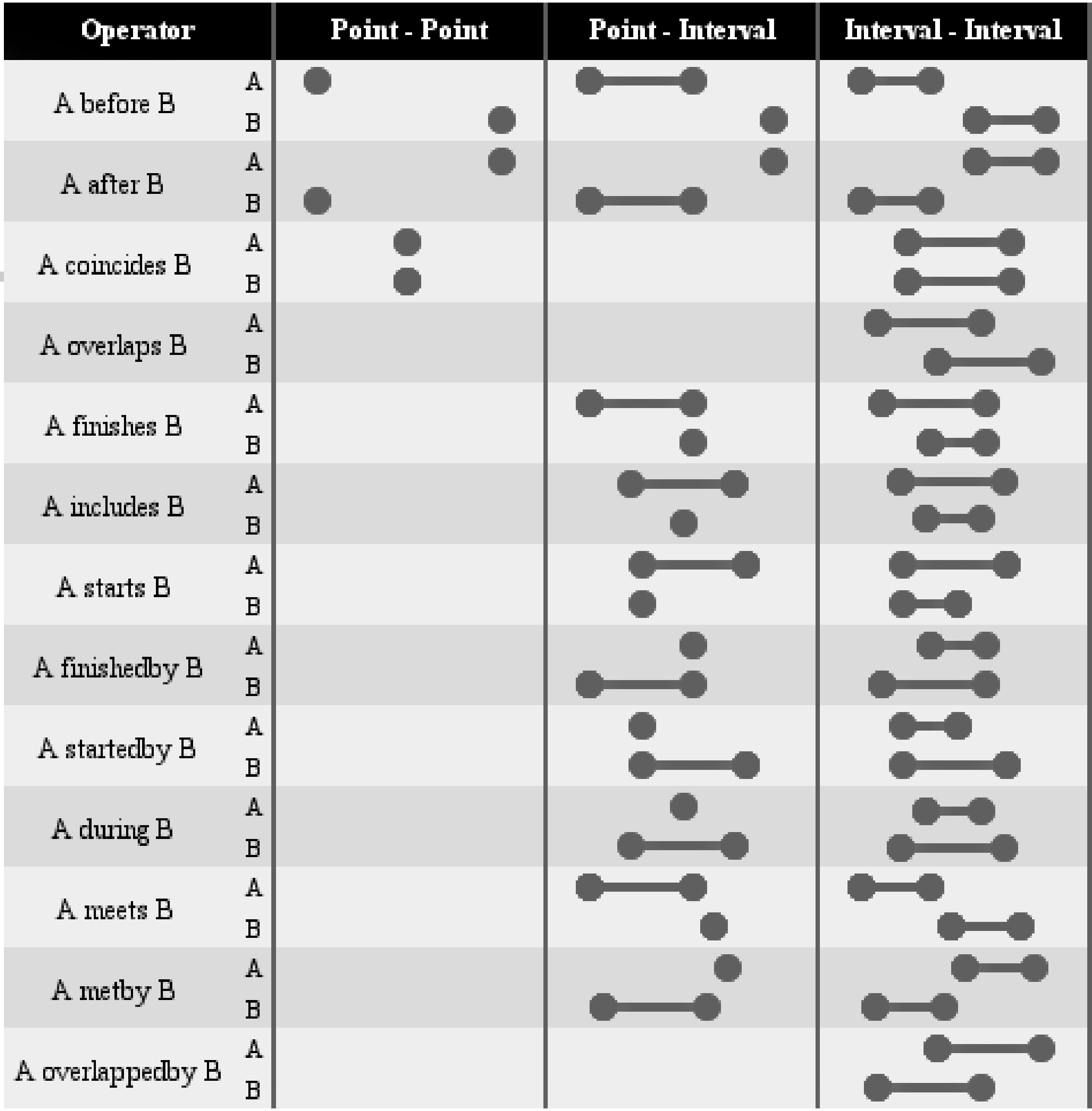
```
declare PhoneCallEvent
  @role(event)
  @timestamp(whenDidWeReceiveTheCall)
  @duration(howLongWasTheCall)
  @expires(2h30m)
  whenDidWeReceiveTheCall: Date
  howLongWasTheCall: Long
  callInfo: String
end
```

Temporal operators

There are 13 temporal operators available which allow to correlate events

For example :

```
declare MyEvent
@role(event)
@timestamp(executionTime)
End

rule "my first time operators example"
  when
    $e1: MyEvent()
    $e2: MyEvent(this after[5m] $e1)
  Then
    System.out.println("We have two events" + " 5 minutes apart");
end
```


Operator
Point - Point
Point - Interval
Interval - Interval
A before B
A after B
A coincides B
A overlaps B
A finishes B
A includes B
A starts B
A finishedby B
A startedby B
A during B
A meets B
A metby B
A overlappedby B
A
B

A sample

```
rule "More than 10 transactions in an hour from one client"
  when
    $t1: TransactionEvent($cId: customerId)
    Number(intValue >= 10) from accumulate(
      $t2: TransactionEvent(this != $t1,
      customerId == $cId, this meets[1h] $t1),
      count($t2) )
    not (SuspiciousCustomerEvent(customerId == $cId,
      reason == "Many transactions"))
  then
    insert(new SuspiciousCustomerEvent($cId,
      "Many transactions"));
end
```

Event-driven architecture

The idea of ***event-driven architecture (EDA)*** is to classify the components in the following four different categories:

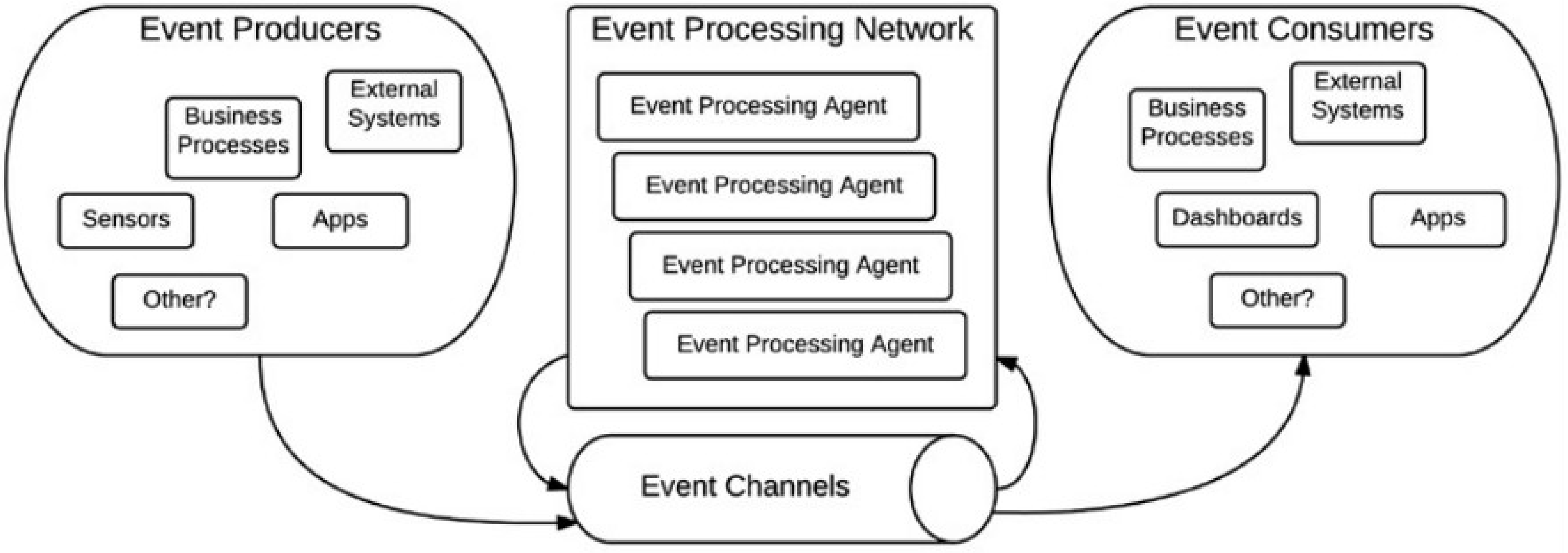
– ***Event Producer*** : Creators of events, for example a sensor

– ***Event Consumer*** : Final output architecture which point the produced value. For example a dashboard

– ***Event Channels*** : Communication protocols between all the other components. For example JMS

– ***Event Processing Agents***: Group the events to detect and process complex events. The Drools rules

Event-driven architecture



Entry points

- ***Entry points*** are a way to partition the working memory
- Rules can express conditions about events from one particular source
- Entry points are declared implicitly by using them in rules
- At insertion, the entry point can be specified :

```
ksession.getEntryPoint("myEntryPoint").insert(new Object());
```

Sample

```
// Insert event from one entry-pont to another
rule "Routing transactions from small resellers"
  when
    $t: TransactionEvent() from
      entry-point "small resellers"
  then
     entryPoints["Stream Y"].insert(t);
end
```

Sliding windows

Sliding windows allow to filter the events of the working memory or any entry point

2 kinds of sliding windows :

- ***Length-based*** : Number of elements
- ***Time-based slicing*** : Elements that happened within a specific time elapsed from now

Sliding windows can be defined

- inside a rule
- or outside for reuse

Length-based sample

```
rule "last 6 transactions are more than 100 dollars"
When
  Number(doubleValue > 100.00) from accumulate(
    TransactionEvent($amount: totalAmount)
      over window:length(6),
    sum($amount))
then
  //... TBD
end
```

Time-based sample

```
rule "obtain last five hours of operations"
when
  $n: Number() from accumulate(
   TransactionEvent($a: totalAmount)
     over window:time(5h),
   sum($a)
  )
Then
System.out.println("total = " + $n);
end
```

Declared sliding windows sample

```
declare window Beats
  @doc("last 10 seconds heart beats")
  HeartBeat() over window:time( 10s )
    from entry-point "heart beat monitor"
end

rule "beats in the window"
  when
    accumulate(HeartBeat() from window Beats,
      $cnt : count(1))
  then
   // there has been $cnt beats over the last 10s
end
```

Running CEP-scenarios

Both the Kie Base and Session that run the CEP cases need special management :

- Kie Base must be configured to support CEP
- Define the way to fire rules : discrete or continous
- The Kie Session internal clock used to evaluate temporal events must be set

KieBase

Kie Base must be configured to use the **STREAM** event processing mode.

This configuration informs the runtime that it should manage events and keep them internally ordered by their timestamp

In *kmodule.xml*

```
<kbase name="cepKbase" eventProcessingMode="stream"
packages="chapter06.cep">
<ksession name="cepKsession"/>
</kbase>
```

Discrete vs Continous

- Firing rules can be done :
  - At specific point of time. After inserting fact, we call *fireAllRules()*
  - Continously *fireUntilHalt()*
- If we have a scenario where the absence of events will trigger a rule, we have to use the continous way
- If the only thing that could trigger new rules is the insertion of new events then discrete rule firing will be enough

Session clock

- By default, Kie Sessions will use the clock of the machine on which is running
- For testing scenarios, we can use *pseudo-clock*
- For complex distributed scenarios, we can configured a *synchronized clock*

Pseudo-clock sample

Configuration :

```
<kbase name="cepKbase" eventProcessingMode="stream"
packages="chapter06.cep">
  <ksession name="cepKsession" clockType="pseudo"/>
</kbase>
```

Usage in test case :

```
SessionPseudoClock clock = ksession.
getSessionClock();
clock.advanceTime(2, TimeUnit.HOURS);
clock.advanceTime(5, TimeUnit.MINUTES);
```

Related Projects

Complex Event Processing

Drools and jBPM

Introduction

Drools and jBPM complement each other, allowing end users to describe business knowledge using different paradigms : Rules and processes

They shared :

- The same API
- The same integration patterns with a business application
- The same mechanisms for building and deploying

Accessing processes from rules

In the action side, a rule has access to *kcontext* and *kcontext.getKieRuntime()*

With this object reference, it is possible

to :

- create, abort, and signal processes
- Access the *WorkItemManager* to complete *WorkItems*

Sample

```
rule "Validate OrderLine Item's cost"
  when
    $ol: OrderLine()
  then
    Map<String, Object> params = new HashMap<String, Oject>();
    params.put("requested_amount", $ol.getItem().getCost());
    kcontext.getKieRuntime().startProcess("simple", params);
end
```

Process instances as facts

- Insertion of Process Instances as facts in the Rule Engine allow to write rules about our processes or groups of processes
- The listener ***RuleAwareProcessEventLister***, provided by jBPM, automatically insert our *ProcessInstances* and update them whenever a variable is changed
- The processes need to include Async activities

