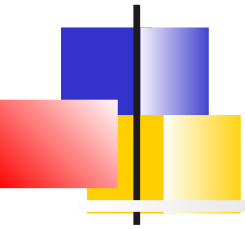
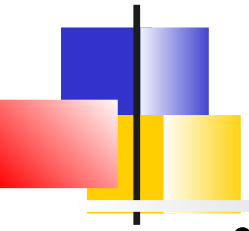


Drools

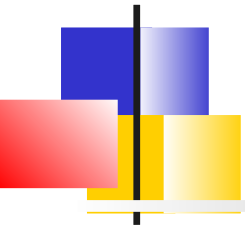
David THIBAU – 2023

david.thibau@gmail.com



Agenda

- Introduction
  - BRMS
  - KIE’s projects
  - Drools Rule’s engine
  - Architecture alternatives
- Getting started
  - KIE APIs
  - Session stateless
  - Session stateful and inference
  - Agenda and conflicts
  - Listeners, Channels, Entry-points
- DRL syntax
  - Main structural elements
  - Rules and attributes
  - LHS / RHS
  - Queries, Agregation
- Other ways to express rules
  - Decision tables
  - Rule’s template
  - DMN
- Related Projects
  - Complex Event Processing
  - Jbpm and Drools interaction
- Annexes
  - Algoritjms : ReteOO and PHREAK
  - DSL



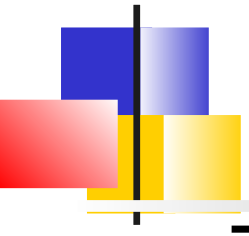
Introduction

BRMS

KIE’s projects

The rules Engine Drools

IDE setup



The problem

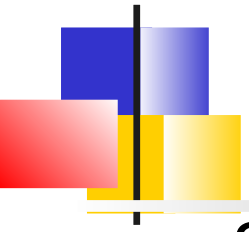
Today, the main challenge for business applications is agility

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?



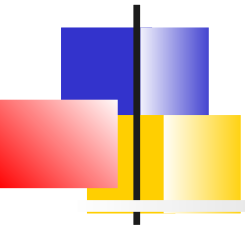
Stored as configuration properties in files or database ?

=> 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

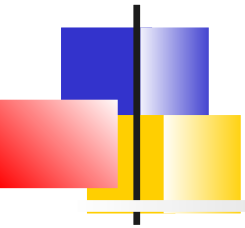
- Low maintenability
- Spaghetti code which may be unefficient



BRMS

A **business rule management system (BRMS)** identifies the notion of business rule as a resource 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)

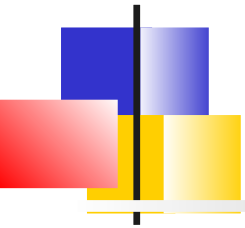
Client (code applicatif) :

– Get a reference to the rule’s engine

– Insert facts

– Ask the engine to trigger rules

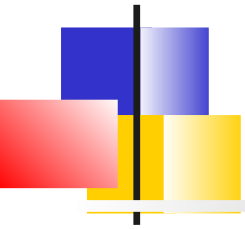
– Retreive the objetcs updated by the rule’s engine



Required steps

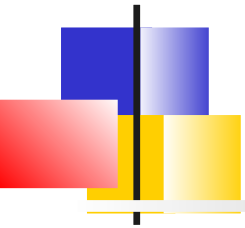
Adopting a rule-based solution requires:

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



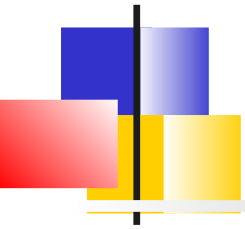
Considerations

- 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** : The data is in 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 ?

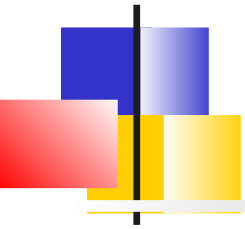
The problem is too complex for the classical code (optimization problems for example, expert system)

The problem is not complex but no robust solution is needed.

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

The business experts exist but are not technical. The rules 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

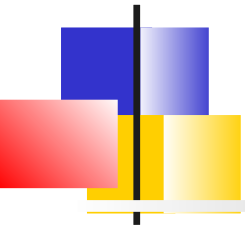
Classical domains and use cases

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, ...



Introduction

BRMS

KIE’s projects

The rules Engine Drools

IDE setup

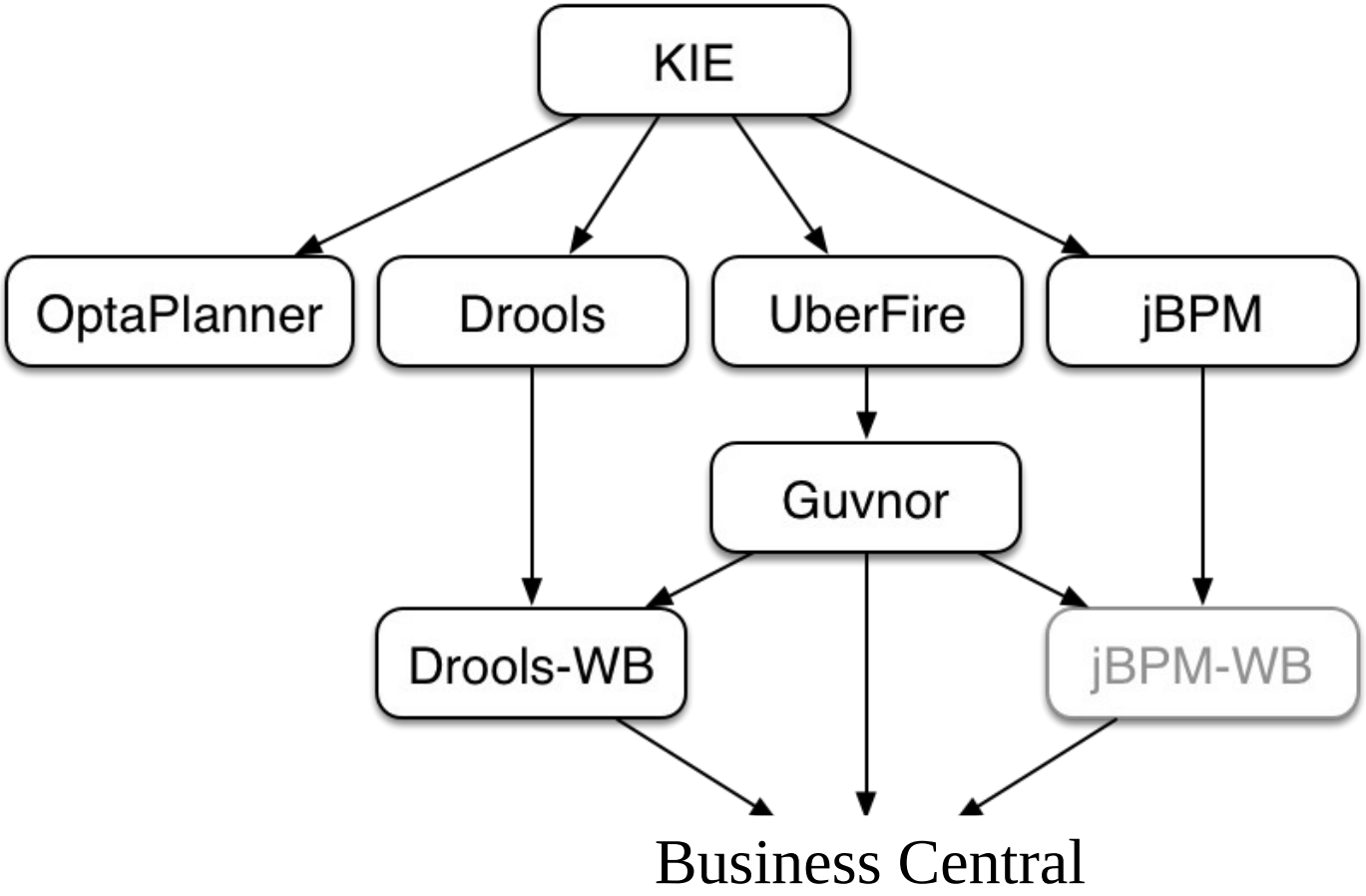
KIE’s projects

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



Business Central Project Lifecycle

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

Build : Build a Deployable Artifact containting Knowledge (***kjar***)

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

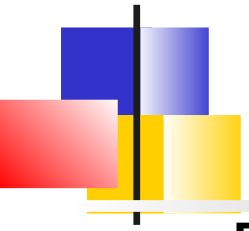
- Business Central and several *KieServer* to deploy knowledge base for testing or production
- Eclipse plugin and Java test classes. Pipeline CI/CD to deploy on *KieServer* or other

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

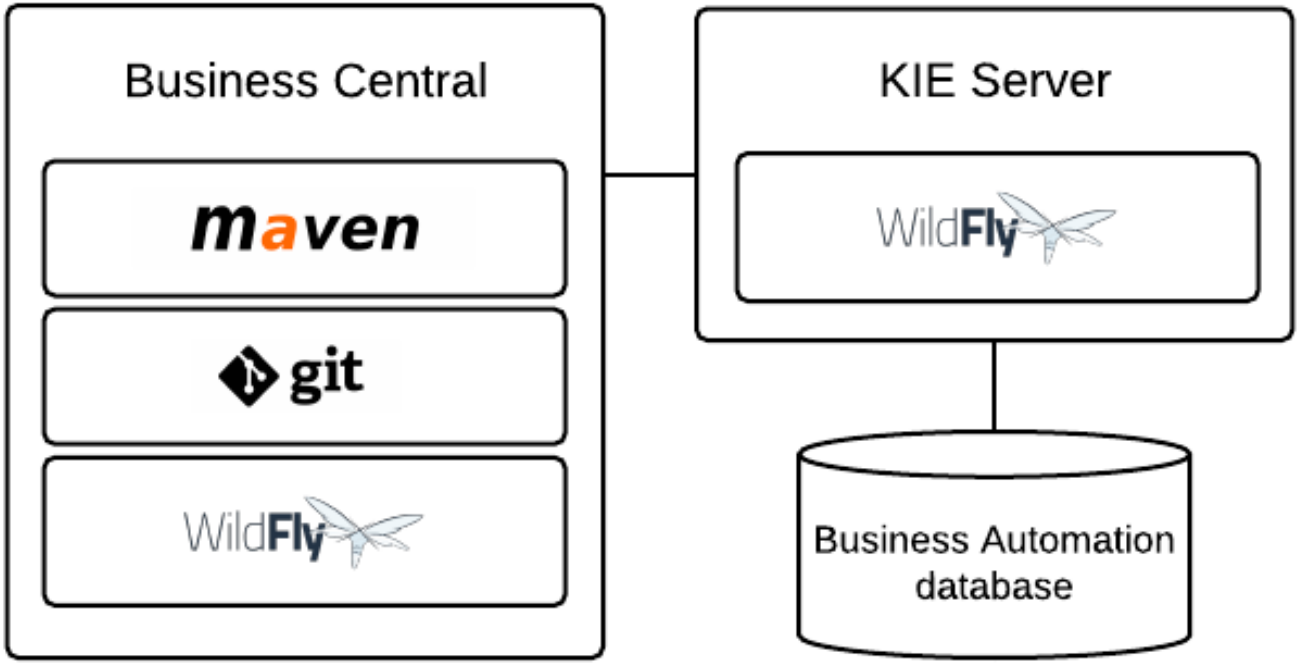


Writing rules

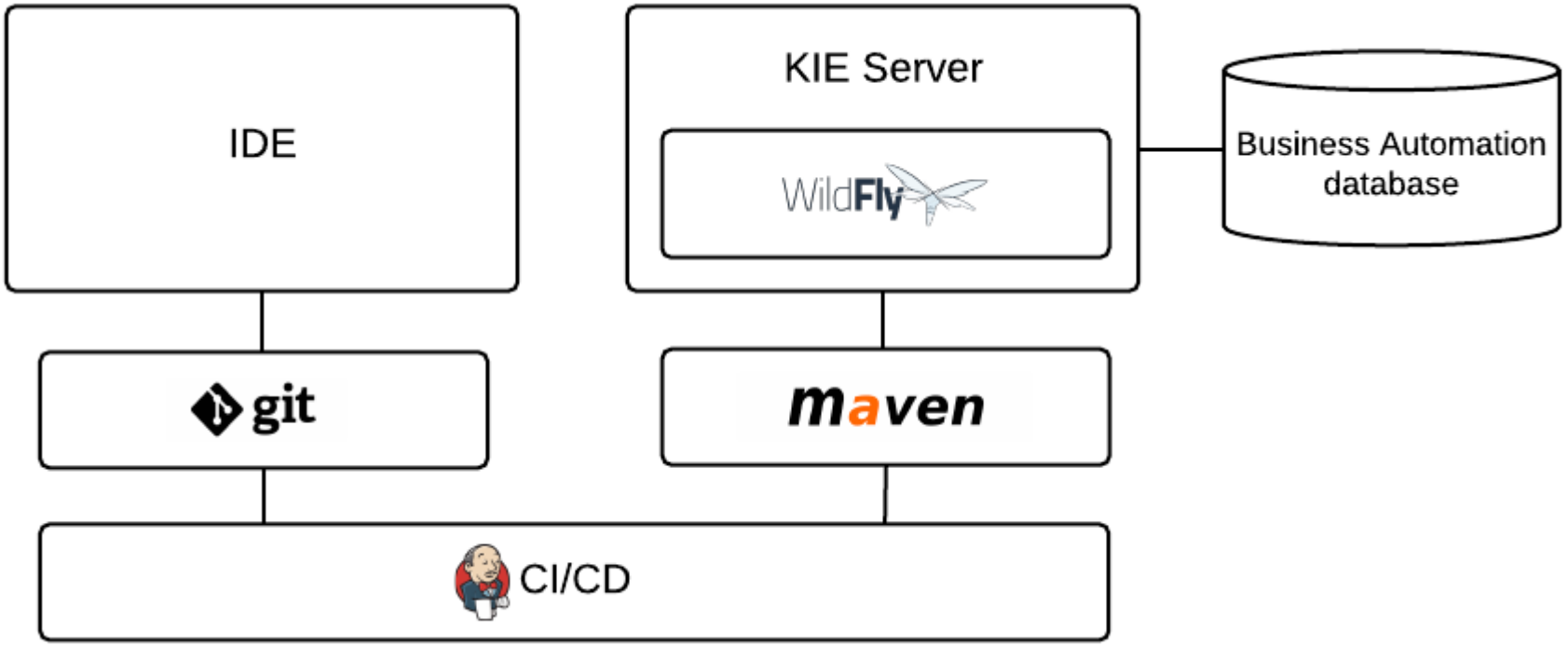
Drools supports different assets to specify rules:

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

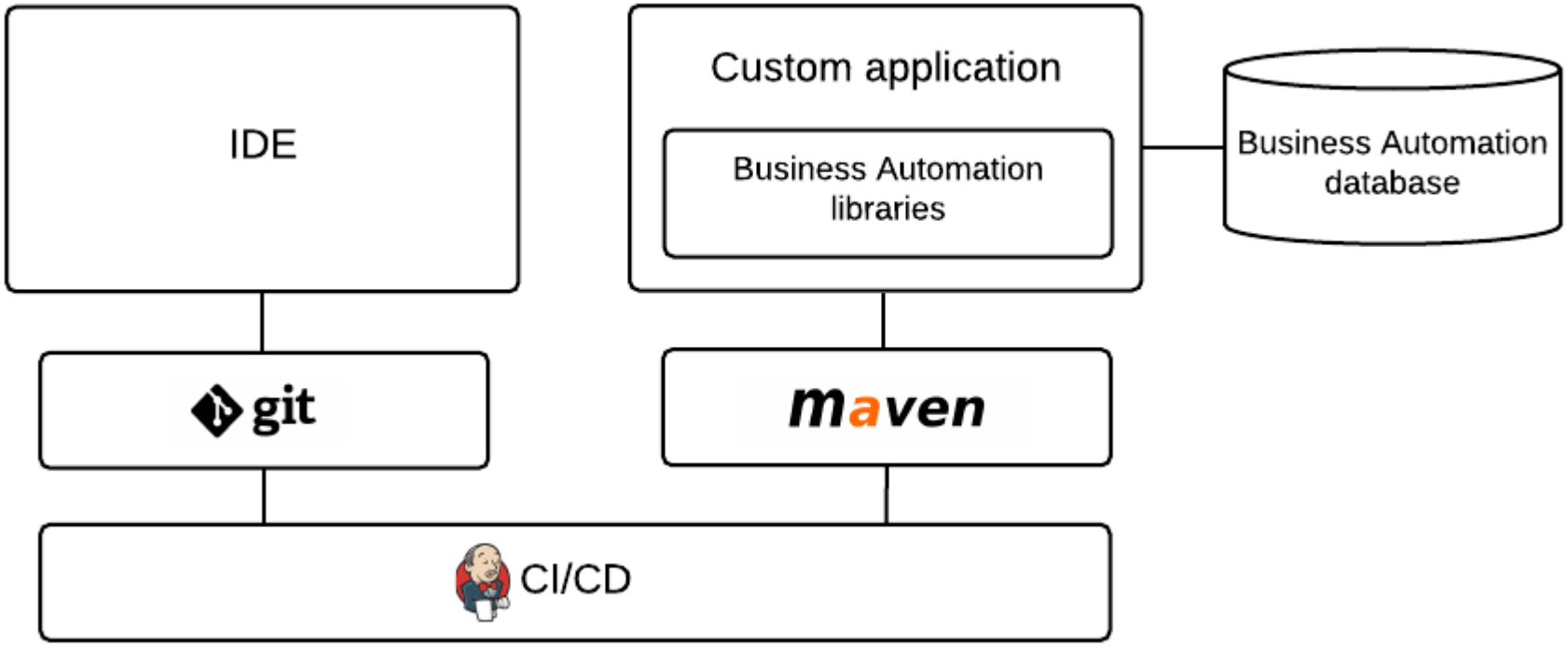
Architecture Business Central

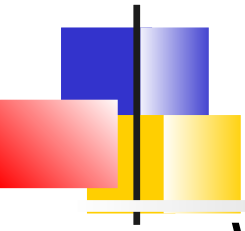


IDE + KieServer



IDE et Java embarqué





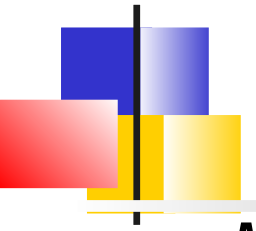
Packaging KJAR

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 the packaging is generally Maven, a plugin allows to validate the rules files

The kjar may or may not containt 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:

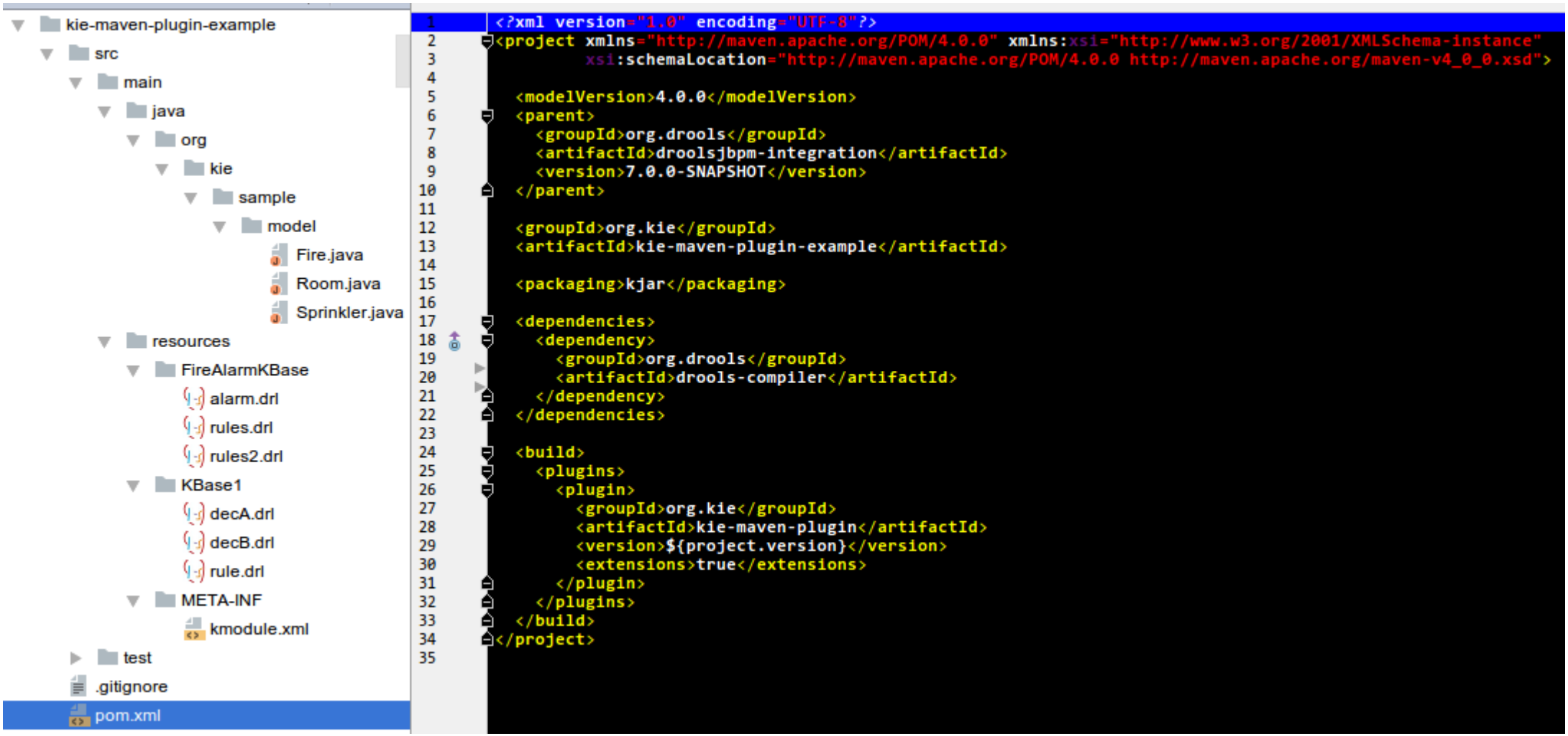
- all resource files found in the classpath are added to the same knowledge base.
- 2 types of sessions (stateless and stateful) are associated with the single knowledge base