Example

```
rule "Too many orders for just our Managers"
  when
    List($managersCount:size > 0) from collect(Manager())
    List(size > ($managersCount * 3)) from
      collect(WorkflowProcessInstance(processId == "process-
order"))
  then
    //There are more than 3 Process Order Flows per manager.
    // Please hire more people :)
end
```

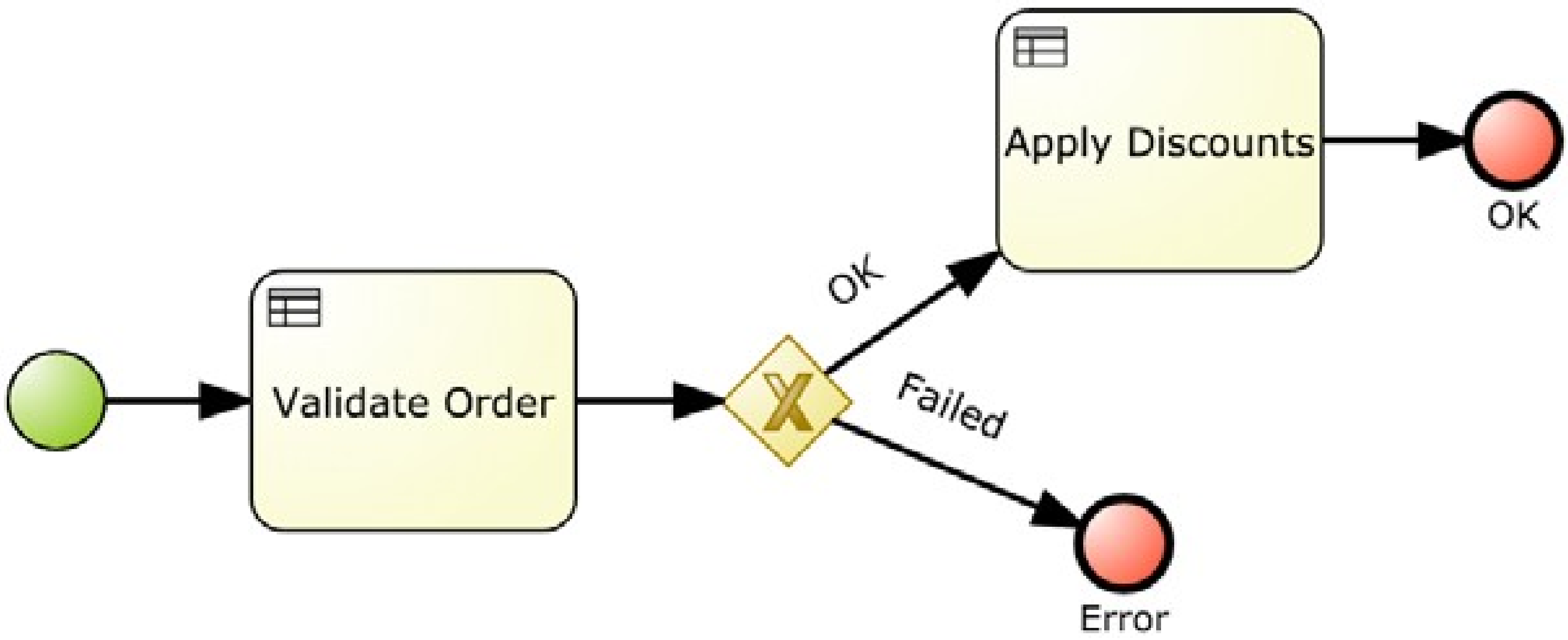
BPMN2 Business Rule Tasks

BPMN2 specification proposes a specific type of task called a ***Business Rule Task***.

It is used in conjunction with the Rule property : ***ruleflow-group*** .

This property allows to specify which rules can be fired when the Business Rule Task is executed as part of a process instance

Example



Integrate Kie

Considerations

Patterns of integration

Maven knowledge repositories

Externalizing knowledge services

Drools Usage

Drools an interact with any and all layers of our application, depending on what we expect to accomplish with it

- It could interact with the UI to provide complex form validations
- It could interact with data sources to load persisted data when a rule evaluation determines it is needed
- It could interact with outside services, to either load complex information into the rules or send messages to outside services about the outcome of the rules execution

Engine/application communiation

Some mechanisms to communicate between Drools and the rest of the application :

- **Global variables** may contain domain objects
- **Entry points** : Stream of facts and event
- **Channels** to send information to the outside world
- **Listeners**

Synchronous mode

If we need to execute our business rules in a synchronous manner

- Using stateless Kie Sessions and create as many sessions as requests
- Use global variables to store specific rule execution information

Asynchronous

- The asynchronous mode is necessary if the absence of input causes the triggering of a rule.
- It can also be used if the components interact with the engine asynchronously
- In this case :
  - Kie Sessions may be shared between different threads, because some of them may insert new information and others might take care of firing rules (fireUntilHalt)
  - Register special listeners that take care of notifying other components about special situations detected by the rules
  - Entry points become a very useful component when multiple sources will be inserting information into a single Kie Session

Integrate Kie

Considerations

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Externalizing knowledge services

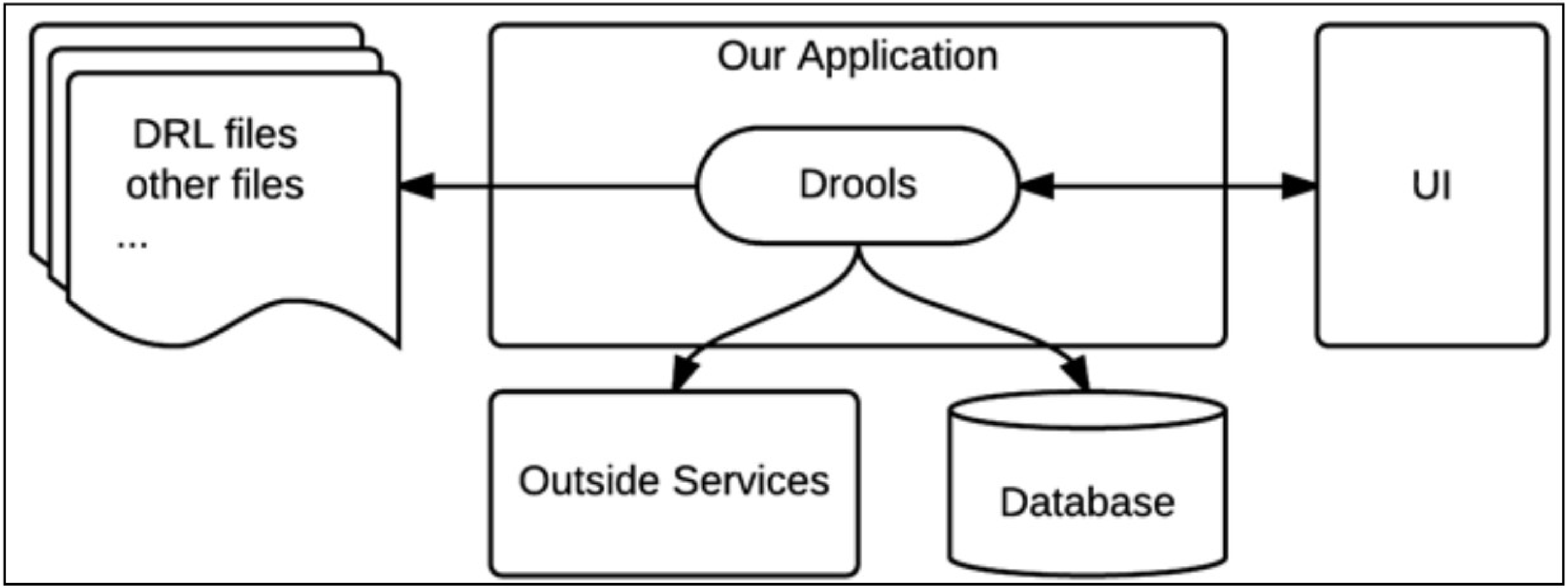
Scenariis of integration

Different ways of integration can be considered :

- Package the Drools runtime in your application
- Externalize rules in a separate Maven repository
- Knowledge as a service

For these scenariis, Drools offers supports for CDI, Spring and Camel

Architecture:
Embedded Drools and Ressources



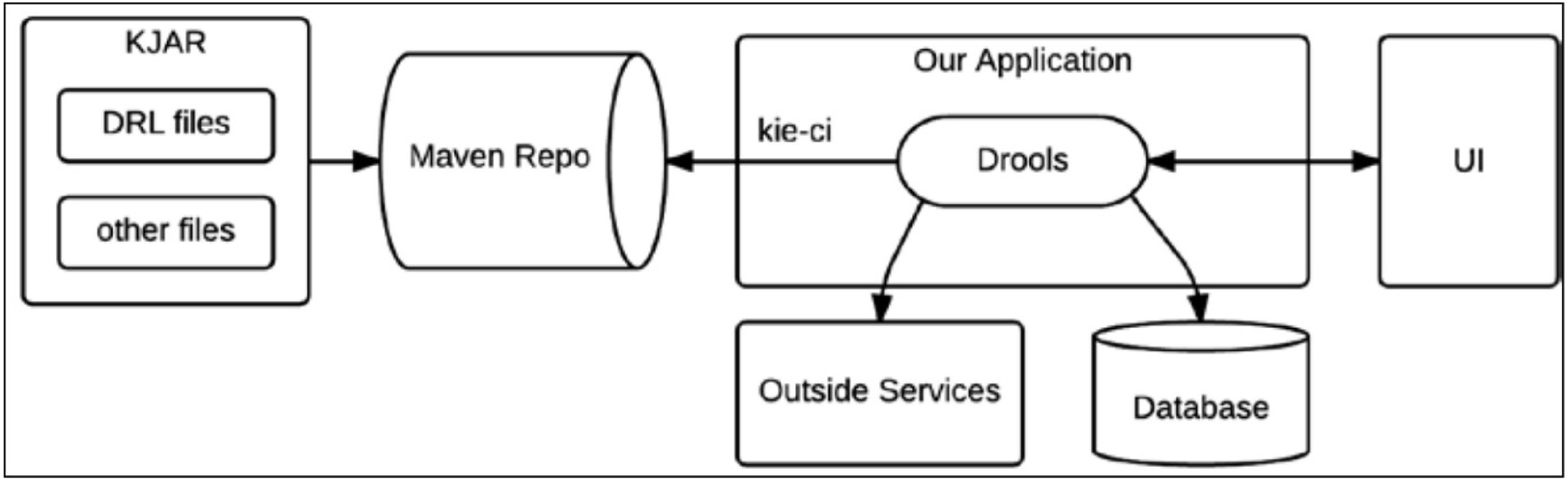
Distinct Maven Repository

Rules can be deployed independently from client application by using a external Maven repository :

- business rules are deployed in the Maven repository as a KJAR
- Components Drools runtime can dynamically load the rules

=> The rules can be updated without having to redeploy the applications.

Architecture
Maven repository



Loading the rules

With CDI

```
@Inject @KSession
@KReleaseId(groupId = "org.drools.devguide",artifactId =
  "chapter-11-kjar", version = "0.1-SNAPSHOT")
KieSession kSession;
```

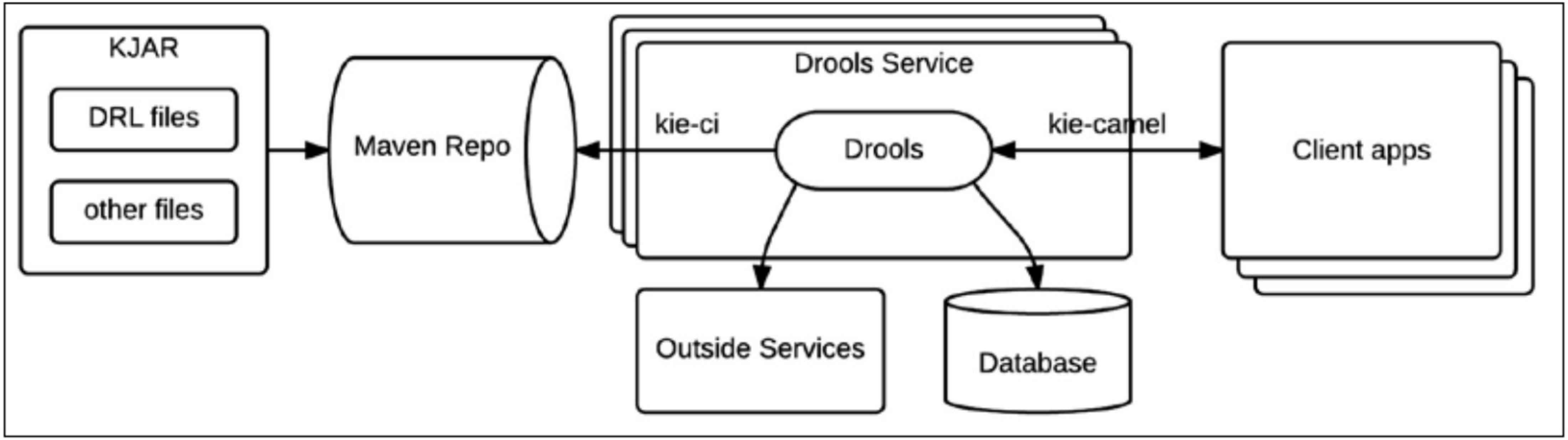
With a scanner *// Check for updates*

```
KieServices ks = KieServices.Factory.get();
KieContainer kContainer = ks.newKieContainer(
ks.newReleaseId("org.drools.devguide",
"chapter-11-kjar", "0.1-SNAPSHOT"));
KieScanner kScanner = ks.newKieScanner(kContainer);
kScanner.start(10_000);
KieSession kSession = kContainer.newKieSession();
```

Knowledge As A Service

- The last approach is to externalize the Drools runtime in an external service.
  - This service expose an API (REST or other)
  - Multiple-applications can use the service
  - The service may be replicated if needed
  - Life cycle of rules are completely independent

Architecture
KAAS



Integrate Kie

Considerations
Patterns of integration
Maven knowledge repositories
Externalizing knowledge services

Dépôt de connaissance Maven

Building a kjar

Loading the container

Introduction

Kie projects relies on Maven to deploy business rules/processes in a repository.