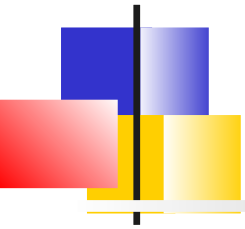
Example *kmodule.xml*

```
<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





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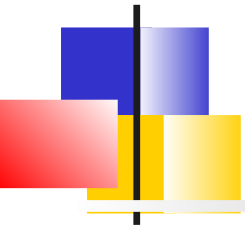
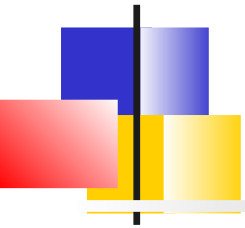
Rule’s engine



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

- The knowledge base groups the **compiled rules**
- The client application inserts facts (objects of the domain model) 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.

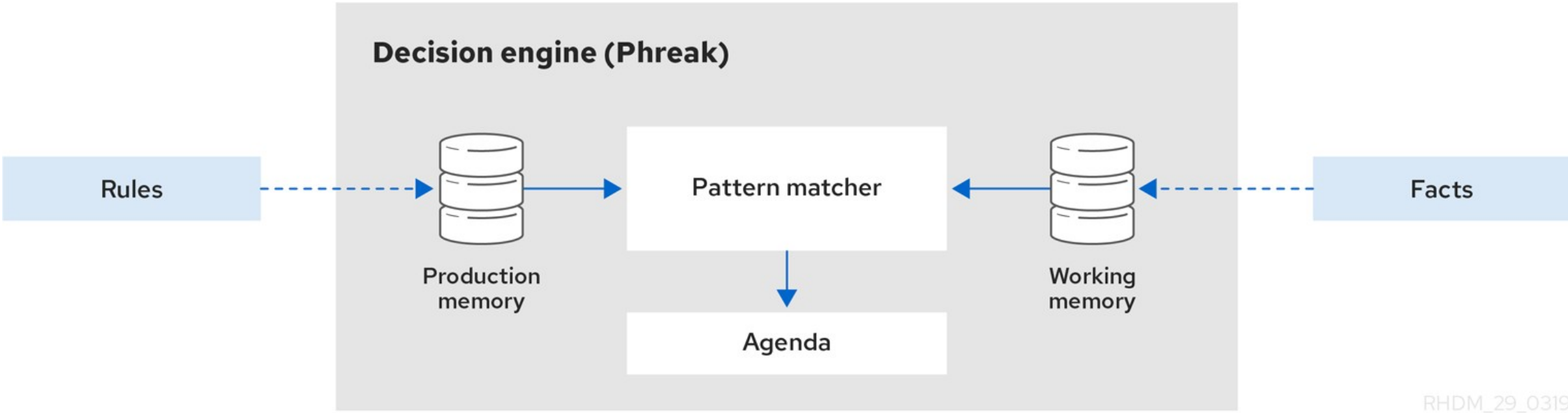


Agenda

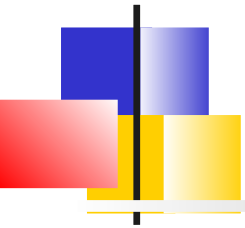
When matching the rules, it is possible that several rules are active simultaneously, it is said that they are in conflict.

The **Agenda** component is responsible for managing the execution order of the conflicting rules by using 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*.

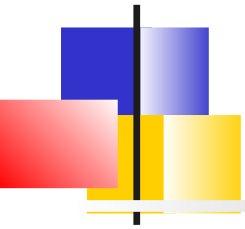
Drools starts to implement and optimize the Rete algorithm in an object technology. (***ReteOO***)

- 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

See Annexes / Algorithms



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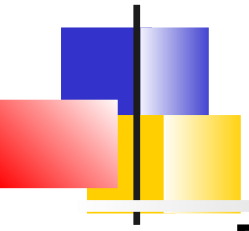


Eclipse plugins

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

Jars and dependencies

knowledge-api.jar :Kie APIs. Required for compiling and runtime

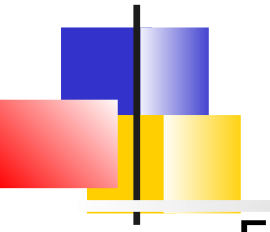
knowledge-internal-api.jar : Interfaces and factories for intaernal use

drools-core.jar : The rule engine Required at runtime

drools-compiler.jar : Rule's compiler. Generallt, requred at runtime riules may be pre-compiled

drools-jsr94.jar : Implementation layer for JSR-94 on top of de drools-compiler.

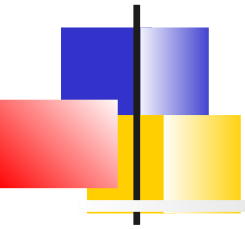
drools-decisiontables.jar : Compiler for decisio, tables .



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 ruels in the agenda. For each rule, the associated variables are displayed.
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 :

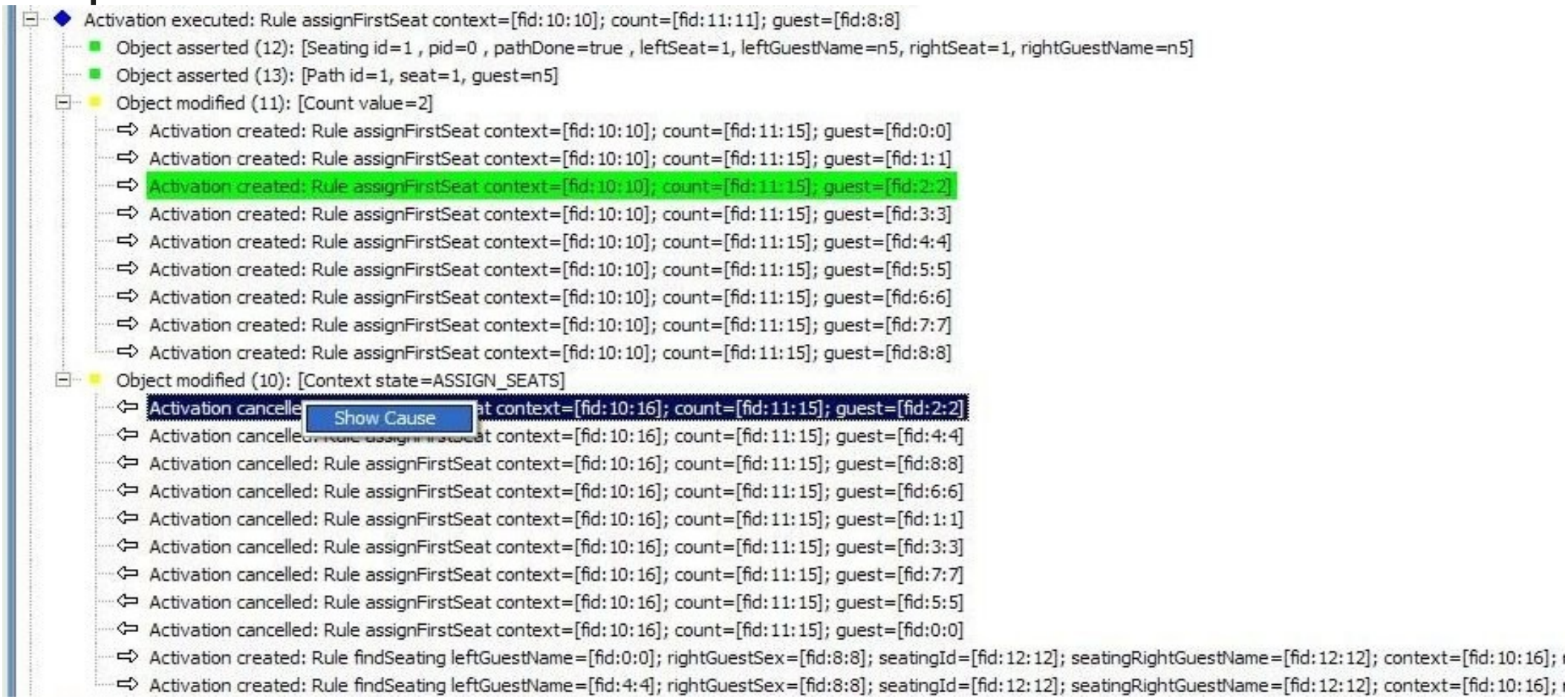
```
KieRuntimeLogger logger =

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

ksession.insert(...);

ksession.fireAllRules();

// stop logging

logger.close();
```

Or which has been configured via *kmodule.xml*

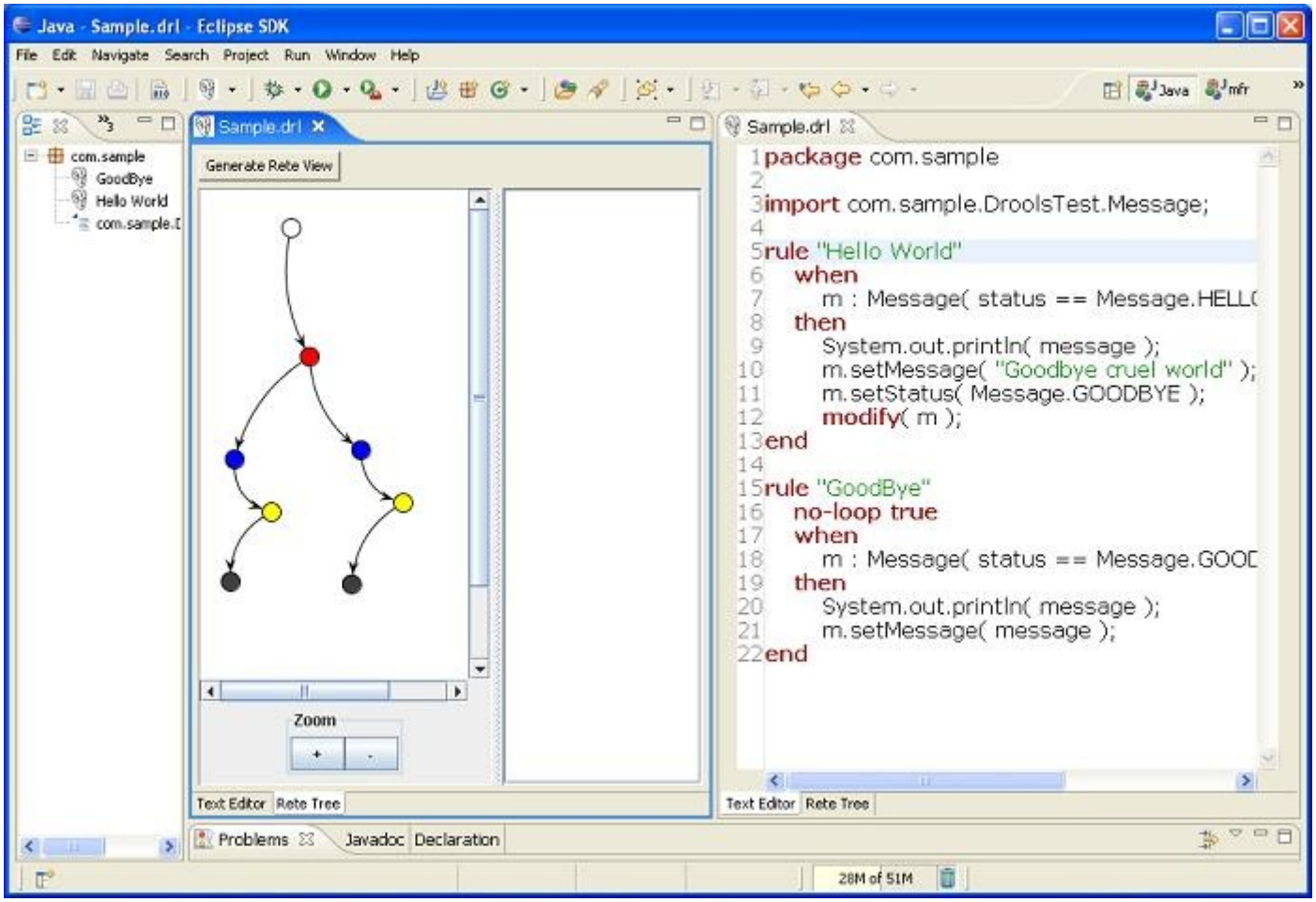
Events of the logfile

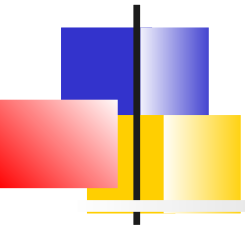
1. Object inserted :
2. Object updated :
3. Object destroyed :
4. Activation created
5. Activation canceled :
6. Activation executed :
7. Sequence of starting or ending of a rule :
8. Activation/desactivation of a rules’s group :
9. Add/remove a rule’s package :
10. Add/remove a rule :

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]
Show Cause
Activation cancelled: Rule assignFirstSeat 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

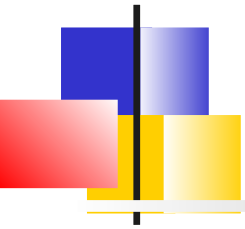

Java - Sample.drl - Eclipse SDK
File Edit Navigate Search Project Run Window Help
com.sample
GoodBye
Hello World
Sample.drl
Generate Rete View
Zoom
Text Editor Rete Tree
Problems Javadoc Declaration
Sample.drl
1 package com.sample
2
3 import com.sample.DroolsTest.Message;
4
5 rule "Hello World"
6 when
7 m : Message(status == Message.HELL
8 then
9 System.out.println(message);
10 m.setMessage("Goodbye cruel world");
11 m.setStatus(Message.GOODBYE);
12 modify(m);
13 end
14
15 rule "GoodBye"
16 no-loop true
17 when
18 m : Message(status == Message.GOOD
19 then
20 System.out.println(message);
21 m.setMessage(message);
22 end
Text Editor Rete Tree
28M of 51M



Rete view legend

- Green: Input point
- Red : *ObjectTypeNode*
- Blue : AlphaNode (Constraint)
- Yellow: Adapter of the left input
- Green : BetaNode
- Black : Rule node

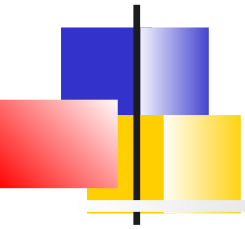
Selection update the properties view



Archetype Maven

An alternative to using the project creation wizard, it is possible to use a Maven archetype:

`org.kie:kie-drools-archetype`



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Main classes

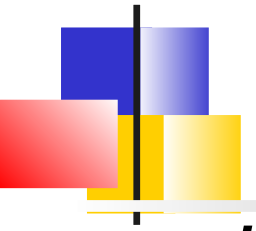
KieServices : Singleton giving access to other Kie services (*Container, Loggers, persistence, Serializer, ...*)

KieModule : The configuration backed by a *kmodule.xml*

KieContainer : The container responsible for locating the knowledge resources defined in a module and to instantiate *KieBase* and *KieSession*

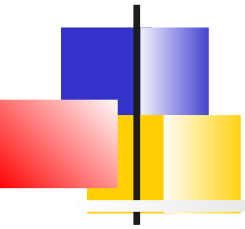
KieBase : A compiled knowledge base

KieSession : API with the working memory.



KieModule

- *KieModule* configure differents *KieBase* et *KieSessions*
- Configuration can be done
  - Via a XML file : *META-INF/kmodule.xml*
  - Or programmatically via *KieModuleModel*



Exemple KieServices

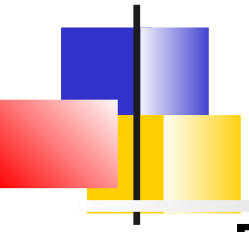
```
// Retreive the singleton KieServices

KieServices kieServices =
  KieServices.Factory.get();

// Instanciate a container which loads ressources

// from classpath

KieContainer container =
  KieServices.getKieClasspathContainer()
```



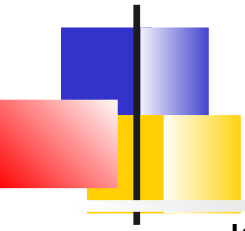
KieContainer

Differents *KieContainer* can be created depending the way to load resources

- From the classpath
- From a maven repository
- From a REST API

From *KieContainer,* we can instantiate :

- *KieBases and KieSessions* defined in the module

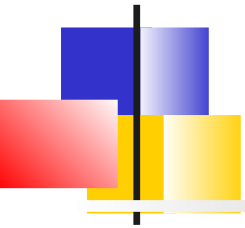


Example

```
KieServices kieServices = KieServices.Factory.get();
KieContainer kContainer = kieServices.getKieClasspathContainer();


// Retrieve kieBase, kieSession from their names
KieBase kBase1 = kContainer.getKieBase("KBase1");
KieSession kieSession1 = kContainer.newKieSession("KSession2_1");

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



ReleaseId

A Kie project is a Maven project

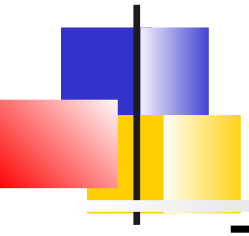
The *groupId*, *artifactId*, and release declared in the *pom.xml* file are used to generate a ***ReleaseId***.

A *KieContainer* can also be constructed with a ReleaseId.

It will load resources from the Maven repository[1]

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

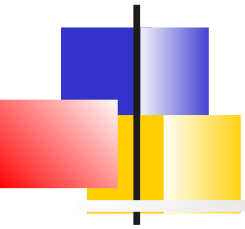

1. By default, the local repository of the user running the Java process



Types of sessions

Two types of Drools session are possible :

- ***stateless*** : *StatelessKieSession which does not use inference*
- ***stateful*** : *KieSession (default)*



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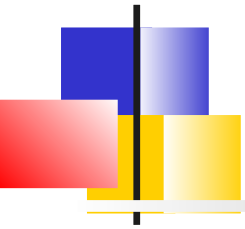


Stateless Knowledge Session

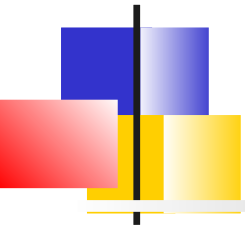
Stateless sessions are the simplest case because they do not use the inference engine.

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

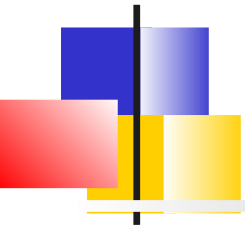
Use cases of stateless sessions :

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

Sample : The domain model (facts)

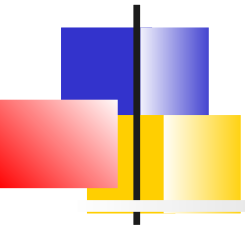


```
public class Applicant {
    private String name;
    private int age;
    // getter and setter methods here
}


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)

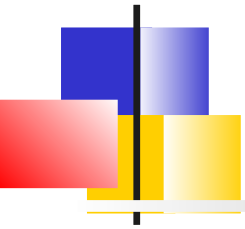
When an instance of an *Applicant* is inserted in the engine, this fact is evaluated against the constraints of the rules.

- 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.

When an inserted instance matches the pattern, the consequence of the rule is executed.

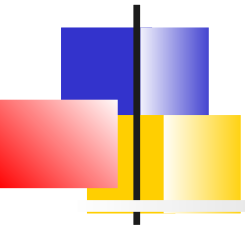
The notation ***$a*** represents a variable to reference the object matched in the consequence. Its properties can be updated in the consequence part.

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



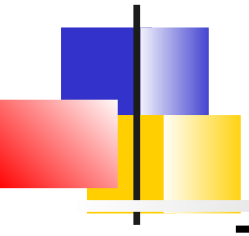
Container’s creation

```
// Get the Singleton

KieServices kieServices = KieServices.Factory.get();

// Load the module from the classpath

// Compile drl files found

// Set the compiled result

KieContainer kContainer =
  kieServices.getKieClasspathContainer();
```



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

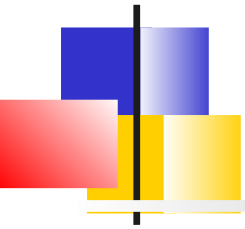
For instance, the second method is equivalent to :

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

BatchExecutor and *CommandFactory*

BatchExecutor are *CommandFactory* are particulary 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" ) );
```



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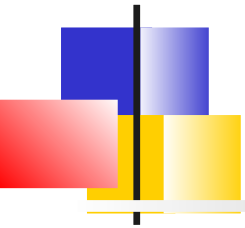
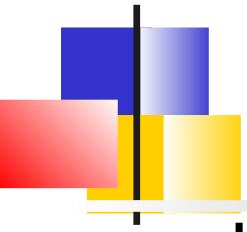


Stateful Session

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

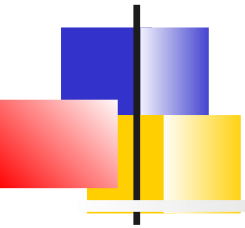
Unlike a Stateless Session, the ***dispose ()*** method must be called to avoid memory leaks (*KieBase* contains references to Stateful Sessions)

A Stateful Knowledge Session is simply called ***KieSession***.

KieSession suppors also the interface *BatchExecutor*

- But, the method ***fireAllRules*** is not triggered automatically.