Applications can then:

- Either declare a Maven dependency to the artifact of containing the business resources
- Loads programmatically the knowledge artefact

Building kjar with Maven

A "Kie project" is a Maven project plus a *kmodule.xml* file configuring the various knowledge bases

The build cycle is enriched with the Kie plugin that precompiles the rules and ensures their validity

```
<packaging>kjar</packaging>
...
<build>
  <plugins>
    <plugin>
      <groupId>org.kie</groupId>
      <artifactId>kie-maven-plugin</artifactId>
      <version>${project.version}</version>
      <extensions>true</extensions>
    </plugin>
  </plugins>
</build>
```

Default configuration

- *kmodule.xml* defines knowledge bases and sessions that can be used in the project
- An empty file gives a default configuration:
  - A single knowledge base including all rules / processes / etc. found in the classpath (typically src/main/ressources folder)
  - A stateful session and a stateless session

Example *kmodule.xml*

```
<kmodule xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance " xmlns="http://jboss.org/kie/6.0.0/kmodule">
  <kbase name="KBase1" default="true" eventProcessingMode="cloud" equalsBehavior="equality">
    <ksession name="KSession2_1" type="stateful" default="true/">
    <ksession name="KSession2_1" type="stateless" default="false" beliefSystem="jtms"/>
</kbase>
<kbase name=""KBase2" default="false" eventProcessingMode="stream" equalsBehavior="equality"
 declarativeAgenda="enabled"
packages="org.domain.pkg2,org.domain.pkg3" includes="KBase1">
<ksession name="KSession2_1" type="stateful" default="false" clockType="realtime">
  <fileLogger file="drools.log" threaded="true" interval="10"/>
  <workItemHandlers>
    <workItemHandler name="name" type="org.domain.WorkItemHandler"/>
  </workItemHandlers>
  <listeners>
    <ruleRuntimeEventListener type="org.domain.RuleRuntimeListener"/>
    <agendaEventListener type="org.domain.FirstAgendaListener"/>
    <agendaEventListener type="org.domain.SecondAgendaListener"/>
    <processEventListener type="org.domain.ProcessListener"/>
  </listeners>
</ksession>
</kbase>
</kmodule>
```

Attributes of kbase

nom	default	values	description
name	none		Mandatory. Used to retreive the base from the container
includes	none	Item list separated with comma	Knowledge bases to include
packages	all	Item list separated with comma	List the resources to compile
default	false	true/false	You do not have to specify the name for the default knowledge base
equalsBehaviour	identity	identity/equality	Test of presence of a fact in the knowledge base
eventProcessingMode	cloud	cloud/stream	Stream for drools-fusion
declarativeAgenda	disabled	disabled/enabled	Declarative agenda activated or not. experimental, the rules can act directly on the activations present in the agenda

Attributes of ksession

nom	default	values	description
name	none	String	Mandatory. Name used to retrieve a container session
type	stateful	stateless/ stateful	
default	false	true/false	It is not necessary to specify the name for the default session
clockType	realtime	realtime/ pseudo	Indicates whether the timestamp of events is provided by the system or by the application
beliefSystem	simple	simple/jtms/ defeasible	System of fact management

Elements of ksession

A ***<ksession> element*** can also define different sub-elements:

- A logger is used to define a trace file that will record all Drools events in a file
- *WorkItemHandlers* allows you to define task managers that are associated with specific jBPM nodes (ex: Human task)
- Event listeners: *ruleRuntimeEventListener*, *agendaEventListener*, or *processEventListener*

Dépôt de connaissance Maven

Building a kjar

Loading the container

Maven and Release ID

It is possible to use the Maven coordinates to instantiate the container

```
KieServices kieServices = KieServices.Factory.get();
ReleaseId releaseId = kieServices.newReleaseId( "org.acme", "project", "1.0" );
KieContainer kieContainer = kieServices.newKieContainer( releaseId ) ;
KieSession kSession = kContainer.newKieSession("ksession1");
```

Deployment

Deployment consist of updating a Maven repository.
mvn deploy

The client application can then :

- Be manually updated to use a new version of the kjar
- Or automatically reloads a specific version :
  - A snapshot
  - The latest version of a family (2.x)

KieScanner

KieScanner allows to periodically scan the Maven repository to check if a new release of the project is available

In this case, the new release is deployed in the *KieContainer* and the new rules are taken into account

The use of KieScanner requires the presence of ***kie-ci.jar*** in the classpath

Scanner registration

```
KieServices kieServices = KieServices.Factory.get();

ReleaseId releaseId = kieServices.newReleaseId( "org.acme",
   "myartifact", "1.0-SNAPSHOT" );

KieContainer kContainer =
   kieServices.newKieContainer( releaseId );

KieScanner kScanner =
   kieServices.newKieScanner( kContainer );

// Start KieScanner

// which scans the repository every 10 seconds

kScanner.start( 10000L );
```

Upgrade

- Automatic update is effective if:
  - the version of the artifact is suffixed with SNAPSHOT, LATEST RELEASE, or a version interval
  - KieScanner finds an update in the Maven repository
- The update consists of downloading the new version and performing an incremental build.
- *KieBases* and *KieSessions* controlled by KieContainer are automatically updated and all new KieBases or KieSessions use the new version of the Knowledge Base.

Integrate Kie

Considerations
Patterns of integration
Maven knowledge repositories
Externalizing knowledge services

Removed in Drools 8.x

Introduction

- KIE provides ***KieServer*** , which can be used to configure similar environments that are only responsible for running Drools rules and processes, taking the kJAR from outside sources (Maven Repo)
- It also provides ***KieWorkbench*** which offers a UI to manage rules and processes : edit, build deploy

NB : In release 7.x, these artefacts are typically deployed in a Wildfly server. KieServer becomes Kogito (based on Quarkus) in release 8.x

Kogito

In Drools 8, Business Knowledge can be deployed as Kogito services.

Application interact with this deployed services with RestFul API

Kogito is cloud-native and typically deployed in OpenShift or Kubernetes

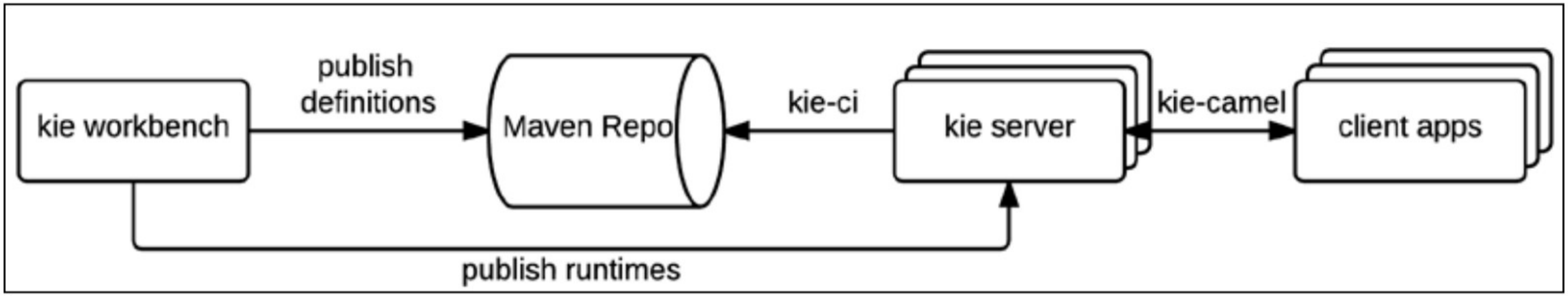
It has integration with moder frameworks like Quarkus and SpringBoot

Externalizing Knowledge services

Kie Server

Kie workbenches

Architecture



Kie Server

- It is a modular, standalone server component that can be used to execute rules and processes, configured as a WAR file
- It is available for web containers and JEE6 and JEE7 application containers
- It can be easily deployed in cloud environments
- Each instance of the Kie Server can manage many Kie Containers
- Its functionality can be extended through Kie Server Extensions

Configuration

The distributions of Kie Server : archive zip or Docker image use a jBoss wildfly server in the full configuration.

Once a user with the role ***kie-server*** configured

The REST API is available at :

http://localhost:8080/kie-server/services/rest/server/

- The API can use XML or JSON formats
- An OpenAPI documentation is available

http://localhost:8080/kie-server/docs/

Sample Response


```
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<response type="SUCCESS" msg="Kie Server info">
    <kie-server-info>
        <capabilities>KieServer</capabilities>
        <capabilities>BRM</capabilities>
        <capabilities>BPM</capabilities>
        <capabilities>CaseMgmt</capabilities>
        <capabilities>BPM-UI</capabilities>
        <capabilities>BRP</capabilities>
        <capabilities>DMN</capabilities>
        <capabilities>Swagger</capabilities>
        <location>http://localhost:8230/kie-server/services/rest/server</location>
        ...
    </kie-server-info>
</response>
```

Native REST client for Execution Server

Interactions with the *kie-server* can be performed by any REST client (curl, postman, Spring restTemplate, ...)

But KIE offers a native rest client suited for this kind of interaction.

Maven dependency :
`org.kie:kie-server-client`

Concepts of the interactions

- Interacting with the KieServer consist of sending a request containing a batch of commands.
- For example :
  - 2 insert commands
  - And a FireAllRulesCommands
- The request also specifies outidentifier, to control the content of the response
- These concepts apply to all the projetcs of Kie (Drools, jBPM, OptaPlanner, ...)

Sample JSON

```
{
  "lookup": "ksession1", // The name of the session
  "commands": [ {
    "insert": {                 // One insert command
     "object": {
      "org.drools.compiler.test.Person": {
        "name": "john",
        "age": 25
      }
     }
    }
  },
  {
    "fire-all-rules": {  // One fireAllRules command
      "max": 10,
      "out-identifier": "firedActivations" // Number of rules fired in the response
    }
  }
  ]
}
```

Sample Java

```
InsertObjectCommand insertCommand = new
InsertObjectCommand(new Person("john", 25));

FireAllRulesCommand fireCommand = new FireAllRulesCommand();

BatchExecutionCommand batch = new
   BatchExecutionCommandImpl(Arrays.asList(insertCommand,
   fireCommand), "ksession1");
```

Response


```
{
  "response": [
    {
      "type": "SUCCESS",
      "msg": "Container command-script-container successfully called.",
      "result": {
        "execution-results": {
          "results": [
            {
            "value": 0,
            "key": "firedActivations"
            }
          ],
         "facts": []
        }
      }
    }
  ]
}
```

KieServer Commands

GetServerInfoCommand : Capabilities of the server

GetServerStateCommand : Status

CreateContainerCommand : Create a container with an Id and a ReleaseId

GetContainerInfoCommand : Details about one container

ListContainersCommand : List of deployed containers

CallContainerCommand : Call a batch of commands

DisposeContainerCommand : Stop the container

GetScannerInfoCommand : Get info about a scanner of a container

UpdateScannerCommand : Update scanner attributes related to a container

UpdateReleaseIdCommand : Update the release ID of a container

Drools Commandnd

- ***BatchExecutionCommand*** : Group several commands together
- ***InsertObjectCommand*** : Insert a fact in a session
- ***RetractCommand*** : Retract a fact from the session
- ***ModifyCommand*** : Update a fact and inform the engine
- ***GetObjectCommand*** : Get an object from its FactHandle
- ***GetObjectsCommand*** : Get objects from the session with an ObjectFilter
- ***InsertElementsCommand*** : Insert a list of objects
- ***FireAllRulesCommand*** : Trigger the rules
- ***QueryCommand*** : Execute a query
- ***SetGlobalCommand*** : Set a global
- ***GetGlobalCommand*** : Get a global

Java Client requests configuration

Configuration of the client includes :

- Credentials of the kie-server user
- KIE Server location, such as *http://localhost:8080/kie-server/services/rest/server*
- Marshalling format for API requests and responses (JSON, JAXB, or XSTREAM)
- A *KieServicesConfiguration* object and a *KieServicesClient* object, which serve as the entry point for starting the server communication using the Java client API
- A *KieServicesFactory* object defining REST protocol and user access
- Any other client services used, such as *RuleServicesClient, ProcessServicesClient*, or *QueryServicesClient*

Types of client

There are different types of client each is specialized in an aspect of KIE :

- ***RuleServicesClient*** : Used to insert/rectract facts and fire rules
- ***ProcessServicesClient*** : Used to start, signal, and abort processes or work items
- ***QueryServicesClient***: Used to query processes, process nodes, and process variables
- ***UserTaskServicesClient*** : Used to perform all user-task operations, such as starting, claiming, or canceling a task
- ...

Example (1)

```
public static void main(String[] args) {
        initializeKieServerClient();
        initializeDroolsServiceClients();
    }
```

Example (2)

```
public static void initializeKieServerClient() {
        conf = KieServicesFactory.newRestConfiguration(URL, USER,
   PASSWORD);
        conf.setMarshallingFormat(FORMAT);
        kieServicesClient =
   KieServicesFactory.newKieServicesClient(conf);
    }


    public static void initializeDroolsServiceClients() {
        ruleClient =
   kieServicesClient.getServicesClient(RuleServicesClient.class);
        dmnClient =
   kieServicesClient.getServicesClient(DMNServicesClient.class);
    }
```

Sample
Use of RuleService

```
public void executeCommands() {

  String containerId = "hello";
  System.out.println("== Sending commands to the server ==");
  RuleServicesClient rulesClient = kieServicesClient.getServicesClient(RuleServicesClient.class);
  KieCommands commandsFactory = KieServices.Factory.get().getCommands();

  Command<?> insert = commandsFactory.newInsert("Some String OBJ");
  Command<?> fireAllRules = commandsFactory.newFireAllRules();
  Command<?> batchCommand = commandsFactory.newBatchExecution(Arrays.asList(insert, fireAllRules));

  ServiceResponse<String> executeResponse = rulesClient.executeCommands(containerId, batchCommand);

  if(executeResponse.getType() == ResponseType.SUCCESS) {
    System.out.println("Commands executed with success! Response: ");
    System.out.println(executeResponse.getResult());
  } else {
    System.out.println("Error executing rules. Message: ");
    System.out.println(executeResponse.getMsg());
  }
}
```

Externalizing Knowledge services

Kie Server

Kie workbenches

Workbenches

Kie projects provide a set of usable workbench tools that allow to create, build, and deploy rule and process definitions in any Kie Server

These workbenches are build with the framework UberFire .

They are web application deployed in a application server (Jboss wildfly)

Installation

Download the distribution which is a war kie-wb-*.war

Deploy it in the application server

- Drools 7 is only available for Wildfly 14

Workbench is available at :

http://<server>:<port>/

Roles and users

A WB use the following roles:

- ***admin*** : Administrator, manages users, repositories,, ...
- ***developer*** : Manage assets (rules, models, processes, forms. Create build and deploy projects
- ***analyst*** : Idem developer with restricted right (no deployment for example)
- ***user*** : Participate in business processes and perform tasks
- ***manager*** : Access to reporting

Getting started

Typical actions to start:

1. Create a user with the admin rôle
2. Add a repository
3. Add a project
4. Provide the business model
5. Create the rules
6. Build and deploy in a KieServer

These actions can be done through the web interface, an online command tool (kie-config-cli.sh) or via a REST interface

Packages

- Package configuration is usually done only once by someone with expertise with rules and templates
- All assets belong to a single package that acts as a namespace
- A package is created by specifying its name

Formats of rules

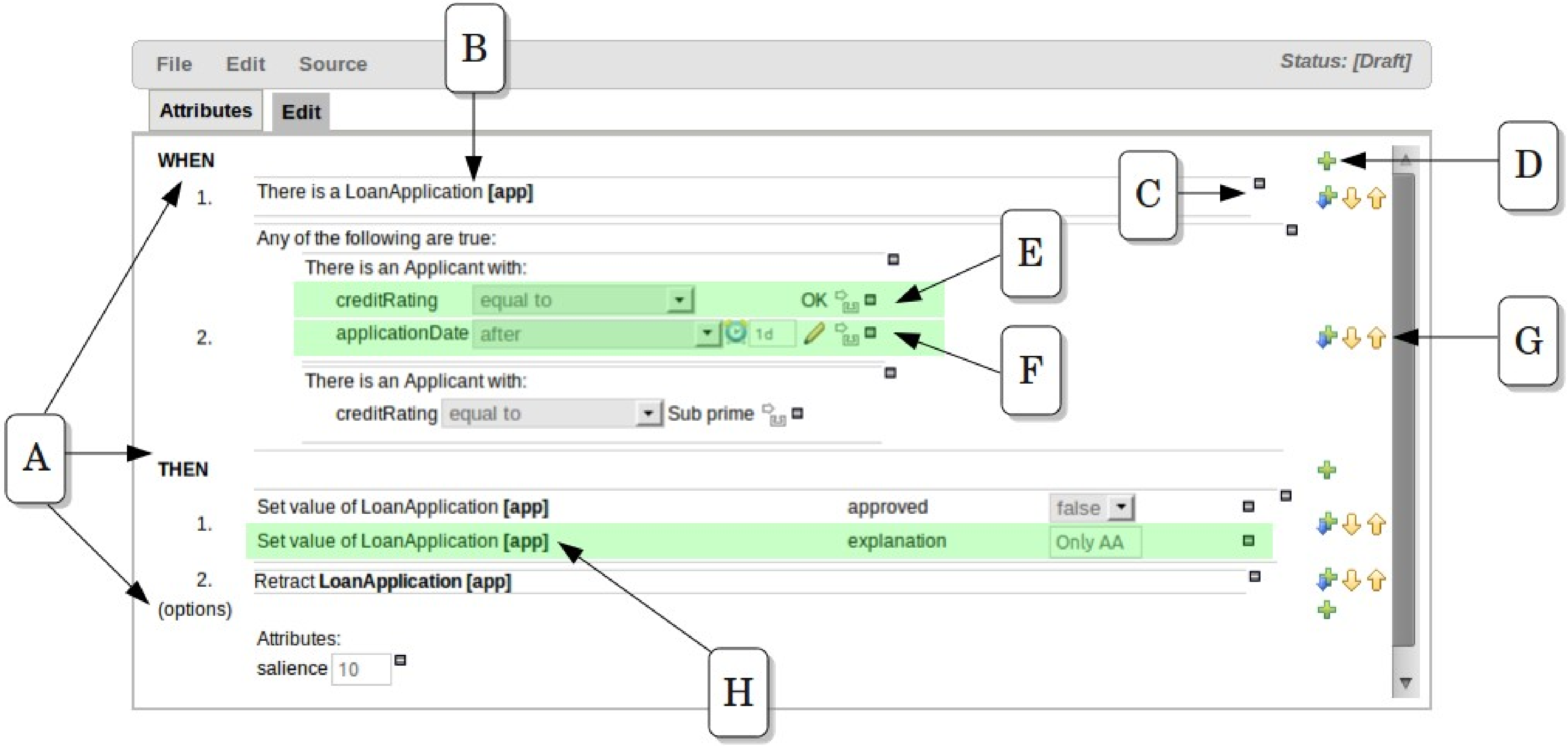
The workbench supports multiple rule formats and editors:

- BRL Format with BRL Editor (also present in Eclipse)
- DSL
- Decision tables in file to upload
- Decision tables edited directly in the web interface
- Rule Flow process to upload
- DRL
- functions
- Configuring lists of values (Enum)
- Rules template powered by data tables
- DMN

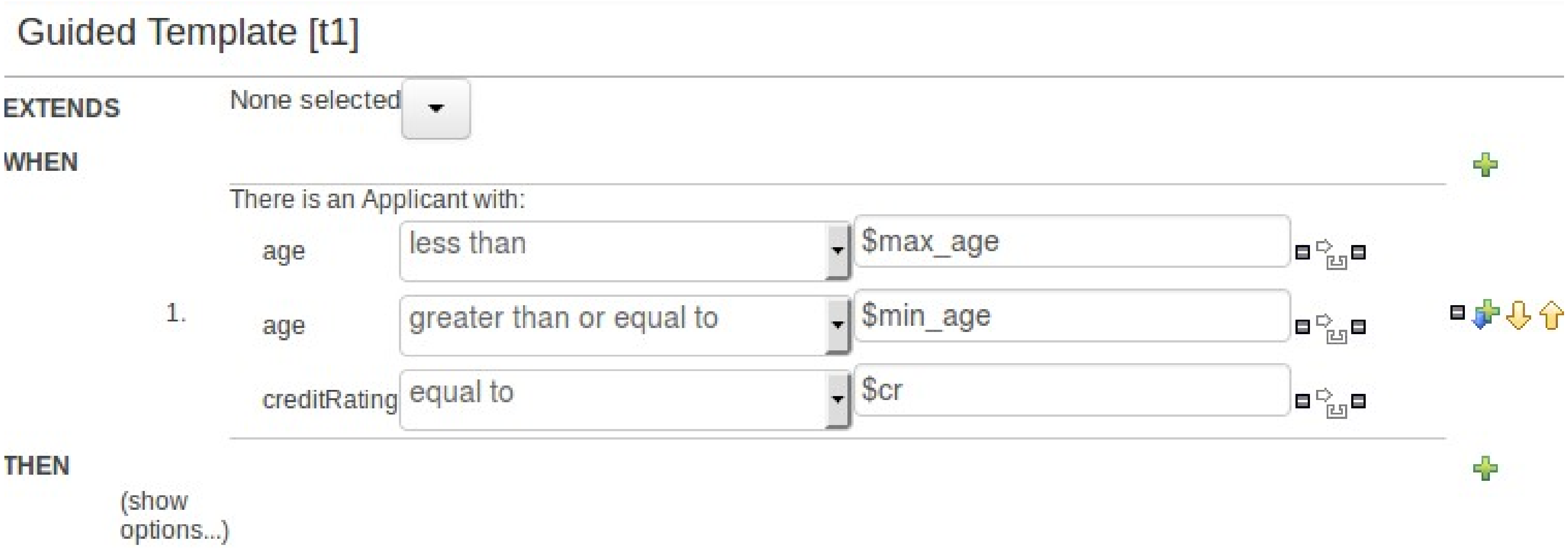
  New Rule → name, category and format

- => A wizard starts
  It is always possible to consult the source in drl

Guided Business Rules Editor



Guided Template Editor



Template data

Guided Template [t1]

Add row...

$max_age	$min_age	$cr
25	20	AA
		OK
		Sub prime
35	25	AA
		OK
		Sub prime
45	35	AA
		OK
		Sub prime

Decision Table Editor

Drools-WB offers an editor for decision tables.