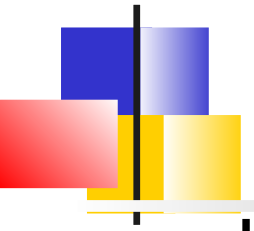
Sample – Domain model



```
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

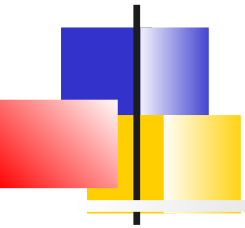
```
rule "When there is a fire turn on the sprinkler"
when
    Fire($room : room)
    $sprinkler : Sprinkler( room == $room, on == false )
then
    modify( $sprinkler ) { setOn( true ) };
    System.out.println( "Turn on the sprinkler for room " + $room.getName() );
end
```



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.

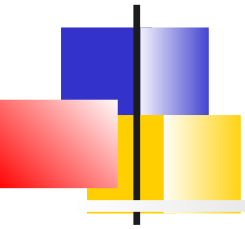
This is called **inference**



not operator

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

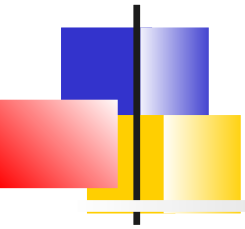
```
rule "When the fire is gone turn off the sprinkler"
when
    $room : Room( )
    $sprinkler : Sprinkler( room == $room, on == true )
    not Fire( room == $room )
then
    modify( $sprinkler ) { setOn( false ) };
    System.out.println( "Turn off the sprinkler for room " +
  $room.getName() );
end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



exists operator

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

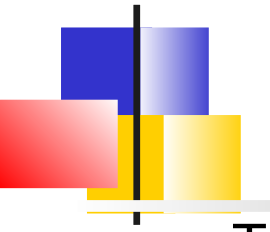
```
rule "Raise the alarm when we have one or more
  fires"
when
    exists Fire()
then
    insert( new Alarm() );
    System.out.println( "Raise the alarm" );
end
```



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
    retract( $alarm );
    System.out.println( "Cancel the alarm" );
end
```

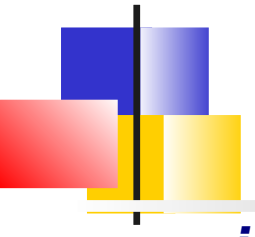


Inference and maintenabilty

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



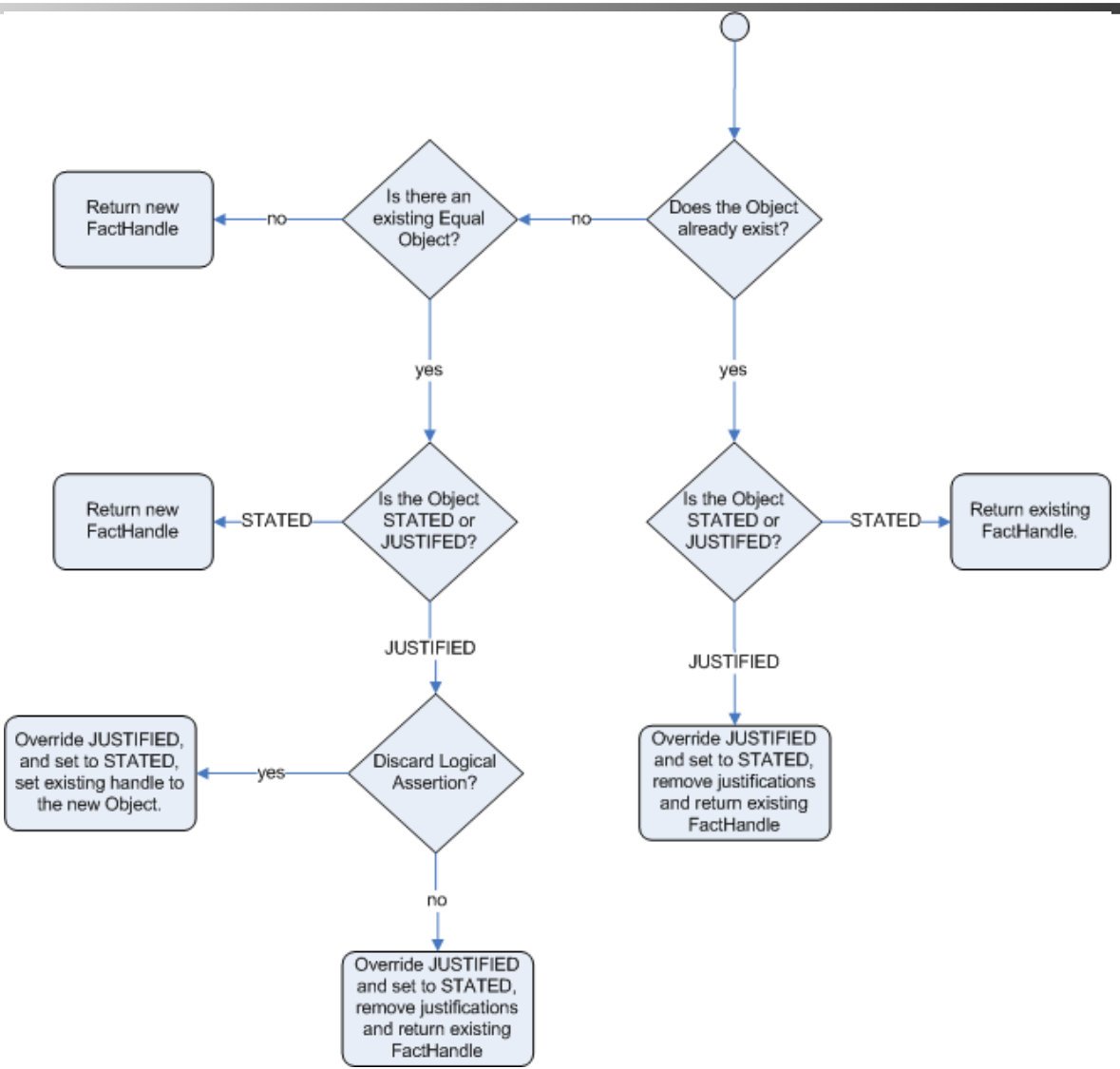
logicalInsert

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

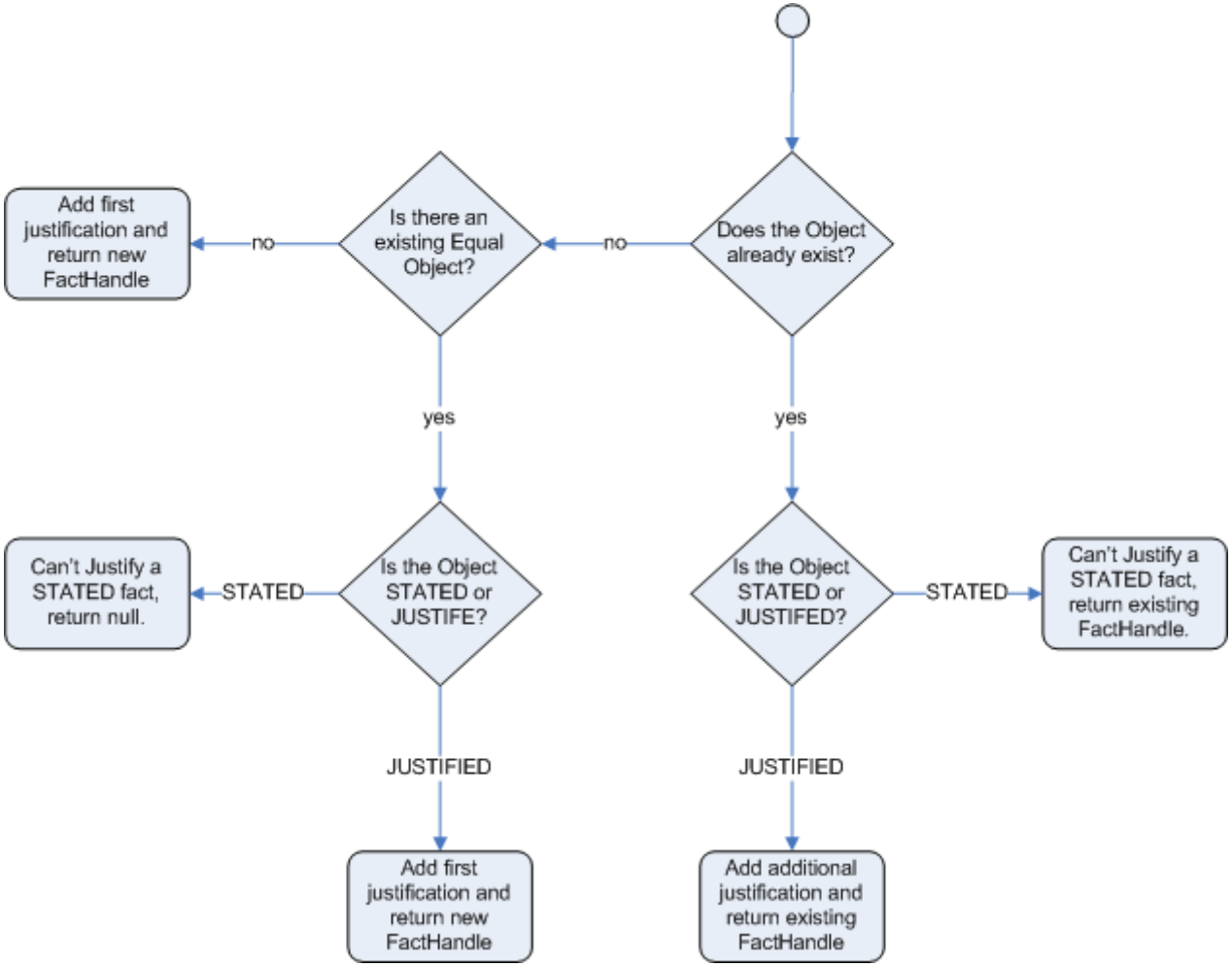
```
rule "Infer Child" when

$p : Person( age < 16 )

then

insertLogical( new IsChild( $p ) )

end
```

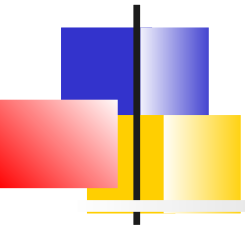
The fact *IsChild ($ p)* is automatically retracted as soon as the person reaches 16

Insertion simple (STATED)



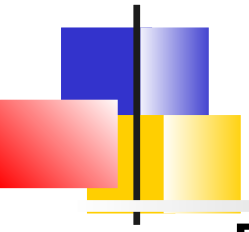
Insertion logique (JUSTIFIED)





Recommendations

- Good practices
  - Separating Knowledge Responsibilities
  - Encapsulate knowledge
  - Provide semantic abstractions for these encapsulations



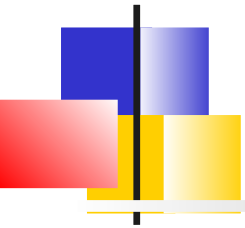
Equality of facts

Determine when 2 facts are the same.

The rule engine handle 2 behaviour :

- ***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">
```

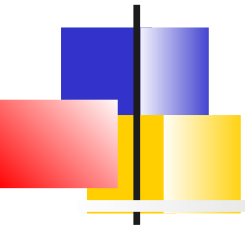


Creation of a stateful session

```
// Compile the drl files found in the classpath
// Set the result in the container
KieServices kieServices = KieServices.Factory.get();
KieContainer kContainer = kieServices.getKieClasspathContainer();
// Creation of the stateful session
KieSession ksession = kContainer.newKieSession();
```

Execution

```
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
```



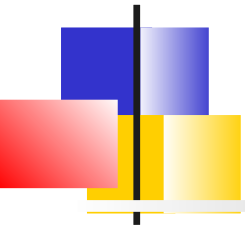
FactHandle

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

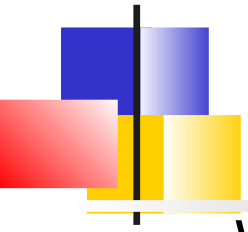
Methods versus Rules

Methods :

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

Rules :

- 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+)**

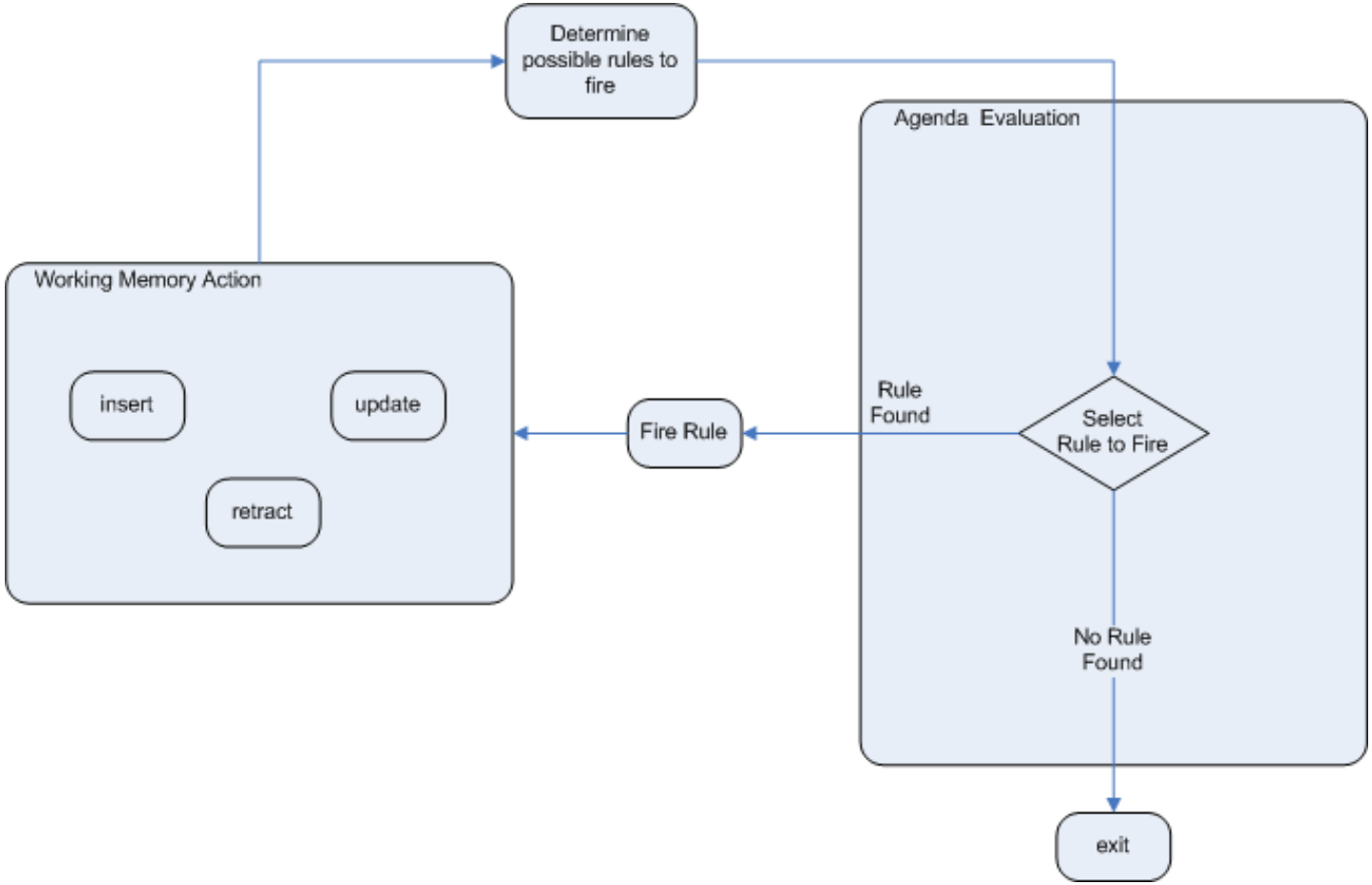
When calling *fireAllRules(),* the rules are evaluated independently of each other

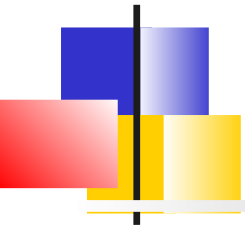
The agenda chooses the first rule based on the active *activation group* and the *salience* attributes of the rule. If 2 rules have the same precedence, the declaration's order is taken in account

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



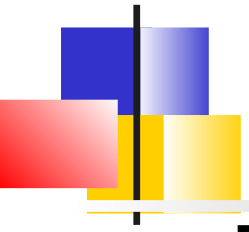


Agenda groups

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

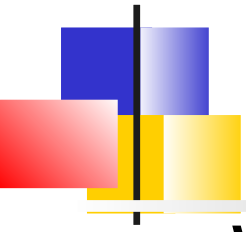
When all the rules have been executed, the agenda pops aother group from the stack.



Execution model

Drools supports 2 rule execution modes :

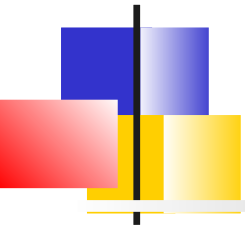
- **Passive mode (default)** : Rules are triggered by ***fireAllRules()***
- **Active mode** : When ***fireUntilHalt()*** is called. Drools continuously evaluates rules until the ***halt()*** method is called. Application which reacts to facts insertion events, or when timers are configured



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

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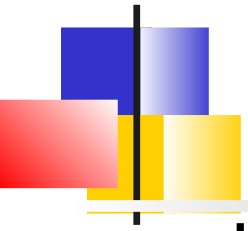


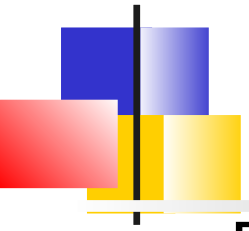
Event Model

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***
- And ***ProcessEventListener*** (for *jBPM*).



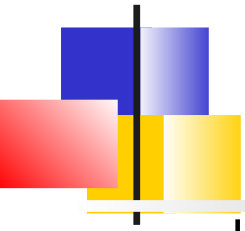
Debug listeners

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(ksessio
  n, "logdir/mylogfile");

...

logger.close();
```

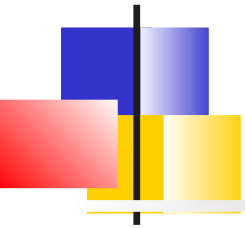


Example

```
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

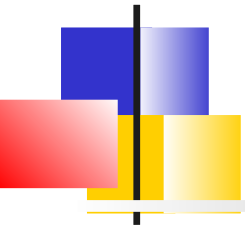
A **channel** is a standardized way to transmit data from within a session to the external world.

- 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



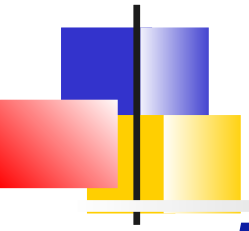
Registration

Channels must be registered :

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

Then can be used in rules :

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



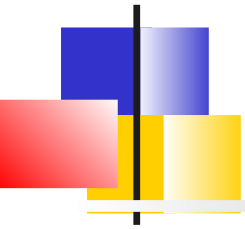
Entry points

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());
```



Rule syntax : DRL

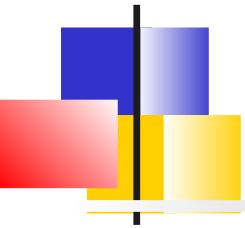
Main elements

Rule’s attributes

LHS

RHS

Query, aggregation



.drl files

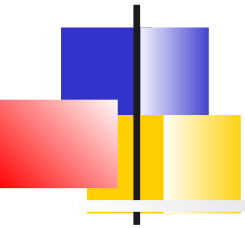
A rules file is a simple text file with the extension ***.drl***

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

Keyword :

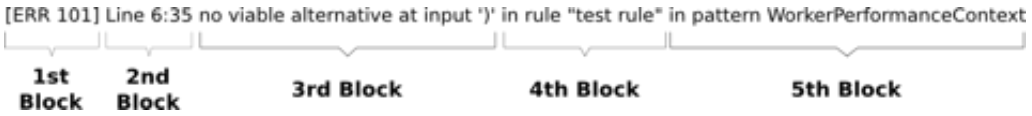
- Hard (*true*, *false*, *accumulate*, *collect*, *from*, *null*, *over*, *then*, *when*). Can not be used as variable
- Soft : only recognized in their context (*package*, *import*, *attributes*, *rule*, ...)

The escape character is ` (backquote) :
Holiday(`when` == "july")

Comments :

- line : **#** ou **//**
- multi-lines : **/* .... */**

Error message



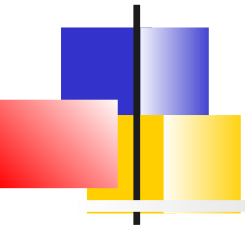
1st block : **Error code**

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.

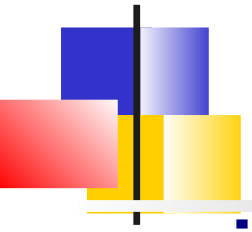


Package

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.



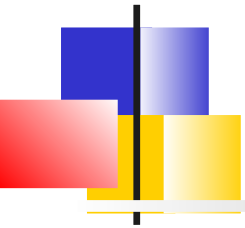
Import

import instructions are similar to java *imports*

The full name of the Java types must be specified.

Drools automatically imports :

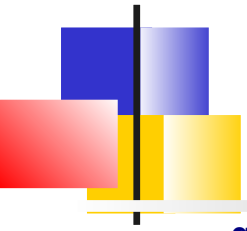
- the Java classes belonging to the package of the same name
- the package *java.lang*.



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

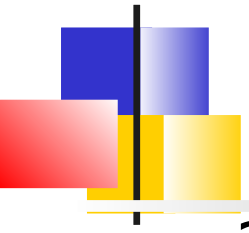
```
global java.util.List myGlobalList;

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.

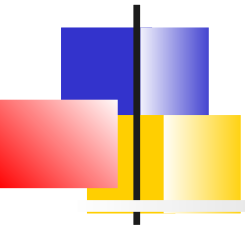
```
function String hello(String name) {
  return "Hello "+name+"!";
}


rule "using a static function"
when
  eval( true )
then
  System.out.println( hello( "Bob" ) );
end
```



Declarations

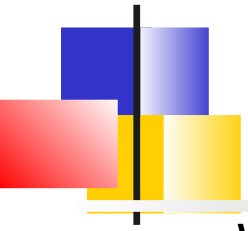
2 kinds of declarations :

- 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

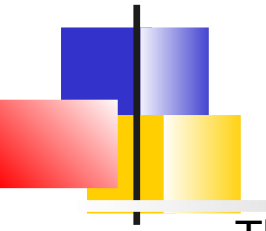
```
declare Address
    number : int
    streetName : String
    city : String
end

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

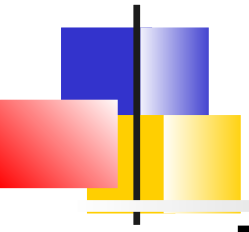
The character **@** is used

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
```

On a existing type

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



Usage of meta-data

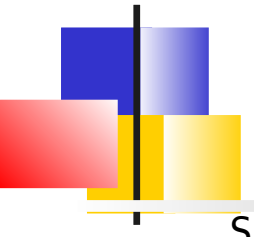
Drools allows the declaration of arbitrary meta-data.

Metadata can be used by queries.

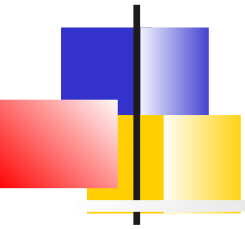
Some meta-data are predefined and have a meaning for the engine. They are especially useful for *Drools-CEP*:

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

Example



```
StatefulKnowledgeSession ksession= createKSession();
// Filtering rules
ksession.fireAllRules(new AgendaFilter() {
  public boolean accept(Activation activation) {
    Map<String, Object> metaData = activation.getRule().getMetaData();
    if (metaData.containsKey("LegalRequirement")) {
      System.out.println(metaData.get("LegalRequirement"));
      return true ;
    }
    return false;
  }
});
```



Rule syntax : DRL

Main elements

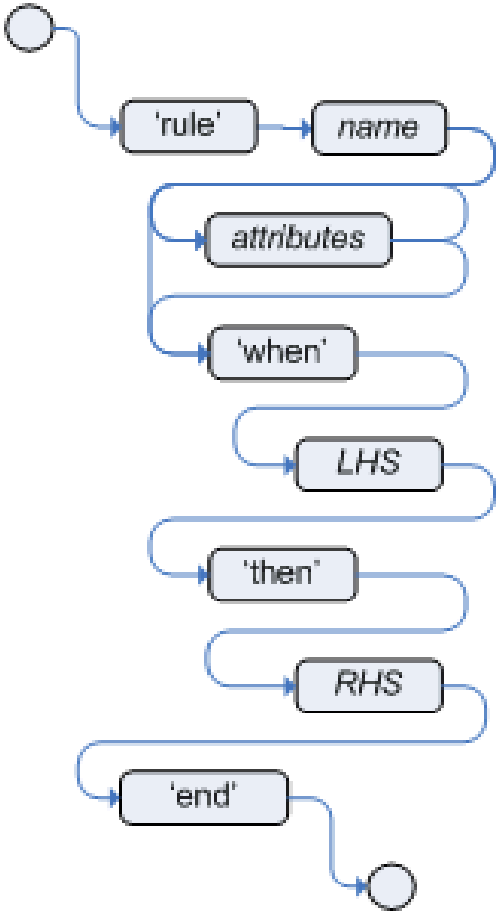
Rule’s attributes

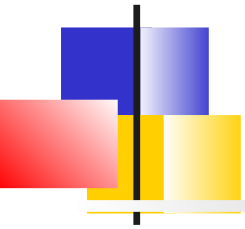
LHS

RHS

Query, aggregation

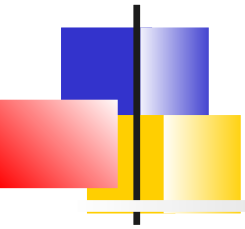
Rule





Rule, syntax

- 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 (Left Hand Side) or condition follows the keyword ***when***
- The Right Hand Side or Consequence follows the keyword ***then***
- The rule ends with the keyword ***end.***
- Rules can not be nested.

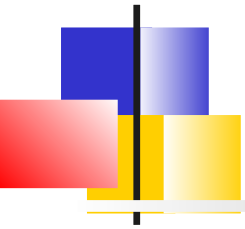


Attributes

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 integer 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)
groups

agenda-group (String, MAIN): This attribute allows you 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.

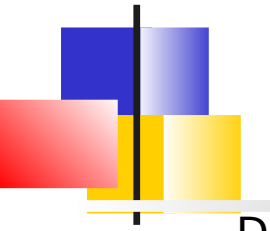
Attributes (3)

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)

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

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



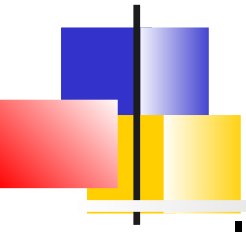
Timer

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

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

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

Example

```
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()

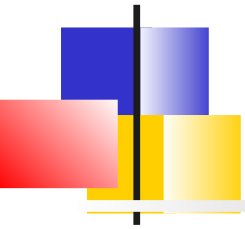
In order for rules using timers to be triggered, the engine must be active.

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

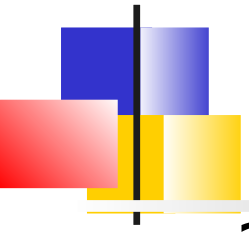
- If no condition element, the LHS is set to *true* and will be activated when the working memory is created
- Conditional elements consist of *patterns* that are implicitly connected by ***and***

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 ()
- **Group ‘s constraints**
  - Concern SEVERAL attributes of the same fact
  - Combined with '**,**' (which means && with a lower precedence)

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

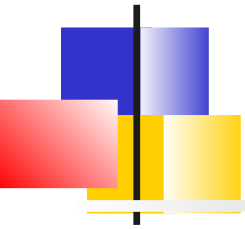
The value of the field can be *String*, *numeric*, *date* (format "*dd-mmm-yyyy*" by default), *boolean* or *Enum*

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 (expr. régulière), 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

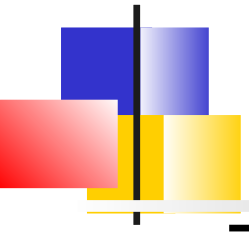
Operators *in* and *not in*, allow to specify multiple values separated by ","

```
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" )
```



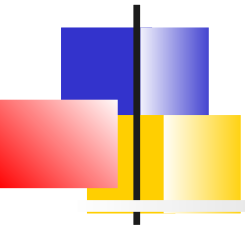
Group’s constraint

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

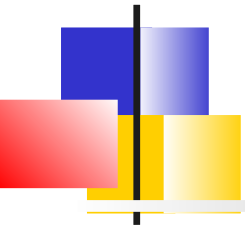
accumulate: Allows you to perform an aggregate function on a collection of objects

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

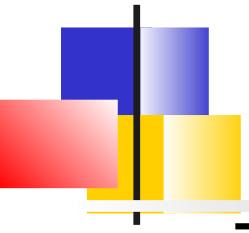
```
# Build a mothers list
# Any woman with a child
$mothers : LinkedList()
from collect( Person( gender == 'F', children > 0 ) )

# 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

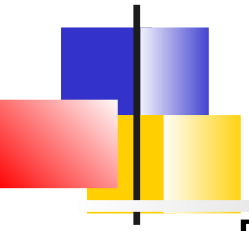


The right part contains a list of actions to perform.

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
- Update 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>)***

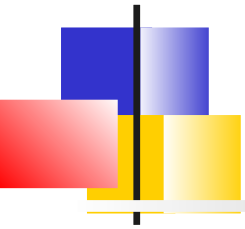
  Used to update a field

```
$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.

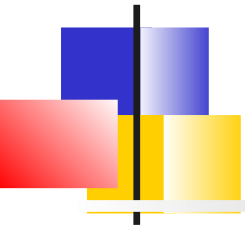
```
LoanApplication.setAmount( 100 );
update( LoanApplication );
```

- **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() );
```

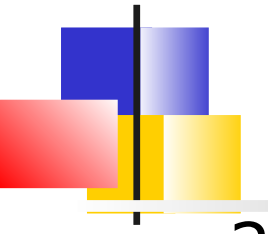


Macro-methods (3)

- **delete : delete(<object>)**

  Used to remove an object from working memory. The retract keyword is also supported

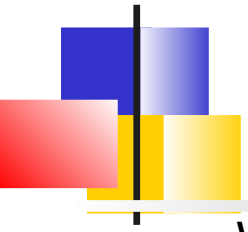
  ```
  delete( Applicant )
  ```



Contexte variables

2 context variables can be used in the RHS :

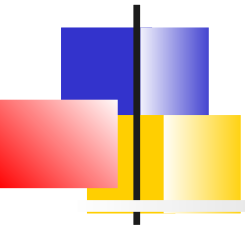
- ***drools*** (*RuleContext*) expose
  - useful methods to retreive information about the rule
    - ***drools.getRule().getName()***: The name of the activated rule
    - ***drools.getMatch()*** : Information on why the rule was activated
  - ***drools.getKieRuntime()*** : Retrieves a KieRuntime reference
- ***kcontext*** is also available and it can retreive a reference of *KieRuntime*



KieRuntime API

With a KieRuntime reference,

- ***halt() :*** Stop the engine in active mode
- ***getAgenda()*** retourne une référence sur l'agenda de la session
  Ex : *getAgenda().getAgendaGroup("CleanUp").setFocus();*
- ***getQueryResults(String query)*** returns the result of a queries
- ***addEventListener, removeEventListener*** : 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
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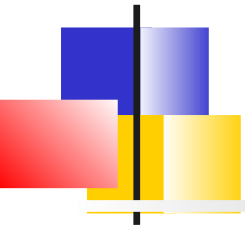
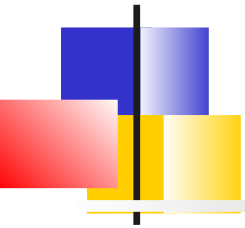
LHS
RHS
Query, agregation



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

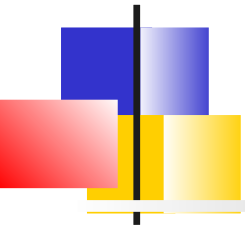
A query can search for facts in the knowledge base

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
```



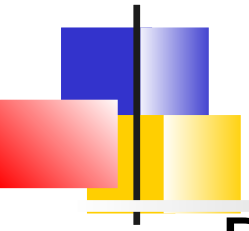
Query on demand

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" );
}
```

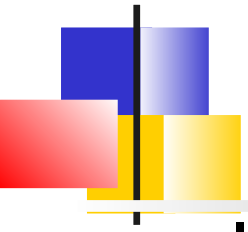


Live queries

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);
```

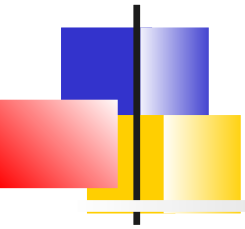


Interface *ViewChangedListener*

Interface ***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

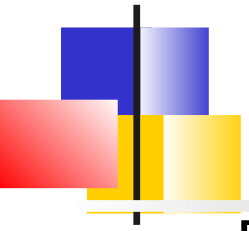


Other ways to express rules

Decision tables

Rule’s templates

DMN



Presentation

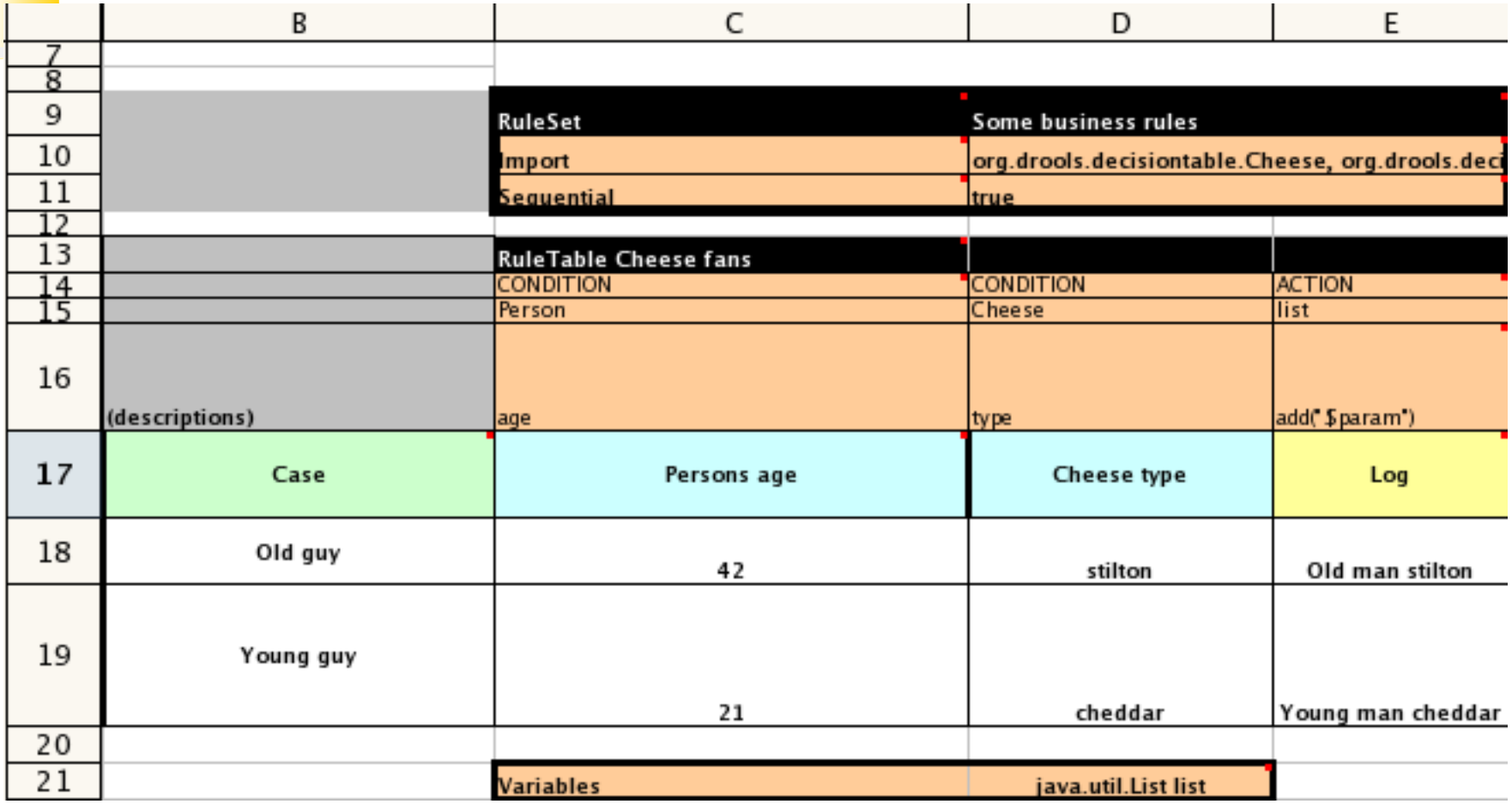
Decision tables are an efficient and compact way to represent conditional logic, they are tailored to business experts

The data entered in a spreadsheet makes it possible to generate the rules.
=> the business expert then benefits from his favorite tool: Excel

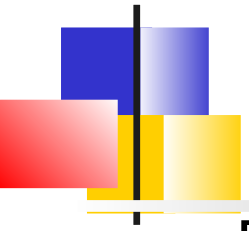
For each line of the decision table, the data is combined with a template to generate a rule.

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.

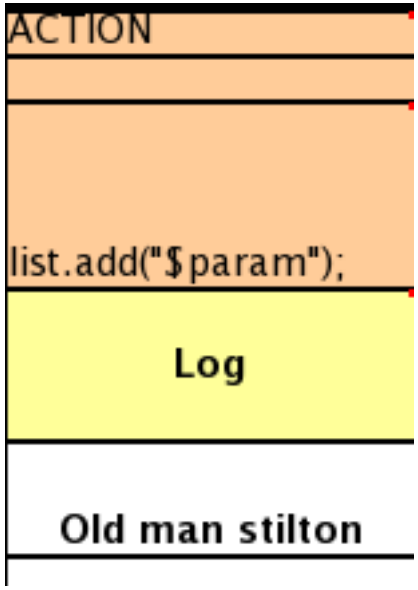
If the cell contains just one attribute, the constraint will be an equality constraint, otherwise the cell will include an operator.

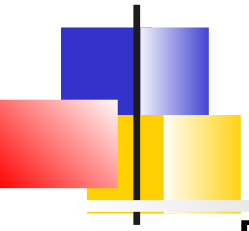
13	RuleTable Cheese fans	
14	CONDITION	CONDITION
15	Person	
16	age	type
17	Persons age	Cheese type
18	42	stilton

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

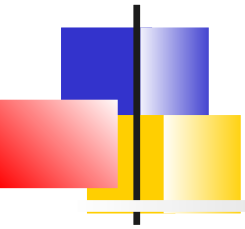
Before the keyword *RuleTable*, the following keywords may be present and condition their cell immediately to the right:

- ***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

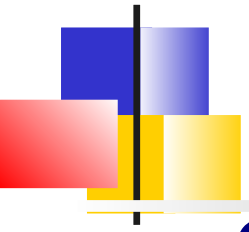
Functions	function boolean isRango(int iValor, int iRangoInicio, int iRangoFinal) {
	if (iRangoInicio <= iValor && iValor <= iRangoFinal)
	return true;
	return false;
	}
	
	function boolean isIgualTipo(TipoVO tipoVO, int p_tipo, boolean isNull) {
	if (tipoVO == null)
	return isNull;
	return tipoVO.getSecuencia().intValue()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

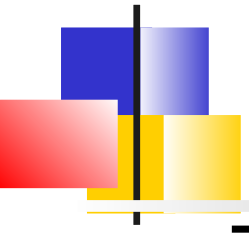
NAME : The name of the rule (optional)

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

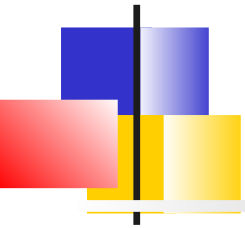


Integration

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



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

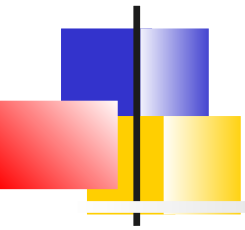
4. The decision table is taken over by a technician who maps the business language to scripts

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 technician can write test cases that check the rules

Lab4.1 : Decision table

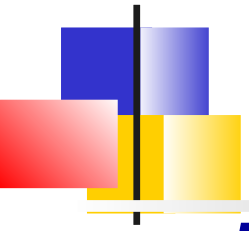


Other ways to express rules

Decision tables

Rule’s templates

DMN



Rules template

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

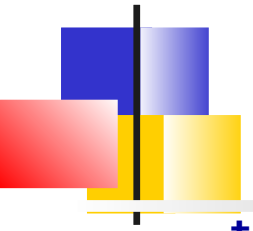
This is a technique that is ultimately more powerful than the decision tables:

- 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

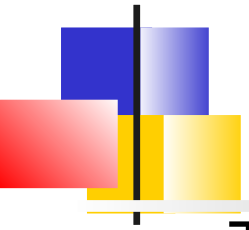
The text file

- starts with a template header header.
- Then the 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.



Exemple

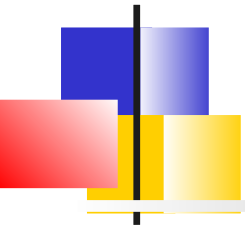
```
template header
age
type
Log

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

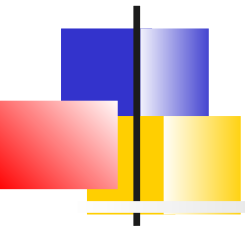
The template must then be included with the associated data file in the *kmodule* definition

```
<?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>
```