The editor proposes facts and fields available in the context of the project

2 types of tables can be created:

- Extended Entries: Column definitions do not specify a value. The values are then indicated in the body of the table. However, they can be restricted by an interval.
- Limited Entries: The column definitions specify a value. The body of the table contains checkboxes

Extended table

Decision table					
	#	Description	Age	Make	Premium
			Applicant [$a]	Vehicle [$v]	
			age [<]	make [==]	
	1		35	BMW	1000
	2		35	Audi	1000

Limited table

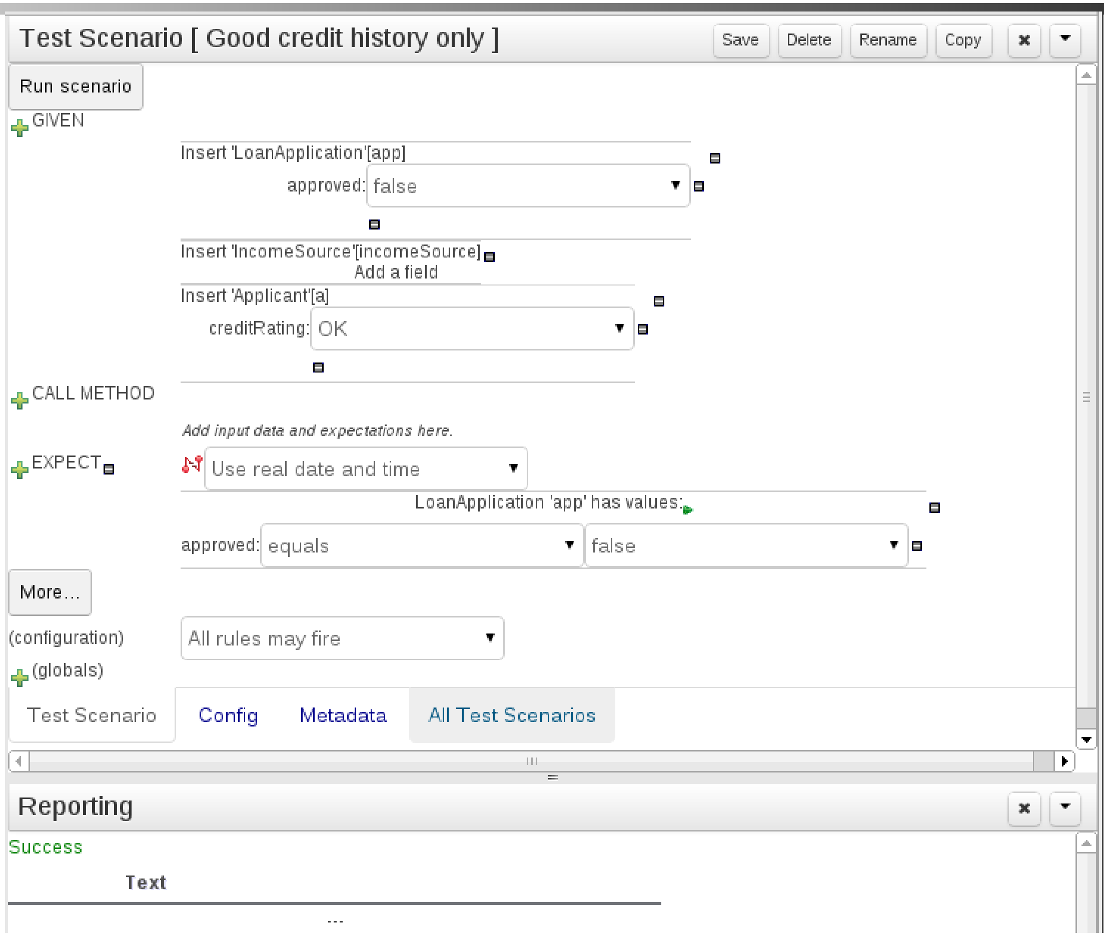
Decision table

#	Description	Age < 35	BMW	Audi	Premium 1000
		Applicant [$a]	Vehicle [$v]		
		age [<35]	make [==BMW]	make [==Audi]	
1		☑	☑	☑	☐
2		☐	☑	☑	☐
3		☑	☐	☑	☐
4		☐	☐	☑	☐
5		☑	☑	☐	☐
6		☐	☑	☐	☐
7		☑	☐	☐	☐
8		☐	☐	☐	☐

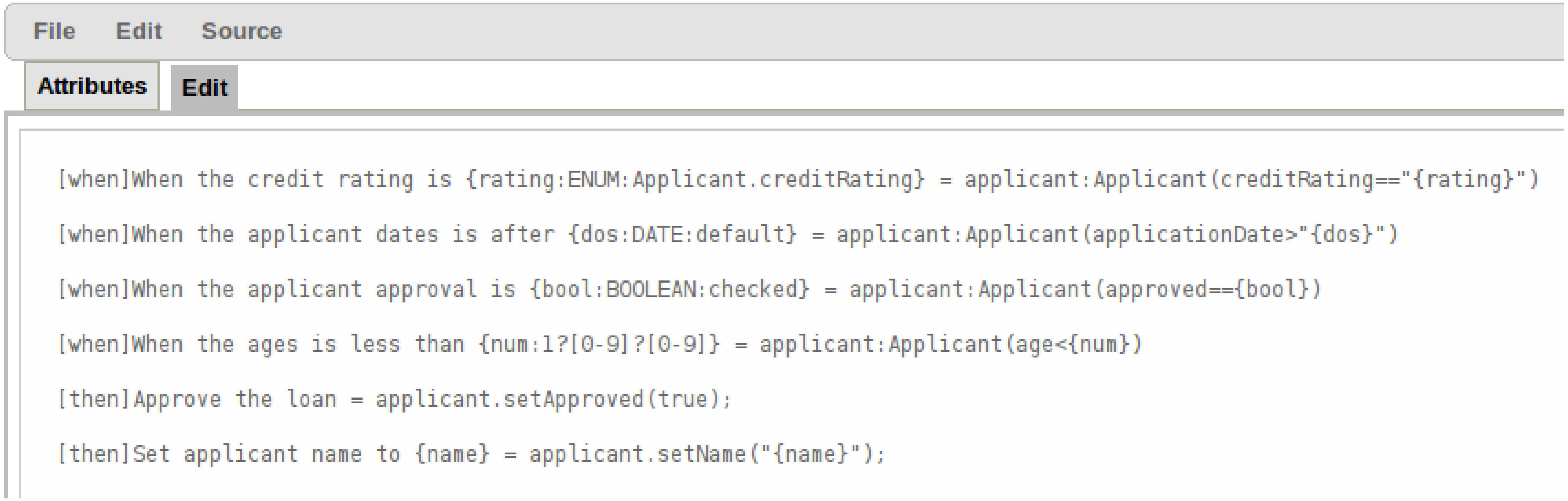
Test scenario

- The test scenarios validate the operation of the rules and avoid regression bugs.
- A test case defines several sections:
  - Given list the test facts
  - Expected lists the expected changes and actions

Test scenario

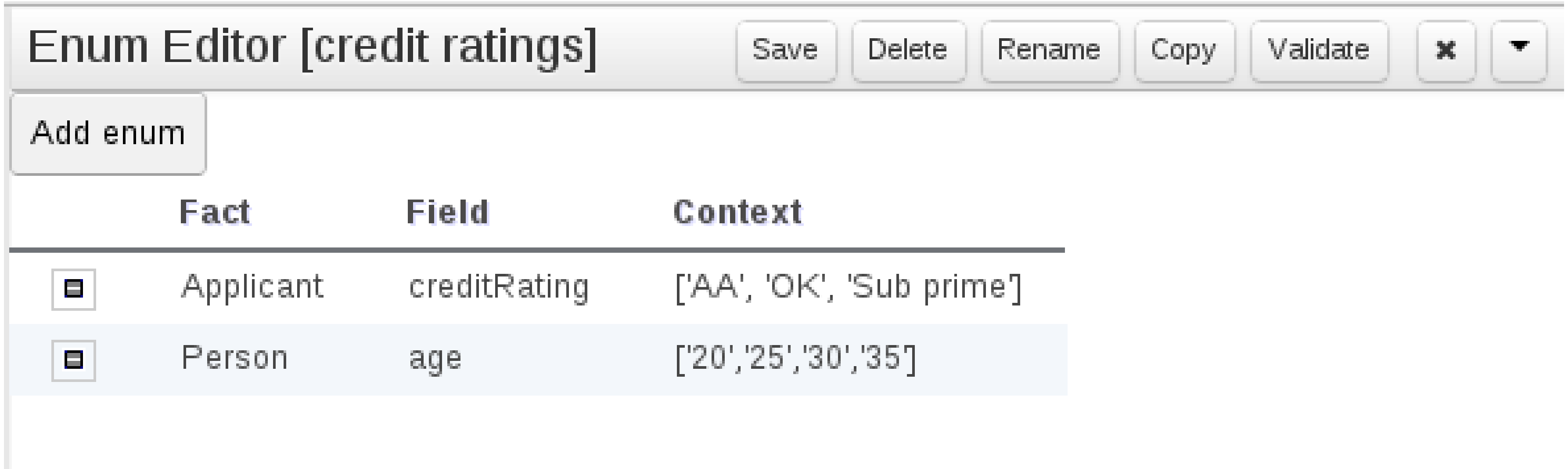


DSL editor



File
Edit
Source
Attributes
Edit
[when]When the credit rating is {rating:ENUM:Applicant.creditRating} = applicant:Applicant(creditRating=="{rating}")
[when]When the applicant dates is after {dos:DATE:default} = applicant:Applicant(applicationDate>"{dos}")
[when]When the applicant approval is {bool:BOOLEAN:checked} = applicant:Applicant(approved=={bool})
[when]When the ages is less than {num:1?[0-9]?[0-9]} = applicant:Applicant(age<{num})
[then]Approve the loan = applicant.setApproved(true);
[then]Set applicant name to {name} = applicant.setName("{name}");

List of values



Access to the Workbench database

```
public class MainKieTest {

    public static void main(String[] args) {

        // works even without -SNAPSHOT versions
        String url = "http://localhost:8080/kie-drools/maven2/de/test/Test/1.2.3/Test-1.2.3.jar";

        // make sure you use "LATEST" here!
        ReleaseIdImpl releaseId = new ReleaseIdImpl("de.test", "Test", "LATEST");

        KieServices ks = KieServices.Factory.get();

        ks.getResources().newUrlResource(url);

        KieContainer kieContainer = ks.newKieContainer(releaseId);

        // check every 5 seconds if there is a new version at the URL
        KieScanner kieScanner = ks.newKieScanner(kieContainer);
        kieScanner.start(5000L);
        // alternatively:
        // kieScanner.scanNow();

        Scanner scanner = new Scanner(System.in);
        while (true) {
            runRule(kieContainer);
            System.out.println("Press enter in order to run the test again....");
            scanner.nextLine();
        }
    }

    private static void runRule(KieContainer kieKontainer) {
        StatelessKieSession kSession = kieKontainer.newStatelessKieSession("testSession");
        kSession.setGlobal("out", System.out);
        kSession.execute("testRuleAgain");
    }
}
```

Thank U!!!

THANK YOU FOR YOUR ATTENTION

Annexes

Construction programmatique d'un *kModule*
DSL
Marshaller et persistance de session
Intégration Spring
Performance

Construction programmatique d'un kModule

Alternative programmatique

- Il est possible de définir les bases de connaissance et les sessions programmatiquement (comme avec Drools 5)
- Il est alors nécessaire de créer un ***KieFileSystem*** et d'y ajouter les ressources

API

KieFileSystem est un système de fichiers mémoire utilisé pour définir programmatiquement les ressources d'un KieModule

KieBuilder est un compilateur pour les ressources contenus dans un *KieModule*

KieRepository : Singleton représentant un dépôt Maven permettant d'accéder aux kieModules via leurs coordonnées

Mise en place

1) Obtenir un *KieFileSystem* à partir du singleton *KieServices*
2) Optionnellement, écrire dans le *KieFileSystem* le *kmodule.xml*
3) Optionnellement, écrire dans le *KieFileSystem* le *pom.xml* (définissant les coordonnées Maven du module)
4) Ajouter une à une les ressources (.drl, .bpmn, ...)
5) Faire appel au builder pour compiler les ressources et vérifier les erreurs
6) Obtenir un container à partir du *KieFileSystem*

Création d’un kModule

```
KieServices kieServices = KieServices.Factory.get();
KieModuleModel kieModuleModel =
  kieServices.newKieModuleModel();
KieBaseModel kieBaseModel1 =
  kieModuleModel.newKieBaseModel( "KBase1 ")
.setDefault( true )
.setEqualsBehavior( EqualityBehaviorOption.EQUALITY )
.setEventProcessingMode( EventProcessingOption.STREAM );
KieSessionModel ksessionModel1 =
  kieBaseModel1.newKieSessionModel( "KSession1" )
.setDefault( true )
.setType( KieSessionModel.KieSessionType.STATEFUL )
.setClockType( ClockTypeOption.get("realtime") );
KieFileSystem kfs = kieServices.newKieFileSystem();
kfs.writeKModuleXML(kieModuleModel.toXML());
```

Ajout des ressources

Les ressources peuvent être ajoutées :

- En indiquant leur chemin
- En utilisant la classe *Ressource* de Drools

```
KieFileSystem kfs = ...
kfs.write(
  "src/main/resources/KBase1/ruleSet1.drl",
  stringContainingAValidDRL )
   .write( "src/main/resources/dtable.xls",
kieServices.getResources().newInputStreamResource(
  dtableFileStream ) );
```

Construction

- La construction du *kieModule* consiste à fournir le *KieFileSystem* à un ***KieBuilder***.
- Si la compilation s'effectue correctement un kModule est stocké dans le *KieRepository* avec ses identifiants Maven :
  - Ceux du *pom.xml*
  - Ou identifiant par défaut si pas de *pom.xml*

Exemple

```
KieServices kieServices = KieServices.Factory.get();
KieFileSystem kfs = ...
kieServices.newKieBuilder( kfs ).buildAll();
ssertEquals( 0,
  kieBuilder.getResults().getMessages( Message.Level.E
  RROR ).size() );
KieContainer kieContainer =
  kieServices.newKieContainer(kieServices.getRepositor
  y().getDefaultReleasId()) ;
```

Internal *KieHelper*

```
KieHelper kieHelper = new KieHelper();
kieHelper.addResource(ResourceFactory.newClassPathReso
  urce("some/file.drl"), ResourceType.DRL);
//add more resources if needed
Results results = kieHelper.verify();
if (results.hasMessages(Message.Level.WARNING,
  Message.Level.ERROR)){
    //fail
}
KieBase kieBase = kieHelper.build()
```

DSL

Introduction

Les ***Domain Specific Languages*** (DSL) permettent d'étendre le langage de règles en l'adaptant au langage métier.

C'est une couche d'abstraction dédiée aux experts métier non technique qui est traduite dans le langage de règle au moment de la compilation

Ils peuvent également être utilisés comme gabarits de conditions ou d'action, permettant ainsi de mutualiser certaines parties de règles

Syntaxe

Le format d'un DSL est tout simplement un fichier texte qui traduit des clés en langage « *naturel* » en des expressions *drl*

Chaque ligne commence par indiquer un ***scope***, puis la traduction du langage étendu dans le langage de règle

```
[when]This is "{something}"=Something(something=="{something})"

[then]Log "{message}"=System.out.println("{message}") ;
```

Il est possible d'utiliser également le scope ***[keyword]*** qui permet de redéfinir un mot-clé :
`[keyword] quand = when`

Les phrases définies sont en fait des expressions régulières. Les wildcards peuvent donc être utilisés.

Exemples

```
[when]There is a Person with name of
  "{name}"=Person(name=="{name}")

[when]Person is at least {age} years old and lives in
  "{location}"=Person(age > {age}, location=="{location}")

[then]Log "{message}"=System.out.println("{message}");
```

```
There is a Person with name of "kitty"
  ---> Person(name="kitty")

Person is at least 42 years old and lives in "atlanta"
  ---> Person(age > 42, location="atlanta")

Log "boo"
  ---> System.out.println("boo");
```

Exemple avec regexp

```
[when][]is less than or equal to=<=
[when][]is less than=<
[when][]is greater than or equal to=>=
[when][]is greater than=>
[when][]is equal to===
[when][]equals===
[when][]There is a Cheese with=Cheese()
[when][]- {field:\w*} {operator} {value:\d*}={field} {operator} {value}
---------------------------------------------------------------------
There is a Cheese with
- age is less than 42
- rating is greater than 50
- type equals 'stilton'
---------------------------------------------------------------------
Cheese(age<42, type=='stilton', rating>50)
```

Mise en place

1. Nommer son fichier DRL avec l'extension *.dslr*

2. Faire référence au fichier DSL dans le fichier de règle avec le mot-clé *expander*

```
expander your-expander.dsl
```

3. Passer le DSL au moment de la compilation (Drools 5) :

```
PackageBuilder builder = new PackageBuilder() ;
builder.addPackageFromDrl( sourceReader,
dslReader );
```

Performance

Réseau Rete/ PHREAK

Backward chaining

Améliorations PHREAK

drools-metric

Algorithme de Rete et ReteOO

Le traitement de comparer les faits aux règles est appelé le **Pattern Matching**, il existe de nombreux algorithmes de pattern matching : *Linear*, *Rete*, *Treat*, *Leaps*.

Drools a dans un premier temps implémenté l'algorithme de Rete dans un technologie objet : **ReteOO**

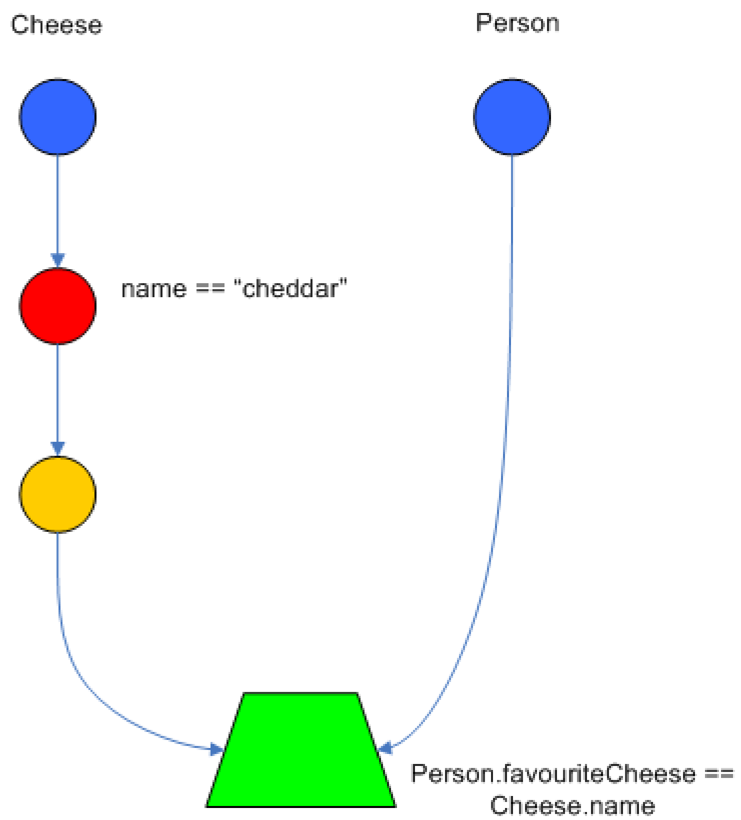
- L'algorithme est particulièrement efficace lorsque le jeu de données (les faits) change régulièrement mais dans de faibles proportions car le moteur de règle se souvient des règles ayant déjà matchée
- Il est gourmand en mémoire

Principes de Rete

L'algorithme de Rete repose sur 2 étapes :

- La compilation des règles créée un réseau discriminant constitué de différents nœuds :
  - ***TypeNode*** : Relatif à un type de fait
  - ***Alpha*** : Contrainte sur un fait
  - ***Beta*** : Comparaison entre des tuples d'objets et un objet unique.
  - ***Règle*** : Si une donnée atteint ce type nœud la règle est déclenchée
- Le pattern matching. Il s'exécute à chaque modification de la base de fait. Les faits sont introduits dans le réseau et traverse les nœuds si les conditions sont satisfaites. Certains nœuds (*Beta*) ont une mémoire associée et collecte les faits qui parviennent au nœud.

Exemple



Cheese
Person
name == "cheddar"
Person.favouriteCheese ==
Cheese.name

Inconvénients de Rete

Rete est un algorithme *eager*

Il effectue de nombreuses actions lors des actions d'insertion, de mise à jour et de suppression afin de trouver des correspondances partielles pour toutes les règles.
=> Cela nécessite beaucoup de temps avant d'exécuter éventuellement les règles, en particulier dans les grands systèmes.

PHREAK

- A partir de Drools 6, l'algorithme PHREAK est utilisé
- C'est un algorithme *lazy*
- La mise en correspondance partielle des règles est délibérément retardée pour traiter plus efficacement de grandes quantités de données.

- *PHREAK* est équivalent à *ReteOO* lorsque le nombre de règles reste modéré mais permet d'éviter des pertes de performances lorsque le nombre de règles grossit
- *PHREAK* permet également des gains de performance lors de l'utilisation de groupes d'agenda et des attributs de priorité (*salience*) des règles

Évaluations des règles avec PHREAK

Lorsque le moteur Drools démarre, toutes les règles sont considérées comme ***unlinked***

Les actions d'insertion, de mise à jour et de suppression de faits sont mises en file d'attente et Phreak utilise une heuristique, pour sélectionner la règle la plus susceptible d'être exécutée.

Lorsque toutes les valeurs d'entrée requises sont renseignées pour une règle (Contraintes sur les types de donnée), la règle est considérée comme étant ***linked*** aux données correspondantes.

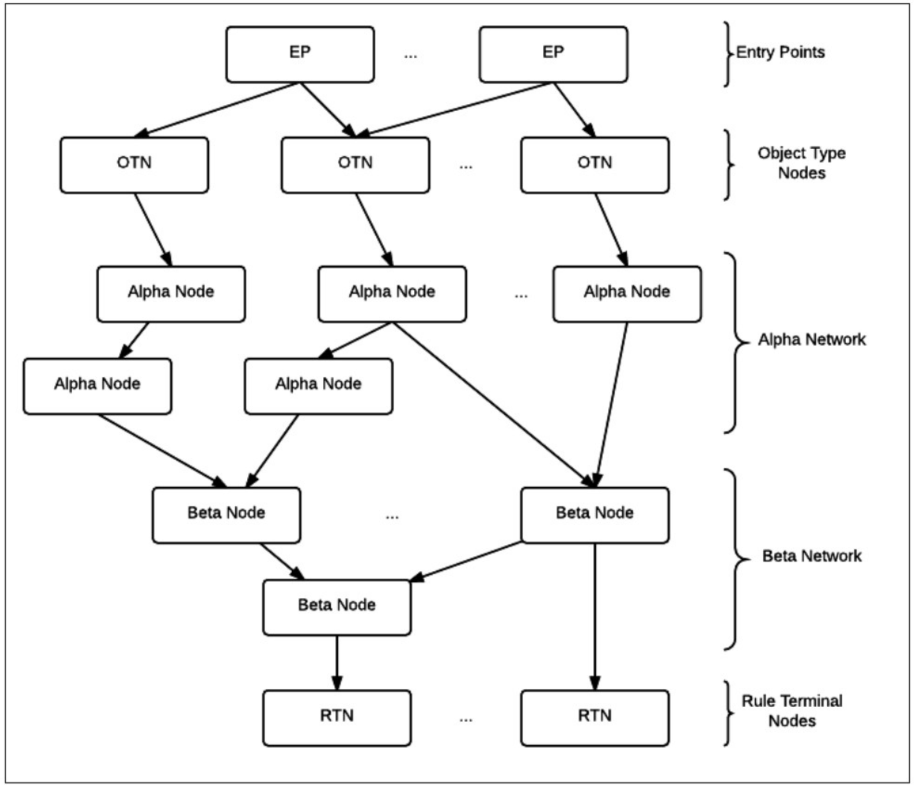
Phreak crée ensuite un **objectif (*goal*)** représentant cette règle et le place dans une file d'attente prioritaire triée par l'attribut *salience*.

Seule la règle pour laquelle l'objectif a été créé est évaluée, et les autres évaluations de règle potentielles sont retardées.

Réseau de règles

PHREAK construit également un réseau Rete à partie des règles

Le réseau est constitués de différents nœuds



ObjectType Node

Un ***Object Type Node (OTN)*** est une contrainte sur le type du fait ~ *instanceof*

=> Le réseau PHREAK contient autant d'OTN que de classes distinctes utilisées dans les règles

=> Les règles utilisant la même classe partagent le même nœud OTN.