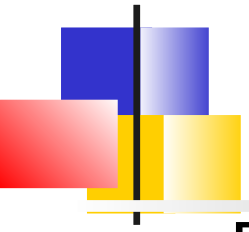
Sample with database

```
// 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
- ***Technical Developers*** : They can create complex decision logic and automate the decisions;
- ***Business Stakeholders*** : They can manage and monitor the decisions.

Main components

Decisions determine an output value depending on:

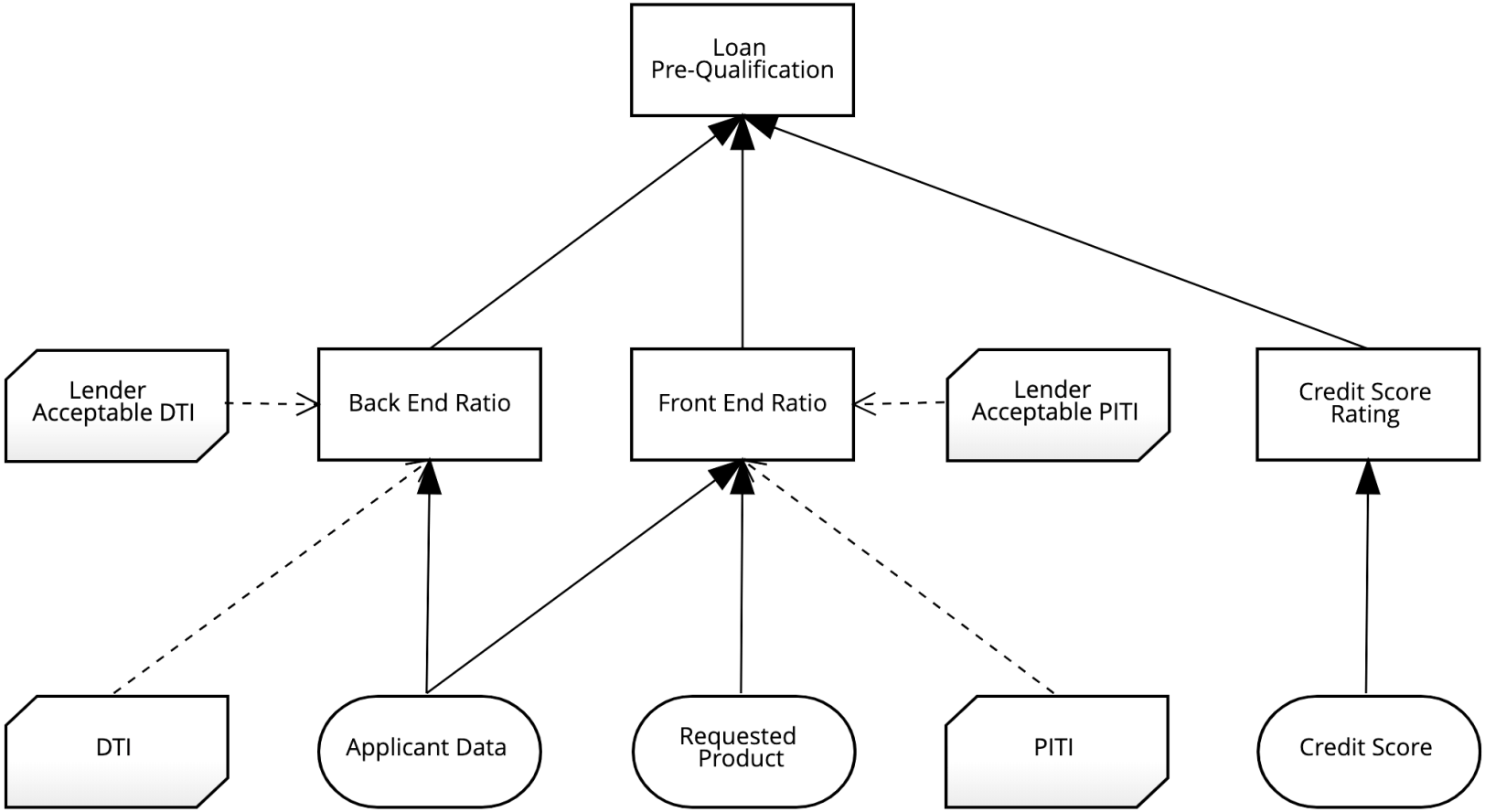
- their input data (input nodes or the output value from other decisions)
- their decision logic - boxed expressions that may reference functions from BKM nodes

Input data : input for one or more decisions. When enclosed within a Business Knowledge Model (BKM), they indicate parameters for the BKM node.

BKMs encapsulate business knowledge as reusable functions.

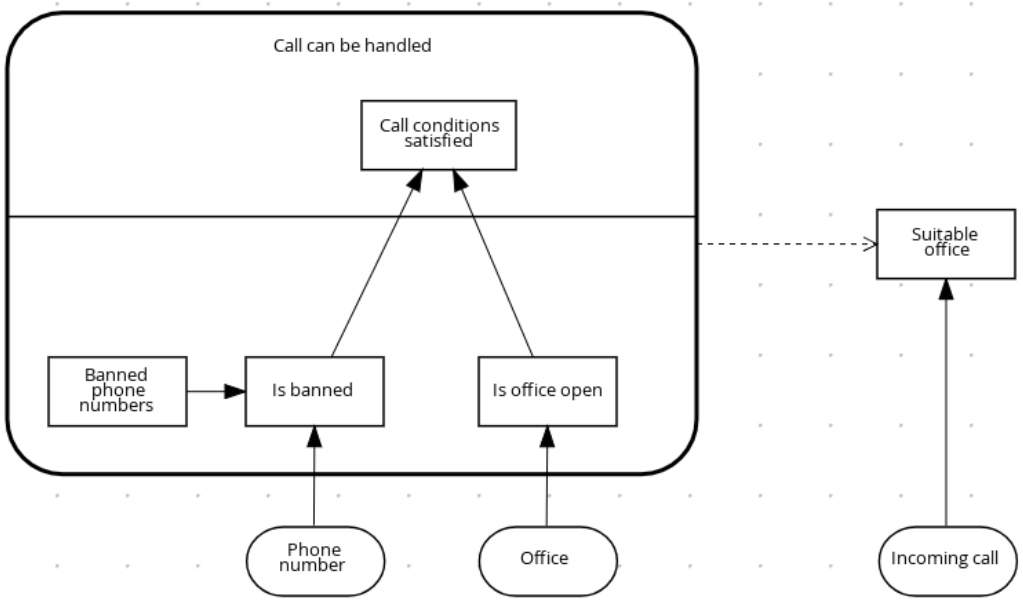
A **knowledge source** denotes an authority for a BKM or a decision node.

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

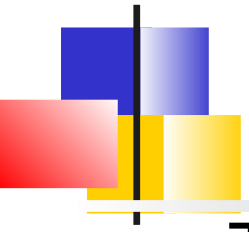
Decision service

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.



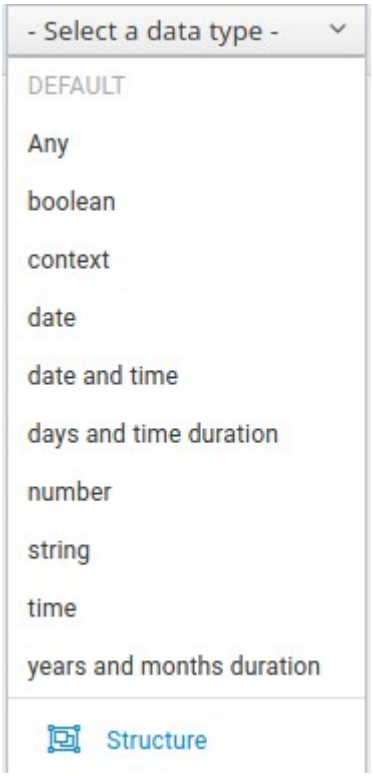
FEEL

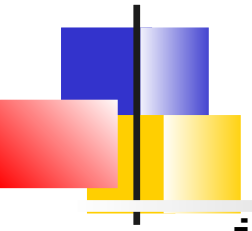
The ***FEEL*** (*Friendly Enough Expression Language*) is intended as a common ground between business analysts, programmers, domain experts and stakeholders.

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)

Data Types


- Select a data type -
DEFAULT
Any
boolean
context
date
date and time
days and time duration
number
string
time
years and months duration
Structure



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)

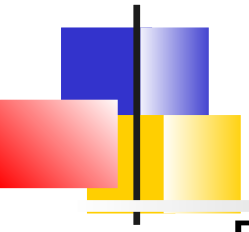
```
every i in [1, 2, 3] satisfies i > 1   //→ false
```

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
```



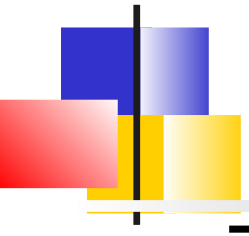
DMN support in Drools

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.



DMN model execution

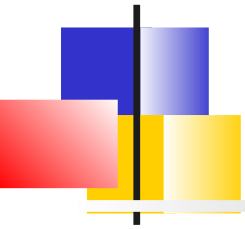
The model execution differs if you use embedeed packaging or remote external service (Kogito)

Embeded, Get the runtime and the model

```
// 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

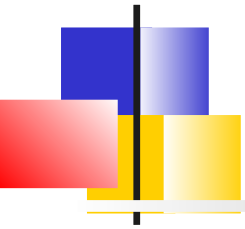
```
// Instantiate a new DMN Context to be the input for the model evaluation
DMNContext dmnContext = dmnRuntime.newContext();

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

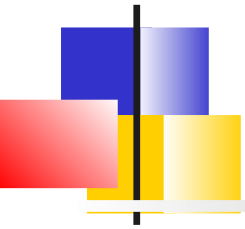


Introduction

Complex event processing (CEP) allow to make decisions based on time 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

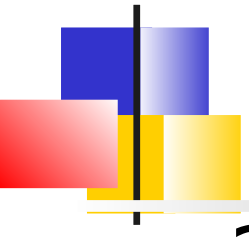
Reasonning is made on **events** which are facts with a time of occurrence



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



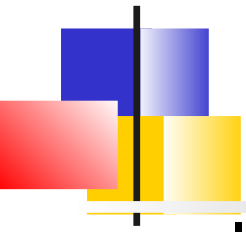
Semantic of events

2 kinds of events are considered :

- **Punctual** event
- **Interval** event

All events are :

- Immutable
- A managed life cycle : when it is too old, it is removed from the session



Declaring time-based-events

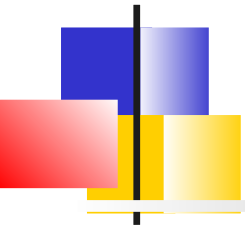
In order to create the CEP rules, we must inform the engine which types of objects must be treated as events

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

Sample

```
@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 */
}
```



Sample (2)

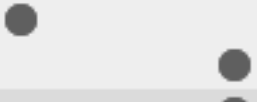
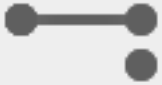
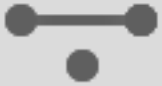
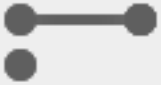
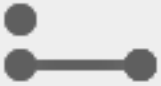
```
declare PhoneCallEvent
  @role(event)
  @timestamp(whenDidWeReceiveTheCall)
  @duration(howLongWasTheCall)
  @expires(2h30m)
  whenDidWeReceiveTheCall: Date
  howLongWasTheCall: Long
  callInfo: String
end
```

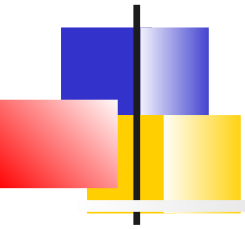
Temporal operators

There are 13 temporal operators available which allow to correlate events

For example :

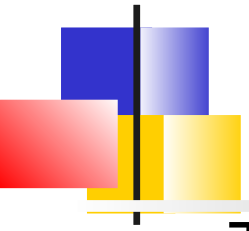
```
declare MyEvent
@role(event)
@timestamp(executionTime)
End

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 B			
A after B	A B			
A coincides B	A B			
A overlaps B	A B			
A finishes B	A B			
A includes B	A B			
A starts B	A B			
A finishedby B	A B			
A startedby B	A B			
A during B	A B			
A meets B	A B			
A metby B	A B			
A overlappedby B	A B			



Another 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
```

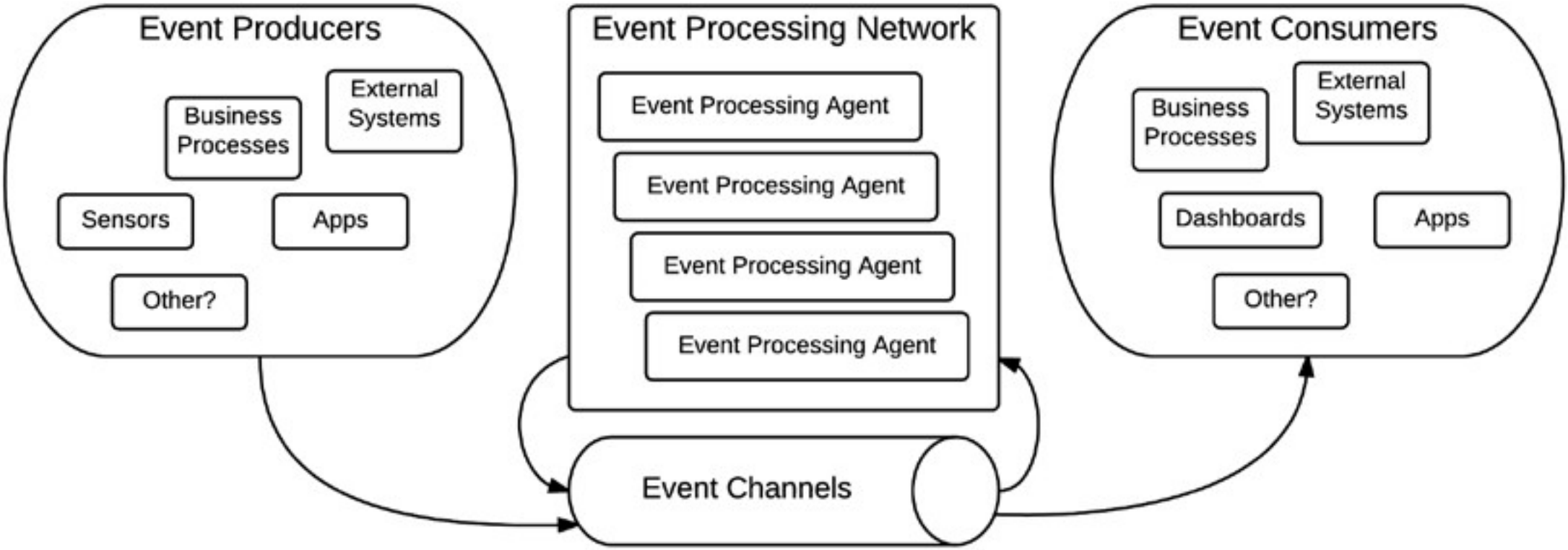


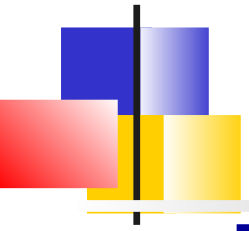
Event-driven architecture

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

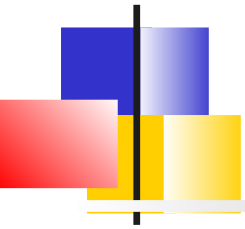
Entry points are a way to partition the working memory

Rules can express conditions about events from one particular source

Entry points are declared implicitly by using them in rules

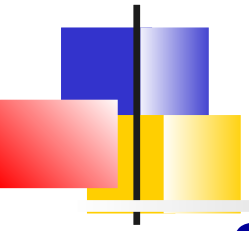
At insertion, the entry point can be specified :

```
ksession.getEntryPoint("myEentryPoint").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

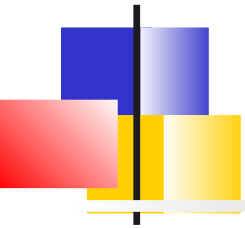
Sliding windows allow to filter the events of the working memory or any entry point

2 kinds of sliding windows :

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

Sliding windows can be defined

- inside a rule
- or outside for reuse



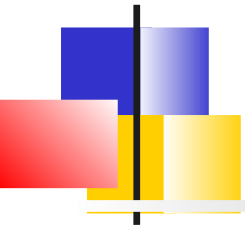
Length-based sample

```
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
```

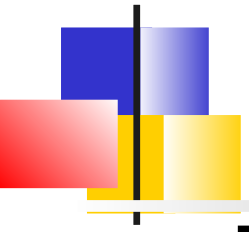
Time-based sample

```
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

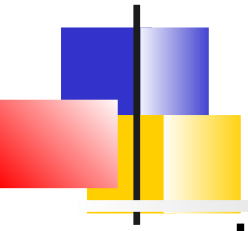


```
declare window Beats
  @doc("last 10 seconds heart beats")
  HeartBeat() over window:time( 10s )
    from entry-point "heart beat monitor"
end

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>
```

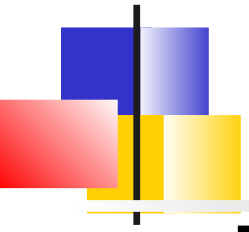
Discrete vs Continous

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

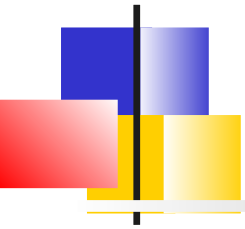


Session clock

By default, Kie Sessions will use the clock of the machine on which is running

For testing scenarios, we can use pseu-clock

For complex distributed scenarios, we can configured in synchronized clock



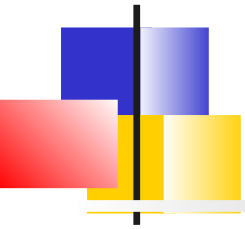
Pseudo-clock sample

Configuration :

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

Usage in test case for example :

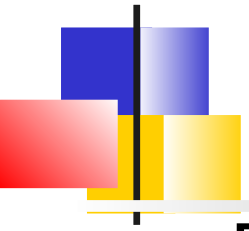
```
SessionPseudoClock clock = ksession.
getSessionClock();
clock.advanceTime(2, TimeUnit.HOURS);
clock.advanceTime(5, TimeUnit.MINUTES);
```



Related Projects

Complex Event Processing

Drools and jBPM

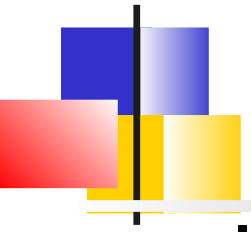


Introduction

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

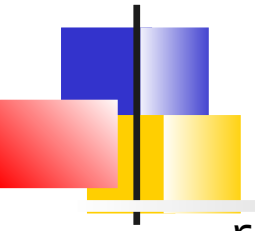


Accessing processes from rules

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

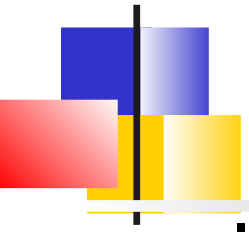
With this object reference, it is possible to :

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



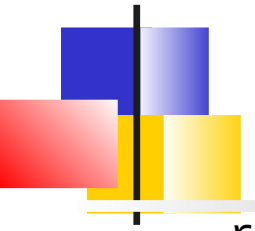
Sample

```
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
```



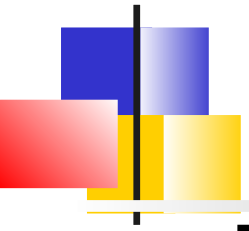
Process instances as facts

- 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



Sample

```
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
```



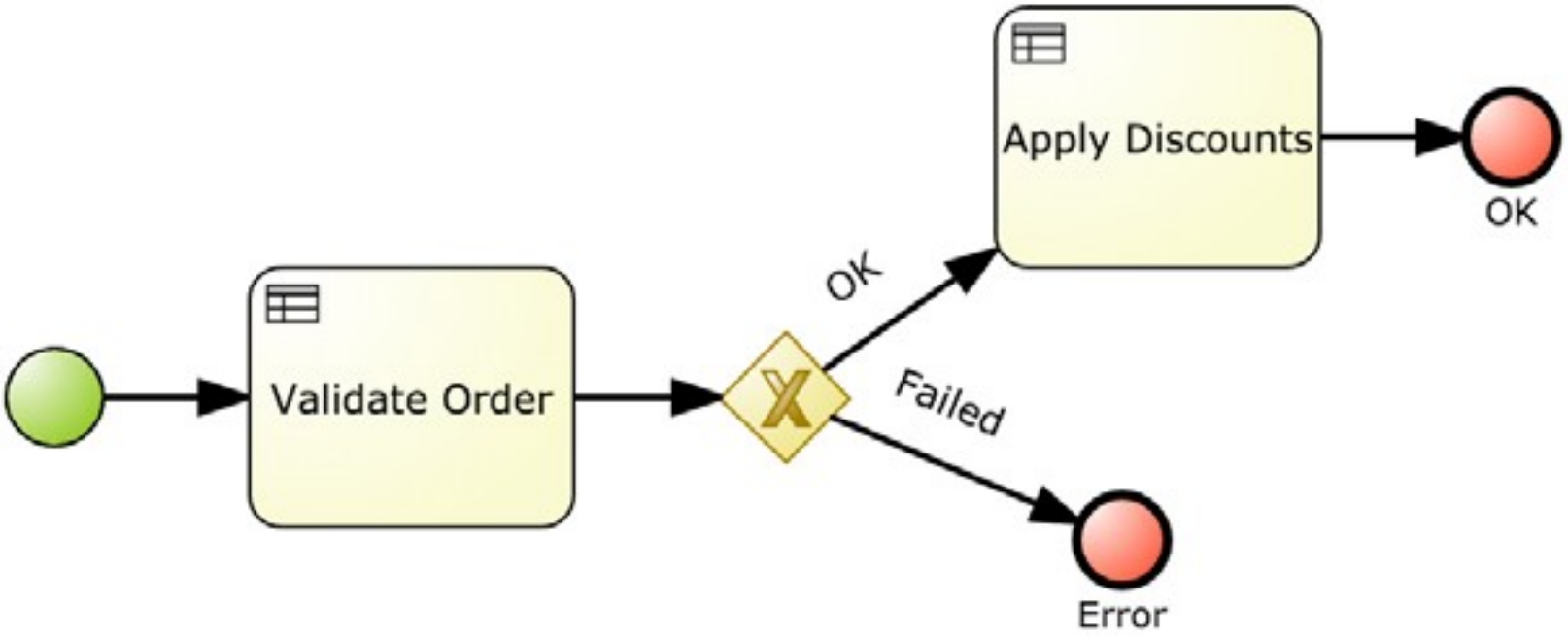
BPMN2 Business Rule Tasks

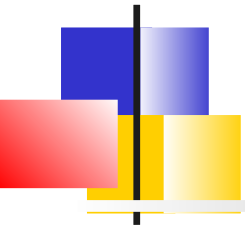
BPMN2 specification proposes a specific type of task called a ***Business Rule Task***.

It is used in conjunction with the Rule Property called ***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

Sample





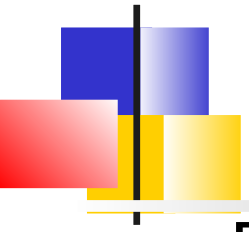
Integrate Kie

Considerations

Patterns of integration

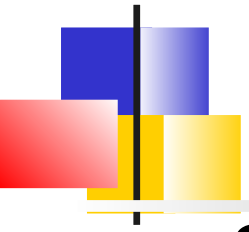
Maven knowledge repositories

Externalizing knowledge services



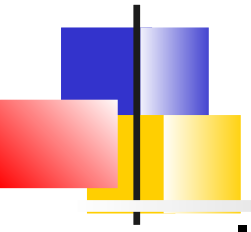
Drools Usage

- 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

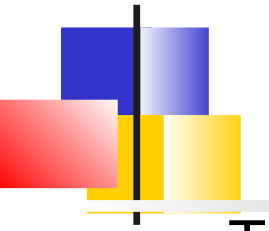
- Some mechanisms to communicate between Drools and the rest of the application :
  - Global variables may contain domain objects
  - Entry points : Stream of facts and event
  - Channels to send information to the outside world
  - Listeners or marshallers



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



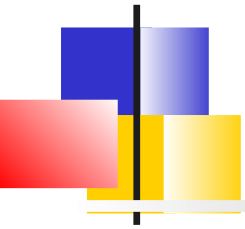
Asynchronous

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 motor 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



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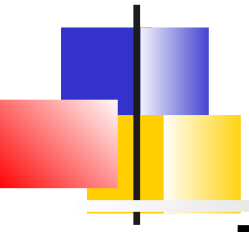


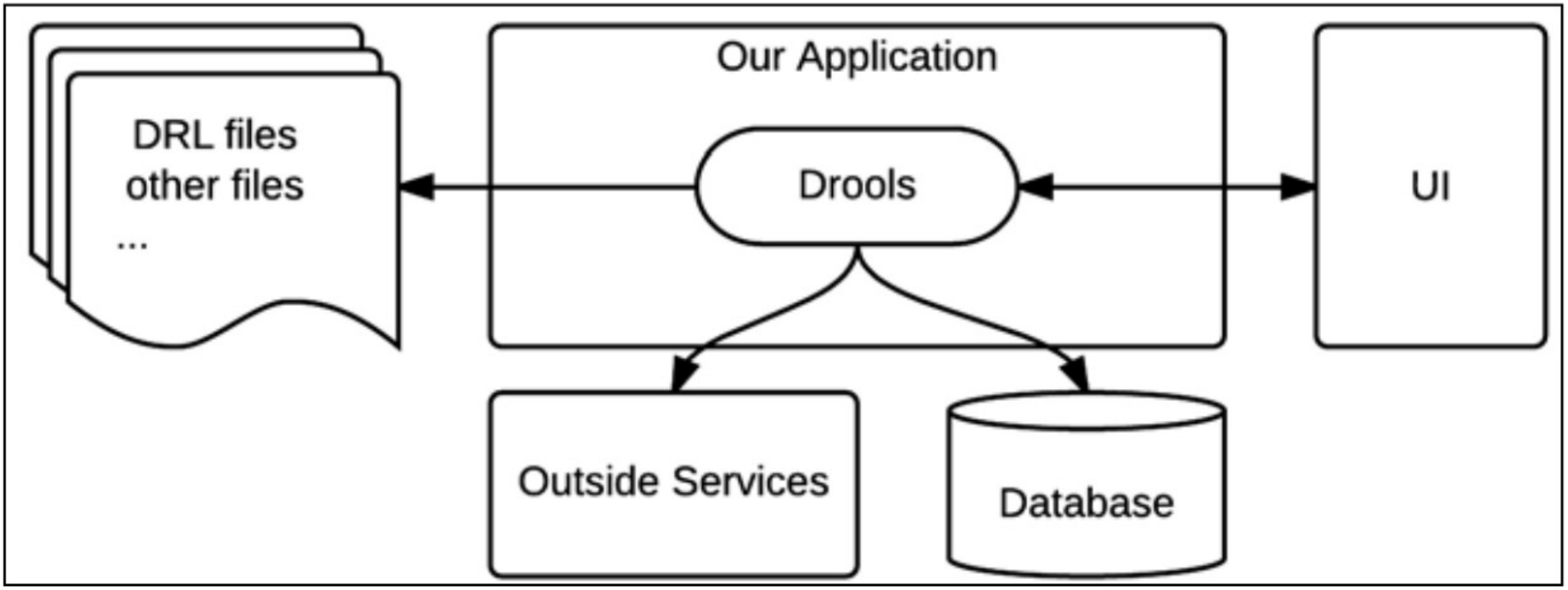
Scenarios of integration

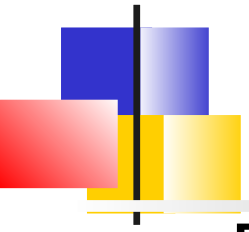
Different ways of integration can be considered :