=> Lorsque le nœud est évalué toutes les règles qui s'y rapportent sont évaluées en même temps

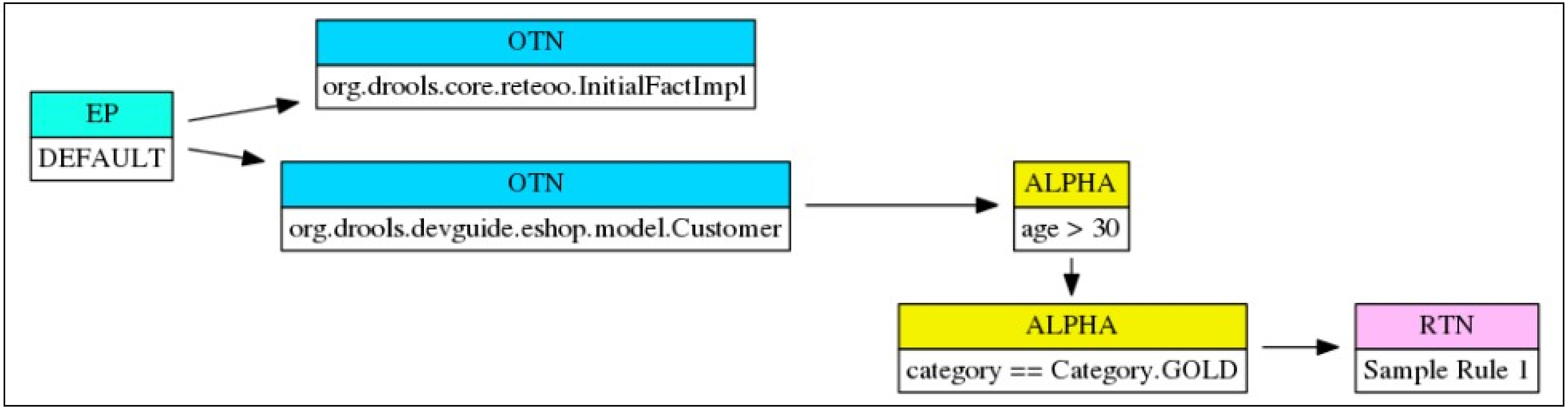
=> Le sous-réseau d'OTN est toujours présent dans PHREAK et sa profondeur est toujours de 1

Alpha Node

- Un pattern peut contenir plusieurs ou aucune contrainte.
- Chaque contrainte individuelle est représentée dans le réseau PHREAK par un **nœud alpha**.
- Le nœud est en charge de l'évaluation de la contrainte particulière qu'il représente.
- Si la contrainte est évaluée à *true* , le prochain nœud du réseau sera évalué

Exemple *AlphaNode*

```
rule "Sample Rule 1"
when
  $c: Customer(age > 30, category == Category.GOLD)
then
  channels["customer-channel"].send($c);
end
```



Ordre des contraintes

L'ordre des Alpha Nodes dépend de l'ordre dans lequel les contraintes correspondantes sont définies dans DRL

Comme pour les OTNs, les nœuds alpha peuvent être partagés entre plusieurs règles.
Si la même contrainte est utilisée dans plusieurs pattern, Drools optimisera la création du réseau PHREAK et un seul nœud Alpha sera utilisé.

=> Attention, afin que le nœud Alpha puisse être partagé, l'ordre de la contrainte doit être le même dans tous les patterns

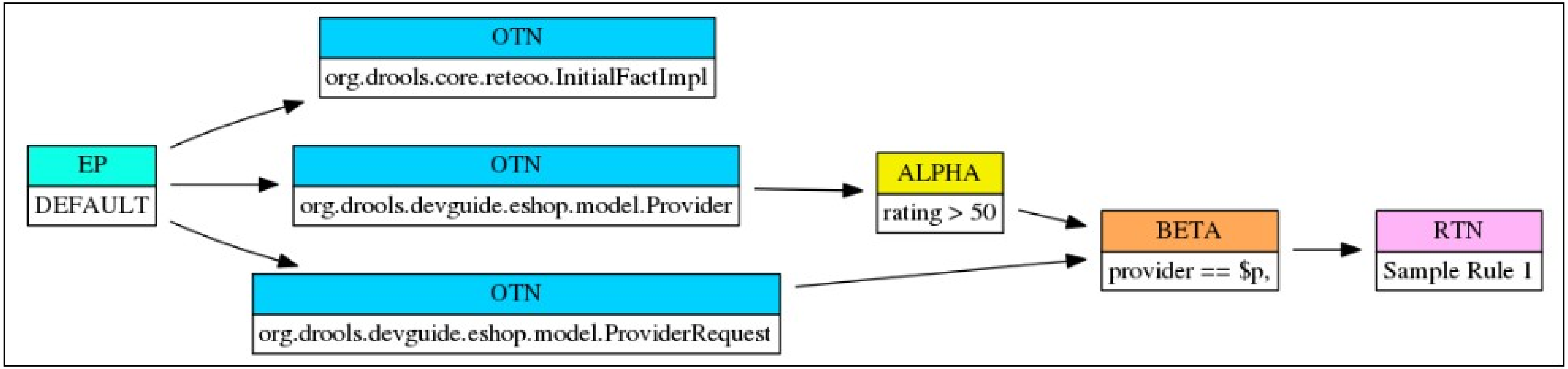
Rq : Voir également compilation JIT des expressions des contraintes.
Propriétés : *ConstraintJittingThresholdOption*

Beta Nodes

- Un **nœud Beta** représente l'opération *join* sur 2 patterns
  - Il a 2 entrées et 1 ou plusieurs sorties
  - Il peut préciser une contrainte supplémentaire sur les 2 entrées
- Les nœuds Beta peuvent également être partagés … si l'ordre des patterns ET des contraintes sont identiques dans plusieurs règles
  => Pas toujours facile à obtenir

Exemple

```
rule "Sample Rule 1"
when
  $p: Provider(rating > 50)
  $pr: ProviderRequest(provider == $p)
then
  channels["request-channel"].send($pr);
end
```

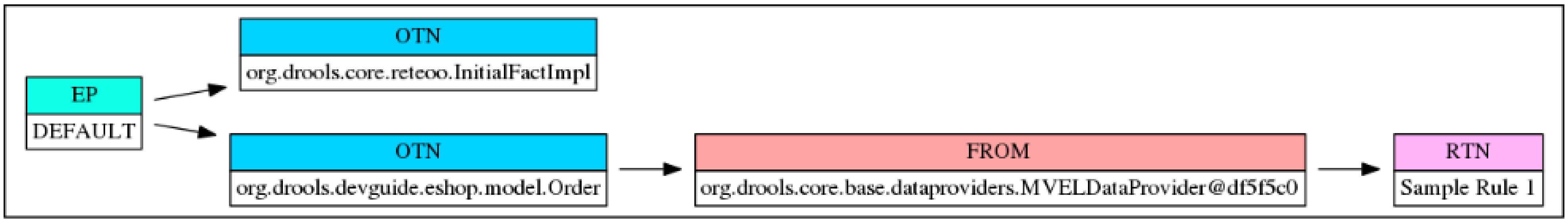


Autres nœuds

- Il existe d’autres nœuds dans le réseau PHREAK correspondant aux éléments conditionnels *not, exists, accumulate* et *from*
  - *NotNode, ExistsNode, AccumulateNode* : BetaNode spécialisés
  - *fromNode* : Plus étrange, la partie droite et gauche de from sont évalués

Exemple *fromNode*

```
rule "Sample Rule 1"
when
  $o: Order()
  $ol: OrderLine(
    item.category == Category.HIGH_RANGE,
    quantity > 10) from $o.getOrderLines()
then
channels["audit-channel"].send($ol);
end
```



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Chaînage avant / arrière

Les moteurs de règles sont à chaînage avant ou arrière :

- Le **chaînage avant** est piloté par les données : à partir d'un fait, des règles s 'appliquent, se propagent et se terminent par une conclusion.
- Le **chaînage arrière** part de la conclusion pour remonter aux causes
  Dans Drools, Il est implémenté via les requêtes

Drools 5 était un moteur à chaînage avant.

Drools 6 est devenu un moteur hybride (avant et arrière)

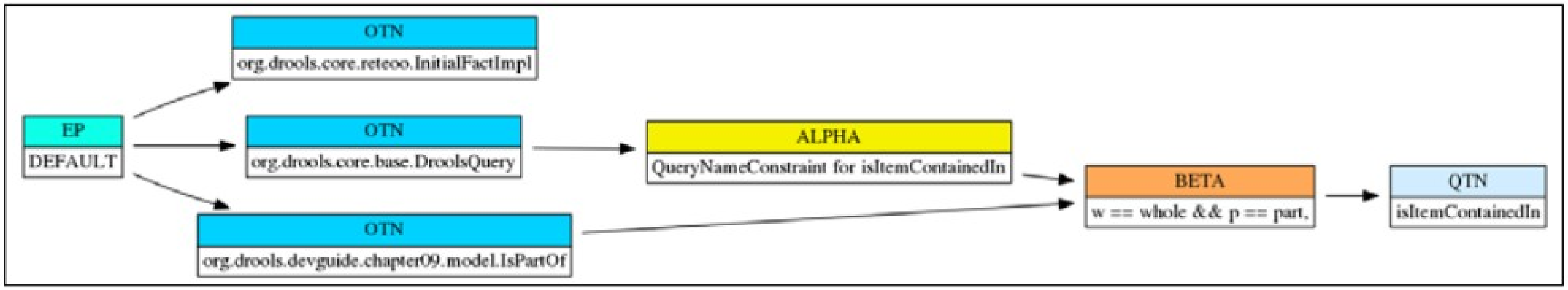
Noeud d’une requête

Les requêtes ont leur représentation dans le réseau PHREAK :

- Un OTN sur DroolsQuery
- Un Alpha sur le nom de la query
- Un Beta sur la condtion de la requête
- Un nœud de sortie QTN

Exemple :

```
query isItemContainedIn(Item p, Item w)
  IsPartOf(whole == w, part == p)
end
```



Requêtes comme condition

Les requêtes peuvent être considérées comme des objectifs ou des sous-objectifs devant être satisfaits par le moteur

=> La façon dont Drools implémente un certain degré de raisonnement en arrière consiste à utiliser des requêtes comme conditions dans une règle

Le nœud Query (Query Element Node) s'enregistre en tant que *ViewChangedEventListener* à la requête correspondante pour réagir aux nouveaux résultats ou aux modifications des résultats générés précédemment.

Performance

Réseau Rete/ PHREAK
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drools-metric

Introduction

- Les améliorations consistent principalement :
  - A différer l'évaluation des règles
  - Propagation des faits via un ensemble permettant le traitement match et le multi-threading
  - Segmentation du réseau et utilisation de bit-mask

Évaluation différée

- Au départ les règles sont unliked
- Lors d’ insertions/modification/suppression de faits, elles ne sont propagées qu’au sous-réseau Alpha, aucun nœud Beta n’est évalué
- Une heuristique détermine quelle règle est la plus susceptible d'aboutir et impose ainsi un ordre d'évaluation entre elles
- Lorsque tous les nœuds d'une règle ont des données à évaluer, la règle est considérée comme liée.
- Toutes les règles liées sont ajoutées à une file d'attente triéeen fonction de l'importance de chaque règle. Différents groupes d'agenda ont des files d'attente différentes et seules les règles de la file d'attente du groupe d'agenda actif sont évaluées.
- => PHREAK retarde l'évaluation du sous-réseau bêta jusqu'à ce que fireAllRules() soit invoquée

Propagation d’ensemble

Avec ReteOO, à chaque modification de fait, le réseau était traversé.

Chaque nœud évalué dans le réseau créait un tuple qui était propagé au nœud suivant.

Avec PHREAK, les modifications mise en attente pour les nœuds Beta sont traités par lot et leurs résultats ajoutés à un ensemble.

Cet ensemble est ensuite transmis au nœud suivant où toutes les actions mises en file d'attente sont à nouveau évaluées et ajoutées au même ensemble

=> Cette propagation orientée ensemble offre des avantages de performances pour certaines règles

Segmentation du réseau

- Les nœuds partagés entre différentes règles forment des segments. Une règle est alors vue par PHREAK comme un chemin de segments plutôt qu'un chemin de nœuds.
- Chaque nœud à l'intérieur d'un segment est affecté à un masque binaire. Chaque segment d'un chemin également.
- Lorsqu'un nœud contient suffisamment de données dans son entrée pour être évalué, son bit est défini sur on . Lorsque tous les nœuds d'un segment sont activés, le segment lui-même est activé.
- Une règle est alors considérée comme liée lorsque tous ses segments sont activés.
- Ces masques binaire sont utilisés par Drools pour éviter la réévaluation des nœuds et segments déjà évalués, fournissant une évaluation plus efficace du réseau PHREAK

Performance

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Performance

Quelques recommandations pour la performance :

- S'assurer que le nom de la propriété de fait se trouve à gauche de l'opérateur et que la valeur (constante ou variable) se trouve à droite.
  ```
  Person( firstName == "John" )
  ```
  plutôt que
  ```
  Person( "John" == firstName )
  ```
- Favoriser l'opérateur ==
- Commencer par les conditions de règle les plus restrictives
- Évitez d'itérer sur de grandes collections d'objets avec des clauses from
  ```
  when
    $c: Company();
    Employee (salary > 100000.00, company == $c)
  ```
  plutôt que
  ```
  when
    $c: Company()
    $e: Employee ( salary > 100000.00) from $c.employees
  ```
- Utiliser des listener plutôt que System.out.println dans les règles pour le debug

drools-metric

- Le module drools-metric peut être utilisé pour identifier les règles lentes au niveau performance
  org.drools : drools-metric
  - Trace logging via logback :
    <logger name="org.drools.metric.util.MetricLogUtils" level="trace"/>
  - Peut être exposé dans Micrometer
    io.micrometer : micrometer-registry-jmx
  - 2 configurations :
    drools.metric.logger.enabled = true
    drools.metric.logger.threshold (seuil minimal pour apparaître dans les logs)

Exemple output

```
TRACE [JoinNode(6) - [ClassObjectType class=com.sample.Order]], evalCount:1000,
  elapsedMicro:5962
TRACE [JoinNode(7) - [ClassObjectType class=com.sample.Order]], evalCount:100000,
  elapsedMicro:95553
TRACE [ AccumulateNode(8) ], evalCount:4999500, elapsedMicro:2172836
TRACE [EvalConditionNode(9)]:
  cond=com.sample.Rule_Collect_expensive_orders_combination930932360Eval1Invoker@
  ee2a6922], evalCount:49500, elapsedMicro:18787
```

evalCount est le nombre d'évaluations de contraintes par rapport aux faits insérés lors de l'exécution du nœud

elapsedMicro est le temps écoulé de l'exécution du nœud en microsecondes

Il est possible retrouver la règle associée au nœud via *ReteDumper.dumpAssociatedRulesRete(kbase)* =>
`[ AccumulateNode(8) ] : [Collect expensive orders combination]`

Élément conditionnel *and*

Les éléments conditionnels peuvent être combinés avec les opérateurs ***and*** (opérateur implicite)

L'opérateur *and* peut-être utilisé en préfixe ou en infixe

Implicite

```
Cheese( cheeseType : type )
Person( favouriteCheese == cheeseType)
```

Préfixe

```
 (and Cheese( cheeseType : type )
Person( favouriteCheese == cheeseType ) )
```

Infixe

```
(Cheese( cheeseType : type ) and
Person( favouriteCheese == cheeseType ) )
```

Élément conditionnel *or*

L'élément conditionnel ***or*** a pour effet de créer plusieurs sous-règles distinctes qui deviennent complètement indépendantes. Il peut s'employer en préfixe ou en infixe.

```
(or Person( sex == "f", age > 60 )
Person( sex == "m", age > 65 )
```

Marshaller et persistance de session

KieMarshallers

Les ***KieMarshallers*** sont utilisés pour sérialiser/désérialiser les *KieSessions*.

```
ByteArrayOutputStream baos = new
  ByteArrayOutputStream();

Marshaller marshaller =
  KieServices.Factory.get().getMarshallers().newMarshal
  ler( kbase );

marshaller.marshall( baos, ksession );

baos.close();
```

Persistance et transactions

- La persistance avec Drools est implémenté via **JPA**.
- Il est cependant nécessaire de disposer d'une implémentation de **Java Transaction API** (JTA)
- Pour les classes de test et le développement l'implémentation *Bitronix Transaction Manager* est suggérée pour un environnement de production *JBoss Transactions* est recommandé.

Exemple

```
KieServices kieServices = KieServices.Factory.get();
Environment env = kieServices.newEnvironment();
env.set( EnvironmentName.ENTITY_MANAGER_FACTORY,
Persistence.createEntityManagerFactory( "emf-name" ) );
env.set( EnvironmentName.TRANSACTION_MANAGER,
 TransactionManagerServices.getTransactionManager() );
KieSession ksession =
kieServices.getStoreServices().newKieSession( kbase, null, env );
int sessionId = ksession.getId();
UserTransaction ut =
(UserTransaction) new InitialContext().lookup( "java:comp/UserTransaction" );
ut.begin();
ksession.insert( data1 );
ksession.insert( data2 );
ksession.startProcess( "process1" );
ut.commit();
```

Chargement d'une session

Pour récupérer une session stockée en base :

```
KieSession ksession =
kieServices.getStoreServices().loadKieSession(
  sessionId, kbase, null, env );
```

Chargement d'une session

Pour récupérer une session stockée en base :

```
KieSession ksession =
kieServices.getStoreServices().loadKieSession(
  sessionId, kbase, null, env );
```

persistence.xml

```
<persistence-unit name="org.drools.persistence.jpa" transaction-type="JTA">
  <provider>org.hibernate.ejb.HibernatePersistence</provider>
  <jta-data-source>jdbc/BitronixJTADataSource</jta-data-source>
  <class>org.drools.persistence.info.SessionInfo</class>
  <class>org.drools.persistence.info.WorkItemInfo</class>
  <properties>
    <property name="hibernate.dialect"
 value="org.hibernate.dialect.H2Dialect"/>
   <property name="hibernate.max_fetch_depth" value="3"/>
   <property name="hibernate.hbm2ddl.auto" value="update" />
   <property name="hibernate.show_sql" value="true" />
   <property name="hibernate.transaction.manager_lookup_class"
value="org.hibernate.transaction.BTMTransactionManagerLookup" />
  </properties>
</persistence-unit>
```

JTA Datasource avec Bitronix

```
PoolingDataSource ds = new PoolingDataSource();
ds.setUniqueName( "jdbc/BitronixJTADataSource" );
ds.setClassName( "org.h2.jdbcx.JdbcDataSource" );
ds.setMaxPoolSize( 3 );
ds.setAllowLocalTransactions(
ds.getDriverProperties().setProperty("driverClassName",
  "org.h2.Driver");
ds.getDriverProperties().setProperty("url",
  "jdbc:h2:tcp://localhost/JPADroolsFlow");
d1.getDriverProperties().setProperty("user", "sa");
ds.getDriverProperties().setProperty("password", "");
ds1.init();
```

jndi.properties

```
java.naming.factory.initial=bitronix.tm.jndi.BitronixInitialContextFactory
```

Intégration Spring

kie-spring

Utilisation d'un kmodule / Bean configuration

utilisation de balise de namespace kie

Le préfixe a changé de 'drools:' pour 'kie:'

Dépendance :

<groupId>org.kie</groupId>

<artifactId>kie-spring</artifactId>

<version>6.2.0.Final</version>

kie-spring

`<kie:kmodule>`

id requis l'id du bean

ne peut contenir que

`<kie:kbase>`

name : requis

packages

includes

default

scope

eventProcessingMode

equalsBehavior

declarativeAgenda

kie-spring

ne peut contenir que kie:ksession

<kie:ksession>

name : requis

type

default

clockType : REALTIME / PSEUDO

listeners-ref

Déclaration nécessaire au fonctionnement de kie-spring Impératif:

```
<bean id="kiePostProcessor"
      class="org.kie.spring.KModuleBeanFactoryPostProcessor"/>
```

ou pour les annotations

```
<bean id="kiePostProcessor"
      class="org.kie.spring.annotations.KModuleAnnotationPostProcessor"/>
```

kie-spring

exemple

```
<kie:kmodule id="sample-kmodule">
  <kie:kbase name="drl_kiesample3" packages="drl_kiesample3">
    <kie:ksession name="ksession1" type="stateless"/>
    <kie:ksession name="ksession2"/>
  </kie:kbase>
</kie:kmodule>

<bean id="kiePostProcessor"
        class="org.kie.spring.KModuleBeanFactoryPostProcessor"/>
```

kie-spring

<kie:releaseId>

id : bean id, requis

groupId : requis

artifactId : requis

version : requis

exemple

```
<kie:releaseId id="beanId" groupId="org.kie.spring"
          artifactId="named-artifactId" version="1.0.0-SNAPSHOT"/>
```

<kie:import />

releaseId

enableScanner

scannerInterval

kie-spring

Utilisation avec releaseID

```
<kie:import releaseId-ref="namedKieSession"
        enableScanner="true" scannerInterval="1000"/>

<kie:releaseId id="namedKieSession" groupId="org.drools"
        artifactId="named-kiesession" version="6.3.0-SNAPSHOT"/>
```

Le scanner peut être récupéré via

```
KieScanner releaseIdScanner =
  context.getBean("namedKieSession#scanner", KieScanner.class);
releaseIdScanner.scanNow();
```

kie-spring

Listeners

Drools supporte trois types de listeners AgendaListener, WorkingMemoryListener, ProcessEventListener

Ils peuvent être déclaré respectivement via

<kie:agendaEventListener/>

<kie:processEventListener/>

<kie:ruleRuntimeEventListener/>

DebugAgendaEventListener

DebugRuleRuntimeEventListener

DebugProcessEventListener

Qui sortent les traces sur System.err

kie-spring

ref : référence optionnelle au bean

avec référence ils utilisent l'impémentation fournie

```
<bean id="mock-agenda-listener" class="mocks.MockAgendaEventListener"/>
<bean id="mock-rr-listener" class="mocks.MockRuleRuntimeEventListener"/>
<bean id="mock-process-listener" class="mocks.MockProcessEventListener"/>

<kie:kmodule id="listeners_kmodule">
  <kie:kbase name="drl_kiesample" packages="drl_kiesample">
    <kie:ksession name="ksession2">
      <kie:agendaEventListener ref="mock-agenda-listener"/>
      <kie:processEventListener ref="mock-process-listener"/>
      <kie:ruleRuntimeEventListener ref="mock-rr-listener"/>
    </kie:ksession>
  </kie:kbase>
</kie:kmodule>

<bean id="kiePostProcessor"
          class="org.kie.spring.KModuleBeanFactoryPostProcessor"/>
```

kie-spring

On peut sortir les listener de la session et en faire un groupe disponible pour tous

```
<bean id="mock-agenda-listener" class="mocks.MockAgendaEventListener"/>
<bean id="mock-rr-listener" class="mocks.MockRuleRuntimeEventListener"/>
<bean id="mock-process-listener" class="mocks.MockProcessEventListener"/>

<kie:kmodule id="listeners_module">
  <kie:kbase name="drl_kiesample" packages="drl_kiesample">
    <kie:ksession name="statelessWithGroupedListeners" type="stateless"
             listeners-ref="debugListeners"/>
  </kie:kbase>
</kie:kmodule>

<kie:eventListeners id="debugListeners">
  <kie:agendaEventListener ref="mock-agenda-listener"/>
  <kie:processEventListener ref="mock-process-listener"/>
  <kie:ruleRuntimeEventListener ref="mock-rr-listener"/>
</kie:eventListeners>
```

kie-spring

Logger

se définit dans la session

Console logger

<kie:consoleLogger/>

File logger

<kie:fileLogger/>

ID : indentifiant unique, requis

file : chemin complet ou fichier, requis

threaded

interval

example :

```
<kie:fileLogger id="tfl_logger" file="#{ systemProperties['java.io.tmpdir'] }/log2"
 threaded="true" interval="5"/>
```

Il faut fermer le logger programmatiquement

LoggerAdaptor adaptor = (LoggerAdaptor) context.getBean("fl_logger");

adaptor.close();

kie-spring

<kie:batch>

A placer dans kie:session

contient

- **insert-object**
  - ref = String (optional)
- **set-global**
  - identifier = String (required)
  - reg = String (optional)
- **fire-all-rules**
  - max : n
- **fire-until-halt**
- **start-process**
- identifier = String (required)
- ref = String (optional)
- **signal-event**
  - ref = String (optional)
  - event-type = String (required)
  - process-instance-id =n (optional)

kie-spring

exemple

```
<kie:batch>
    <kie:insert-object ref="person2"/>
    <kie:set-global identifier="persons" ref="personsList"/>
    <kie:fire-all-rules max="10"/>
</kie:batch>
```

kie-spring

Persistence

Il faut définir kie:jpa-persistence

puis un transaction manager

puis un entity manager factory

kie-spring

exemple complet:

```
<kie:kstore id="kstore" /> <!-- provides KnowledgeStoreService implementation
 -->


<bean id="myEmf"

 class="org.springframework.orm.jpa.LocalContainerEntityManagerFactoryBean">
   <property name="dataSource" ref="ds" />
   <property name="persistenceUnitName"
       value="org.drools.persistence.jpa.local" />
</bean>


<bean id="txManager"
 class="org.springframework.orm.jpa.JpaTransactionManager">
   <property name="entityManagerFactory" ref="myEmf" />
</bean>
```

kie-spring

```
<kie:kmodule id="persistence_module">
  <kie:kbase name="drl_kiesample" packages="drl_kiesample">
    <kie:ksession name="jpaSingleSessionCommandService">
      <kie:configuration>
         <kie:jpa-persistence>
           <kie:transaction-manager ref="txManager"/>
           <kie:entity-manager-factory ref="myEmf"/>
         </kie:jpa-persistence>
      </kie:configuration>
    </kie:ksession>
  </kie:kbase>
</kie:kmodule>

<bean id="kiePostProcessor"
          class="org.kie.spring.KModuleBeanFactoryPostProcessor"/>
```

kie-spring

Spring Profiles

On peut défnir dans le même fichier des configurations suivant les environnements

en encadrant les tags kmodule par

<beans profile="environnement">

<kie:kmodule

..

</beans>

à spécifier ensuite dans le system.properties ou équivalent

spring.profiles.active="production"

ou par option

-Dspring.profiles.active="development"