- Embed Drools runtime in your application
- Externalize rules in a separate repository
- Knowledge as a service

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

Architecture





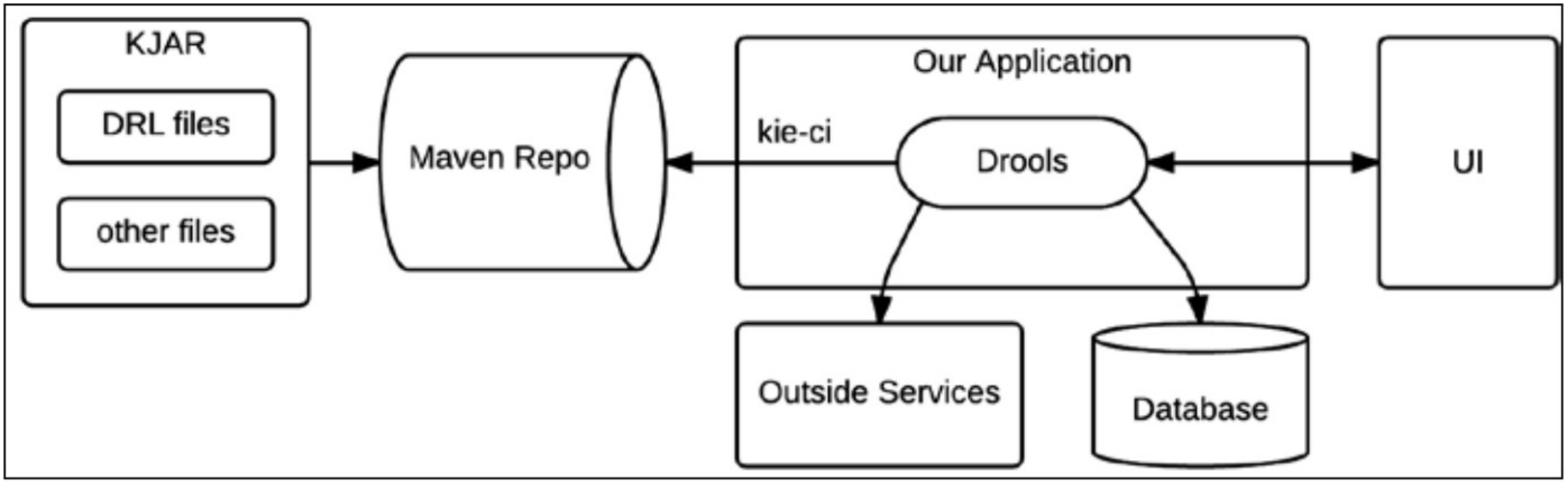
Distinct Maven Repository

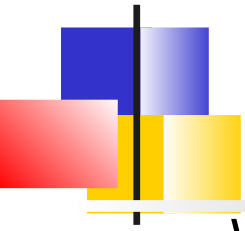
Rules can be deployed independently from client application by using a Maven repository :

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

=> The rules can be developed, deployed, and managed as many times as needed without having to redeploy the applications.

Architecture





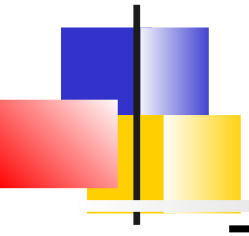
Loading the rules

With CDI

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

With a scanner

```
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();
```

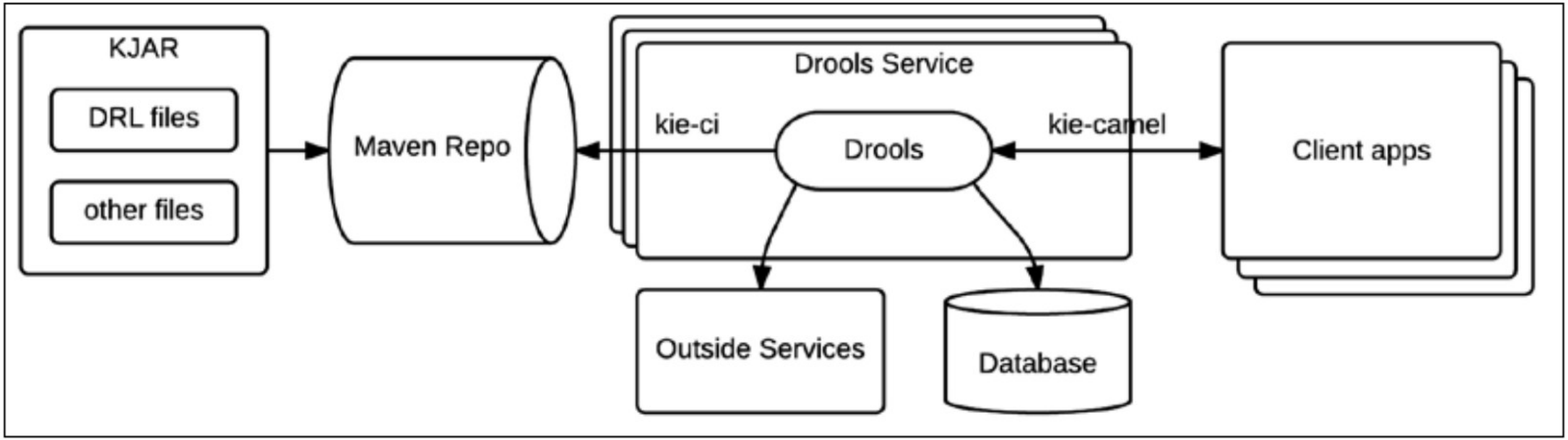


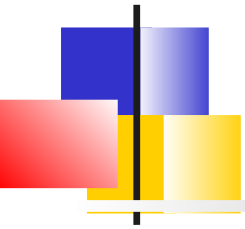
Knowledge as a service

The last approach is to externalize the Drools runtime in an external services.

- This service expose une API (REST or other)
- Multiple-applications can access the service
- The service may be replicated if needed
- Life cycle of rules are completely independent

Architecture





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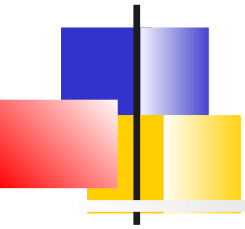
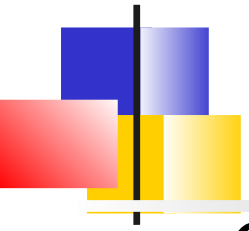


Maven knowledge repositories

Building a kjar

Business resources update



Introduction

One of the primary goals when using a rule/process engine is to decorrelate the business rules/processes from the application that uses it.

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

Applications can then:

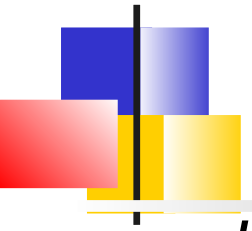
- Either declare a Maven dependency to the artifact of containing the business resources
- The Maven repository can be local or remote

Building *kjar* with Maven

A "Kie resources" project is typically 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 *resources* directory of jar
- A stateful session and a stateless session

Another *kmodule.xml*

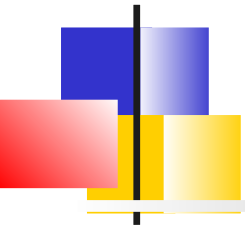
```
<kmodule xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance " xmlns="http://jboss.org/kie/6.0.0/kmodule">
  <kbase name="KBase1" default="true" eventProcessingMode="cloud" equalsBehavior="equality">
    <ksession name="KSession2_1" type="stateful" default="true/">
    <ksession name="KSession2_1" 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	défaut	autorisé	description
name	none		Mandatory. Used to retreive the base from the container
includes	none	Liste d'item séparés par des virgules	Knowledge bases to include
packages	all	Liste d'item séparés par des virgules	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		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

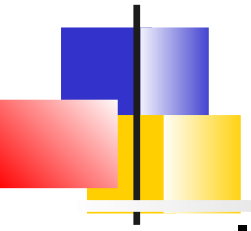


Elements of *ksession*

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

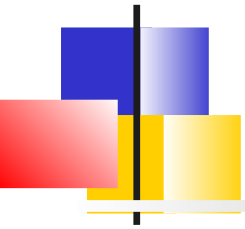
- A **logger** is used to define a trace file that will record all Drools events in a file
- **WorkItemHandlers** allows you to define task managers that are associated with specific Drools-flow nodes (ex: Human task)
- **Event listeners**: *ruleRuntimeEventListener*, *agendaEventListener*, or *processEventListener*

Maven and Release ID



If the KIE project is a Maven project, it is possible to use the Maven coordinates to instantiate the container.

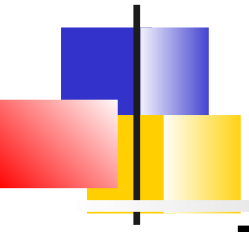
```
KieServices kieServices = KieServices.Factory.get();
ReleaseId releaseId = kieServices.newReleaseId( "org.acme", "project", "1.0" );
KieContainer kieContainer = kieServices.newKieContainer( releaseId ) ;

KieSession kSession = kContainer.newKieSession("ksession1");
```



Maven knowledge repositories

Building a kjar

Business resources update



Deploymenent

Deployment consist of updating a Maven repository.

The client application can then :

- Be manually updated to use a new version of the *kjar*
- Be dependent of the latest version
- Be dependent of a family of version

KieScanner

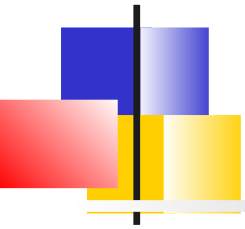
KieScanner allows to constantly scan the Maven repository to check if a new release of the project is available

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 );
```



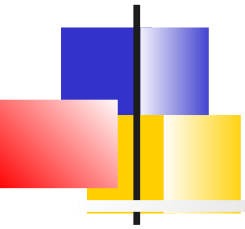
Upgrade

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 project.



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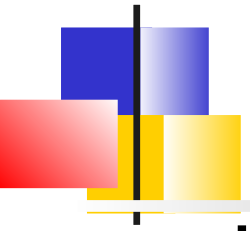
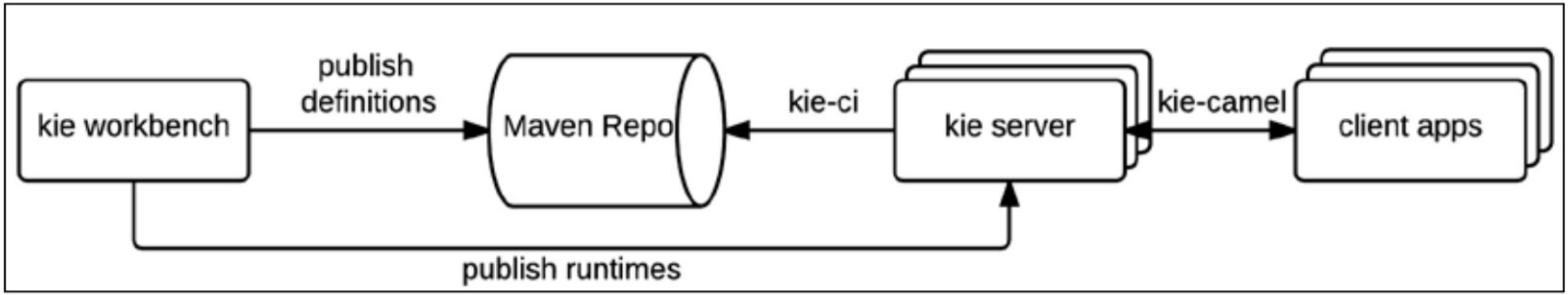


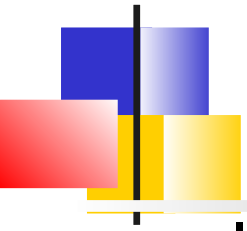
Introduction

KIE provides a module called ***kie-server*** , which can be used to configure similar environments that are only responsible for running Drools rules and processes, taking the kJAR from outside sources

It provides also ***kie-workbench*** which can manage rules and processes : edit, build deploy

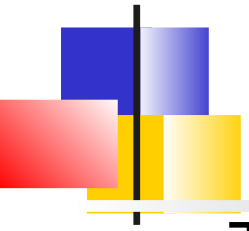
Architecture





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

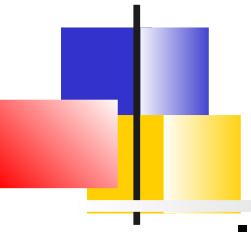
The REST API is available at : http://localhost:8080/kie-server/services/rest/server/

A swagger documentation is avaiable

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

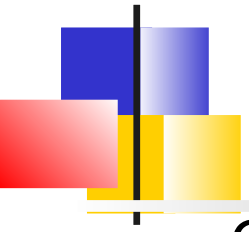
Sample Response

```
<?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

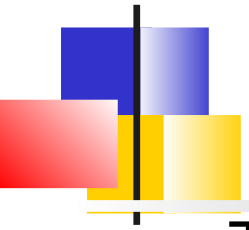
- Interaction with the kie-server can be performed by any REST client (curl, postman, Spring restTemplate, ...)
- But KIE offers a native rest client suited for this kind of interaction. It is available with the org.kie:kie-server-client dependency



Client request configuration

Configuration of the client includes :

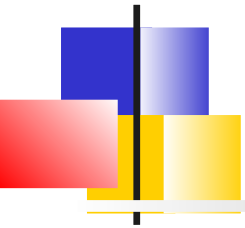
- Credentials of the kie-server user
- KIE Server location, such as http://localhost:8080/kie-server/services/rest/server
- Marshalling format for API requests and responses (JSON, JAXB, or XSTREAM)
- A KieServicesConfiguration object and a KieServicesClient object, which serve as the entry point for 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 type 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 tas
- ...



Sample (1)

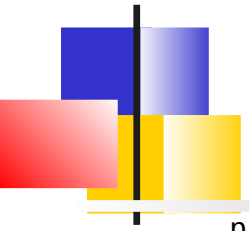
```
public static void main(String[] args) {
        initializeKieServerClient();
        initializeDroolsServiceClients();
        initializeJbpmServiceClients();
    }
```

Sample (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 (3)

```
public static void initializeJbpmServiceClients() {
        caseClient =
   kieServicesClient.getServicesClient(CaseServicesClient.class);
        documentClient =
   kieServicesClient.getServicesClient(DocumentServicesClient.class);
        jobClient =
   kieServicesClient.getServicesClient(JobServicesClient.class);
        processClient =
   kieServicesClient.getServicesClient(ProcessServicesClient.class);
        queryClient =
   kieServicesClient.getServicesClient(QueryServicesClient.class);
        uiClient = kieServicesClient.getServicesClient(UIServicesClient.class);
        userTaskClient =
   kieServicesClient.getServicesClient(UserTaskServicesClient.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());
  }
}
```

JBPM Commands

StartProcessCommand

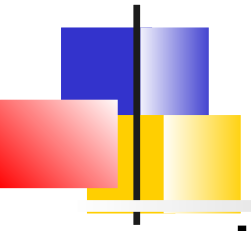
SignalEventCommand

CompleteWorkItemCommand

AbortWorkItemCommand

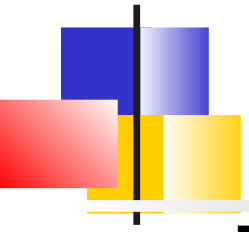
QueryCommand

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)



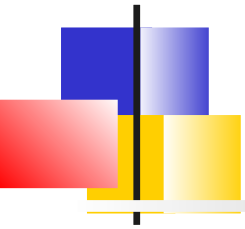
Installation

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>/

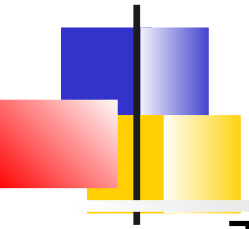


Roles and users

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

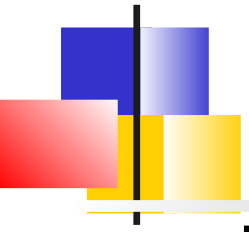
3) Add a project

4) Provide the business model

5) Create the rules

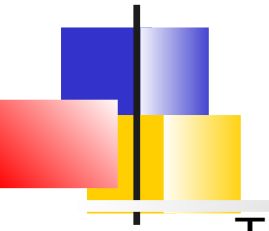
6) Build and deploy

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:

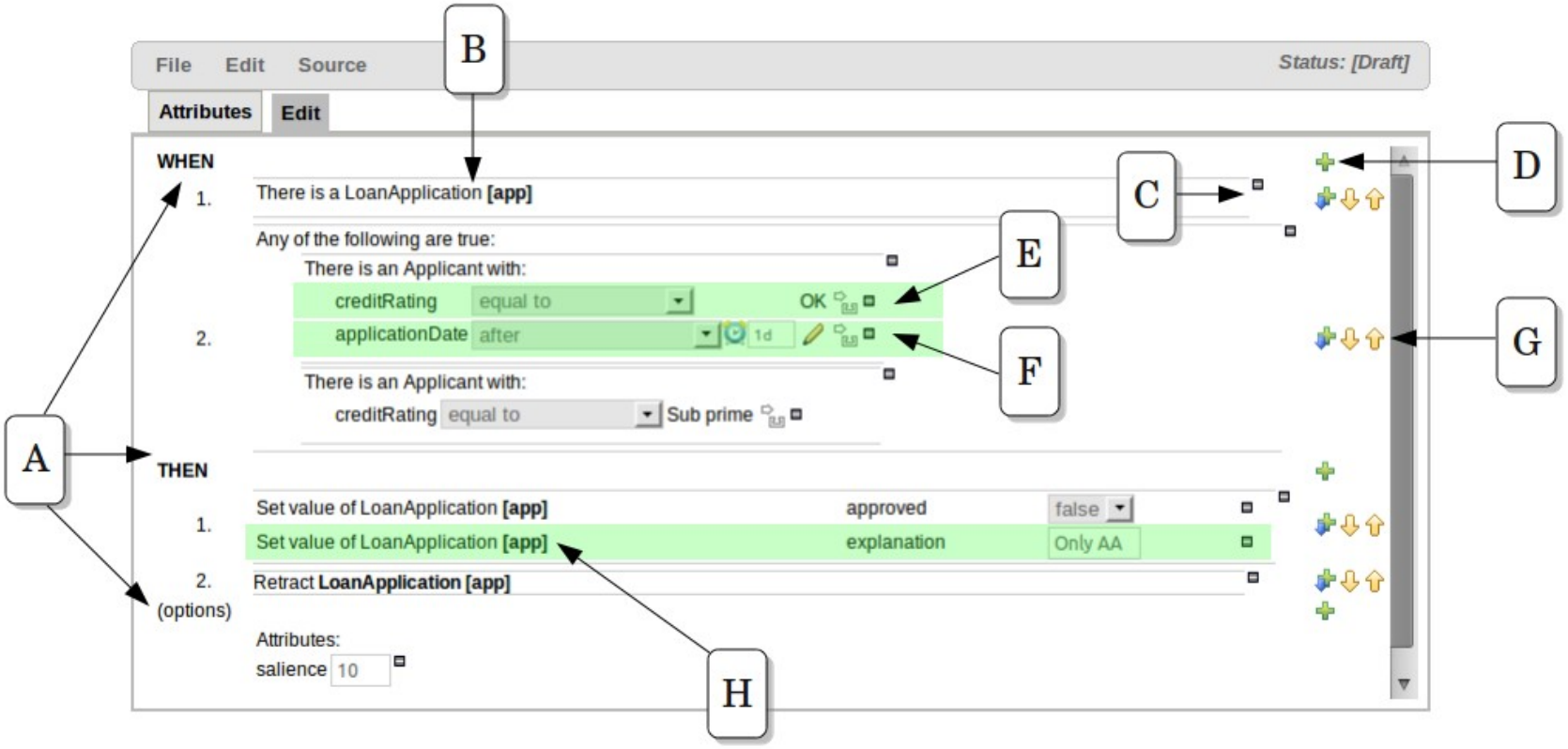
- BRL Format with BRL Editor (also present in Eclipse)
- DSL
- Decision tables in file to upload
- Decision tables edited directly in the web interface
- Rule Flow process to upload
- DRL
- functions
- Configuring lists of values (Enum)
- Rules template powered by data tables

New Rule → name, category and format

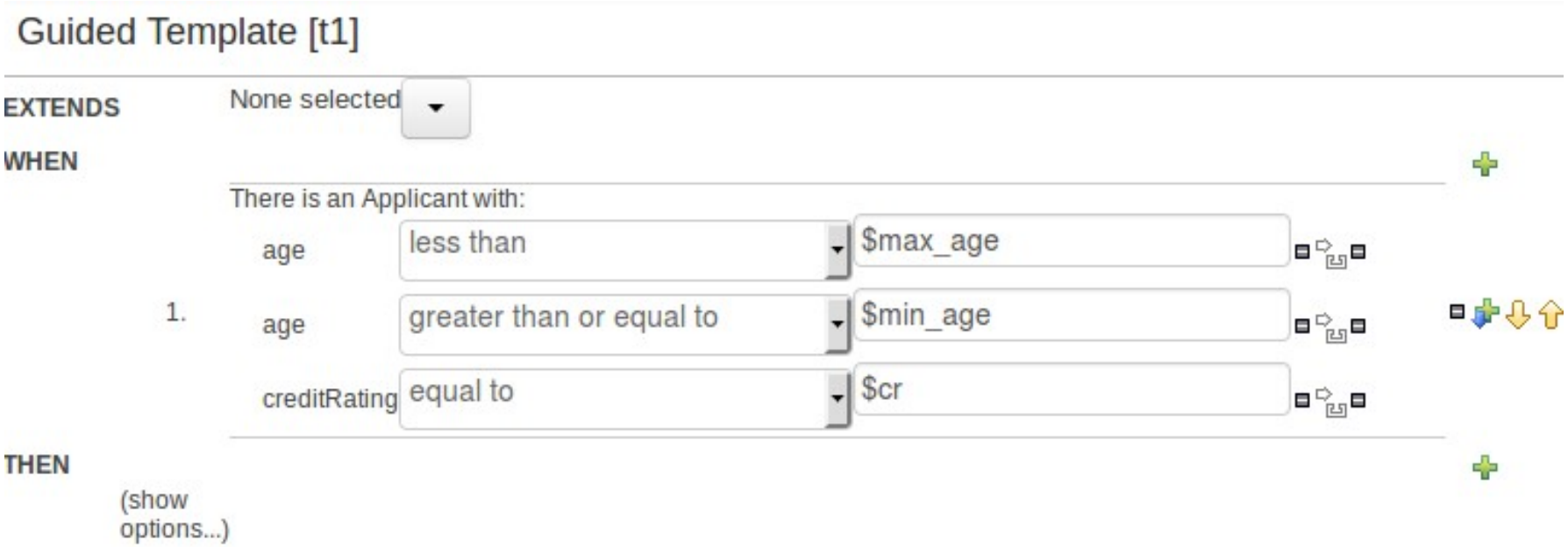
=> A wizard starts

It is always possible to consult the source in drl

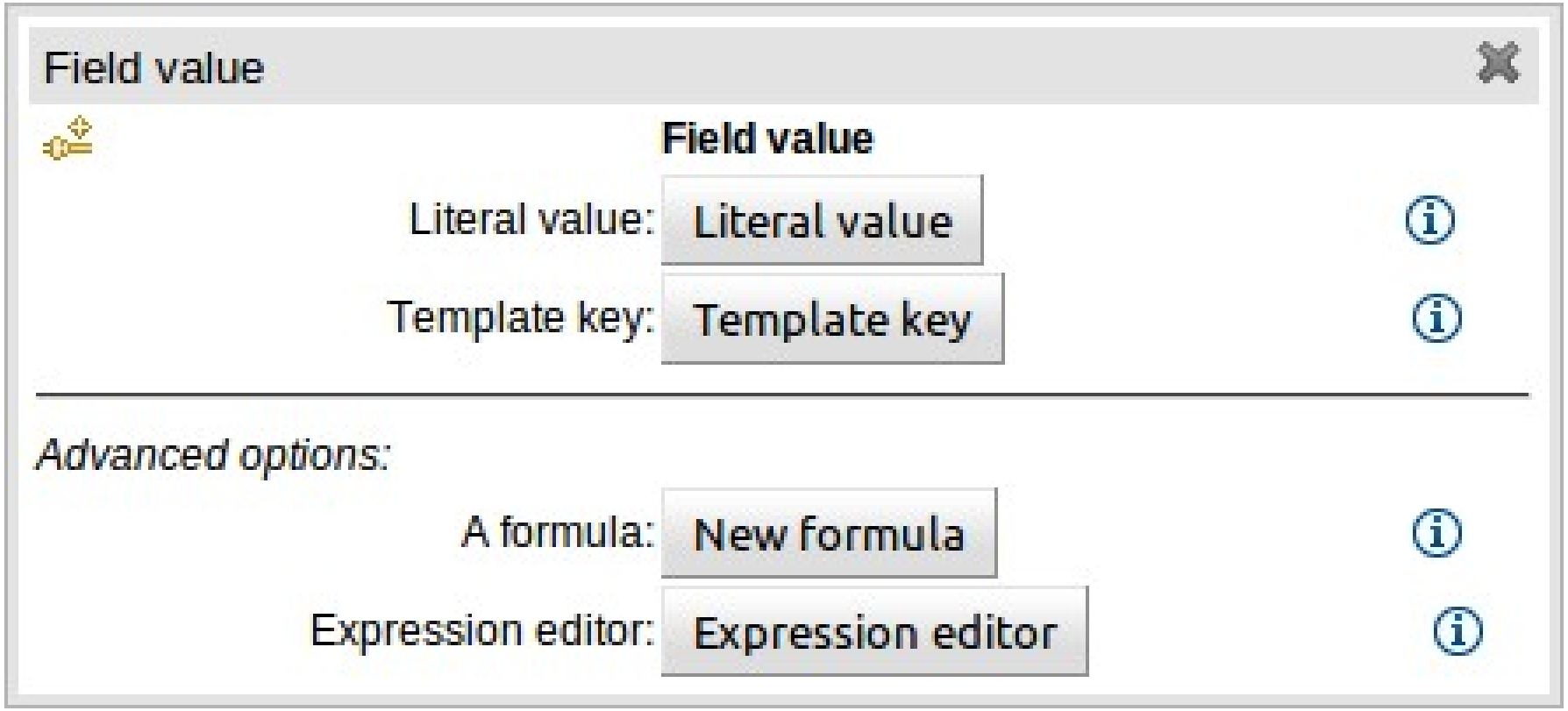
Guided Business Rules Editor



Guided Template Editor



Keys of templates

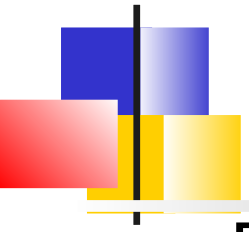


Template data

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

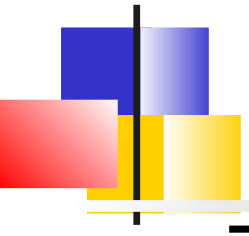
Decision table

#	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		☐	☐	☐	☐



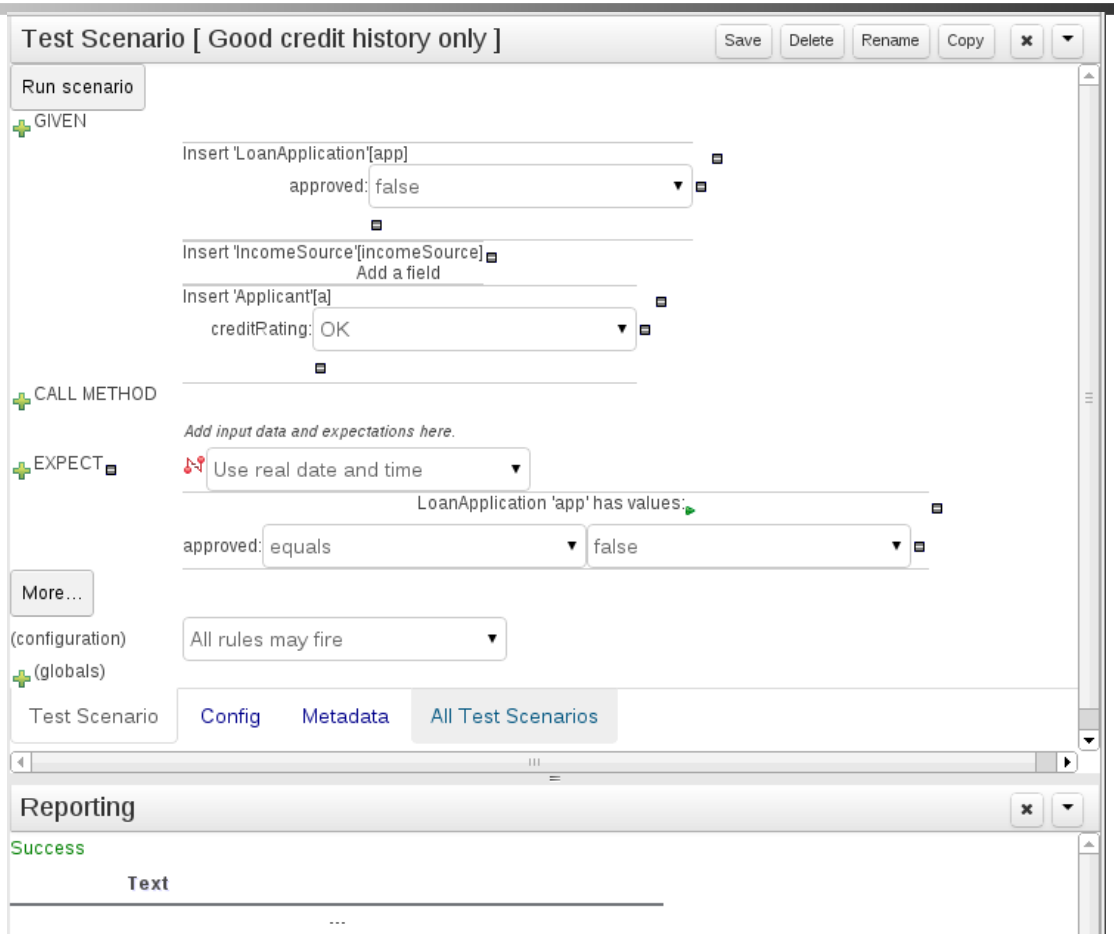
Test scenario

The test scenarios validate the operation of the rules and avoid regression bugs.

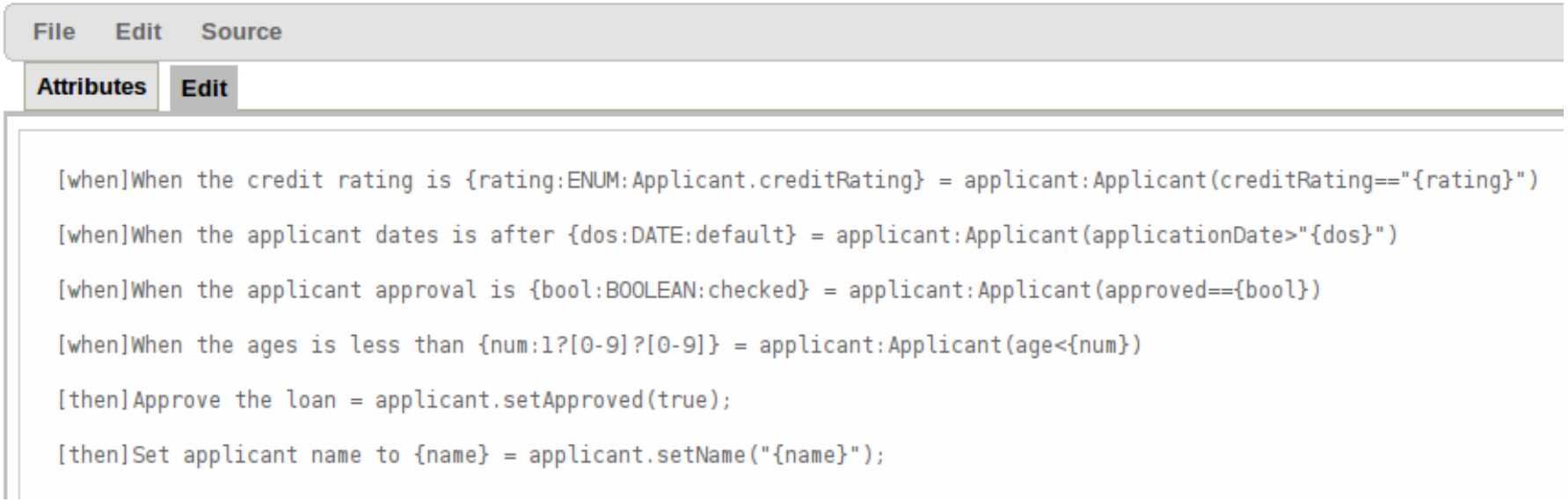
A test case defines several sections:

- **Given** list the test facts
- **Expected** lists the expected changes and actions

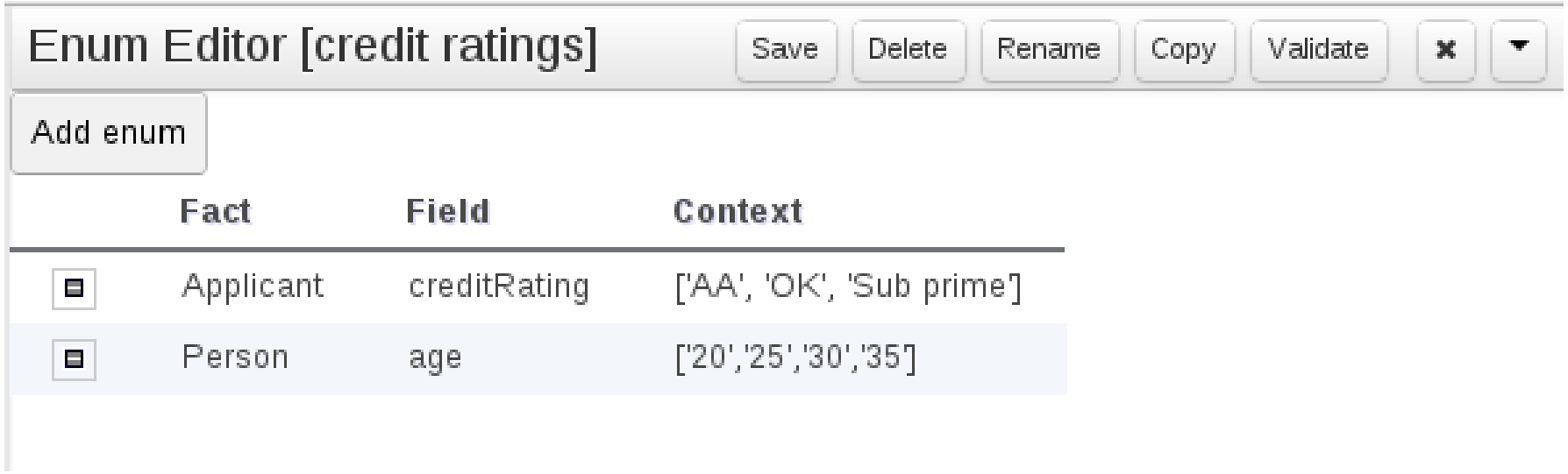
Test scenario



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}");

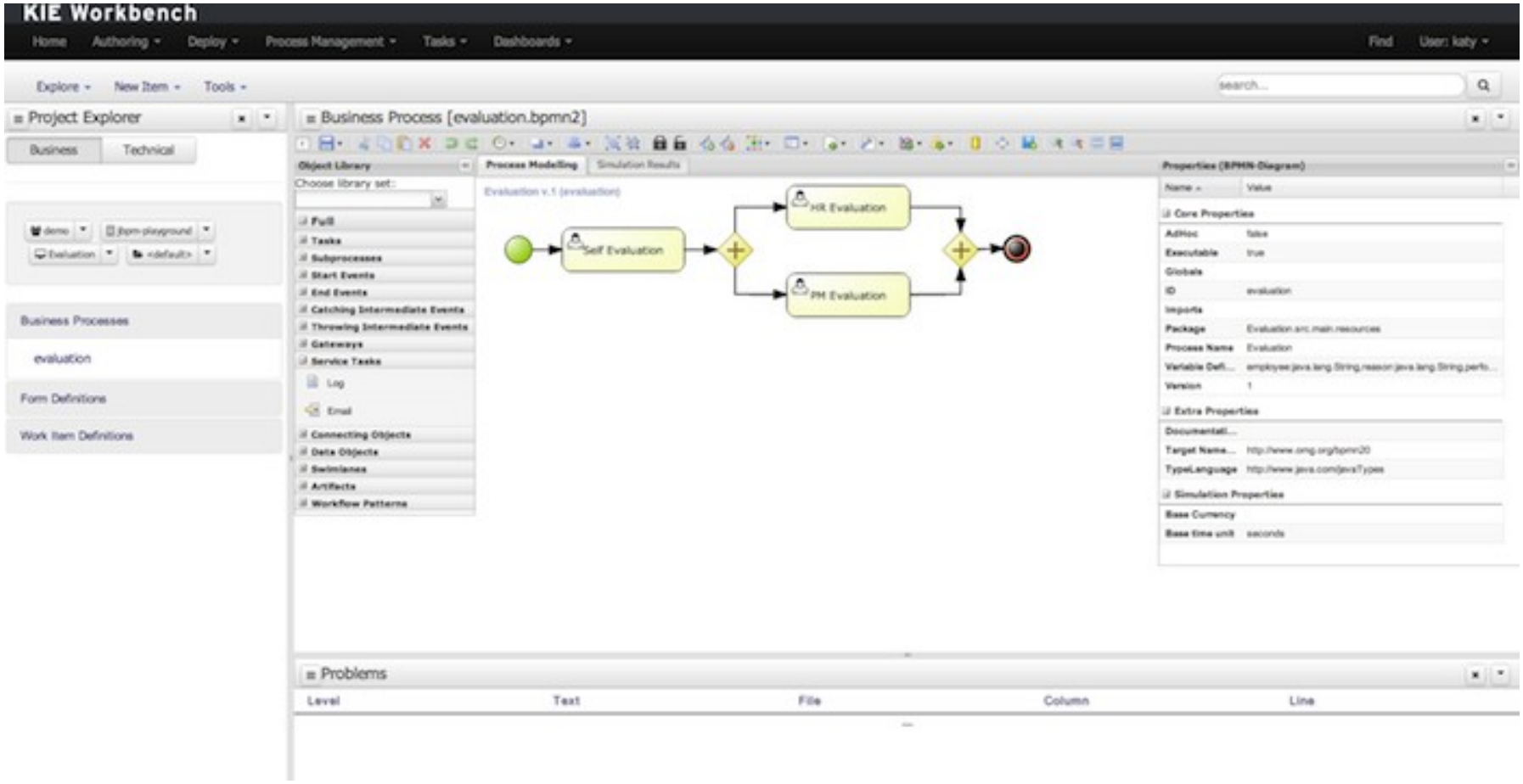
List of values



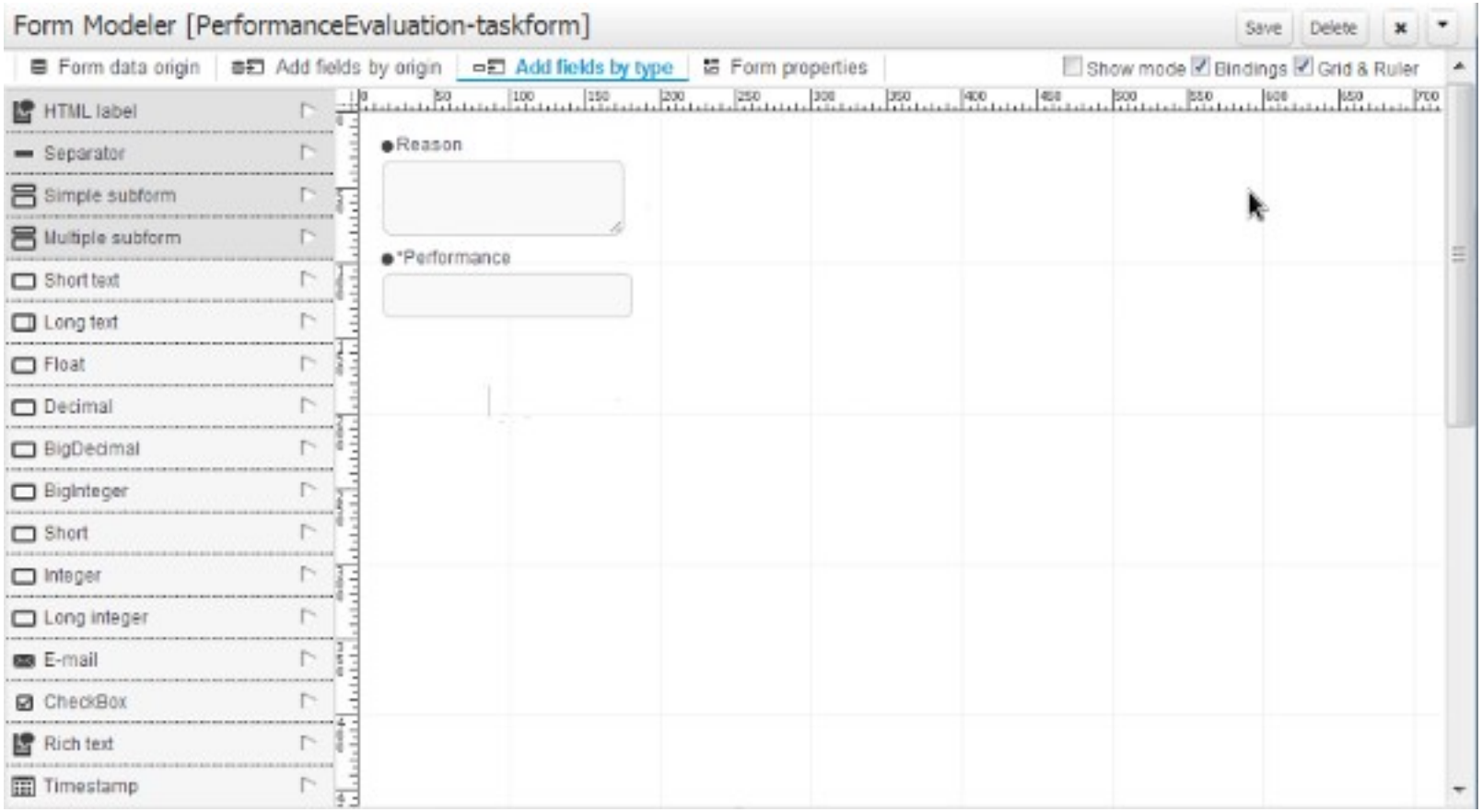
Access to the Workbench database

```
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");
    }
}
```

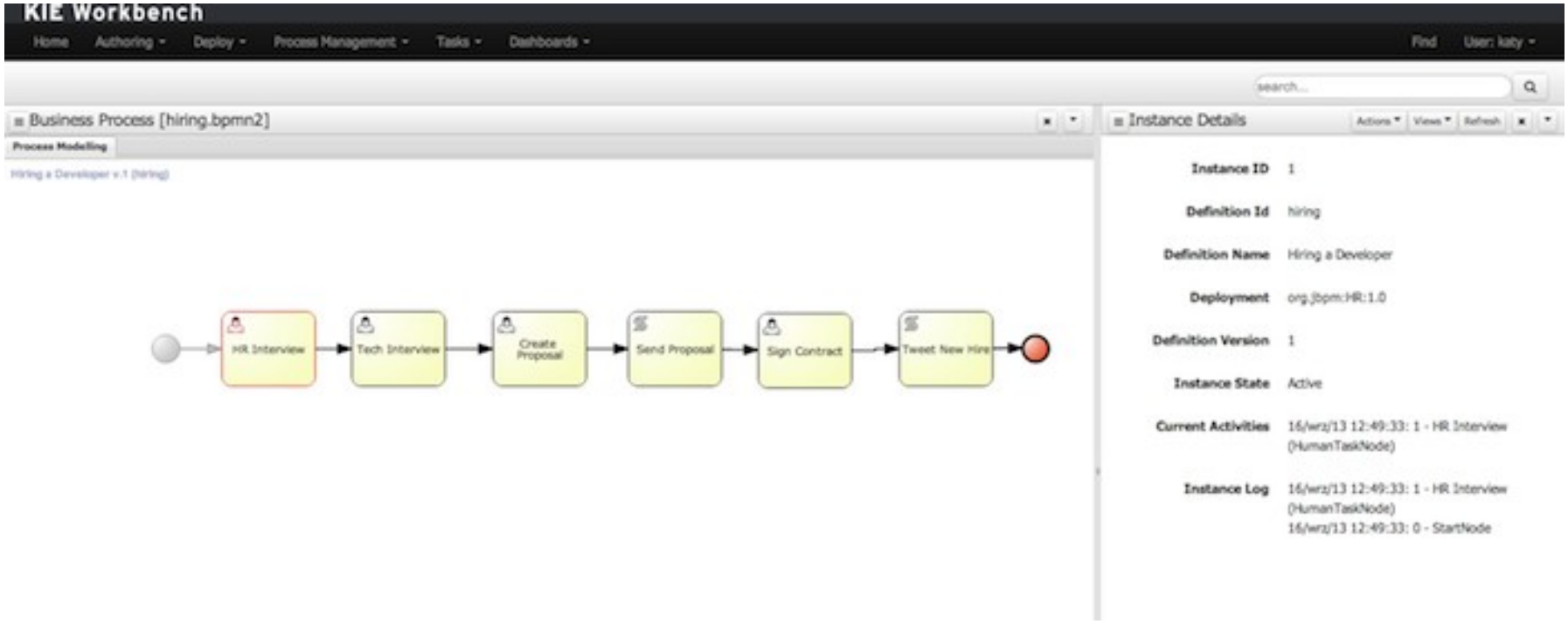
Web Editor


KIE Workbench
Home
Authoring
Deploy
Process Management
Tasks
Dashboards
Find
User: katy
Explore
New Item
Tools
search...
Project Explorer
Business
Technical
Business Processes
evaluation
Form Definitions
Work Item Definitions
Business Process [evaluation.bpmn2]
Object Library
Process Modeling
Simulation Results
Choose library set:
Full
Tasks
Subprocesses
Start Events
End Events
Catching Intermediate Events
Throwing Intermediate Events
Gateways
Service Tasks
Log
Email
Connecting Objects
Data Objects
Swimlanes
Artifacts
Workflow Patterns
Evaluation v.1 (evaluation)
Self Evaluation
HR Evaluation
PM Evaluation
Properties (BPMN Diagram)
Name
Value
Core Properties
AdHoc
false
Executable
true
Globals
ID
evaluation
Imports
Package
Evaluation.src.main.resources
Process Name
Evaluation
Variable Defi...
employee:java.lang.String,reason:java.lang.String,perfo...
Version
1
Extra Properties
Documentati...
Target Name...
http://www.omg.org/bpmn20
TypeLanguage
http://www.java.com/javaTypes
Simulation Properties
Base Currency
Base time unit
seconds
Problems
Level
Text
File
Column
Line

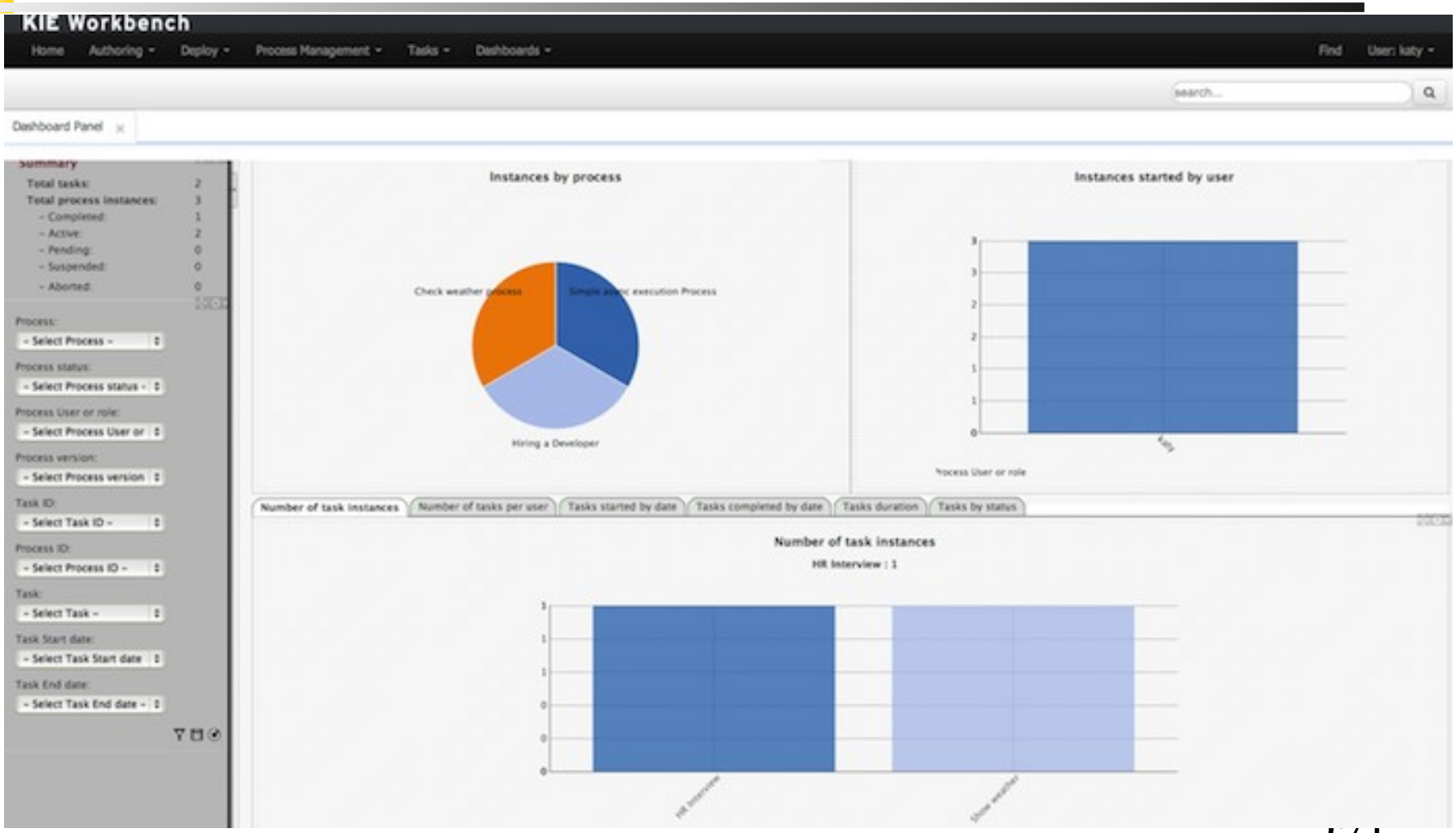
Data modelling

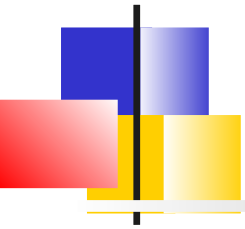


Process Instances Management



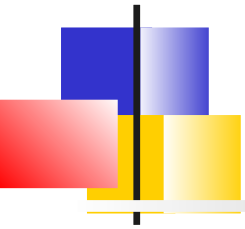
BAM Reporting (Birt)





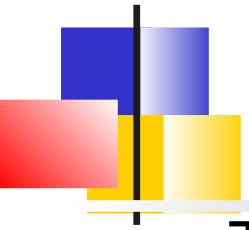
Thank U!!!

- THANK YOU FOR YOUR ATTENTION



Annexes

Algorithms
DSL

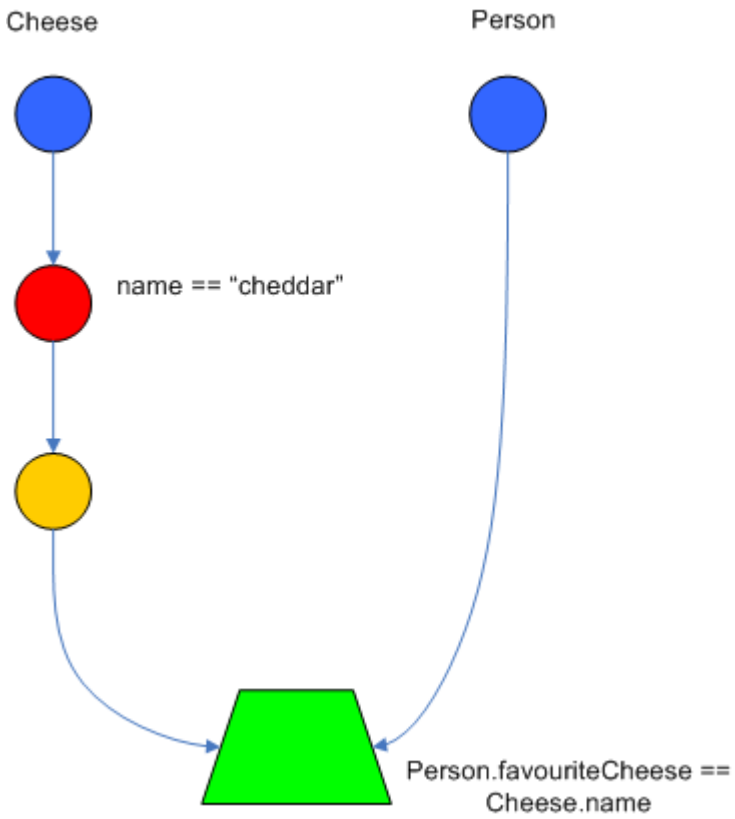


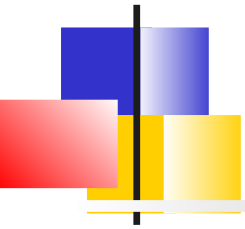
Rete’s principles

The algorithm is performed in 2 steps

- The compilation of rules creates a discriminant network composed of different nodes :
  - ***TypeNode*** : Relative to fact Type
  - ***Alpha*** : Constraint on a fact
  - ***Beta*** : Comparaison between a tuple of objects .
  - ***Rule*** : Activation of a specific rule
- The pattern matching. Executed whenever the working memory changes. Facts are introduced into the network and crosses the nodes if the conditions are satisfied. Some nodes (Beta) have an associated memory which stores the facts that have reached the node.

Example


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



Forward or backward chaining

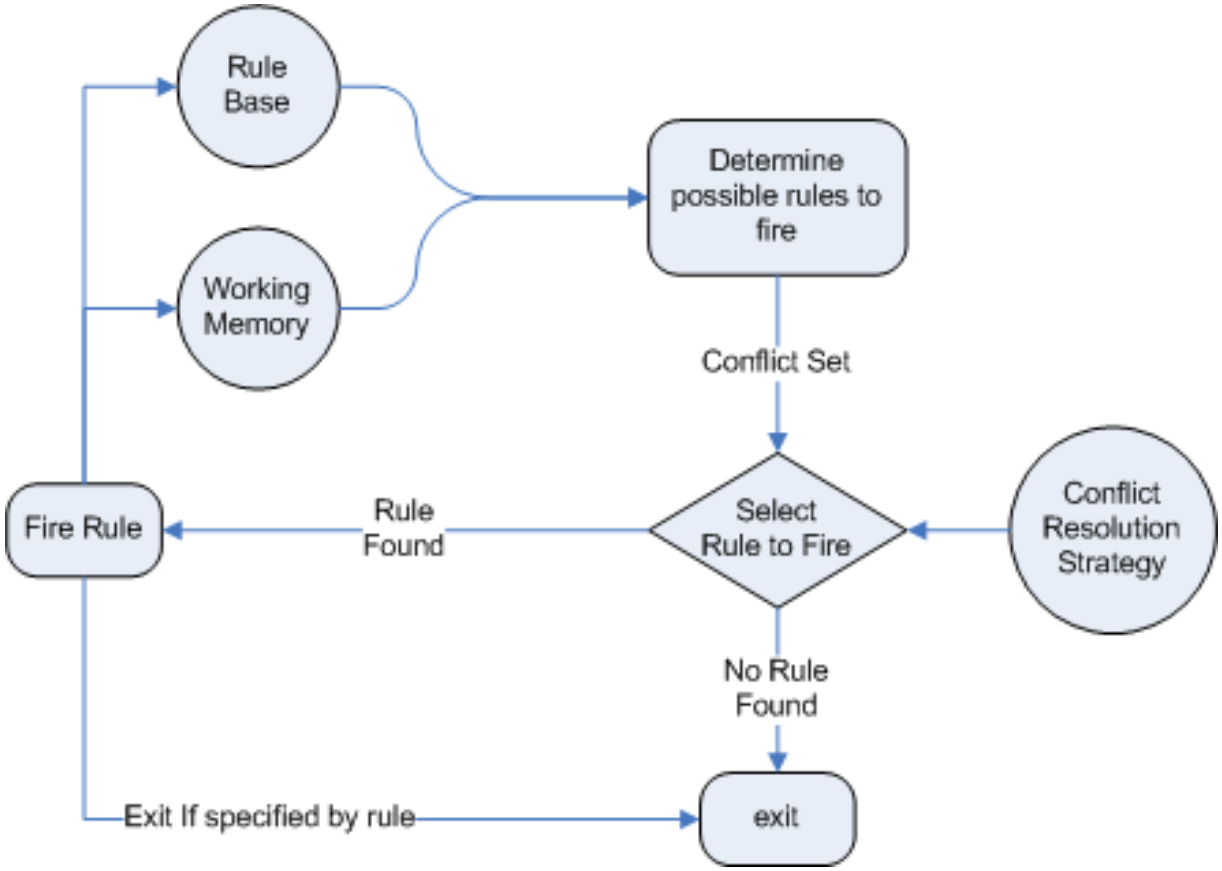
We can distinguish 2 kinds of rule's engine

- **Forward chaining** . The engine is driven by data: from a fact, rules apply, propagate and end with a conclusion.
- **Backward chaining** . The engine start from the rules to go back to the rules

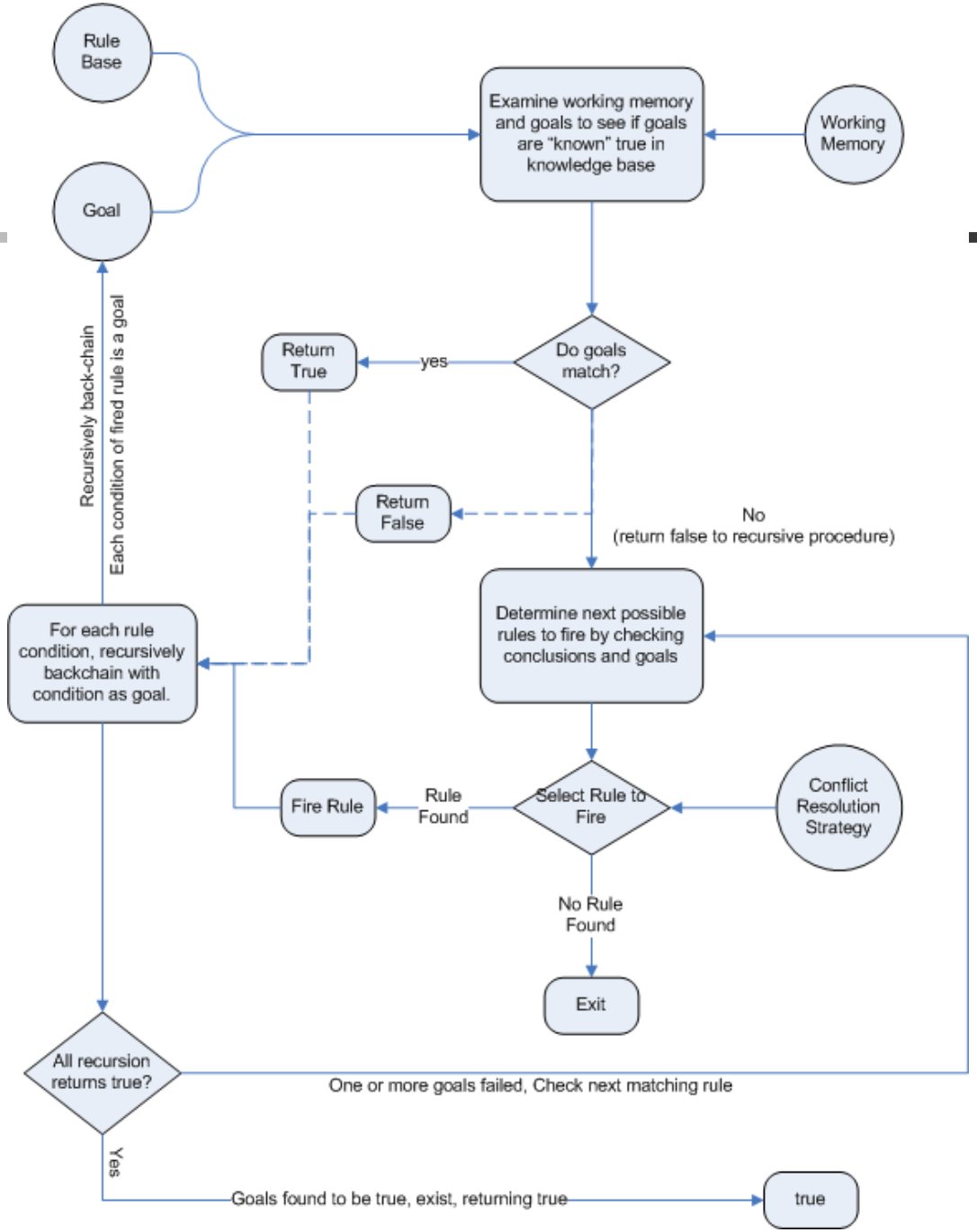
Drools 5 was a forward chaining .

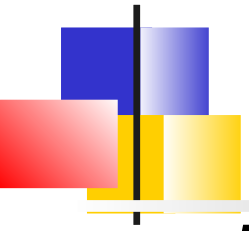
Drools 6 is hybrid but default to backward chaining

Forward chaining



Backward chaining

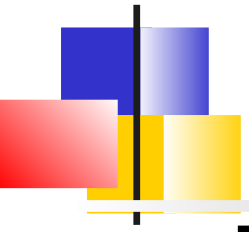




ReteOO optimizations

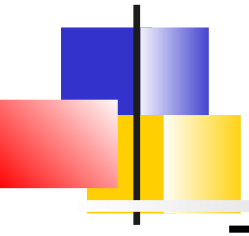
ReteOO is the algorithm of versions 3, 4 and 5 of Drools.

The job of pattern matching is done every time the facts in memory changes (*insert, update, delete*)
=> This can cause a lot of unnecessary work (inserting fact not causing, executing rules)



PHREAK algorithm

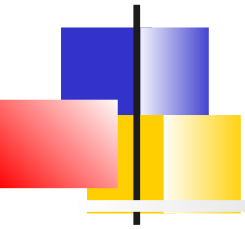
- Drools6 introduces the new PHREAK algorithm that improves ReteOO
  - PHREAK is equivalent to ReteOO when the number of rules remains moderate but avoids performance losses when the number of rules grows
  - PHREAK also allows performance gains when using calendar groups and priority attributes (salience) rules



Phreak’s principles

The main differences with ReteOO are:

- Phreak is lazy, the pattern matching work is only done when an explicit rule is triggered (*fireAllRules()* method)
- It is chained backward, each eligible rule is evaluated independently of the others

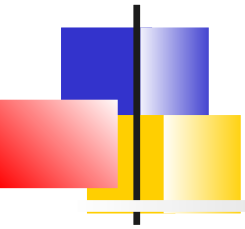


Other ways to express rules

DSL

Decision tables

Rule’s templates

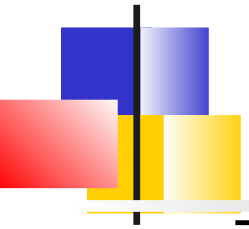


Introduction

Domain Specific Languages (DSL) allow to extend the rules language by adapting it to the business language.

This is an abstraction layer dedicated to non-technical business experts that is translated into the rule language at compile time

They can also be used as templates of conditions or actions, allowing to share certain parts of rules

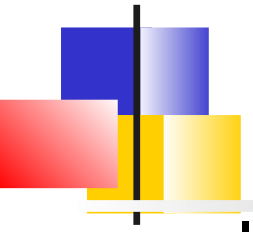


Syntax

The format of a DSL is simply a text file that translates "natural" language keys into drl expressions

Each line starts with a scope and then the extended language translation in the rule language

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

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

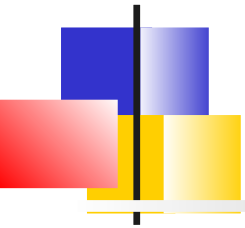


Syntax

It is also possible to use the scope ***[keyword]*** which makes it possible to redefine a keyword:

```
[keyword] quand = when
```

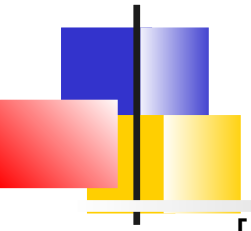
The defined sentences are actually regular expressions. Wildcards can therefore be used.



Examples

```
[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");
```



Example with 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)
```

Steps

1. Name your DRL file with the *.dslr* extension

2. Refer to the DSL file in the rule file with the keyword expander

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

3. Put resources in the *KieContainer*'*s* classpath: