jBPM User Guide

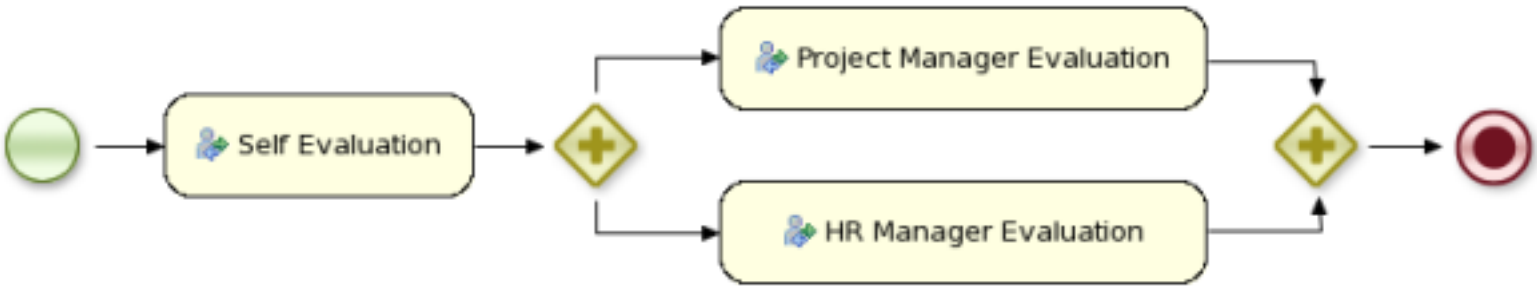

jBPM

Chapter 1. Overview

1.1. What is jBPM?

jBPM is a flexible Business Process Management (BPM) Suite. It's light-weight, fully open-source (distributed under Apache license) and written in Java. It allows you to model, execute and monitor business processes, throughout their life cycle.

A business process allows you to model your business goals by describing the steps that need to be executed to achieve that goal and the order, using a flow chart. This greatly improves the visibility and agility of your business logic. jBPM focuses on executable business process, which are business processes that contain enough detail so they can actually be executed on a BPM engine. Executable business processes bridge the gap between business users and developers as they are higher-level and use domain-specific concepts that are understood by business users but can also be executed directly.



The core of jBPM is a light-weight, extensible workflow engine written in pure Java that allows you to execute business processes using the latest BPMN 2.0 specification. It can run in any Java environment, embedded in your application or as a service.

On top of the core engine, a lot of features and tools are offered to support business processes throughout their entire life cycle:

- Eclipse-based and web-based editor to support the graphical creation of your business processes (drag and drop)
- Pluggable persistence and transactions based on JPA / JTA
- Pluggable human task service based on WS-HumanTask for including tasks that need to be performed by human actors
- Management console supporting process instance management, task lists and task form management, and reporting
- Optional process repository to deploy your process (and other related knowledge)

- History logging (for querying / monitoring / analysis)
- Integration with Seam, Spring, OSGi, etc.

BPM makes the bridge between business analysts, developers and end users, by offering process management features and tools in a way that both business users and developers like it. Domain-specific nodes can be plugged into the palette, making the processes more easily understood by business users.

jBPM supports adaptive and dynamic processes that require flexibility to model complex, real-life situations that cannot easily be described using a rigid process. We bring control back to the end users by allowing them to control which parts of the process should be executed, to dynamically deviate from the process, etc.

jBPM is also not just an isolated process engine. Complex business logic can be modeled as a combination of business processes with business rules and complex event processing. jBPM can be combined with the Drools project to support one unified environment that integrates these paradigms where you model your business logic as a combination of processes, rules and events.

Apart from the core engine itself, there are quite a few additional (optional) components that you can use, like an Eclipse-based or web-based designer and a management console.

1.2. Overview

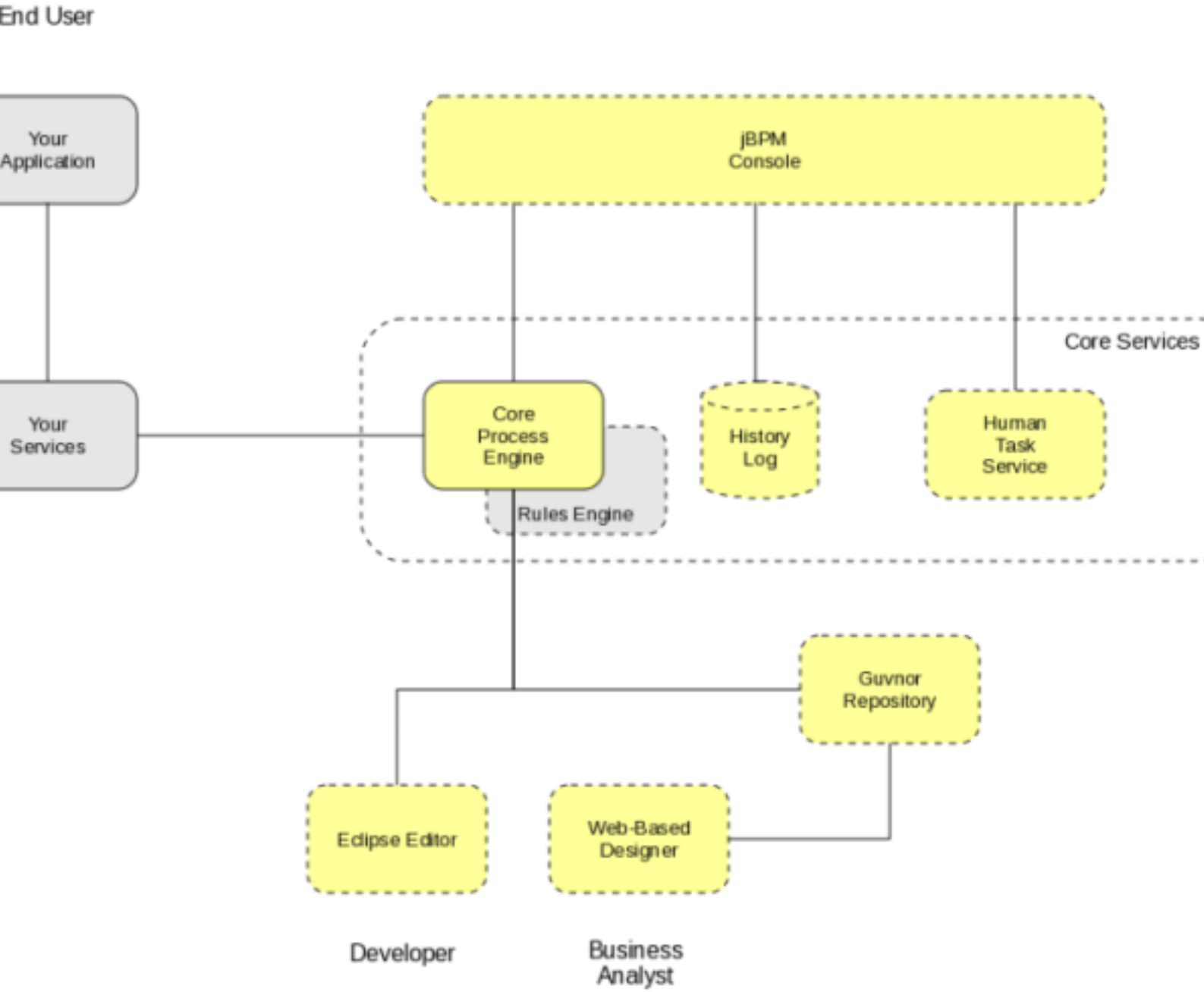


Figure 1.1.

This figure gives an overview of the different components of the jBPM project. jBPM can integrate with a lot of other services as (and we've shown a few using grey bloxes on the figure) but here we focus on the components that are part of the jBPM project itself.

- The process engine is the core of the project and is required if you want to execute business processes (all other components are optional, as indicated by the dashed border). Your

application services typically invoke the core engine (to start processes or to signal events) whenever necessary.

  - An optional core service is the history log, that will log all information about the current and previous state of all your process instances.

  - Another optional core service is the human task service, that will take care of the human task life cycle if human actors participate in the process.

- Two types of graphical editors are supported for defining your business processes:

  - The Eclipse plugin is an extension to the Eclipse IDE, targeted towards developers, and allows you to create business processes using drag and drop, advanced debugging, etc.

  - The web-based designer allows business users to manage business processes in a web-based environment.

- The Guvnor repository is an optional component that can be used to store all your business processes. It supports collaboration, versioning, etc. There is integration with both the Eclipse plugin and web-based designer, supporting round-tripping between the different tools.

- The jBPM console is a web-based console that allows business users to manage their business processes (start new processes, inspect running instances), their task list and see reports.

Each of the components are described in more detail below.

1.3. Core Engine

The core jBPM engine is the heart of the project. It's a light-weight workflow engine that executes your business processes. It can be embedded as part of your application or deployed as a service (possibly on the cloud). It's most important features are:

- Solid, stable core engine for executing your process instances

- Native support for the latest BPMN 2.0 specification for modeling and executing business processes

- Strong focus on performance and scalability

- Light-weight (can be deployed on almost any device that supports a simple Java Runtime Environment, does not require any web container at all)

- (Optional) pluggable persistence with a default JPA implementation

- Pluggable transaction support with a default JTA implementation

- Implemented as a generic process engine, so it can be extended to support new node types or other process languages

- Listeners to be notified of various events
- Ability to migrate running process instances to a new version of their process definition

The core engine can also be integrated with a few other (independent) core services:

- The human task service can be used to manage human tasks when human actors need to participate in the process. It is fully pluggable and the default implementation is based on the WS-HumanTask specification and manages the life cycle of the tasks, task lists, task forms and some more advanced features like escalation, delegation, rule-based assignments, etc.
- The history log can store all information about the execution of all the processes on the engine. This is necessary if you need access to historic information as runtime persistence only stores the current state of all active process instances. The history log can be used to store all current and historic state of active and completed process instances. It can be used to query for any information related to the execution of process instances, for monitoring, analysis, etc.

1.4. Eclipse Editor

The Eclipse editor is an plugin to the Eclipse IDE and allows you to integrate your business processes in your development environment. It is targeted towards developers and has some wizards to get started, a graphical editor for creating your business processes (using drag and drop) and a lot of advanced testing and debugging capabilities.

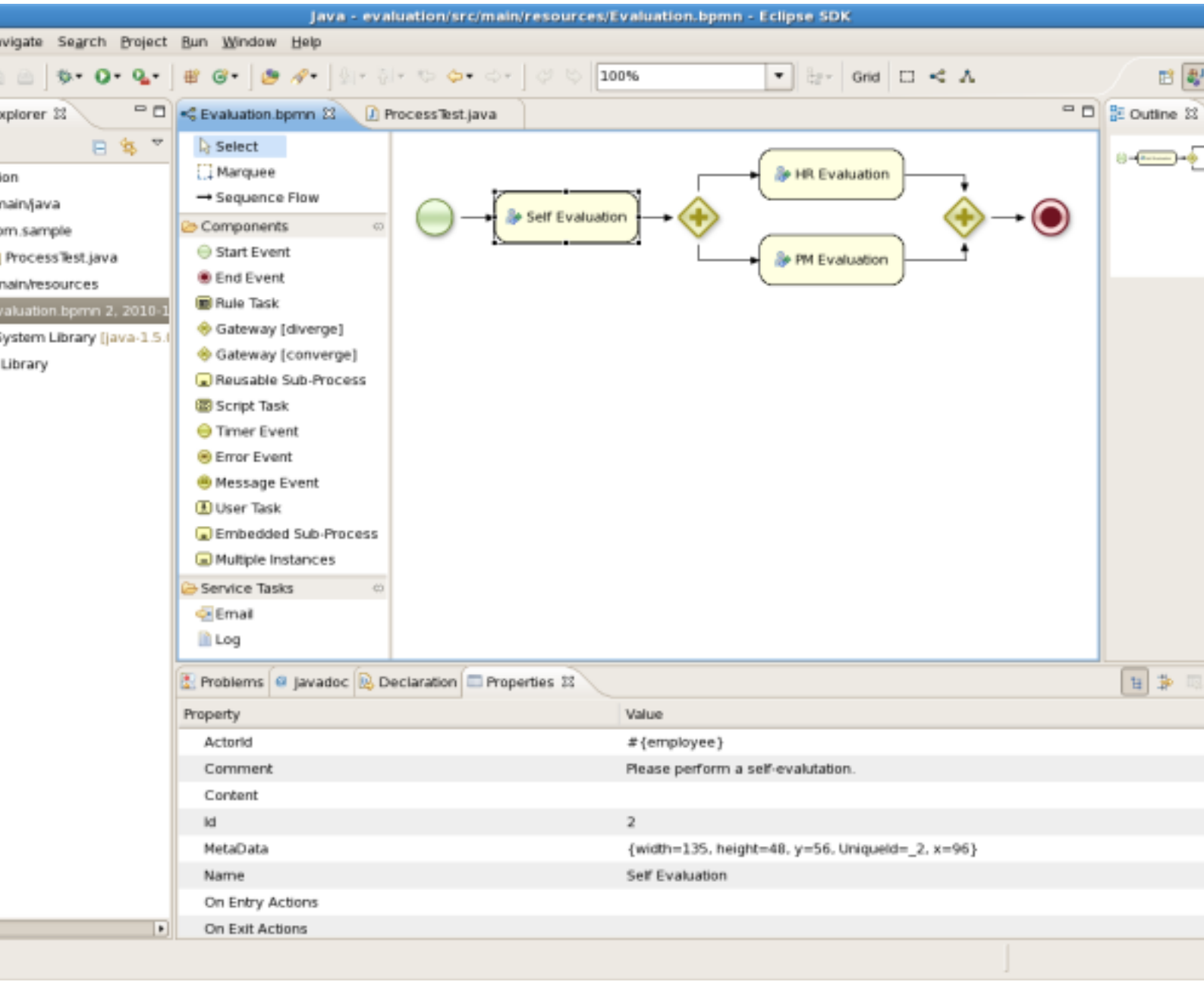


Figure 1.2. Eclipse editor for creating BPMN2 processes

It includes features like:

- Wizard for creating a new jBPM project
- A graphical editor for BPMN 2.0 processes
- Plugging in your own domain-specific nodes
- Validation

- Runtime support (so you can select which version of jBPM you would like to use)
- Graphical debugging, to see all running process instances of a selected session, to visualize the current state of one specific process instance, etc.
- Audit view to get an overview of what happened at runtime
- Unit testing your processes
- Integration with the knowledge repository

1.5. Web-based Designer

The web-based designer allows you to model your business processes in a web-based environment. It is targeted towards more business users and offers a graphical editor for viewing and editing your business processes (using drag and drop), similar to the Eclipse plugin. It supports round-tripping between the Eclipse editor and the web-based designer.

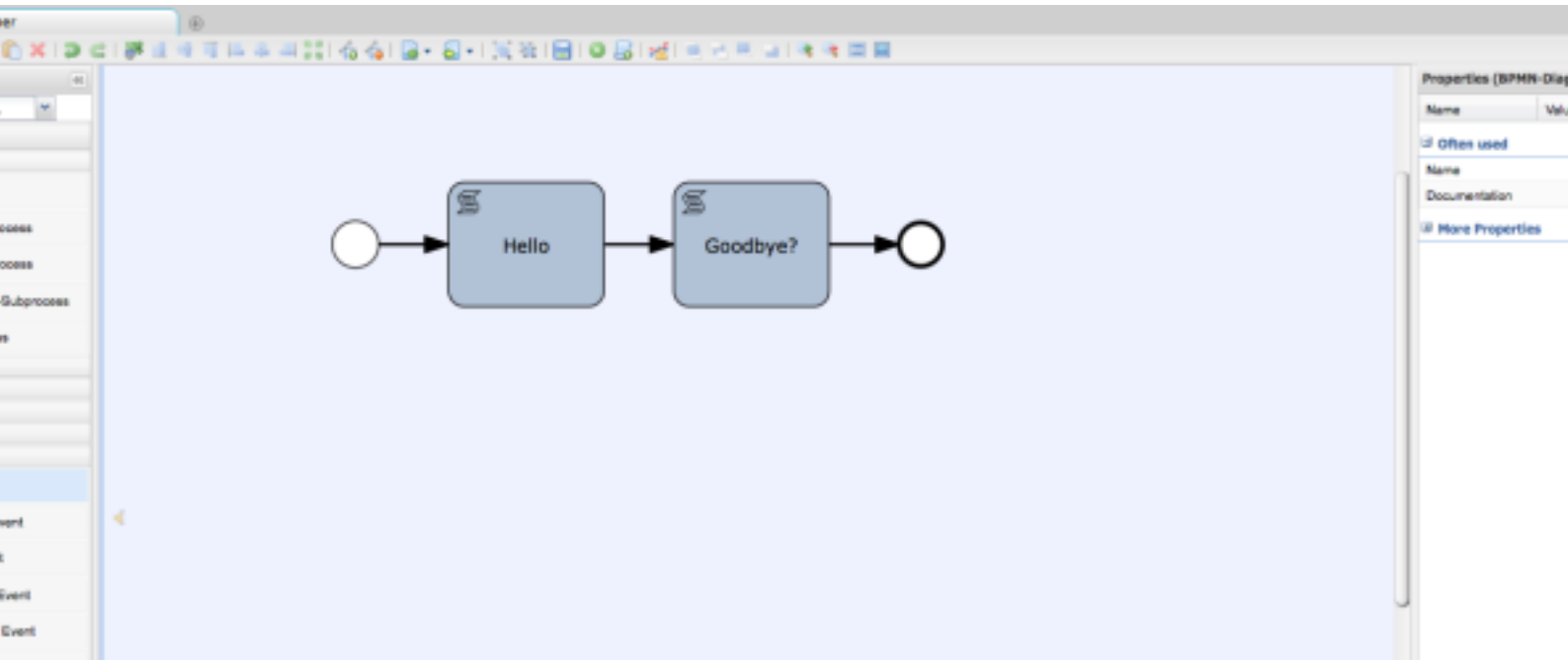


Figure 1.3. Web-based designer for creating BPMN2 processes

Optionally, you can use one or more knowledge repositories to store your business processes (and other related artefacts). The web-based designer is integrated in the Guvnor repository, which is targeted towards business users and allows you to manage your processes separately from your application. It supports:

- A repository service to store your business processes and related artefacts, using a JCR repository, which supports versioning, remotely accessing it as a file system or using REST services, etc.

- A web-based user interface to manage your business processes, targeted towards business users, supporting the visualization (and editing) of your processes (the web-based designer is integrated here), but also categorisation, scenario testing, deployment, etc.
- Collaboration features to have multiple actors (for example business users and developers) work together on the same process definition.
- A knowledge agent to easily create new sessions based on the process definitions in the repository. This also supports (optionally) dynamically updating all sessions if a new process has been deployed.

1.6. jBPM Console

Business processes can be managed through a web console. It is targeted towards business users and its main features are:

- Process instance management: the ability to start new process instances, get a list of running process instances, visually inspect the state of a specific process instances, etc.
- Human task management: being able to get a list of all your current tasks (either assigned to you or that you might be able to claim), completing tasks on your task list (using customizable task forms), etc.
- Reporting: get an overview of the state of your application and/or system using dynamically generated (customizable) reports, that give you an overview of your key performance indicators (KPIs).

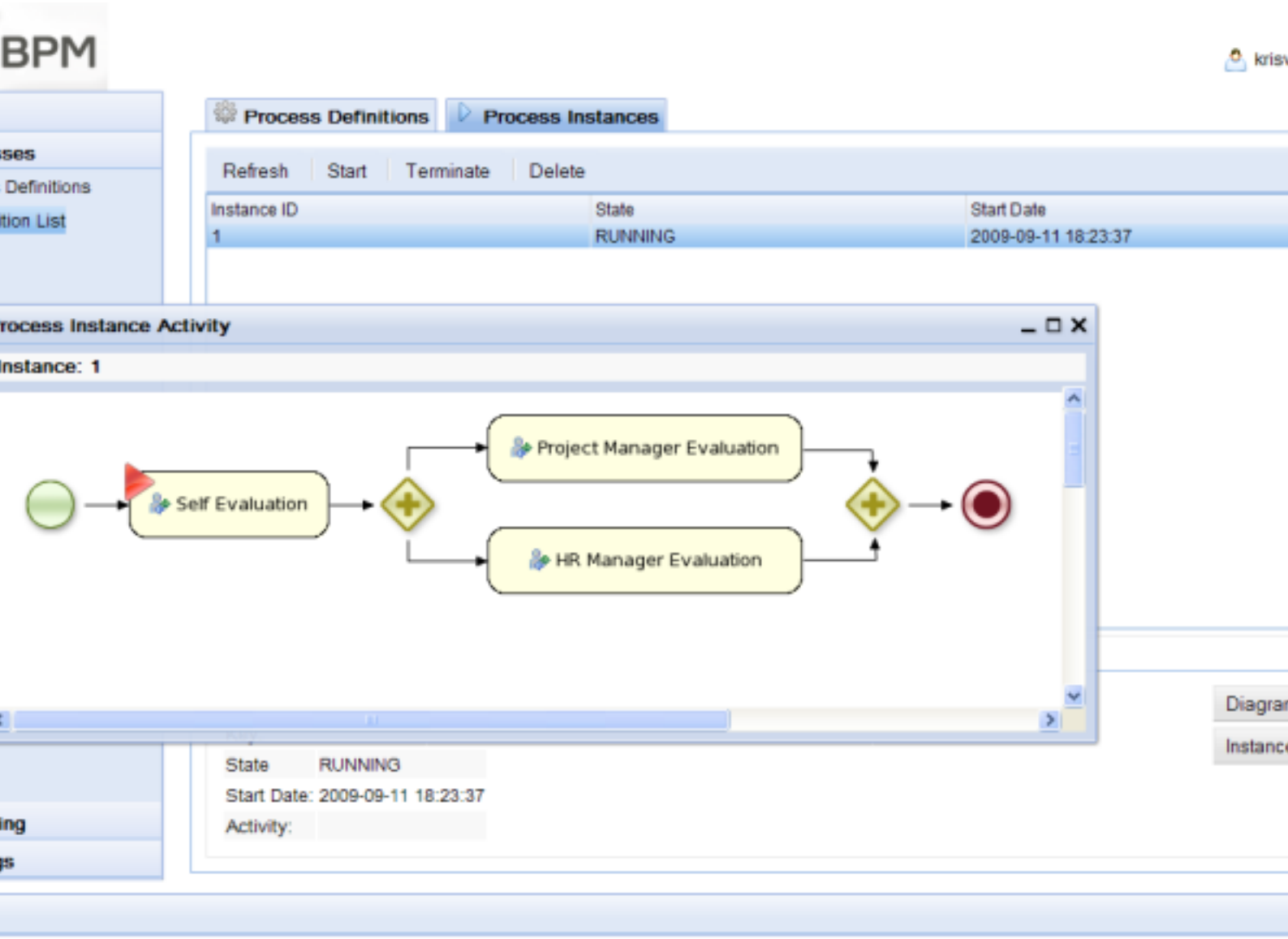


Figure 1.4. Managing your process instances

1.7. Documentation

The documentation is structured as follows:

- Overview: the overview chapter gives an overview of the different components
- Getting Started: the getting started chapter teaches you where to download the binaries and sources and contains a lot of useful links
- Installer: the installer helps you getting a running demo setup including most of the jBPM components and runs you through them using a simple example and some 10-minute tutorials including screencasts

- Core engine: the next 4 chapters describe the core engine: the process engine API, the process definition language (BPMN 2.0), persistence and transactions, and examples
- Eclipse editor: the next 2 chapters describe the Eclipse plugin for developers, both the old one and the new BPMN 2.0 tooling which is being developed
- Designer: describes the web-based designer that allows business users to edit business processes in a web-based context
- Console: the jBPM console can be used for managing process instances, human task lists and reports
- Important features
  - Human tasks: When using human actors, you need a human task service to manage the life cycle of the tasks, the task lists, etc.
  - Domain-specific processes: plug in your own higher-level, domain-specific nodes in your processes
  - Testing and debugging: how to test and debug your processes
  - Process repository: a process repository could be used to manage your business processes
- Advanced concepts
  - Business activity monitoring: event processing to monitor the state of your systems
  - Flexible processes: model much more adaptive, flexible processes using advanced process constructs and integration with business rules and event processing
  - Integration: how to integrate with other technologies like maven, OSGi, etc.

Chapter 2. Getting Started

2.1. Downloads

All releases can be downloaded from *SourceForge* [https://sourceforge.net/projects/jbpm/files/]. Select the version you want to download and then select which artefact you want:

- bin: all the jBPM binaries (jars) and their dependencies
- src: the sources of the core components
- gwt-console: the jbpm console, a zip file containing both the server and client war
- docs: the documentation
- examples: some jBPM examples, can be imported into Eclipse
- installer: the jbpm-installer, downloads and installs a demo setup of jBPM
- installer-full: the jbpm-installer, downloads and installs a demo setup of jBPM, already contains a number of dependencies prepackages (so they don't need to be downloaded separately)

2.2. Getting started

If you like to take a quick tutorial that will guide you through most of the components using a simple example, take a look at the Installer chapter. This will learn you how to download and use the installer to create a demo setup, including most of the components. It uses a simple example to guide you through the most important features. Screencasts are available to help you out as well.

If you like to get read more information first, the following chapters first focus on the core engine (API, BPMN 2.0, etc.). Further chapters will then describe the other components and other more complex topics like domain-specific processes, flexible processes, etc. After reading the core chapters, you should be able to jump to other chapters that you might find interesting.

You can also start playing around with some examples that are offered in a separate download. Check out the examples chapter to see how to start playing with these.

After that, you should be ready to start creating your own processes and integrate the engine with your application, for example by starting from the installer or another example, or by starting from scratch.

2.3. Community

Here are a lot of useful links if we want to become part of the jBPM community:

- A feed of *blog entries* [http://planet.jboss.org/view/feed.seam?name=jbossjbpm] related to jBPM

- The *#jbossjbpm twitter account* [http://twitter.com/jbossjbpm].
- A *user forum* [http://www.jboss.com/index.html?module=bb&op=viewforum&f=217] for asking questions and giving answers
- A *JIRA bug tracking system* [https://jira.jboss.org/jira/browse/JBPM] for bugs, feature requests and roadmap
- A *continuous build server* [https://hudson.jboss.org/hudson/job/jBPM/] for getting the *latest snapshots* [https://hudson.jboss.org/hudson/job/jBPM/lastSuccessfulBuild/artifact/jbpm-distribution/target/]

Please feel free to join us in our IRC channel at irc.codehaus.org #jbpm. This is where most of the real-time discussion about the project takes place and where you can find most of the developers most of their time as well. Don't have an IRC client installed? Simply go to *http://irc.codehaus.org*, input your desired nickname, and specify #jbpm. Then click login to join the fun.

2.4. Sources

2.4.1. License

The jBPM code itself is using the Apache License v2.0.

Some other components we integrate with have their own license:

- The new Eclipse BPMN2 plugin is Eclipse Public License (EPL) v1.0.
- The web-based designer is based on Oryx/Wapama and is MIT License
- The BPM console is GNU Lesser General Public License (LGPL) v2.1
- The Drools project is Apache License v2.0.

2.4.2. Source code

jBPM now uses git for its source code version control system. The sources of the jBPM project can be found here (including all releases starting from jBPM 5.0-CR1):

https://github.com/droolsjbpm/jbpm

The source of some of the other components we integrate with can be found here:

- Other components related to the jBPM and Drools project can be found *here* [https://github.com/droolsjbpm].
- The jBPM Eclipse plugin can be found *here* [http://anonsvn.jboss.org/repos/jbosstools/trunk/bpmn/plugins/org.jboss.tools.jbpm/].

- The new Eclipse BPMN2 plugin can be found *here* [https://github.com/droolsjbpm/bpmn2-eclipse-editor].
- The web-based designer can be found *here* [https://github.com/tsurdilo/process-designer]
- The BPM console can be found *here* [https://github.com/bpmc/bpm-console]

2.4.3. Building from source

If you're interested in building the source code, contributing, releasing, etc. make sure to read this *README* [https://github.com/droolsjbpm/droolsjbpm-build-bootstrap/blob/master/README.md].

Chapter 3. Installer

This guide will assist you in installing and running a demo setup of the various components of the jBPM project. If you have any feedback on how to improve this guide, if you encounter problems, or if you want to help out, do not hesitate to contact the jBPM community as described in the "What to do if I encounter problems or have questions?" section.

3.1. Prerequisites

This script assumes you have Java JDK 1.5+ (set as JAVA_HOME), and Ant 1.7+ installed. If you don't, use the following links to download and install them:

Java: *http://java.sun.com/javase/downloads/index.jsp*

Ant: *http://ant.apache.org/bindownload.cgi*

3.2. Download the installer

First of all, you need to *download* [https://sourceforge.net/projects/jbpm/files/jBPM%205/] the installer. There are two versions, a full installer (which already contains a lot of the dependencies that are necessary during the installation) and a minimal installer (which only contains the installer and will download all dependencies). In general, it is probably best to download the full installer: jBPM-{version}-installer-full.zip

You can also find the latest snapshot release here (only minimal installer) here:

https://hudson.jboss.org/jenkins/job/jBPM/lastSuccessfulBuild/artifact/jbpm-distribution/target/ [https://hudson.jboss.org/jenkins/job/jBPM/lastSuccessfulBuild/artifact/jbpm-distribution/target/]

3.3. Demo setup

The easiest way to get started is to simply run the installation script to install the demo setup. Simply go into the install folder and run:

```
ant install.demo
```

This will:

- Download JBoss AS
- Download Eclipse
- Install Drools Guvnor into JBoss AS

- Install Oryx Designer into JBoss AS
- Install the jBPM gwt-console into JBoss AS
- Install the jBPM Eclipse plugin
- Install the Drools Eclipse plugin

This could take a while (REALLY, not kidding, we are downloading an application server and Eclipse installation, even if you downloaded the full installer). The script however always shows which file it is downloading (you could for example check whether it is still downloading by checking the whether the size of the file in question in the jbpm-installer/lib folder is still increasing). If you want to avoid downloading specific components (because you will not be using them or you already have them installed somewhere else), check below for running only specific parts of the demo or directing the installer to an already installed component.

To limit the amount of data that needs to be downloaded, we have disabled the download of the Eclipse BIRT plugin for reporting by default. If you want to try out reporting as well in the jBPM console, make sure to put the jBPM.birt.download property in the build.properties file to true before running the installer.

Once the demo setup has finished, you can start playing with the various components by starting the demo setup:

```
ant start.demo
```

This will:

- Start the H2 database
- Start the JBoss AS
- Start Eclipse
- Start the Human Task Service

Once everything is started, you can start playing with the Eclipse tooling, Guvnor repository and jBPM console, as explained in the next three sections.

3.4. 10-Minute Tutorial: Using the Eclipse tooling

The *following screencast* [http://people.redhat.com/kverlaen/install-eclipse-jbpm.swf] gives an overview of how to run a simple demo process in Eclipse. It shows you:

- How to import an existing example project into your workspace, containing

- a sample BPMN2 process for requesting a performance evaluation
- a sample Java class to start the process

- How to start the process

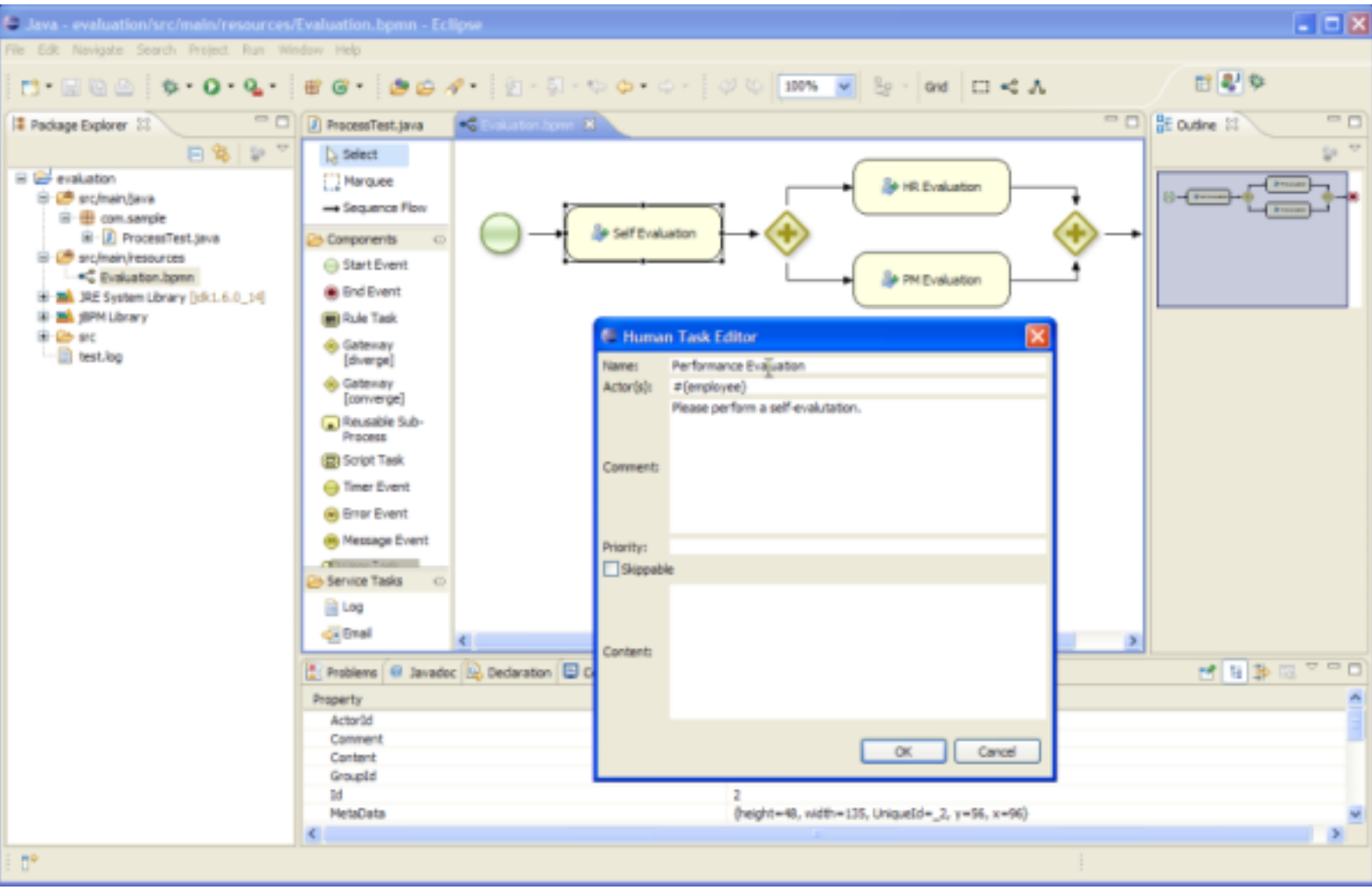


Figure 3.1.

[http://people.redhat.com/kverlaen/install-eclipse-jbpm.swf]

Do the following:

- Once Eclipse has opened, simple import (using "File -> Import ..." and then under the General category, select "Existing Projects into Workspace") the existing sample project (in the jbpm-installer/sample/evaluation directory). This should add the sample project, including a simple BPMN2 process and a Java file to start the process.

- You can open the BPMN2 process and the Java class by double-clicking it.

- We will now debug the process, so we can visualize its runtime state using the debug tooling. First put a breakpoint on line "ksession.startProcess" of the ProcessTest class. To start debugging, right-click on ProcessTest.java in the com.sample package (under "src/main/java") and select "Debug As - Java Application", and switch to the debug perspective.
- Open up the various debug views: Under "Window - Show View -> Other ...", select the Process Instances View and Process Instance View (under Drools category) and the Human Task View (under Drools Task) and click OK.
- The program will hit the breakpoint right before starting the process. Click on the "Step Over" (F6) to start the process. In this case, it will simply start the process, which will result in the creation of a new user task for the user "krisv" in the human task service, after which the process will wait for its execution. Go to the Human Task View, fill in "krisv" under UserId and click Refresh. A new Performance Evaluation task should show up.
- To show the state of the process instance you just started graphically, click on the Process Instances View and then select the ksession variable in the Variables View. This will show all active process instances in the selected session. In this case, there is only one process instance. Double-click it to see the state of that process instance annotated on the process flow chart.
- Now go back to the Task View, select the Performance Evaluation task and first start and then complete the selected task. Now go back to the Process Instances view and double click the process instance again to see its new state.

You could also create a new project using the jBPM project wizard. This sample project contains a simple HelloWorld BPMN2 process and an associated Java file to start the process. Simple select "File - New ... - Project ..." and under the "jBPM" category, select "jBPM project" and click "Next". Give the project a name and click "Finish". You should see a new project containing a "sample.bpmn" process and a "com.sample.ProcessTest" Java class. You can open the BPMN2 process by double-clicking it. To execute the process, right-click on ProcessTest.java and select "Run As - Java Application". You should see a "Hello World" statement in the output console.

3.5. 10-Minute Tutorial: Using the jBPM Console

Open up the process management console:

http://localhost:8080/jbpm-console

Log in, using krisv / krisv as username / password. The *following screencast* [http://people.redhat.com/kverlaen/install-gwt-console-jbpm.swf] gives an overview of how to manage your process instances. It shows you:

- How to start a new process
- How to look up the current status of a running process instance
- How to look up your tasks

- How to complete a task
- How to generate reports to monitor your process execution

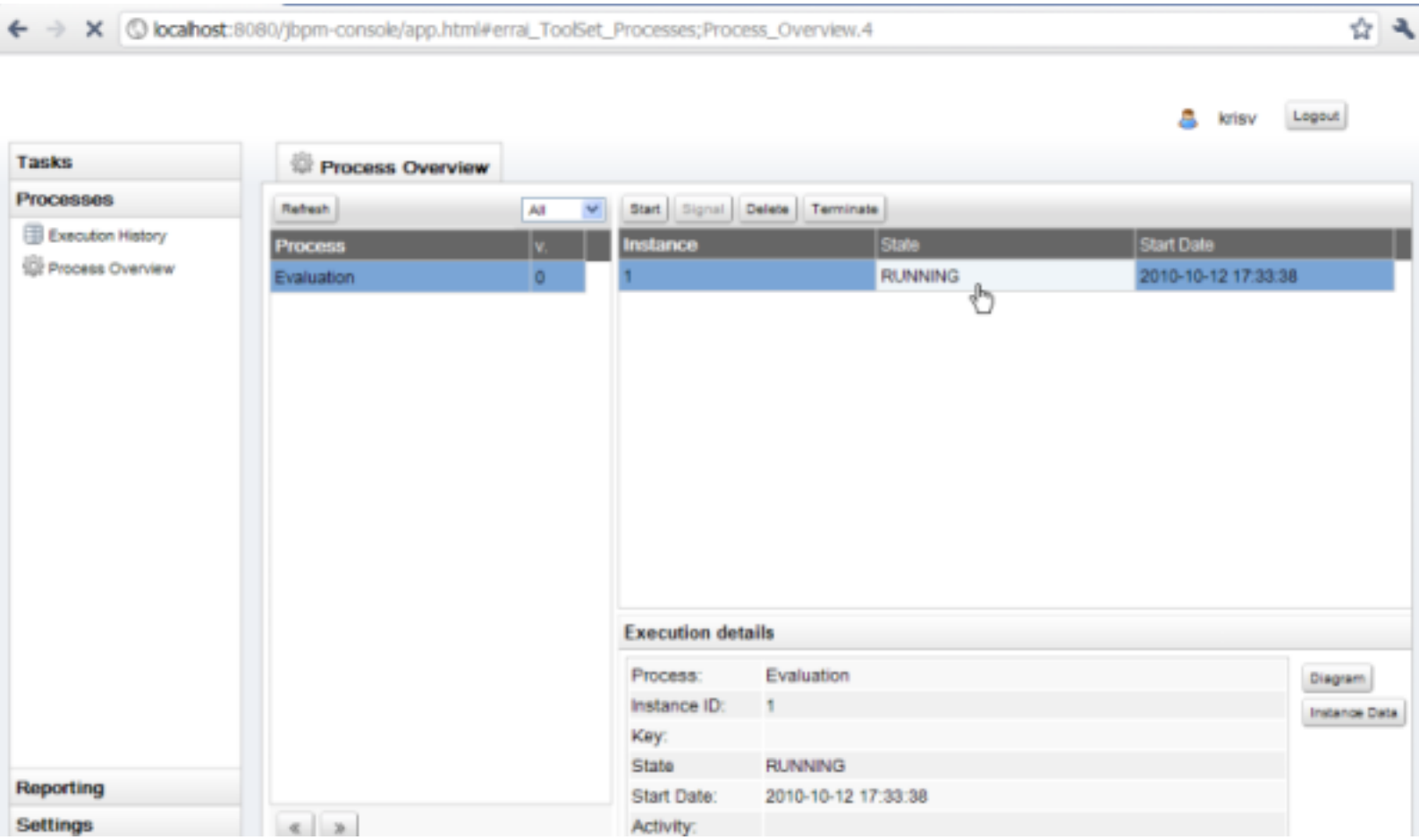


Figure 3.2.

[http://people.redhat.com/kverlaen/install-gwt-console-jbpm.swf]

- To manage your process instances, click on the "Processes" tab at the left an select "Process Overview". After a slight delay (if you are using the application for the first time, due to session initalization etc.), the "Process" list should show all the known processes. The jbpm-console in the demo setup currently loads all the process in the "src/main/resources" folder of the evaluation sample in "jbpm-installer/sample/evaluation". If you click the process, it will show you all current running instances. Since there are no running instances at this point, the "Instance" table will remain empty.
- You can start a new process instance by click on the "Start" button. After confirming that you want to start a new execution of this process, you will see a process form where you need to fill in the necessary information to start the process. In this case, you need to fill in your username

"krisv", after which you can complete the form and close the window. A new instance should show up in the "Instance" table. If you click the process instance, you can check its details below and the diagram and instance data by click on the "Diagram" and "Instance Data" buttons respectively. The process instance that you just started is first requiring a self-evaluation of the user and is waiting until the user has completed this task.

- To see the tasks that have been assigned to you, choose the "Tasks" tab on the left and select "Personal Tasks" (you may need to click refresh to update your task view). The personal tasks table should show a "Performance Evaluation" task for you. You can complete this task by selecting it and clicking the "View" button. This will open the task form for performance evaluations. You can fill in the necessary data and then complete the form and close the window. After completing the task, you could check the "Process Overview" once more to check the progress of your process instance. You should be able to see that the process is now waiting for your HR manager and project manager to also perform an evaluation. You could log in as "john" / "john" and "mary" / "mary" to complete these tasks.

- After starting and/or completing a few process instances and human tasks, you can generate a report of what happened so far. Under "Reporting", select "Report Templates". By default, the console has two report templates, one for generating a generic overview for all processes and one for inspecting once specific process definition. If you select the latter, make sure to enter "com.sample.evaluation" as the process definition id to see the activity related to the evaluation process. Click the "Create Report" button to generate a realtime report of the current status. Notice that the initialization of the reports might take a moment, especially the first time you use the application.

3.6. 10-Minute Tutorial: Using Guvnor repository and Designer

The Guvnor repository can be used as a process repository to store business processes. It also offers a web-based interface to manage your processes. This includes a web-based editor for viewing and editing processes.

Open up Drools Guvnor:

http://localhost:8080/drools-guvnor

Log in, using any non-empty username / password (we disabled authentication for demo purposes). The *following screencast* [http://people.redhat.com/kverlaen/install-guvnor-jbpm.swf] gives an overview of how to manage your repository. It shows you:

- How to import an existing process (in this case the evaluation process) from eclipse into guvnor
- How to open up the evaluation process in the web editor
- How to build a package so it can be used for creating a session

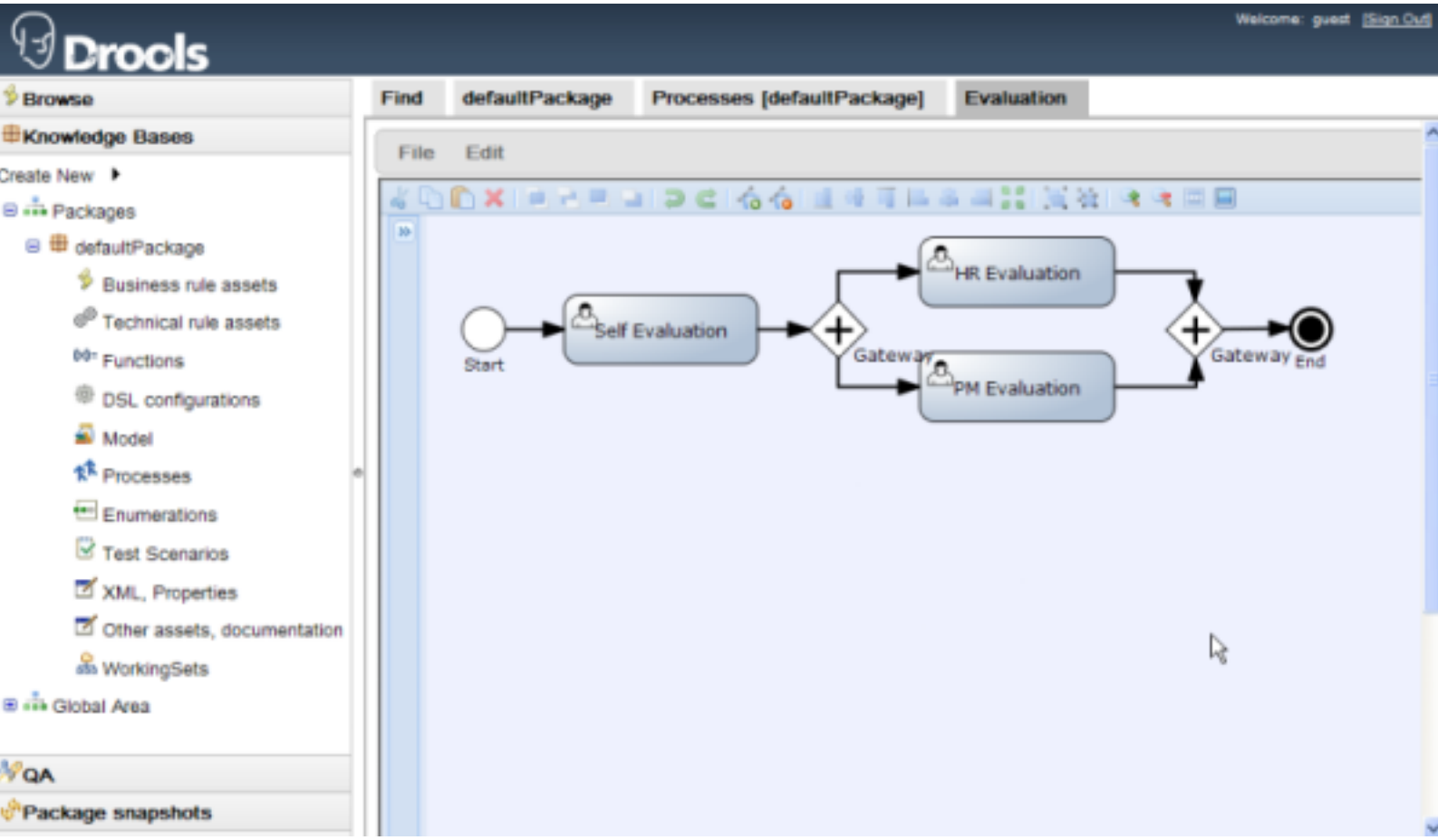


Figure 3.3.

[http://people.redhat.com/kverlaen/install-guvnor-jbpm.swf]

If you want to know more, we recommend you take a look at the rest of the Drools Guvnor documentation.

Once you're done playing:

```
ant stop.demo
```

and simply close all the rest.

3.7. What to do if I encounter problems or have questions?

You can always contact the jBPM community for assistance.

Email: jbpm-dev@lists.jboss.org

IRC: #jbpm at irc.codehaus.org

jBPM User Forum [http://community.jboss.org/en/jbpm?view=discussions]

3.8. Frequently asked questions

Some common issues are explained below.

Q: What if the installer complains it cannot download component X?

A: Are you connected to the internet? Do you have a firewall turned on? Do you require a proxy? It might be possible that one of the locations we're downloading the components from is temporarly offline. Try downloading the components manually (possibly from alternate locations) and put them in the jbpm-installer/lib folder.

Q: What if the installer complains it cannot extract / unzip a certain jar/war/zip?

A: If your download failed while downloading a component, it is possible that the installer is trying to use an incomplete file. Try deleting the component in question from the jbpm-installer/lib folder and reinstall, so it will be downloaded again.

Q: What if I have been changing my installation (and it no longer works) and I want to start over again with a clean installation?

A: You can use ant clean.demo to remove all the installed components, so you end up with a fresh installation again.

Q: I sometimes see exceptions when trying to stop or restart certain services, what should I do?

A: If you see errors during shutdown, are you sure the services were still running? If you see exceptions during restart, are you sure the service you started earlier was successfully shutdown? Maybe try killing the services manually if necessary.

Q: Something seems to be going wrong when running Eclipse but I have no idea what. What can I do?

A: Always check the consoles for output like error messages or stack traces. You can also check the Eclipse Error Log for exceptions. Try adding an audit logger to your session to figure out what's happening at runtime, or try debugging your application.

Q: Something seems to be going wrong when running the a web-based application like the jbpm-console, Guvnor and the Designer. What can I do?

A: You can check the server log for possible exceptions in the jbpm-installer/jboss-4.2.3.GA/server/default/log directory.

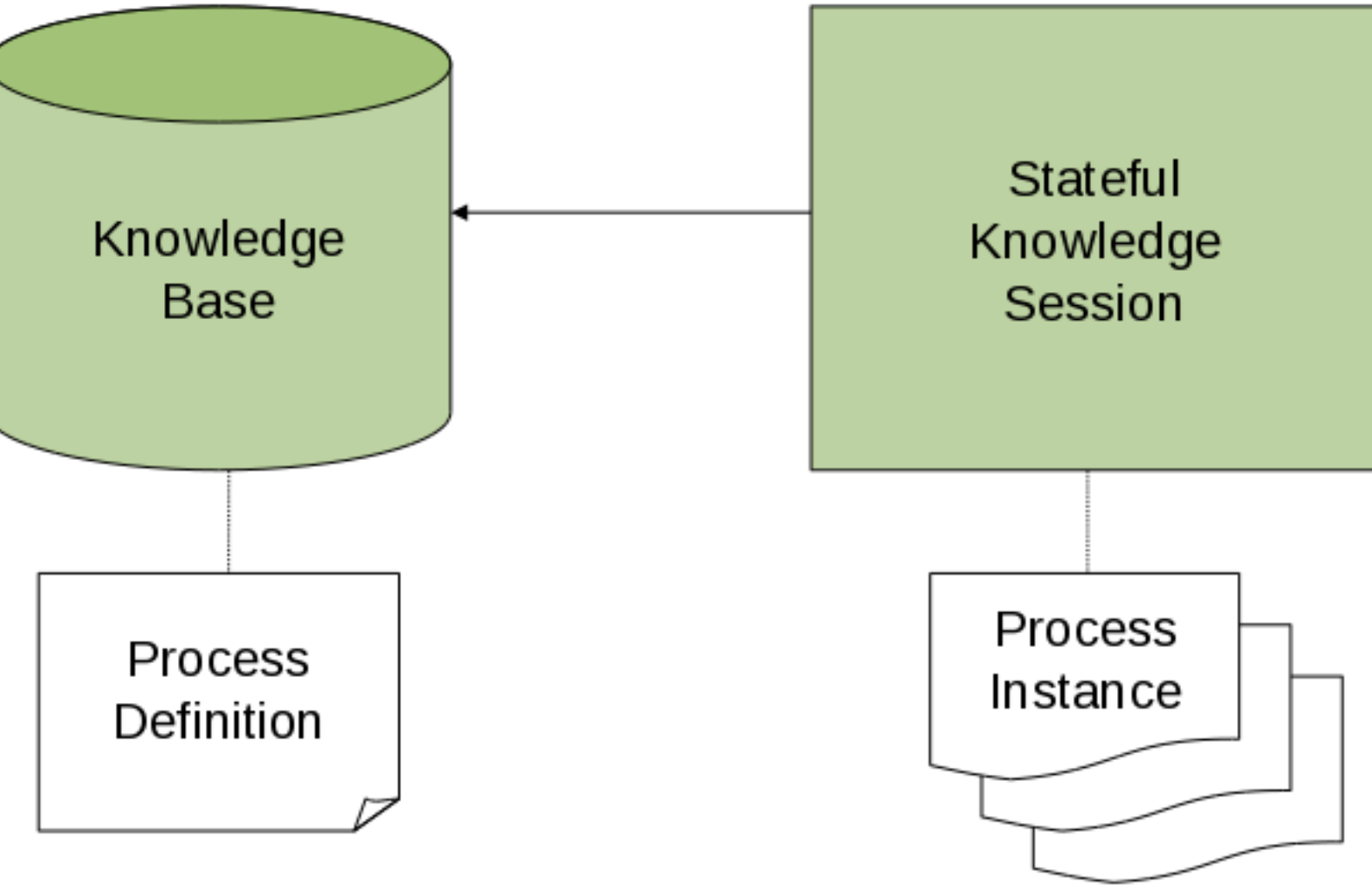
For all other questions, try contacting the jBPM community as described above.

Chapter 4. Core Engine: API

This chapter introduces the API you need to load processes and execute them. For more detail on how to define the processes themselves, check out the chapter on BPMN 2.0.

To interact with the process engine (to for example start a process), you need to set up a session. This session will be used to communicate with the process engine. A session needs to have a reference to a knowledge base, which contains a reference to all the relevant process definitions. This knowledge base is used to look up the process definitions whenever necessary. To create a session, you first need to create a knowledge base, load all the necessary process definition (this can be from various sources, like from classpath, file system or process repository) and then instantiate a session.

Once you have set up a session, you can use it to start executing processes. Whenever a process is started, a new process instance is created (for that process definition) that maintains the state of that specific instance of the process.



For example, image you are writing an application to process sales orders. You could then define one or more process definitions that define how the order should be processed. When starting up your application, you first need to create a knowledge base that contains those process definitions. You can then create a session based on this knowledge base so that, whenever a new sales order then comes in, a new process instance is started for that sales order. That process instance contains the state of the process for that specific sales request.

A knowledge base can be shared across sessions and usually is only created once, at the start of the application (as creating a knowledge base can be rather heavy-weight as it involves parsing and compiling the process definitions). Knowledge bases can be dynamically changed (so you can add or remove processes at runtime).

Sessions can be created based on a knowledge base and are used to execute processes and interact with the engine. You can create as much independent session as you want and creating a session is considered relatively lightweight. How many sessions you create is up to you. In general, most simple cases start out with creating one session that is then called from various places in your application. You could decide to create multiple sessions if for example you want to have multiple independent processing units (for example, you want all processes from one customer be completely independent of processes of another customer so you could create an independent session for each customer), or if you need multiple sessions for scalability reasons. If you don't know what to do, simply start by having one knowledge base that contains all your process definitions and one create session that you then use to execute all your processes.

4.1. The jBPM API

The jBPM project has a clear separation between the API the users should be interacting with and the actual implementation classes. The public API exposes most of the features we believe "normal" users can safely use and should remain rather stable across releases. Expert users can still access internal classes but should be aware that they should know what they are doing and that internal API might still change in the future.

As explained above, the jBPM API should thus be used to (1) create a knowledge base that contains your process definitions, and to (2) create a session to start new process instances, signal existing ones, register listeners, etc.

4.1.1. Knowledge Base

The jBPM API allows you to first create a knowledge base. This knowledge base should include all your process definitions that might need to be executed by that session. To create a knowlegde base, use a knowledge builder to load processes from various resources (for example from the classpath or from file system), and then create a new knowledge base from that builder. The following code snippet shows how to create a knowledge base consisting of only one process definition (using in this case a resource from the classpath).

```
KnowledgeBuilder kbuilder = KnowledgeBuilderFactory.newKnowledgeBuilder();
kbuilder.add(ResourceFactory.newClassPathResource("MyProcess.bpmn"), ResourceType.BPMN2);
KnowledgeBase kbase = kbuilder.newKnowledgeBase();
```

The ResourceFactory has similar methods to load files from file system, from URL, InputStream, Reader, etc.

4.1.2. Session

Once you've loaded your knowledge base, you should create a session to interact with the engine. This session can then be used to start new processes, signal events, etc. The following code snippet shows how easy it is to create a session based on the earlier created knowledge base, and to start a process (by id).

```
StatefulKnowledgeSession ksession = kbase.newStatefulKnowledgeSession();
ProcessInstance processInstance = ksession.startProcess("com.sample.MyProcess");
```

The `ProcessRuntime` interface defines all the session methods for interacting with processes, as shown below.

```
/**
 * Start a new process instance.  The process (definition) that should
 * be used is referenced by the given process id.
 *
 * @param processId  The id of the process that should be started
 * @return the ProcessInstance that represents the instance of the process that was started
 */
ProcessInstance startProcess(String processId);

/**
 * Start a new process instance.  The process (definition) that should
 * be used is referenced by the given process id.  Parameters can be passed
 * to the process instance (as name-value pairs), and these will be set
 * as variables of the process instance.
 *
 * @param processId  the id of the process that should be started
 * @param parameters  the process variables that should be set when starting the process instance
 * @return the ProcessInstance that represents the instance of the process that was started
 */
ProcessInstance startProcess(String processId,
```

```
                    Map<String, Object> parameters);

  /**
   * Signals the engine that an event has occurred. The type parameter defines
   * which type of event and the event parameter can contain additional information
   * related to the event.  All process instances that are listening to this type
   * of (external) event will be notified.  For performance reasons, this type of event
   * signaling should only be used if one process instance should be able to notify
   * other process instances. For internal event within one process instance, use the
   * signalEvent method that also include the processInstanceId of the process instance
   * in question.
   *
   * @param type the type of event
   * @param event the data associated with this event
   */
  void signalEvent(String type,
                   Object event);

  /**
   * Signals the process instance that an event has occurred. The type parameter defines
   * which type of event and the event parameter can contain additional information
   * related to the event.  All node instances inside the given process instance that
   * are listening to this type of (internal) event will be notified.  Note that the event
   * will only be processed inside the given process instance.  All other process instances
   * waiting for this type of event will not be notified.
   *
   * @param type the type of event
   * @param event the data associated with this event
   * @param processInstanceId the id of the process instance that should be signaled
   */
  void signalEvent(String type,
                   Object event,
                   long processInstanceId);

  /**
   * Returns a collection of currently active process instances.  Note that only process
   * instances that are currently loaded and active inside the engine will be returned.
   * When using persistence, it is likely not all running process instances will be loaded
   * as their state will be stored persistently.  It is recommended not to use this
   * method to collect information about the state of your process instances but to use
   * a history log for that purpose.
   *
   * @return a collection of process instances currently active in the session
   */
```

```
  Collection<ProcessInstance> getProcessInstances();

  /**
   * Returns the process instance with the given id.  Note that only active process instances
   * will be returned.  If a process instance has been completed already, this method will return
   * null.
   *
   * @param id the id of the process instance
   * @return the process instance with the given id or null if it cannot be found
   */
  ProcessInstance getProcessInstance(long processInstanceId);

  /**
   * Aborts the process instance with the given id.  If the process instance has been completed
   * (or aborted), or the process instance cannot be found, this method will throw an
   * IllegalArgumentException.
   *
   * @param id the id of the process instance
   */
  void abortProcessInstance(long processInstanceId);

  /**
   * Returns the WorkItemManager related to this session.  This can be used to
   * register new WorkItemHandlers or to complete (or abort) WorkItems.
   *
   * @return the WorkItemManager related to this session
   */
  WorkItemManager getWorkItemManager();
```

4.1.3. Events

The session provides methods for registering and removing listeners. A `ProcessEventListener` can be used to listen to process-related events, like starting or completing a process, entering and leaving a node, etc. Below, the different methods of the `ProcessEventListener` class are shown. An event object provides access to related information, like the process instance and node instance linked to the event. You can use this API to register your own event listeners.

```
public interface ProcessEventListener {

  void beforeProcessStarted( ProcessStartedEvent event );
  void afterProcessStarted( ProcessStartedEvent event );
  void beforeProcessCompleted( ProcessCompletedEvent event );
```

```
  void afterProcessCompleted( ProcessCompletedEvent event );
  void beforeNodeTriggered( ProcessNodeTriggeredEvent event );
  void afterNodeTriggered( ProcessNodeTriggeredEvent event );
  void beforeNodeLeft( ProcessNodeLeftEvent event );
  void afterNodeLeft( ProcessNodeLeftEvent event );
  void beforeVariableChanged(ProcessVariableChangedEvent event);
  void afterVariableChanged(ProcessVariableChangedEvent event);

}
```

jBPM out-of-the-box provides a listener that can be used to create an audit log (either to the console or the a file on the file system). This audit log contains all the different events that occurred at runtime so it's easy to figure out what happened. Note that these loggers should only be used for debugging purposes. The following logger implementations are supported by default:

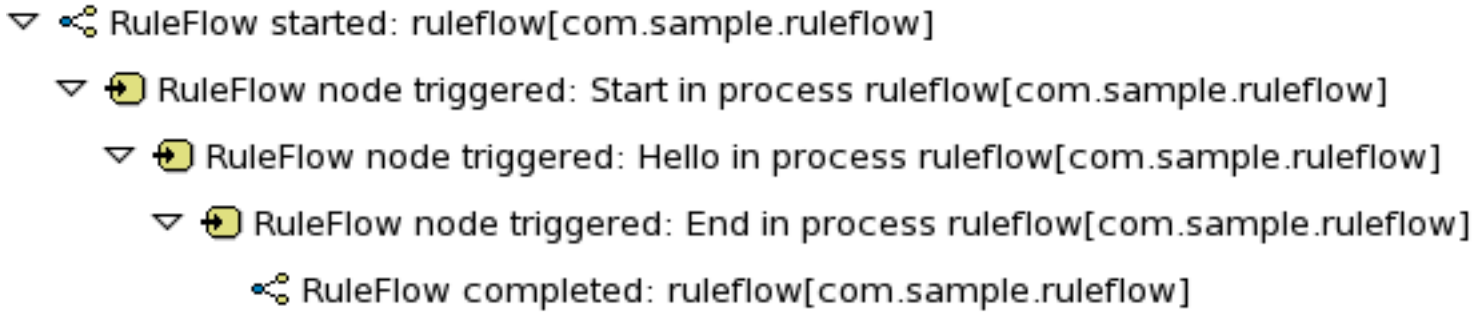
1. Console logger: This logger writes out all the events to the console.
2. File logger: This logger writes out all the events to a file using an XML representation. This log file might then be used in the IDE to generate a tree-based visualization of the events that occurred during execution.
3. Threaded file logger: Because a file logger writes the events to disk only when closing the logger or when the number of events in the logger reaches a predefined level, it cannot be used when debugging processes at runtime. A threaded file logger writes the events to a file after a specified time interval, making it possible to use the logger to visualize the progress in realtime, while debugging processes.

The `KnowledgeRuntimeLoggerFactory` lets you add a logger to your session, as shown below. When creating a console logger, the knowledge session for which the logger needs to be created must be passed as an argument. The file logger also requires the name of the log file to be created, and the threaded file logger requires the interval (in milliseconds) after which the events should be saved. You should always close the logger at the end of your application.

```
KnowledgeRuntimeLogger logger =
    KnowledgeRuntimeLoggerFactory.newFileLogger( ksession, "test" );
// add invocations to the process engine here,
// e.g. ksession.startProcess(processId);
...
logger.close();
```

The log file that is created by the file-based loggers contains an XML-based overview of all the events that occurred at runtime. It can be opened in Eclipse, using the Audit View in the Drools

Eclipse plugin, where the events are visualized as a tree. Events that occur between the before and after event are shown as children of that event. The following screenshot shows a simple example, where a process is started, resulting in the activation of the Start node, an Action node and an End node, after which the process was completed.



4.2. Knowledge-based API

As you might have noticed, the API as exposed by the jBPM project is a knowledge API. That means that it doesn't only focus on processes, but potentially also allows other types of knowledge to be loaded. The impact for users that are only interested in processes however is very small. It just means that, instead of having a ProcessBase or a ProcessSession, you are using a KnowledgeBase and a KnowledgeSession.

However, if you ever plan to use business rules or complex event processing as part of your application, the knowledge-based API allows users to add different types of resources, such as processes and rules, in almost identical ways into the same knowledge base. This enables a user who knows how to use jBPM to start using Drools Expert (for business rules) or Drools Fusion (for event processing) almost instantaneously (and even to integrate these different types of Knowledge) as the API and tooling for these different types of knowledge is unified.

Chapter 5. Core Engine: Basics

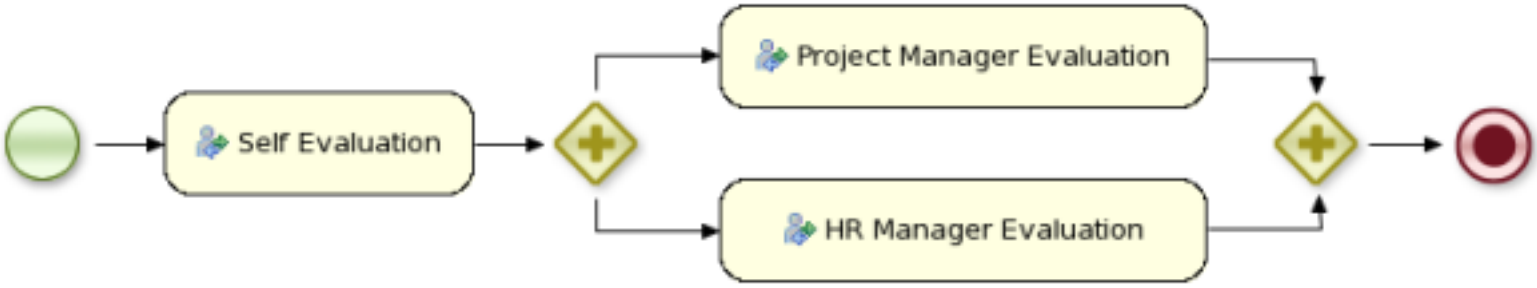


Figure 5.1.

A business process is a graph that describes the order in which a series of steps need to be executed, using a flow chart. A process consists of a collection of nodes that are linked to each other using connections. Each of the nodes represents one step in the overall process while the connections specify how to transition from one node to the other. A large selection of predefined node types have been defined. This chapter describes how to define such processes and use them in your application.

5.1. Creating a process

Processes can be created by using one of the following three methods:

1. Using the graphical process editor in the Eclipse plugin
2. As an XML file, according to the XML process format as defined in the XML Schema Definition in the BPMN 2.0 specification.
3. By directly creating a process using the Process API.

5.1.1. Using the graphical BPMN2 Editor

The graphical BPMN2 editor is a editor that allows you to create a process by dragging and dropping different nodes on a canvas and editing the properties of these nodes. The graphical BPMN2 editor is part of the jBPM / Drools Eclipse plugin. Once you have set up a jBPM project (see the installer for creating an working Eclipse environment where you can start), you can start adding processes. When in a project, launch the "New" wizard (use Ctrl+N) or right-click the directory you would like to put your process in and select "New", then "File". Give the file a name and the extension bpmn (e.g. MyProcess.bpmn). This will open up the process editor (you can safely ignore the warning that the file could not be read, this is just because the file is still empty).

First, ensure that you can see the Properties View down the bottom of the Eclipse window, as it will be necessary to fill in the different properties of the elements in your process. If you cannot see the properties view, open it using the menu "Window", then "Show View" and "Other...", and under the "General" folder select the Properties View.

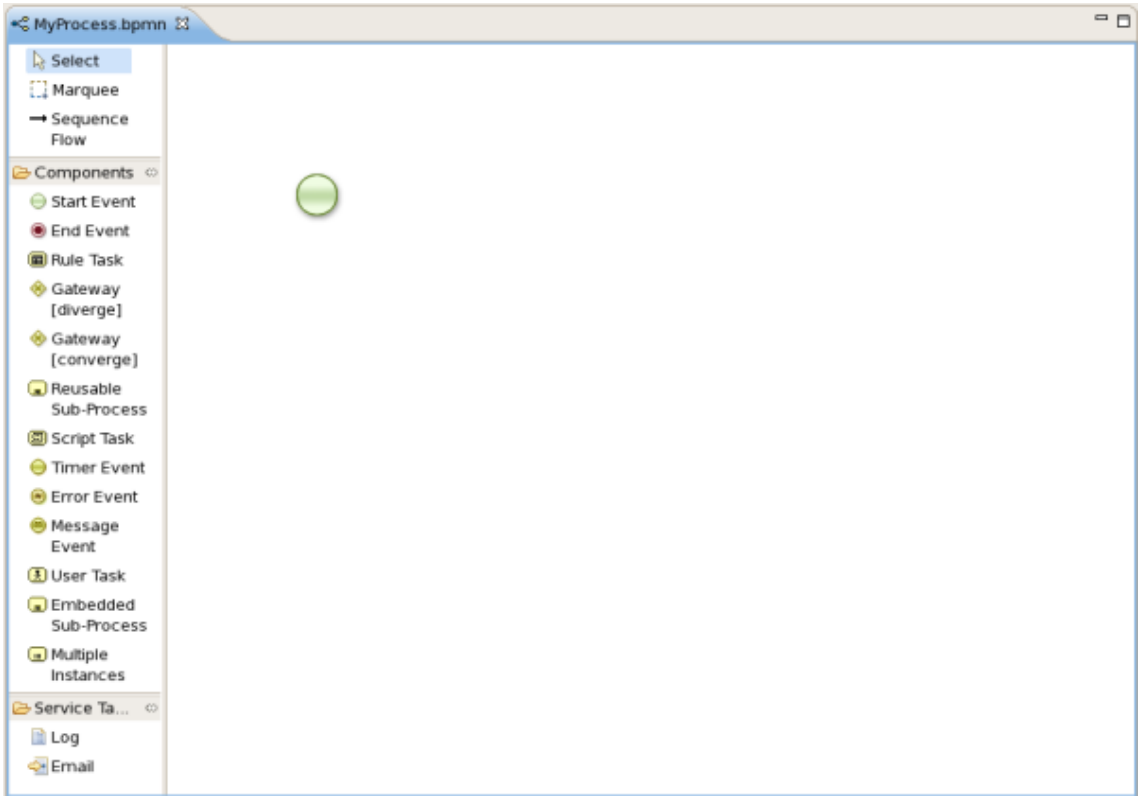


Figure 5.2. New process

The process editor consists of a palette, a canvas and an outline view. To add new elements to the canvas, select the element you would like to create in the palette and then add them to the canvas by clicking on the preferred location. For example, click on the "End Event" icon in the "Components" palette of the GUI. Clicking on an element in your process allows you to set the properties of that element. You can connect the nodes (as long as it is permitted by the different types of nodes) by using "Sequence Flow" from the "Components" palette.

You can keep adding nodes and connections to your process until it represents the business logic that you want to specify.

5.1.2. Defining processes using XML

It is also possible to specify processes using the underlying BPMN 2.0 XML directly. The syntax of these XML processes is defined using the BPMN 2.0 XML Schema Definition. For example, the following XML fragment shows a simple process that contains a sequence of a Start Event, a Script Task that prints "Hello World" to the console, and an End Event.

```
<?xml version="1.0" encoding="UTF-8"?>
<definitions id="Definition"
             targetNamespace="http://www.jboss.org/drools"
             typeLanguage="http://www.java.com/javaTypes"
             expressionLanguage="http://www.mvel.org/2.0"
```

```
        xmlns="http://www.omg.org/spec/BPMN/20100524/MODEL"Rule Task
        xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
      xsi:schemaLocation="http://www.omg.org/spec/BPMN/20100524/MODEL BPMN20.xsd"
        xmlns:g="http://www.jboss.org/drools/flow/gpd"
        xmlns:bpmndi="http://www.omg.org/spec/BPMN/20100524/DI"
        xmlns:dc="http://www.omg.org/spec/DD/20100524/DC"
        xmlns:di="http://www.omg.org/spec/DD/20100524/DI"
        xmlns:tns="http://www.jboss.org/drools">

  <process processType="Private" isExecutable="true" id="com.sample.hello" name="Hello
Process" >

    <!-- nodes -->
    <startEvent id="_1" name="Start" />
    <scriptTask id="_2" name="Hello" >
      <script>System.out.println("Hello World");</script>
    </scriptTask>
    <endEvent id="_3" name="End" >
       <terminateEventDefinition/>
    </endEvent>

    <!-- connections -->
    <sequenceFlow id="_1-_2" sourceRef="_1" targetRef="_2" />
    <sequenceFlow id="_2-_3" sourceRef="_2" targetRef="_3" />

  </process>

  <bpmndi:BPMNDiagram>
    <bpmndi:BPMNPlane bpmnElement="com.sample.hello" >
      <bpmndi:BPMNShape bpmnElement="_1" >
        <dc:Bounds x="16" y="16" width="48" height="48" />
      </bpmndi:BPMNShape>
      <bpmndi:BPMNShape bpmnElement="_2" >
        <dc:Bounds x="96" y="16" width="80" height="48" />
      </bpmndi:BPMNShape>
      <bpmndi:BPMNShape bpmnElement="_3" >
        <dc:Bounds x="208" y="16" width="48" height="48" />
      </bpmndi:BPMNShape>
      <bpmndi:BPMNEdge bpmnElement="_1-_2" >
        <di:waypoint x="40" y="40" />
        <di:waypoint x="136" y="40" />
      </bpmndi:BPMNEdge>
      <bpmndi:BPMNEdge bpmnElement="_2-_3" >
        <di:waypoint x="136" y="40" />
```

```
      <di:waypoint x="232" y="40" />
    </bpmndi:BPMNEdge>
  </bpmndi:BPMNPlane>
</bpmndi:BPMNDiagram>

</definitions>
```

The process XML file consists of two parts, the top part (the "process" element) contains the definition of the different nodes and their properties, the lower part (the "BPMNDiagram" element) contains all graphical information, like the location of the nodes. The process XML consist of exactly one <process> element. This element contains parameters related to the process (its type, name, id and package name), and consists of three subsections: a header section (where process-level information like variables, globals, imports and lanes can be defined), a nodes section that defines each of the nodes in the process, and a connections section that contains the connections between all the nodes in the process. In the nodes section, there is a specific element for each node, defining the various parameters and, possibly, sub-elements for that node type.

5.1.3. Defining Processes Using the Process API

While it is recommended to define processes using the graphical editor or the underlying XML (to shield yourself from internal APIs), it is also possible to define a process using the Process API directly. The most important process model elements are defined in the packages `org.jbpm.workflow.core` and `org.jbpm.workflow.core.node`. A "fluent API" is provided that allows you to easily construct processes in a readable manner using factories. At the end, you can validate the process that you were constructing manually.

5.1.3.1. Example

This is a simple example of a basic process with a script task only:

```
RuleFlowProcessFactory factory =
    RuleFlowProcessFactory.createProcess("org.jbpm.HelloWorld");
factory
    // Header
    .name("HelloWorldProcess")
    .version("1.0")
    .packageName("org.jbpm")
    // Nodes
    .startNode(1).name("Start").done()
    .actionNode(2).name("Action")
        .action("java", "System.out.println(\"Hello World\");").done()
    .endNode(3).name("End").done()
    // Connections
```

```
    .connection(1, 2)
    .connection(2, 3);
RuleFlowProcess process = factory.validate().getProcess();
```

You can see that we start by calling the static `createProcess()` method from the `RuleFlowProcessFactory` class. This method creates a new process with the given id and returns the `RuleFlowProcessFactory` that can be used to create the process. A typical process consists of three parts. The header part comprises global elements like the name of the process, imports, variables, etc. The nodes section contains all the different nodes that are part of the process. The connections section finally links these nodes to each other to create a flow chart.

In this example, the header contains the name and the version of the process and the package name. After that, you can start adding nodes to the current process. If you have auto-completion you can see that you have different methods to create each of the supported node types at your disposal.

When you start adding nodes to the process, in this example by calling the `startNode()`, `actionNode()` and `endNode()` methods, you can see that these methods return a specific `NodeFactory`, that allows you to set the properties of that node. Once you have finished configuring that specific node, the `done()` method returns you to the current `RuleFlowProcessFactory` so you can add more nodes, if necessary.

When you are finished adding nodes, you must connect them by creating connections between them. This can be done by calling the method `connection`, which will link previously created nodes.

Finally, you can validate the generated process by calling the `validate()` method and retrieve the created `RuleFlowProcess` object.

5.2. Details of different process constructs: Overview

The following chapters will describe the different constructs that you can use to model your processes (and their properties) in detail. Executable processes in BPMN consist of a different types of nodes being connected to each other using sequence flows. The BPMN 2.0 specification defines three main types of nodes:

- *Events*: They are used to model the occurrence of a particular event. This could be a start event (that is used to indicate the start of the process), end events (that define the end of the process, or of that subflow) and intermediate events (that indicate events that might occur during the execution of the process).
- *Activities*: These define the different actions that need to be performed during the execution of the process. Different types of tasks exist, depending on the type of activity you are trying to model (e.g. human task, service task, etc.) and actvities could also be nested (using different types of sub-processes).

- *Gateways*: Can be used to define multiple paths in the process. Depending on the type of gateway, these might indicate parallel execution, choice, etc.

The following sections will describe the properties of the process itself and of each of these different node types in detail, as supported by the Eclipse plugin and shown in the following figure of the palette. Note that the Eclipse property editor might show more properties for some of the supported node types, but only the properties as defined in this section are supported when using the BPMN 2.0 XML format.

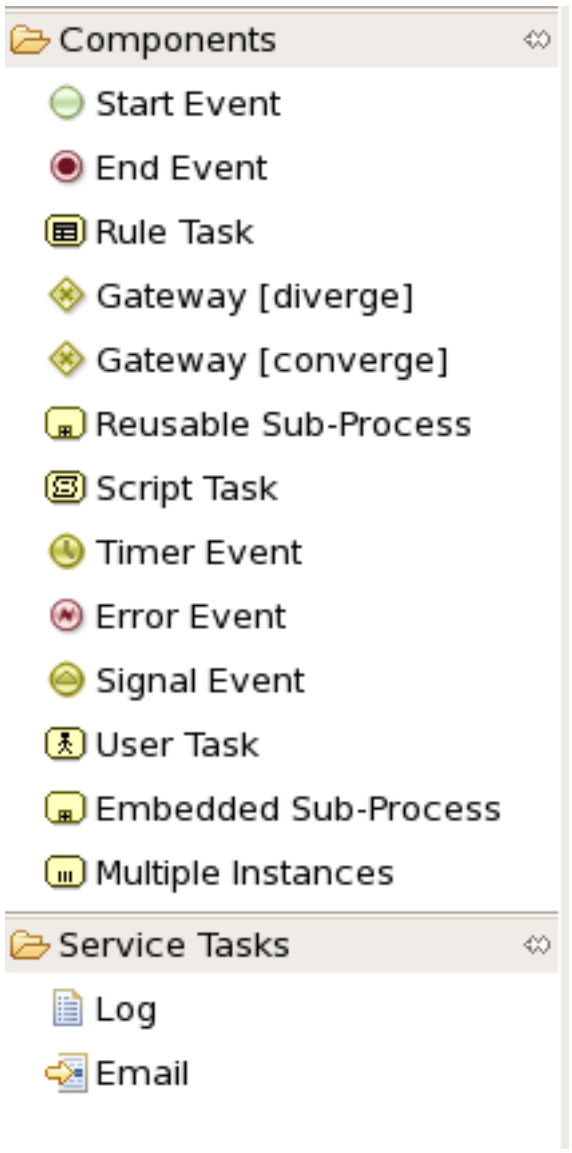


Figure 5.3. The different types of BPMN2 nodes

5.3. Details: Process properties

A BPMN2 process is a flow chart where different types of nodes are linked using connections. The process itself exposes the following properties:

- *Id*: The unique id of the process.
- *Name*: The display name of the process.
- *Version*: The version number of the process.
- *Package*: The package (namespace) the process is defined in.
- *Variables*: Variables can be defined to store data during the execution of your process. See section “*Data*” for details.
- *Swimlanes*: Specify the swimlanes used in this process for assigning human tasks. See chapter “*Human Tasks*” for details.

5.4. Details: Events

5.4.1. Start event

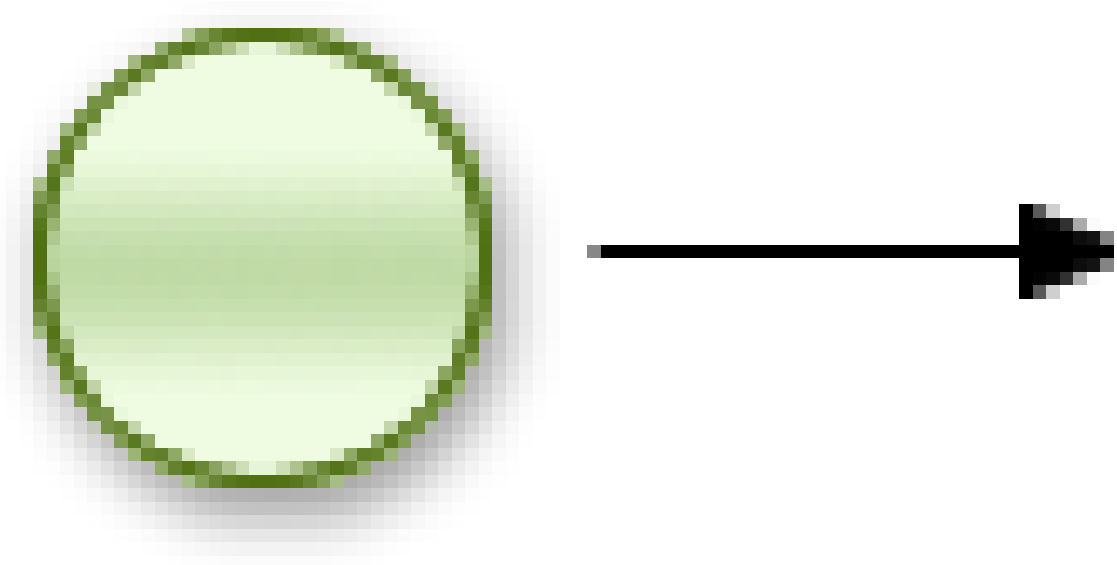


Figure 5.4. Start event

The start of the process. A process should have exactly one start node, which cannot have incoming connections and should have one outgoing connection. Whenever a process is started, execution will start at this node and automatically continue to the first node linked to this start event, and so on. It contains the following properties:

- *Id*: The id of the node (which is unique within one node container).
- *Name*: The display name of the node.

5.4.2. End events

5.4.2.1. End event

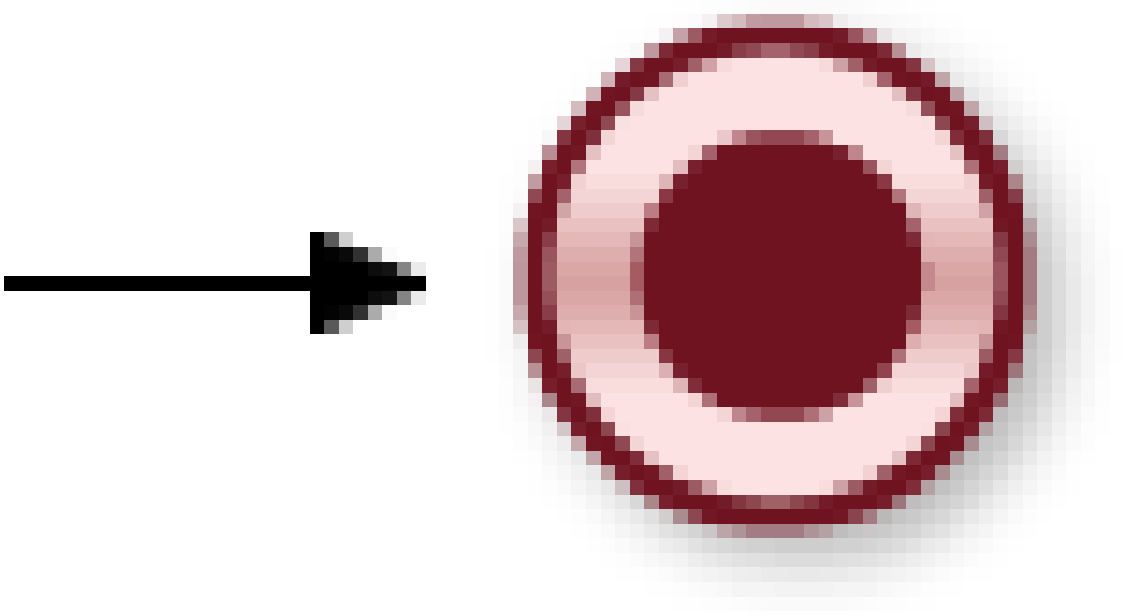


Figure 5.5. End event

The end of the process. A process should have one or more end events. The End Event should have one incoming connection and cannot have outgoing connections. It contains the following properties:

- *Id*: The id of the node (which is unique within one node container).
- *Name*: The display name of the node.
- *Terminate*: An End Event can be terminating for the entire process or just for the path. When a process instance is terminated, it means its state is set to completed and all other nodes that might still be active (on parallel paths) in this process instance are cancelled. Non-terminating end events are simply ends for this path (execution of this branch will end here), but other parallel paths can still continue. A process instances will automatically complete if there are no more active paths inside that process instance (for example, if a process instance reaches a non-terminating end node but there are no more active branches inside the process instance, the process instance will be completed anyway). Terminating end event are visualized using a full circle inside the event node, non-terminating event nodes are empty. Note that, if you use a terminating event node inside a sub-process, you are terminating the top-level process instance, not just that sub-process.

5.4.2.2. Throwing error event

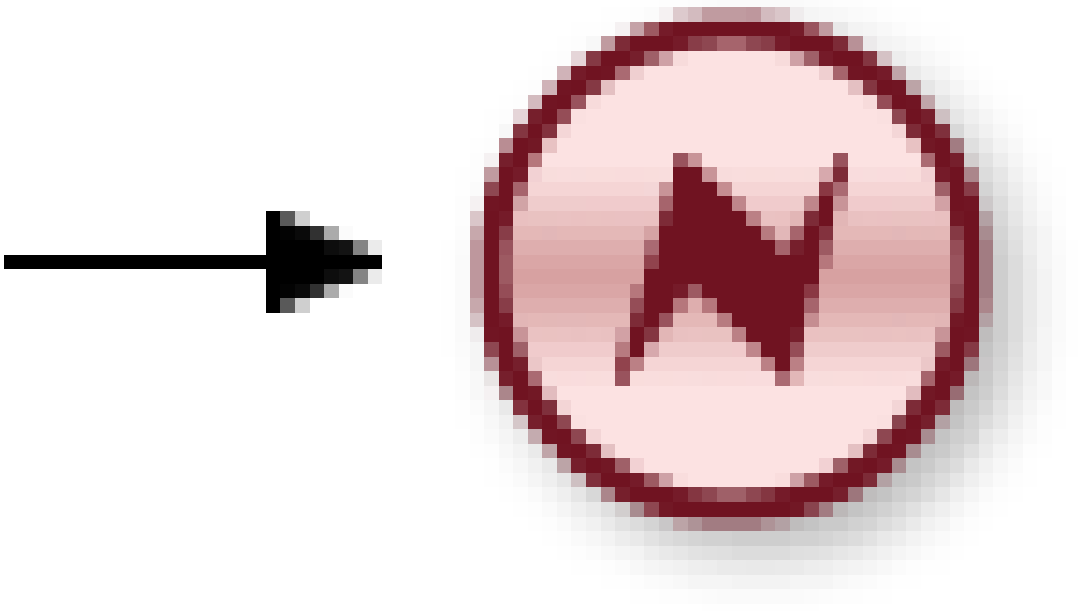


Figure 5.6. Throwing error event

An Error Event can be used to signal an exceptional condition in the process. It should have one incoming connection and no outgoing connections. When an Error Event is reached in the process, it will throw an error with the given name. The process will search for an appropriate error handler that is capable of handling this kind of fault. If no error handler is found, the process instance will be aborted. An Error Event contains the following properties:

- *Id*: The id of the node (which is unique within one node container).
- *Name*: The display name of the node.
- *FaultName*: The name of the fault. This name is used to search for appriopriate exception handlers that is capable of handling this kind of fault.
- *FaultVariable*: The name of the variable that contains the data associated with this fault. This data is also passed on to the exception handler (if one is found).

Error handlers can be specified using boundary events. This is however currently only possible by doing this in XML directly. We will be adding support for graphically specifying this in the new BPMN2 editor.

5.4.3. Intermediate events

5.4.3.1. Catching timer event

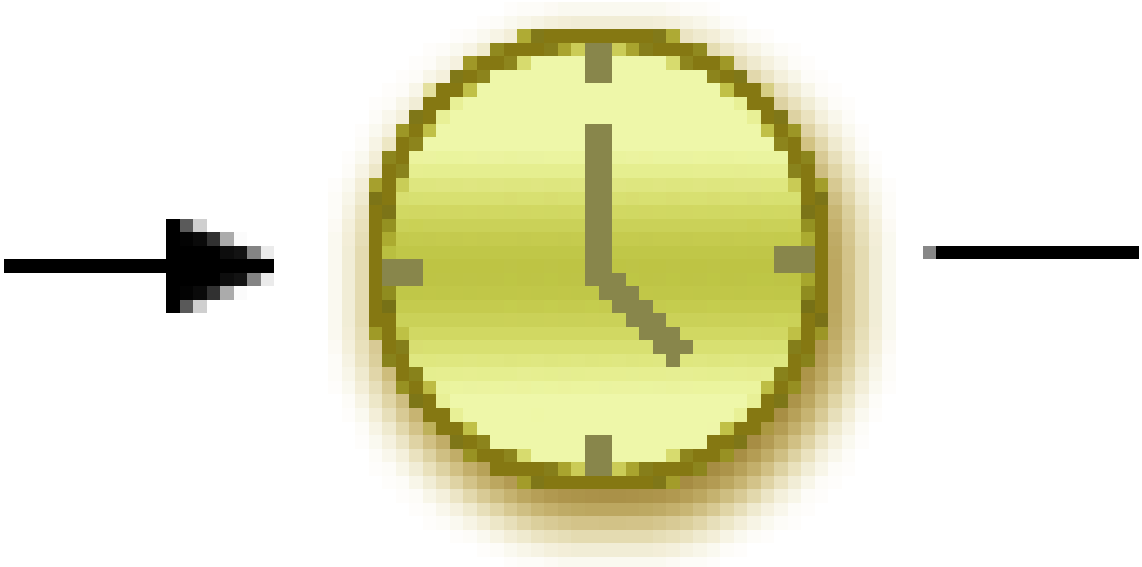


Figure 5.7. Catching timer event

Represents a timer that can trigger one or multiple times after a given period of time. A Timer Event should have one incoming connection and one outgoing connection. The timer delay specifies how long the timer should wait before triggering the first time. When a Timer Event is reached in the process, it will start the associated timer. The timer is cancelled if the timer node is cancelled (e.g., by completing or aborting the enclosing process instance). Consult the section "*Timers*" for more information. The Timer Event contains the following properties:

- *Id*: The id of the node (which is unique within one node container).
- *Name*: The display name of the node.
- *Timer delay*: The delay that the node should wait before triggering the first time. The expression should be of the form `[#d][#h][#m][#s][#[ms]]`. This means that you can specify the amount of days, hours, minutes, seconds and multiseconds (which is the default if you don't specify anything). For example, the expression "1h" will wait one hour before triggering the timer. The expression could also use #{expr} to dynamically derive the delay based on some process variable. Expr in this case could be a process variable, or a more complex expression based on a process variable (e.g. myVariable.getValue()).
  .

- *Timer period*: The period between two subsequent triggers. If the period is 0, the timer should only be triggered once. The expression should be of the form `[#d][#h][#m][#s][#[ms]]`. This means that you can specify the amount of days, hours, minutes, seconds and multiseconds (which is the default if you don't specify anything). For example, the expression "1h" will wait one hour before triggering the timer again. The expression could also use #{expr} to dynamically derive the period based on some process variable. Expr in this case could be a process variable, or a more complex expression based on a process variable (e.g. myVariable.getValue()).

Timer events could also be specified as boundary events on sub-processes. This is however currently only possible by doing this in XML directly. We will be adding support for graphically specifying this in the new BPMN2 editor.

5.4.3.2. Catching signal event

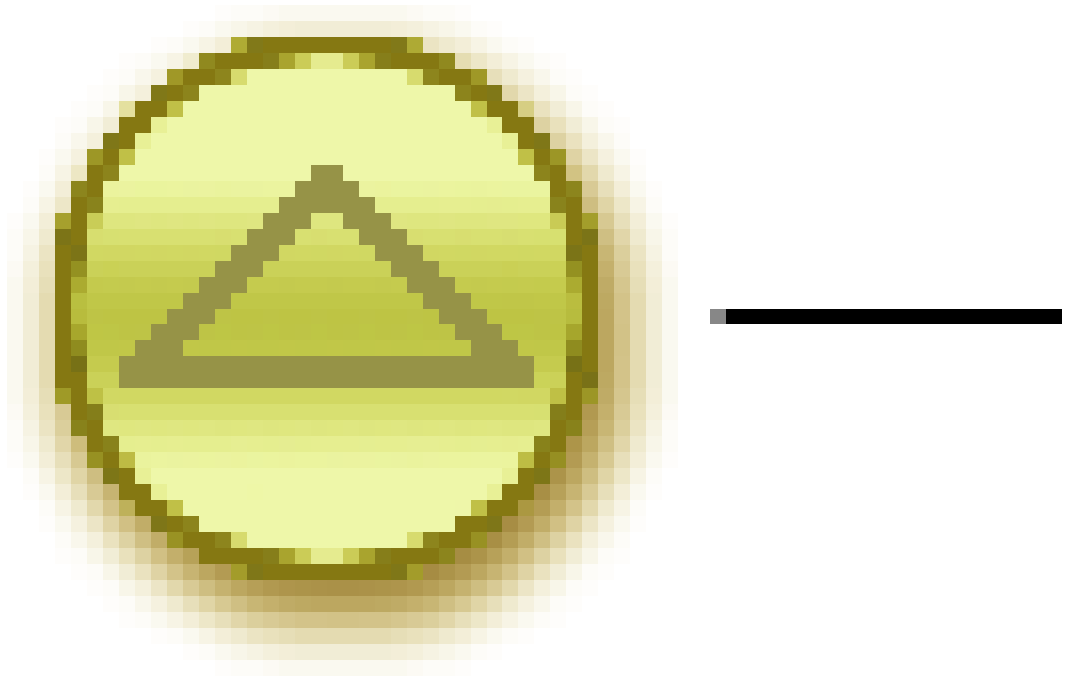


Figure 5.8. Catching signal event

A Signal Event can be used to respond to internal or external events during the execution of the process. A Signal Event should have no incoming connections and one outgoing connection. It specifies the type of event that is expected. Whenever that type of event is detected, the node connected to this event node will be triggered. It contains the following properties:

- *Id*: The id of the node (which is unique within one node container).
- *Name*: The display name of the node.
- *EventType*: The type of event that is expected.
- *VariableName*: The name of the variable that will contain the data associated with this event (if any) when this event occurs.

A process instance can be signaled that a specific event occurred using

```
ksession.signalEvent(eventType, data, processInstanceId)
```

This will trigger all (active) signal event nodes in the given process instance that are waiting for that event type. Data related to the event can be passed using the data parameter. If the event node specifies a variable name, this data will be copied to that variable when the event occurs.

It is also possible to use event nodes inside sub-processes. These event nodes will however only be active when the sub-process is active.

You can also generate a signal from inside a process instance. A script (in a script task or using on entry or on exit actions) can use

```
kcontext.getKnowledgeRuntime().signalEvent(
  eventType, data, kcontext.getProcessInstance().getId());
```

A throwing signal events could also be used to model the signaling of an event. This is however currently only possible by doing this in XML directly. We will be adding support for graphically specifying this in the new BPMN2 editor.

5.5. Details: Activities

5.5.1. Script task

Figure 5.9. Script task

Represents a script that should be executed in this process. A Script Task should have one incoming connection and one outgoing connection. The associated action specifies what should be executed, the dialect used for coding the action (i.e., Java or MVEL), and the actual action code. This code can access any variables and globals. There is also a predefined variable `kcontext` that references the `ProcessContext` object (which can, for example, be used to access the current `ProcessInstance` or `NodeInstance`, and to get and set variables, or get access to the ksession using `kcontext.getKnowledgeRuntime()`). When a Script Task is reached in the process, it will execute the action and then continue with the next node. It contains the following properties:

- *Id*: The id of the node (which is unique within one node container).
- *Name*: The display name of the node.
- *Action*: The action script associated with this action node.

Note that you can write any valid Java code inside a script node. This basically allows you to do anything inside such a script node. There are some caveats however:

- When trying to create a higher-level business process, that should also be understood by business users, it is probably wise to avoid low-level implementation details inside the process, including inside these script tasks. Script task could still be used to quickly manipulate variables etc. but other concepts like a service task could be used to model more complex behaviour in a higher-level manner.
- Scripts should be immediate. They are using the engine thread to execute the script. Scripts that could take some time to execute should probably be modeled as an asynchronous service task.
- You should try to avoid contacting external services through a script node. Not only does this usually violate the first two caveats, it is also interacting with external services without the

knowledge of the engine, which can be problematic, especially when using persistence and transactions. In general, it is probably wiser to model communication with an external service using a service task.

- Scripts should not throw exceptions. Runtime exceptions should be caught and for example managed inside the script or transformed into signals or errors that can then be handled inside the process.

5.5.2. Service task

Figure 5.10. Service task

Represents an (abstract) unit of work that should be executed in this process. All work that is executed outside the process engine should be represented (in a declarative way) using a Service Task. Different types of services are predefined, e.g., sending an email, logging a message, etc. Users can define domain-specific services or work items, using a unique name and by defining the parameters (input) and results (output) that are associated with this type of work. Check the chapter on domain-specific processes for a detailed explanation and illustrative examples of how to define and use work items in your processes. When a Service Task is reached in the process, the associated work is executed. A Service Task should have one incoming connection and one outgoing connection.

- *Id*: The id of the node (which is unique within one node container).
- *Name*: The display name of the node.
- *Parameter mapping*: Allows copying the value of process variables to parameters of the work item. Upon creation of the work item, the values will be copied.
- *Result mapping*: Allows copying the value of result parameters of the work item to a process variable. Each type of work can define result parameters that will (potentially) be returned after the work item has been completed. A result mapping can be used to copy the value of the given result parameter to the given variable in this process. For example, the "FileFinder" work item returns a list of files that match the given search criteria within the result parameter `Files`. This list of files can then be bound to a process variable for use within the process. Upon completion of the work item, the values will be copied.

- *On-entry and on-exit actions*: Actions that are executed upon entry or exit of this node, respectively.
- *Additional parameters*: Each type of work item can define additional parameters that are relevant for that type of work. For example, the "Email" work item defines additional parameters such as `From`, `To`, `Subject` and `Body`. The user can either provide values for these parameters directly, or define a parameter mapping that will copy the value of the given variable in this process to the given parameter; if both are specified, the mapping will have precedence. Parameters of type `String` can use `#{expression}` to embed a value in the string. The value will be retrieved when creating the work item, and the substitution expression will be replaced by the result of calling `toString()` on the variable. The expression could simply be the name of a variable (in which case it resolves to the value of the variable), but more advanced MVEL expressions are possible as well, e.g., `#{person.name.firstname}`.

5.5.3. User task

Figure 5.11. User task

Processes can also involve tasks that need to be executed by human actors. A User Task represents an atomic task to be executed by a human actor. It should have one incoming connection and one outgoing connection. User Tasks can be used in combination with Swimlanes to assign multiple human tasks to similar actors. Refer to the chapter on human tasks for more details. A User Task is actually nothing more than a specific type of service node (of type "Human Task"). A User Task contains the following properties:

- *Id*: The id of the node (which is unique within one node container).
- *Name*: The display name of the node.
- *TaskName*: The name of the human task.
- *Priority*: An integer indicating the priority of the human task.

- *Comment*: A comment associated with the human task.
- *ActorId*: The actor id that is responsible for executing the human task. A list of actor id's can be specified using a comma (',') as separator.
- *GroupId*: The group id that is responsible for executing the human task. A list of group id's can be specified using a comma (',') as separator.
- *Skippable*: Specifies whether the human task can be skipped, i.e., whether the actor may decide not to execute the task.
- *Content*: The data associated with this task.
- *Swimlane*: The swimlane this human task node is part of. Swimlanes make it easy to assign multiple human tasks to the same actor. See the human tasks chapter for more detail on how to use swimlanes.
- *On entry and on exit actions*: Action scripts that are executed upon entry and exit of this node, respectively.
- *Parameter mapping*: Allows copying the value of process variables to parameters of the human task. Upon creation of the human tasks, the values will be copied.
- *Result mapping*: Allows copying the value of result parameters of the human task to a process variable. Upon completion of the human task, the values will be copied. A human task has a result variable "Result" that contains the data returned by the human actor. The variable "ActorId" contains the id of the actor that actually executed the task.

A user task should define the type of task that needs to be executed (using properties like TaskName, Comment, etc.) and who needs to perform it (using either actorId or groupId). Note that, if there is data related to this specific process instance that the end user needs when performing the task, this data should be passed as the content of the task. The task for example does not have access to process variables. Check out the chapter on human tasks to get more detail on how to pass data between human tasks and the process instance.

5.5.4. Reusable sub-process

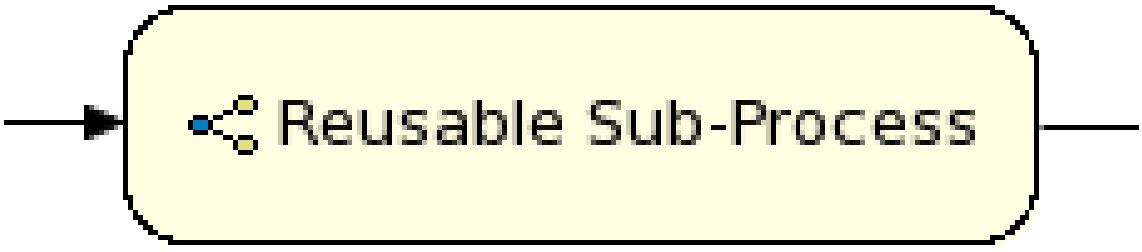


Figure 5.12. Reusable sub-process

Represents the invocation of another process from within this process. A sub-process node should have one incoming connection and one outgoing connection. When a Reusable Sub-Process node is reached in the process, the engine will start the process with the given id. It contains the following properties:

- *Id*: The id of the node (which is unique within one node container).
- *Name*: The display name of the node.
- *ProcessId*: The id of the process that should be executed.
- *Wait for completion*: If this property is true, this sub-process node will only continue if the child process that was started has terminated its execution (completed or aborted); otherwise it will continue immediately after starting the subprocess (so it will not wait for its completion).
- *Independent*: If this property is true, the child process is started as an independent process, which means that the child process will not be terminated if this parent process is completed (or this sub-process node is cancelled for some other reason); otherwise the active sub-process will be cancelled on termination of the parent process (or cancellation of the sub-process node).
- *On-entry and on-exit actions*: Actions that are executed upon entry or exit of this node, respectively.
- *Parameter in/out mapping*: A sub-process node can also define in- and out-mappings for variables. The variables given in the "in" mapping will be used as parameters (with the associated parameter name) when starting the process. The variables of the child process that are defined the "out" mappings will be copied to the variables of this process when the child process has been completed. Note that you can use "out" mappings only when "Wait for completion" is set to true.

5.5.5. Business rule task

Figure 5.13. Business rule task

Represents a set of rules that need to be evaluated. The rules are evaluated when the node is reached. A Rule Task should have one incoming connection and one outgoing connection. Rules are defined in separate files using the Drools rule format. Rules can become part of a specific

ruleflow group using the `ruleflow-group` attribute in the header of the rule. When a Rule Task is reached in the process, the engine will start executing rules that are part of the corresponding ruleflow-group (if any). Execution will automatically continue to the next node if there are no more active rules in this ruleflow group. This means that, during the execution of a ruleflow group, it is possible that new activations belonging to the currently active ruleflow group are added to the Agenda due to changes made to the facts by the other rules. Note that the process will immediately continue with the next node if it encounters a ruleflow group where there are no active rules at that time. If the ruleflow group was already active, the ruleflow group will remain active and execution will only continue if all active rules of the ruleflow group has been completed. It contains the following properties:

- *Id*: The id of the node (which is unique within one node container).
- *Name*: The display name of the node.
- *RuleFlowGroup*: The name of the ruleflow group that represents the set of rules of this RuleFlowGroup node.

5.5.6. Embedded sub-process

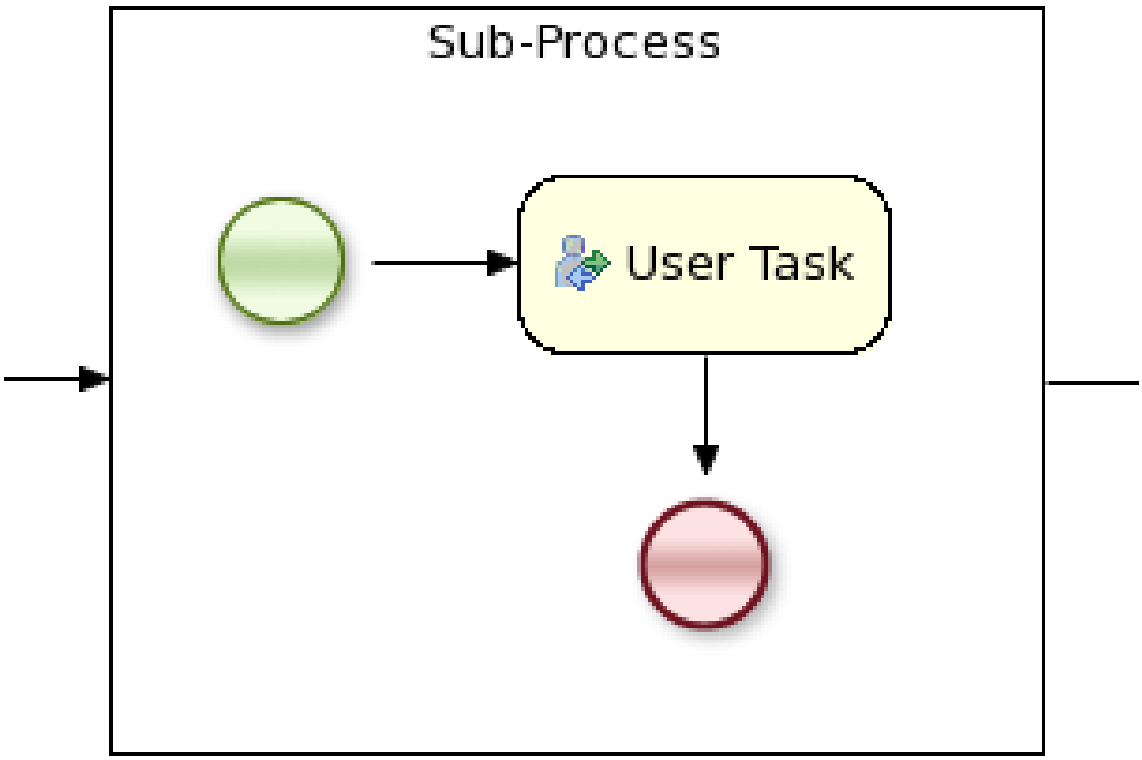


Figure 5.14. Embedded sub-process

A Sub-Process is a node that can contain other nodes so that it acts as a node container. This allows not only the embedding of a part of the process within such a sub-process node, but also the definition of additional variables that are accessible for all nodes inside this container. A sub-process should have one incoming connection and one outgoing connection. It should also contain one start node that defines where to start (inside the Sub-Process) when you reach the sub-process. It should also contain one or more end events. Note that, if you use a terminating event node inside a sub-process, you are terminating the top-level process instance, not just that sub-process, so in general you should use non-terminating end nodes inside a sub-process. A sub-process ends when there are no more active nodes inside the sub-process. It contains the following properties:

- *Id*: The id of the node (which is unique within one node container).
- *Name*: The display name of the node.
- *Variables*: Additional variables can be defined to store data during the execution of this node. See section "*Data*" for details.

5.5.7. Multi-instance sub-process

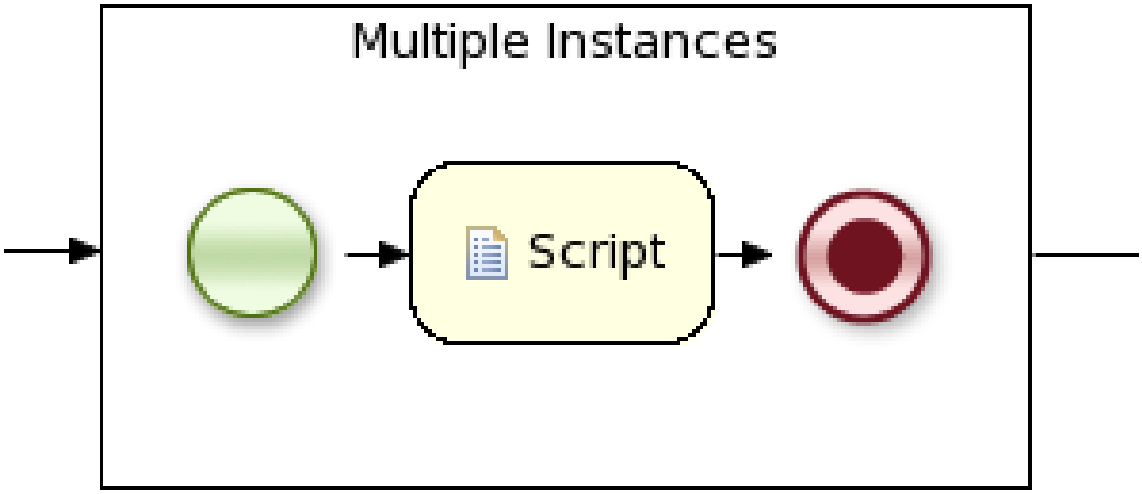


Figure 5.15. Multi-instance sub-process

A Multiple Instance sub-process is a special kind of sub-process that allows you to execute the contained process segment multiple times, once for each element in a collection. A multiple instance sub-process should have one incoming connection and one outgoing connection. It waits until the embedded process fragment is completed for each of the elements in the given collection before continuing. It contains the following properties:

- *Id*: The id of the node (which is unique within one node container).

- *Name*: The display name of the node.
- *CollectionExpression*: The name of a variable that represents the collection of elements that should be iterated over. The collection variable should be an array or of type `java.util.Collection`. If the collection expression evaluates to null or an empty collection, the multiple instances sub-process will be completed immediate and follow its outgoing connection.
- *VariableName*: The name of the variable to contain the current element from the collection. This gives nodes within the composite node access to the selected element.

5.6. Details: Gateways

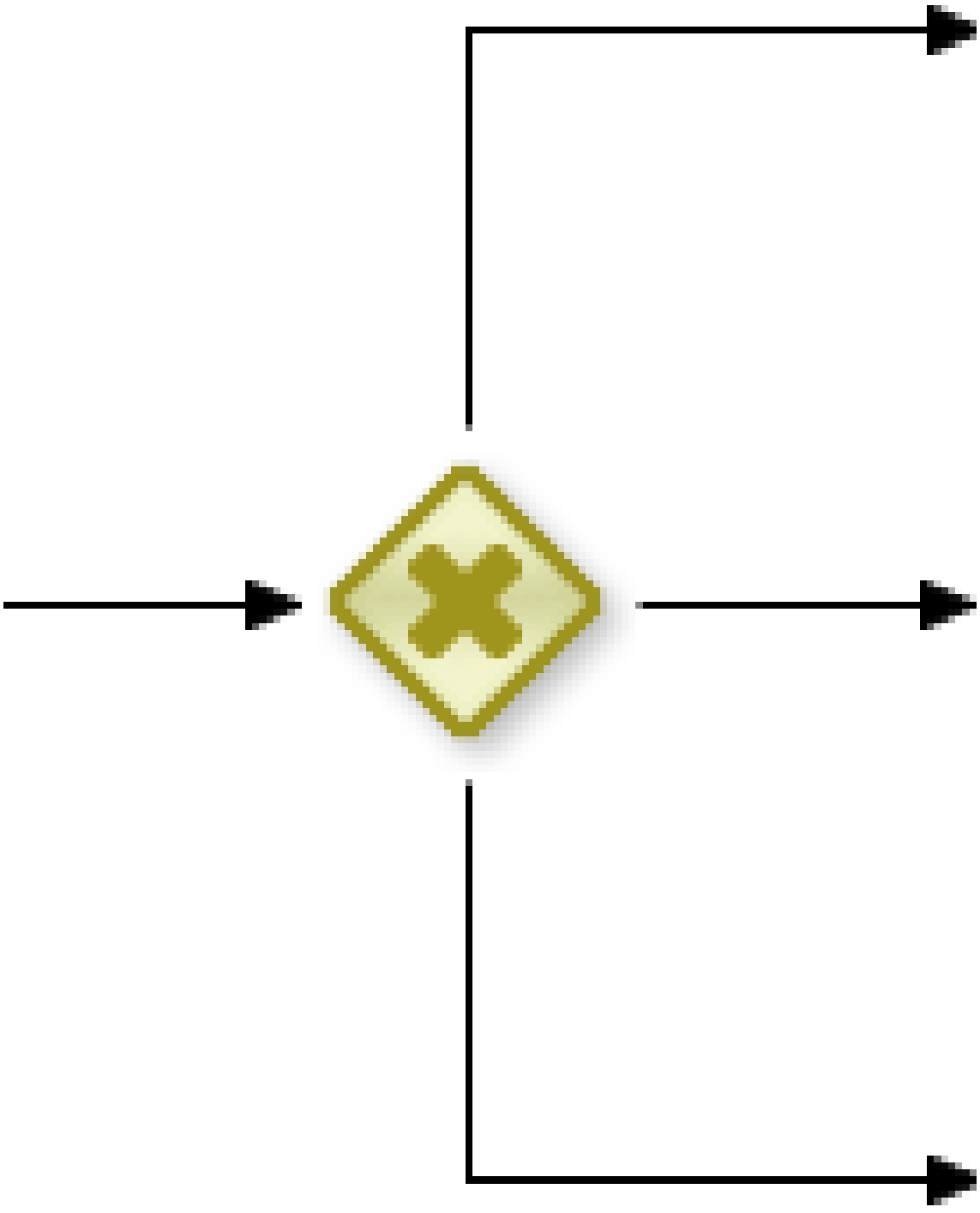


Figure 5.16. Diverging gateway

Allows you to create branches in your process. A Diverging Gateway should have one incoming connection and two or more outgoing connections. There are three types of gateway nodes currently supported:

- AND or parallel means that the control flow will continue in all outgoing connections simultaneously.
- XOR or exclusive means that exactly one of the outgoing connections will be chosen. The decision is made by evaluating the constraints that are linked to each of the outgoing connections. The constraint with the *lowest* priority number that evaluates to true is selected. Constraints can be specified using different dialects. Note that you should always make sure that at least one of the outgoing connections will evaluate to true at runtime (the ruleflow will throw an exception at runtime if it cannot find at least one outgoing connection).
- OR or inclusive means that all outgoing connections whose condition evaluates to true are selected. Conditions are similar to the exclusive gateway, except that no priorities are taken into account. Note that you should make sure that at least one of the outgoing connections will evaluate to true at runtime because the process will throw an exception at runtime if it cannot determine an outgoing connection.

It contains the following properties:

- *Id*: The id of the node (which is unique within one node container).
- *Name*: The display name of the node.
- *Type*: The type of the split node, i.e., AND, XOR or OR (see above).
- *Constraints*: The constraints linked to each of the outgoing connections (in case of an exclusive or inclusive gateway).

5.6.2. Converging gateway

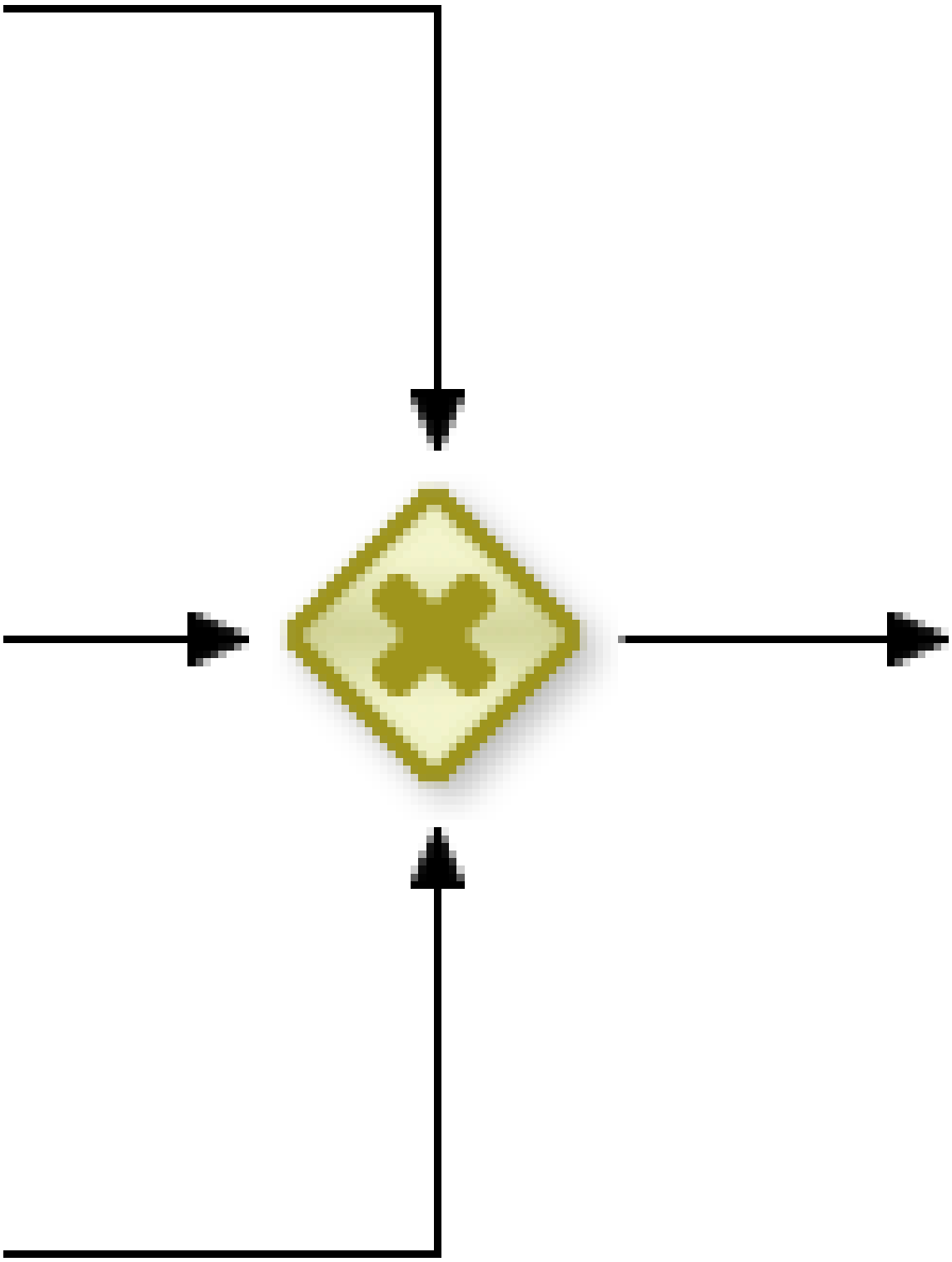


Figure 5.17. Converging gateway

Allows you to synchronize multiple branches. A Converging Gateway should have two or more incoming connections and one outgoing connection. There are two types of splits currently supported:

- AND or parallel means that is will wait until *all* incoming branches are completed before continuing.
- XOR or exclusive means that it continues as soon as *one* of its incoming branches has been completed. If it is triggered from more than one incoming connection, it will trigger the next node for each of those triggers.

It contains the following properties:

- *Id*: The id of the node (which is unique within one node container).
- *Name*: The display name of the node.
- *Type*: The type of the Join node, i.e. AND or XOR.

5.7. Using a process in your application

As explained in more detail in the API chapter, there are two things you need to do to be able to execute processes from within your application: (1) you need to create a Knowledge Base that contains the definition of the process, and (2) you need to start the process by creating a session to communicate with the process engine and start the process.

1. *Creating a Knowledge Base*: Once you have a valid process, you can add the process to the Knowledge Base:

```
KnowledgeBuilder kbuilder = KnowledgeBuilderFactory.newKnowledgeBuilder();
kbuilder.add( ResourceFactory.newClassPathResource("MyProcess.bpmn2"),
              ResourceType.BPMN2 );
```

   After adding all your process to the builder (you can add more than one process), you can create a new knowledge base like this:

```
KnowledgeBase kbase = kbuilder.newKnowledgeBase();
```

   Note that this will throw an exception if the knowledge base contains errors (because it could not parse your processes correctly).

2. *Starting a process*: To start a particular process, you will need to call the `startProcess` method on your session and pass the id of the process you want to start. For example:

```
StatefulKnowledgeSession ksession = kbase.newStatefulKnowledgeSession();
ksession.startProcess("com.sample.hello");
```

   The parameter of the `startProcess` method is the id of the process that needs to be started. When defining a process, this process id needs to be specified as a property of the process (as for example shown in the Properties View in Eclipse when you click the background canvas of your process).

   When you start the process, you may specify additional parameters that are used to pass additional input data to the process, using the `startProcess(String processId, Map parameters)` method. The additional set of parameters is a set of name-value pairs. These parameters are copied to the newly created process instance as top-level variables of the process, so they can be accessed in the remainder of your process directly.

5.8. Other features

5.8.1. Data

While the flow chart focuses on specifying the control flow of the process, it is usually also necessary to look at the process from a data perspective. Throughout the execution of a process, data can retrieved, stored, passed on and used.

For storing runtime data, during the execution of the process, process variables can be used. A variable is defined by a name and a data type. This could be a basic data type, such as boolean, int, or String, or any kind of Object subclass. Variables can be defined inside a variable *scope*. The top-level scope is the variable scope of the process itself. Subscopes can be defined using a Sub-Process. Variables that are defined in a subscope are only accessible for nodes within that scope.

Whenever a variable is accessed, the process will search for the appropriate variable scope that defines the variable. Nesting of variable scopes is allowed. A node will always search for a variable in its parent container. If the variable cannot be found, it will look in that one's parent container, and so on, until the process instance itself is reached. If the variable cannot be found, a read access yields null, and a write access produces an error message, with the process continuing its execution.

Variables can be used in various ways:

- Process-level variables can be set when starting a process by providing a map of parameters to the invocation of the `startProcess` method. These parameters will be set as variables on the process scope.

- Script actions can access variables directly, simply by using the name of the variable as a local parameter in their script. For example, if the process defines a variable of type "org.jbpm.Person" in the process, a script in the process could access this directly:

```
// call method on the process variable "person"
person.setAge(10);
```

  Changing the value of a variable in a script can be done through the knowledge context:

```
kcontext.setVariable(variableName, value);
```

- Service tasks (and reusable sub-processes) can pass the value of process variables to the outside world (or another process instance) by mapping the variable to an outgoing parameter. For example, the parameter mapping of a service task could define that the value of the process variable x should be mapped to a task parameter y right before the service is being invoked. You can also inject the value of process variable into a hard-coded parameter String using `#{expression}`. For example, the description of a human task could be defined as `You need to contact person #{person.getName()}` (where person is a process variable), which will replace this expression by the actual name of the person when the service needs to be invoked. Similarly results of a service (or reusable sub-process) can also be copied back to a variable using a result mapping.
- Various other nodes can also access data. Event nodes for example can store the data associated to the event in a variable, etc. Check the properties of the different node types for more information.

Finally, processes (and rules) all have access to globals, i.e. globally defined variables and data in the Knowledge Session. Globals are directly accessible in actions just like variables. Globals need to be defined as part of the process before they can be used. You can for example define globals by clicking the globals button when specifying an action script in the Eclipse action property editor. You can also set the value of a global from the outside using `ksession.setGlobal(name, value)` or from inside process scripts using `kcontext.getKnowledgeRuntime().setGlobal(name,value);`.

5.8.2. Constraints

Constraints can be used in various locations in your processes, for example in a diverging gateway. jBPM supports two types of constraints:

- *Code constraints* are boolean expressions, evaluated directly whenever they are reached. We currently support two dialects for expressing these code constraints: Java and MVEL. Both Java and MVEL code constraints have direct access to the globals and variables defined in the process. Here is an example of a valid Java code constraint, `person` being a variable in the process:

```
return person.getAge() > 20;
```

A similar example of a valid MVEL code constraint is:

```
return person.age > 20;
```

- *Rule constraints* are equals to normal Drools rule conditions. They use the Drools Rule Language syntax to express possibly complex constraints. These rules can, like any other rule, refer to data in the Working Memory. They can also refer to globals directly. Here is an example of a valid rule constraint:

```
Person( age > 20 )
```

This tests for a person older than 20 being in the Working Memory.

Rule constraints do not have direct access to variables defined inside the process. It is however possible to refer to the current process instance inside a rule constraint, by adding the process instance to the Working Memory and matching for the process instance in your rule constraint. We have added special logic to make sure that a variable `processInstance` of type `WorkflowProcessInstance` will only match to the current process instance and not to other process instances in the Working Memory. Note that you are however responsible yourself to insert the process instance into the session and, possibly, to update it, for example, using Java code or an on-entry or on-exit or explicit action in your process. The following example of a rule constraint will search for a person with the same name as the value stored in the variable "name" of the process:

```
processInstance : WorkflowProcessInstance()
Person( name == ( processInstance.getVariable("name") ) )
# add more constraints here ...
```

5.8.3. Action scripts

Action scripts can be used in different ways:

- Within a Script Task,
- As entry or exit actions, with a number of nodes.

Actions have access to globals and the variables that are defined for the process and the predefined variable `kcontext`. This variable is of type `org.drools.runtime.process.ProcessContext` and can be used for several tasks:

- Getting the current node instance (if applicable). The node instance could be queried for data, such as its name and type. You can also cancel the current node instance.

```
NodeInstance node = kcontext.getNodeInstance();
String name = node.getNodeName();
```

- Getting the current process instance. A process instance can be queried for data (name, id, processId, etc.), aborted or signaled an internal event.

```
ProcessInstance proc = kcontext.getProcessInstance();
proc.signalEvent( type, eventObject );
```

- Getting or setting the value of variables.
- Accessing the Knowledge Runtime allows you do things like starting a process, signaling (external) events, inserting data, etc.

jBPM currently supports two dialects, Java and MVEL. Java actions should be valid Java code. MVEL actions can use the business scripting language MVEL to express the action. MVEL accepts any valid Java code but additionally provides support for nested accesses of parameters (e.g., `person.name` instead of `person.getName()`), and many other scripting improvements. Thus, MVEL expressions are more convenient for the business user. For example, an action that prints out the name of the person in the "requester" variable of the process would look like this:

```
// Java dialect
System.out.println( person.getName() );

//  MVEL dialect
System.out.println( person.name );
```

5.8.4. Events

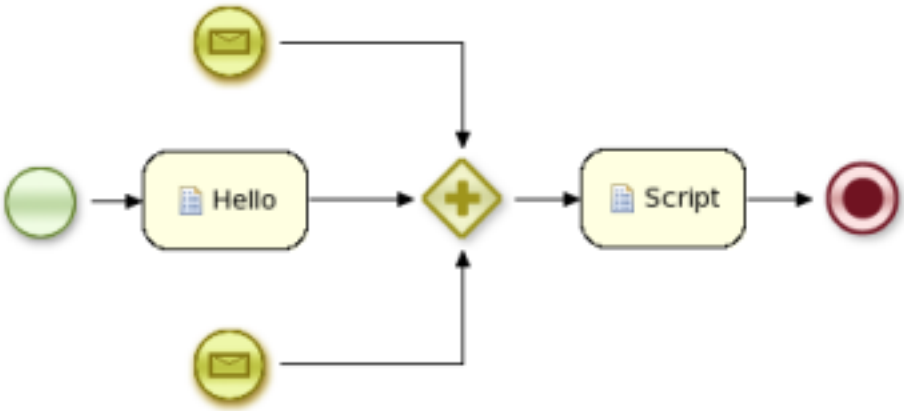


Figure 5.18. A sample process using events

During the execution of a process, the process engine makes sure that all the relevant tasks are executed according to the process plan, by requesting the execution of work items and waiting for the results. However, it is also possible that the process should respond to events that were not directly requested by the process engine. Explicitly representing these events in a process allows the process author to specify how the process should react to such events.

Events have a type and possibly data associated with them. Users are free to define their own event types and their associated data.

A process can specify how to respond to events by using a Message Event. An Event node needs to specify the type of event the node is interested in. It can also define the name of a variable, which will receive the data that is associated with the event. This allows subsequent nodes in the process to access the event data and take appropriate action based on this data.

An event can be signaled to a running instance of a process in a number of ways:

- Internal event: Any action inside a process (e.g., the action of an action node, or an on-entry or on-exit action of some node) can signal the occurence of an internal event to the surrounding process instance, using code like the following:

```
kcontext.getProcessInstance().signalEvent(type, eventData);
```

- External event: A process instance can be notified of an event from outside using code such as:

```
processInstance.signalEvent(type, eventData);
```

- External event using event correlation: Instead of notifying a process instance directly, it is also possible to have the engine automatically determine which process instances might be

interested in an event using *event correlation*, which is based on the event type. A process instance that contains an event node listening to external events of some type is notified whenever such an event occurs. To signal such an event to the process engine, write code such as:

```
ksession.signalEvent(type, eventData);
```

Events could also be used to start a process. Whenever a Message Start Event defines an event trigger of a specific type, a new process instance will be started every time that type of event is signalled to the process engine.

5.8.5. Timers

Timers wait for a predefined amount of time, before triggering, once or repeatedly. They can be used to trigger certain logic after a certain period, or to repeat some action at regular intervals.

A Timer node is set up with a delay and a period. The delay specifies the amount of time to wait after node activation before triggering the timer the first time. The period defines the time between subsequent trigger activations. A period of 0 results in a one-shot timer.

The (period and delay) expression should be of the form [#d][#h][#m][#s][#[ms]]. This means that you can specify the amount of days, hours, minutes, seconds and multiseconds (which is the default if you don't specify anything). For example, the expression "1h" will wait one hour before triggering the timer (again).

The timer service is responsible for making sure that timers get triggered at the appropriate times. Timers can also be cancelled, meaning that the timer will no longer be triggered.

Timers can be used in two ways inside a process:

- A Timer Event may be added to the process flow. Its activation starts the timer, and when it triggers, once or repeatedly, it activates the Timer node's successor. This means that the outgoing connection of a timer with a positive period is triggered multiple times. Cancelling a Timer node also cancels the associated timer, after which no more triggers will occur.
- Timers can be associated with a Sub-Process as a boundary event. This is however currently only possible by doing this in XML directly. We will be adding support for graphically specifying this in the new BPMN2 editor.

5.8.6. Updating processes

Over time, processes may evolve, for example because the process itself needs to be improved, or due to changing requirements. Actually, you cannot really update a process, you can only deploy a new version of the process, the old process will still exist. That is because existing process instances might still need that process definition. So the new process should have a different id,

though the name could be the same, and you can use the version parameter to show when a process is updated (the version parameter is just a String and is not validated by the process framework itself, so you can select your own format for specifying minor/major updates, etc.).

Whenever a process is updated, it is important to determine what should happen to the already running process instances. There are various strategies one could consider for each running instance:

- *Proceed*: The running process instance proceeds as normal, following the process (definition) as it was defined when the process instance was started. As a result, the already running instance will proceed as if the process was never updated. New instances can be started using the updated process.
- *Abort (and restart)*: The already running instance is aborted. If necessary, the process instance can be restarted using the new process definition.
- *Transfer*: The process instance is migrated to the new process definition, meaning that - once it has been migrated successfully - it will continue executing based on the updated process logic.

By default, jBPM uses the proceed approach, meaning that multiple versions of the same process can be deployed, but existing process instances will simply continue executing based on the process definition that was used when starting the process instance. Running process instances could always be aborted as well of course, using the process management API. Process instance migration is more difficult and is explained in the following paragraphs.

5.8.6.1. Process instance migration

A process instance contains all the runtime information needed to continue execution at some later point in time. This includes all the data linked to this process instance (as variables), but also the current state in the process diagram. For each node that is currently active, a node instance is used to represent this. This node instance can also contain additional state linked to the execution of that specific node only. There are different types of node instances, one for each type of node.

A process instance only contains the runtime state and is linked to a particular process (indirectly, using id references) that represents the process logic that needs to be followed when executing this process instance (this clear separation of definition and runtime state allows reuse of the definition accross all process instances based on this process and minimizes runtime state). As a result, updating a running process instance to a newer version so it used the new process logic instead of the old one is simply a matter of changing the referenced process id from the old to the new id.

However, this does not take into account that the state of the process instance (the variable instances and the node instances) might need to be migrated as well. In cases where the process is only extended and all existing wait states are kept, this is pretty straightforward, the runtime state of the process instance does not need to change at all. However, it is also possible that a more sofisticated mapping is necessary. For example, when an existing wait state is removed, or split into multiple wait states, an existing process instance that is waiting in that state cannot

simply be updated. Or when a new process variable is introduced, that variable might need to be initiazed correctly so it can be used in the remainder of the (updated) process.

The WorkflowProcessInstanceUpgrader can be used to upgrade a workflow process instance to a newer process instance. Of course, you need to provide the process instance and the new process id. By default, jBPM will automatically map old node instances to new node instances with the same id. But you can provide a mapping of the old (unique) node id to the new node id. The unique node id is the node id, preceded by the node ids of its parents (with a colon inbetween), to allow to uniquely identify a node when composite nodes are used (as a node id is only unique within its node container. The new node id is simply the new node id in the node container (so no unique node id here, simply the new node id). The following code snippet shows a simple example.

```
// create the session and start the process "com.sample.process"
KnowledgeBuilder kbuilder = ...
StatefulKnowledgeSession ksession = ...
ProcessInstance processInstance = ksession.startProcess("com.sample.process");

// add a new version of the process "com.sample.process2"
kbuilder = KnowledgeBuilderFactory.newKnowledgeBuilder();
kbuilder.add(..., ResourceType.BPMN2);
kbase.addKnowledgePackages(kbuilder.getKnowledgePackages());

// migrate process instance to new version
Map<String, Long> mapping = new HashMap<String, Long>();
// top level node 2 is mapped to a new node with id 3
mapping.put("2", 3L);
// node 2, which is part of composite node 5, is mapped to a new node with id 4
mapping.put("5.2", 4L);
WorkflowProcessInstanceUpgrader.upgradeProcessInstance(
  ksession, processInstance.getId(),
  "com.sample.process2", mapping);
```

If this kind of mapping is still insufficient, you can still describe your own custom mappers for specific situations. Be sure to first disconnect the process instance, change the state accordingly and then reconnect the process instance, similar to how the WorkflowProcessinstanceUpgrader does it.

Chapter 6. Core Engine: BPMN 2.0

6.1. Business Process Model and Notation (BPMN) 2.0 specification

> The primary goal of BPMN is to provide a notation that is readily understandable by all business users,
> from the business analysts that create the initial drafts of the processes, to the technical developers
> responsible for implementing the technology that will perform those processes, and finally, to the business people who will manage and monitor those processes."

The Business Process Model and Notation (BPMN) 2.0 specification is an OMG specification that not only defines a standard on how to graphically represent a business process (like BPMN 1.x), but now also includes execution semantics for the elements defined, and an XML format on how to store (and share) process definitions.

jBPM5 allows you to execute processes defined using the BPMN 2.0 XML format. That means that you can use all the different jBPM5 tooling to model, execute, manage and monitor your business processes using the BPMN 2.0 format for specifying your executable business processes. Actually, the full BPMN 2.0 specification also includes details on how to represent things like choreographies and and collaboration. The jBPM project however focuses on that part of the specification that can be used to specify executable processes.

Executable processes in BPMN consist of a different types of nodes being connected to each other using sequence flows. The BPMN 2.0 specification defines three main types of nodes:

- *Events*: They are used to model the occurrence of a particular event. This could be a start event (that is used to indicate the start of the process), end events (that define the end of the process, or of that subflow) and intermediate events (that indicate events that might occur during the execution of the process).
- *Activities*: These define the different actions that need to be performed during the execution of the process. Different types of tasks exist, depending on the type of activity you are trying to model (e.g. human task, service task, etc.) and actvities could also be nested (using different types of sub-processes).
- *Gateways*: Can be used to define multiple paths in the process. Depending on the type of gateway, these might indicate parallel execution, choice, etc.

jBPM5 does not implement all elements and attributes as defined in the BPMN 2.0 specification. We do however support a significant subset, including the most common node types that can be

used inside executable processes. This includes (almost) all elements and attributes as defined in the "Common Executable" subclass of the BPMN 2.0 specification, extended with some additional elements and attributes we believe are valuable in that context as well. The full set of elements and attributes that are supported can be found below, but it includes elements like:

- *Flow objects*
  - Events
    - Start Event (None, Conditional, Signal, Message, Timer)
    - End Event (None, Terminate, Error, Escalation, Signal, Message, Compensation)
    - Intermediate Catch Event (Signal, Timer, Conditional, Message)
    - Intermediate Throw Event (None, Signal, Escalation, Message, Compensation)
    - Non-interrupting Boundary Event (Escalation, Timer)
    - Interrupting Boundary Event (Escalation, Error, Timer, Compensation)
  - Activities
    - Script Task
    - Task
    - Service Task
    - User Task
    - Business Rule Task
    - Manual Task
    - Send Task
    - Receive Task
    - Reusable Sub-Process (Call Activity)
    - Embedded Sub-Process
    - Ad-Hoc Sub-Process
    - Data-Object
  - Gateways
    - Diverging
      - Exclusive

        - Inclusive
        - Parallel
        - Event-Based
    - Converging
        - Exclusive
        - Parallel
    - Lanes
- *Data*
    - Java type language
    - Process properties
    - Embedded Sub-Process properties
    - Activity properties
- *Connecting objects*
    - Sequence flow

For example, consider the following "Hello World" BPMN 2.0 process, which does nothing more that writing out a "Hello World" statement when the process is started.

An executable version of this process expressed using BPMN 2.0 XML would look something like this:

```
<?xml version="1.0" encoding="UTF-8"?>
<definitions id="Definition"
             targetNamespace="http://www.example.org/MinimalExample"
             typeLanguage="http://www.java.com/javaTypes"
             expressionLanguage="http://www.mvel.org/2.0"
             xmlns="http://www.omg.org/spec/BPMN/20100524/MODEL"
             xmlns:xs="http://www.w3.org/2001/XMLSchema-instance"
            xs:schemaLocation="http://www.omg.org/spec/BPMN/20100524/MODEL BPMN20.xsd"
             xmlns:bpmndi="http://www.omg.org/spec/BPMN/20100524/DI"
             xmlns:dc="http://www.omg.org/spec/DD/20100524/DC"
```

```
          xmlns:di="http://www.omg.org/spec/DD/20100524/DI"
          xmlns:tns="http://www.jboss.org/drools">

<processprocessType="Private"isExecutable="true"id="com.sample.HelloWorld"name="Hello
 World" >

  <!-- nodes -->
  <startEvent id="_1" name="StartProcess" />
  <scriptTask id="_2" name="Hello" >
    <script>System.out.println("Hello World");</script>
  </scriptTask>
  <endEvent id="_3" name="EndProcess" >
     <terminateEventDefinition/>
  </endEvent>

  <!-- connections -->
  <sequenceFlow id="_1-_2" sourceRef="_1" targetRef="_2" />
  <sequenceFlow id="_2-_3" sourceRef="_2" targetRef="_3" />

 </process>

 <bpmndi:BPMNDiagram>
  <bpmndi:BPMNPlane bpmnElement="Minimal" >
    <bpmndi:BPMNShape bpmnElement="_1" >
      <dc:Bounds x="15" y="91" width="48" height="48" />
    </bpmndi:BPMNShape>
    <bpmndi:BPMNShape bpmnElement="_2" >
      <dc:Bounds x="95" y="88" width="83" height="48" />
    </bpmndi:BPMNShape>
    <bpmndi:BPMNShape bpmnElement="_3" >
      <dc:Bounds x="258" y="86" width="48" height="48" />
    </bpmndi:BPMNShape>
    <bpmndi:BPMNEdge bpmnElement="_1-_2" >
      <di:waypoint x="39" y="115" />
      <di:waypoint x="75" y="46" />
      <di:waypoint x="136" y="112" />
    </bpmndi:BPMNEdge>
    <bpmndi:BPMNEdge bpmnElement="_2-_3" >
      <di:waypoint x="136" y="112" />
      <di:waypoint x="240" y="240" />
      <di:waypoint x="282" y="110" />
    </bpmndi:BPMNEdge>
  </bpmndi:BPMNPlane>
 </bpmndi:BPMNDiagram>
```

```
</definitions>
```

To create your own process using BPMN 2.0 format, you can

- Create a new Flow file using the Drools Eclipse plugin wizard and in the last page of the wizard, make sure you select Drools 5.1 code compatibility. This will create a new process using the BPMN 2.0 XML format. Note however that this is not exactly a BPMN 2.0 editor, as it still uses different attributes names etc. It does however save the process using valid BPMN 2.0 syntax. Also note that the editor does not support all node types and attributes that are already supported in the execution engine.
- The Designer is an open-source web-based editor that supports the BPMN 2.0 format. We have embedded it into Guvnor for BPMN 2.0 process visualization and editing. You could use the Designer (either standalone or integrated) to create / edit BPMN 2.0 processes and then export them to BPMN 2.0 format or save them into Guvnor and import them so they can be executed.
- A new BPMN2 Eclipse plugin is being created to support the full BPMN2 specification. It is currently still under development and only supports a limited number of constructs and attributes, but can already be used to create simple BPMN2 processes. To create a new BPMN2 file for this editor, use the wizard (under Examples) to create a new BPMN2 file, which will generate a .bpmn2 file and a .prd file containing the graphical information. Double-click the .prd file to edit the file using the graphical editor. For more detail, check out the chapter on the new BPMN2 Eclipse plugin.
- You can always manually create your BPMN 2.0 process files by writing the XML directly. You can validate the syntax of your processes against the BPMN 2.0 XSD, or use the validator in the Eclipse plugin to check both syntax and completeness of your model.

The following code fragment shows you how to load a BPMN2 process into your knowledge base ...

```
private static KnowledgeBase createKnowledgeBase() throws Exception {
  KnowledgeBuilder kbuilder = KnowledgeBuilderFactory.newKnowledgeBuilder();
  kbuilder.add(ResourceFactory.newClassPathResource("sample.bpmn2"), ResourceType.BPMN2);
  return kbuilder.newKnowledgeBase();
}
```

... and how to execute this process ...

```
KnowledgeBase kbase = createKnowledgeBase();
StatefulKnowledgeSession ksession = kbase.newStatefulKnowledgeSession();
```

```
ksession.startProcess("com.sample.HelloWorld");
```

For more detail, check out the chapter on the API and the basics.

6.2. Examples

The BPMN 2.0 specification defines the attributes and semantics of each of the node types (and other elements).

The jbpm-bpmn2 module contains a lot of junit tests for each of the different node types. These test processes can also serve as simple examples: they don't really represent an entire real life business processes but can definitely be used to show how specific features can be used. For example, the following figures shows the flow chart of a few of those examples. The entire list can be found in the src/main/resources folder for the jbpm-bpmn2 module like *here* [http://github.com/krisv/jbpm/tree/master/jbpm-bpmn2/src/test/resources/].

6.3. Supported elements / attributes

Table 6.1. Keywords

Element	Supported attributes	Supported elements	Extension attributes	Extension elements
definitions		rootElement BPMNDiagram		
process	processType isExecutable name id	property laneSet flowElement	packageName adHoc version	import global
sequenceFlow	sourceRef targetRef isImmediate name id	conditionExpression	priority bendpoints	
interface	name id	operation		
operation	name id	inMessageRef		
laneSet		lane		
lane	name id	flowNodeRef		
import*		name		
global*		identifier type		
Events				
startEvent	name id	dataOutput dataOutputAssociation	x y width height	

Element	Supported attributes	Supported elements	Extension attributes	Extension elements
		outputSet eventDefinition		
endEvent	name id	dataInput dataInputAssociation inputSet eventDefinition	x y width height	
intermediateCatchEvent	name id	dataOutput dataOutputAssociation outputSet eventDefinition	x y width height	
intermediateThrowEvent	name id	dataInput dataInputAssociation inputSet eventDefinition	x y width height	
boundaryEvent	cancelActivity attachedToRef name id	eventDefinition	x y width height	
terminateEventDefinition				
cancelEventDefinition				
compensateEventDefinition	activityRef	documentation extensionElements		
conditionalEventDefinition		condition		
errorEventDefinition	errorRef			
error	errorCode id			
escalationEventDefinition	escalationRef			
escalation	escalationCode id			
messageEventDefinition	messageRef			
message	itemRef id			
signalEventDefinition	signalRef			
timerEventDefinition		timeCycle timeDuration		
Activities				
task	name id	ioSpecification dataInputAssociation dataOutputAssociation	taskName x y width height	

Element	Supported attributes	Supported elements	Extension attributes	Extension elements
scriptTask	scriptFormat name id	script	x y width height	
script		text[mixed content]		
userTask	name id	ioSpecification dataInputAssociation dataOutputAssociation resourceRole	x y width height	onEntry-script onExit-script
potentialOwner		resourceAssignmentExpression		
resourceAssignmentExpression		expression		
businessRuleTask	name id		x y width height ruleFlowGroup	onEntry-script onExit-script
manualTask	name id		x y width height	onEntry-script onExit-script
sendTask	messageRef name id	ioSpecification dataInputAssociation	x y width height	onEntry-script onExit-script
receiveTask	messageRef name id	ioSpecification dataOutputAssociation	x y width height	onEntry-script onExit-script
serviceTask	operationRef name id	ioSpecification dataInputAssociation dataOutputAssociation	x y width height	onEntry-script onExit-script
subProcess	name id	flowElement property loopCharacteristics	x y width height	
adHocSubProcess	cancelRemainingInstances name id	completionCondition flowElement property	x y width height	
callActivity	calledElement name id	ioSpecification dataInputAssociation dataOutputAssociation	x y width height waitForCompletion independent	onEntry-script onExit-script
multiInstanceLoopCharacteristics		loopDataInputRef inputDataItem		
onEntry-script*	scriptFormat		script	
onExit-script*	scriptFormat		script	
Gateways				

Element	Supported attributes	Supported elements	Extension attributes	Extension elements
parallelGateway	gatewayDirection name id		x y width height	
eventBasedGateway	gatewayDirection name id		x y width height	
exclusiveGateway	default gatewayDirection name id		x y width height	
inclusiveGateway	default gatewayDirection name id		x y width height	
Data				
property	itemSubjectRef id			
dataObject	itemSubjectRef id			
itemDefinition	structureRef id			
ioSpecification		dataInput dataOutput inputSet outputSet		
dataInput	name id			
dataInputAssociation		sourceRef targetRef assignment		
dataOutput	name id			
dataOutputAssociation		sourceRef targetRef assignment		
inputSet		dataInputRefs		
outputSet		dataOutputRefs		
assignment		from to		
formalExpression	language	text[mixed content]		
BPMNDI				

Element	Supported attributes	Supported elements	Extension attributes	Extension elements
BPMNDiagram		BPMNPlane		
BPMNPlane	bpmnElement	BPMNEdge BPMNShape		
BPMNShape	bpmnElement	Bounds		
BPMNEdge	bpmnElement	waypoint		
Bounds	x y width height			
waypoint	x y			

Chapter 7. Core Engine: Persistence and transactions

jBPM allows the persistent storage of certain information, i.e., the process runtime state, the history information, etc.

7.1. Runtime State

Whenever a process is started, a process instance is created, which represents the execution of the process in that specific context. For example, when executing a process that specifies how to process a sales order, one process instance is created for each sales request. The process instance represents the current execution state in that specific context, and contains all the information related to that process instance. Note that it only contains the minimal runtime state that is needed to continue the execution of that process instance at some later time, but it does not include information about the history of that process instance if that information is no longer needed in the process instance.

The runtime state of an executing process can be made persistent, for example, in a database. This allows to restore the state of execution of all running processes in case of unexpected failure, or to temporarily remove running instances from memory and restore them at some later time. jBPM allows you to plug in different persistence strategies. By default, if you do not configure the process engine otherwise, process instances are not made persistent.

7.1.1. Binary Persistence

jBPM provides a binary persistence mechanism that allows you to save the state of a process instance as a binary dataset. This way, the state of all running process instances can always be stored in a persistent location. Note that these binary datasets usually are relatively small, as they only contain the minimal execution state of the process instance. For a simple process instance, this usually contains one or a few node instances, i.e., any node that is currently executing, and, possibly, some variable values.

7.1.2. Safe Points

The state of a process instance is stored at so-called "safe points" during the execution of the process engine. Whenever a process instance is executing, after its start or continuation from a wait state, the engine proceeds until no more actions can be performed. At that point, the engine has reached the next safe state, and the state of the process instance and all other process instances that might have been affected is stored persistently.

7.1.3. Configuring Persistence

By default, the engine does not save runtime data persistently. It is, however, pretty straightforward to configure the engine to do this, by adding a configuration file and the necessary dependencies.

Persistence itself is based on the Java Persistence API (JPA) and can thus work with several persistence mechanisms. We are using Hibernate by default, but feel free to employ alternatives. A H2 database is used underneath to store the data, but you might choose your own alternative for this, too.

First of all, you need to add the necessary dependencies to your classpath. If you're using the Eclipse IDE, you can do that by adding the jar files to your jBPM runtime directory, or by manually adding these dependencies to your project. First of all, you need the jar file `jbpm-persistence-jpa.jar`, as that contains code for saving the runtime state whenever necessary. Next, you also need various other dependencies, depending on the persistence solution and database you are using. For the default combination with Hibernate as the JPA persistence provider, the H2 database and Bitronix for JTA-based transaction management, the following list of additional dependencies is needed:

1. jbpm-persistence-jpa (org.jbpm)
2. drools-persistence-jpa (org.drools)
3. persistence-api (javax.persistence)
4. hibernate-entitymanager (org.hibernate)
5. hibernate-annotations (org.hibernate)
6. hibernate-commons-annotations (org.hibernate)
7. hibernate-core (org.hibernate)
8. dom4j (dom4j)
9. jta (javax.transaction)
10. btm (org.codehaus.btm)
11. javassist (javassist)
12. slf4j-api (org.slf4j)
13. slf4j-jdk14 (org.slf4j)
14. h2 (com.h2database)
15. commons-collections (commons-collections)

Next, you need to configure the jBPM engine to save the state of the engine whenever necessary. The easiest way to do this is to use `JPAKnowledgeService` to create your knowledge session, based on a knowledge base, a knowledge session configuration (if necessary) and an environment. The environment needs to contain a reference to your Entity Manager Factory. For example:

```
// create the entity manager factory and register it in the environment
```

```
EntityManagerFactory emf =
    Persistence.createEntityManagerFactory( "org.jbpm.persistence.jpa" );
Environment env = KnowledgeBaseFactory.newEnvironment();
env.set( EnvironmentName.ENTITY_MANAGER_FACTORY, emf );

// create a new knowledge session that uses JPA to store the runtime state
StatefulKnowledgeSession ksession =
    JPAKnowledgeService.newStatefulKnowledgeSession( kbase, null, env );
int sessionId = ksession.getId();

// invoke methods on your method here
ksession.startProcess( "MyProcess" );
ksession.dispose();
```

You can also yse the `JPAKnowledgeService` to recreate a session based on a specific session id:

```
// recreate the session from database using the sessionId
ksession = JPAKnowledgeService.loadStatefulKnowledgeSession( sessionId, kbase, null, env );
```

Note that we only save the minimal state that is needed to continue execution of the process instance at some later point. This means, for example, that it does not contain information about already executed nodes if that information is no longer relevant, or that process instances that have been completed or aborted are removed from the database. If you want to search for history-related information, you should use the history log, as explained later.

You need to add a persistence configuration to your classpath to configures JPA to use Hibernate and the H2 database (or your preference), called `persistence.xml` in the META-INF directory, as shown below. For more details on how to change this for your own configuration, we refer to the JPA and Hibernate documentation for more information.

```
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<persistence
  version="1.0"
  xsi:schemaLocation=
    "http://java.sun.com/xml/ns/persistence
     http://java.sun.com/xml/ns/persistence/persistence_1_0.xsd
     http://java.sun.com/xml/ns/persistence/orm
     http://java.sun.com/xml/ns/persistence/orm_1_0.xsd"
  xmlns:orm="http://java.sun.com/xml/ns/persistence/orm"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xmlns="http://java.sun.com/xml/ns/persistence">
```

```
 <persistence-unit name="org.jbpm.persistence.jpa">
   <provider>org.hibernate.ejb.HibernatePersistence</provider>
   <jta-data-source>jdbc/processInstanceDS</jta-data-source>
   <class>org.drools.persistence.info.SessionInfo</class>
   <class>org.jbpm.persistence.processinstance.ProcessInstanceInfo</class>
   <class>org.drools.persistence.info.WorkItemInfo</class>

   <properties>
     <property name="hibernate.dialect" value="org.hibernate.dialect.H2Dialect"/>
     <property name="hibernate.max_fetch_depth" value="3"/>
     <property name="hibernate.hbm2ddl.auto" value="update"/>
     <property name="hibernate.show_sql" value="true"/>
     <property name="hibernate.transaction.manager_lookup_class"
           value="org.hibernate.transaction.BTMTransactionManagerLookup"/>
   </properties>
 </persistence-unit>
</persistence>
```

This configuration file refers to a data source called "jdbc/processInstanceDS". The following Java fragment could be used to set up this data source, where we are using the file-based H2 database.

```
PoolingDataSource ds = new PoolingDataSource();
ds.setUniqueName("jdbc/testDS1");
ds.setClassName("org.h2.jdbcx.JdbcDataSource");
ds.setMaxPoolSize(3);
ds.setAllowLocalTransactions(true);
ds.getDriverProperties().put("user", "sa");
ds.getDriverProperties().put("password", "sasa");
ds.getDriverProperties().put("URL", "jdbc:h2:file:/NotBackedUp/data/process-instance-db");
ds.init();
```

If you're deploying to an application server, you can usually create a datasource by dropping a configuration file in the deploy directory, for example:

```
<?xml version="1.0" encoding="UTF-8"?>
<datasources>
 <local-tx-datasource>
   <jndi-name>jdbc/testDS1</jndi-name>
   <connection-url>jdbc:h2:file:/NotBackedUp/data/process-instance-db</connection-url>
   <driver-class>org.h2.jdbcx.JdbcDataSource</driver-class>
   <user-name>sa</user-name>
```

```
    <password>sasa</password>
  </local-tx-datasource>
</datasources>
```

7.1.4. Transactions

Whenever you do not provide transaction boundaries inside your application, the engine will automatically execute each method invocation on the engine in a separate transaction. If this behavior is acceptable, you don't need to do anything else. You can, however, also specify the transaction boundaries yourself. This allows you, for example, to combine multiple commands into one transaction.

You need to register a transaction manager at the environment before using user-defined transactions. The following sample code uses the Bitronix transaction manager. Next, we use the Java Transaction API (JTA) to specify transaction boundaries, as shown below:

```
// create the entity manager factory and register it in the environment
EntityManagerFactory emf =
    Persistence.createEntityManagerFactory( "org.jbpm.persistence.jpa" );
Environment env = KnowledgeBaseFactory.newEnvironment();
env.set( EnvironmentName.ENTITY_MANAGER_FACTORY, emf );
env.set( EnvironmentName.TRANSACTION_MANAGER,
        TransactionManagerServices.getTransactionManager() );

// create a new knowledge session that uses JPA to store the runtime state
StatefulKnowledgeSession ksession =
    JPAKnowledgeService.newStatefulKnowledgeSession( kbase, null, env );

// start the transaction
UserTransaction ut =
  (UserTransaction) new InitialContext().lookup( "java:comp/UserTransaction" );
ut.begin();

// perform multiple commands inside one transaction
ksession.insert( new Person( "John Doe" ) );
ksession.startProcess( "MyProcess" );

// commit the transaction
ut.commit();
```

7.2. Process Definitions

Process definition files are usually written in an XML format. These files can easily be stored on a file system during development. However, whenever you want to make your knowledge accessible to one or more engines in production, we recommend using a knowledge repository that (logically) centralizes your knowledge in one or more knowledge repositories.

Guvnor is a Drools sub-project that provides exactly that. It consists of a repository for storing different kinds of knowledge, not only process definitions but also rules, object models, etc. It allows easy retrieval of this knowledge using WebDAV or by employing a knowledge agent that automatically downloads the information from Guvnor when creating a knowledge base, and provides a web application that allows business users to view and possibly update the information in the knowledge repository. Check out the Drools Guvnor documentation for more information on how to do this.

7.3. History Log

In many cases it is useful (if not necessary) to store information about the execution of process instances, so that this information can be used afterwards, for example, to verify what actions have been executed for a particular process instance, or to monitor and analyze the efficiency of a particular process. Storing history information in the runtime database is usually not a good idea, as this would result in ever-growing runtime data, and monitoring and analysis queries might influence the performance of your runtime engine. That is why history information about the execution of process instances is stored separately.

This history log of execution information is created based on the events generated by the process engine during execution. The jBPM runtime engine provides a generic mechanism to listen to different kinds of events. The necessary information can easily be extracted from these events and made persistent, for example in a database. Filters can be used to only store the information you find relevant.

7.3.1. Storing Process Events in a Database

The jbpm-bam module contains an event listener that stores process-related information in a database using JPA or Hibernate directly. The database contains two tables, one for process instance information and one for node instance information (see the figure below):

1. *ProcessInstanceLog:* This lists the process instance id, the process (definition) id, the start date and (if applicable) the end date of all process instances.

2. *NodeInstanceLog:* This table contains more detailed information about which nodes were actually executed inside each process instance. Whenever a node instance is entered from one of its incomming connections or is exited through one of its outgoing connections, that information is stored in this table. For this, it stores the process instance id and the process id of the process instance it is being executed in, and the node instance id and the corresponding

node id (in the process definition) of the node instance in question. Finally, the type of event (0 = enter, 1 = exit) and the date of the event is stored as well.

ID	PROCESSINSTANCEID	PROCESSID	START_DATE

ID	TYPE	NODEINSTANCEID	NODEID	PROCESSINSTANCEID	PROCESSID	LOG_DATE

To log process history information in a database like this, you need to register the logger on your session (or working memory) like this:

```
StatefulKnowledgeSession ksession = ...;
JPAWorkingMemoryDbLogger logger = new JPAWorkingMemoryDbLogger(ksession);

// invoke methods one your session here

logger.dispose();
```

Note that this logger is like any other audit logger, which means that you can add one or more filters by calling the method `addFilter` to ensure that only relevant information is stored in the database. Only information accepted by all your filters will appear in the database. You should dispose the logger when it is no longer needed.

To specify the database where the information should be stored, modify the file `persistence.xml` file to include the audit log classes as well (ProcessInstanceLog, NodeInstanceLog and VariableInstanceLog), as shown below.

```
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<persistence
  version="1.0"
  xsi:schemaLocation=
    "http://java.sun.com/xml/ns/persistence
     http://java.sun.com/xml/ns/persistence/persistence_1_0.xsd
     http://java.sun.com/xml/ns/persistence/orm
     http://java.sun.com/xml/ns/persistence/orm_1_0.xsd"
  xmlns:orm="http://java.sun.com/xml/ns/persistence/orm"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xmlns="http://java.sun.com/xml/ns/persistence">

  <persistence-unit name="org.jbpm.persistence.jpa">
```

```
    <provider>org.hibernate.ejb.HibernatePersistence</provider>
    <jta-data-source>jdbc/processInstanceDS</jta-data-source>
    <class>org.drools.persistence.info.SessionInfo</class>
    <class>org.jbpm.persistence.processinstance.ProcessInstanceInfo</class>
    <class>org.drools.persistence.info.WorkItemInfo</class>
    <class>org.jbpm.process.audit.ProcessInstanceLog</class>
    <class>org.jbpm.process.audit.NodeInstanceLog</class>
    <class>org.jbpm.process.audit.VariableInstanceLog</class>

    <properties>
      <property name="hibernate.dialect" value="org.hibernate.dialect.H2Dialect"/>
      <property name="hibernate.max_fetch_depth" value="3"/>
      <property name="hibernate.hbm2ddl.auto" value="update"/>
      <property name="hibernate.show_sql" value="true"/>
      <property name="hibernate.transaction.manager_lookup_class"
            value="org.hibernate.transaction.BTMTransactionManagerLookup"/>
    </properties>
  </persistence-unit>
</persistence>
```

All this information can easily be queried and used in a lot of different use cases, ranging from creating a history log for one specific process instance to analyzing the performance of all instances of a specific process.

This audit log should only be considered a default implementation. We don't know what information you need to store for analysis afterwards, and for performance reasons it is recommended to only store the relevant data. Depending on your use cases, you might define your own data model for storing the information you need, and use the process event listeners to extract that information.

Chapter 8. Core Engine: Examples

8.1. jBPM Examples

There is a separate jBPM examples module that contains a set of example processes that show how to use the jBPM engine and the behavior or the different process constructs as defined by the BPMN 2.0 specification.

To start using these, simply unzip the file somewhere and open up your Eclipse development environment with all required plugins installed. If you don't know how to do this yet, take a look at the installer chapter, where you can learn how to create a demo environment, including a fully configured Eclipse IDE, using the jBPM installer. You can also take a look at the Eclipse plugin chapter if you want to learn how to manually install and configure this.

To take a look at the examples, simply import the downloaded examples project into Eclipse (File -> Import ... -> Under General: Existing Projects into Workspace), browse to the folder where you unzipped the jBPM examples artefact and click finish. This should import the examples project in your workspace, so you can start looking at the processes and executing the classes.

8.2. Examples

The examples module contains a number of examples, from basic to advanced:

- Looping: An example that shows how you can use exclusive gateways to loop a part your process until the loop condition is no longer valid. The process takes the 'count' (the number of times the loop needs to be repeated) as input and simply prints out a statement during every loop until the process is completed.
- MultiInstance: This example shows how to execute a sub-process for each element in a collection. The process takes a collection of names as input and creates a review task for a sales representative for each person in that list. The process completes if the task has been executed for every person on that list.
- Evaluation: A performance evaluation process that shows how to integrate human actors in the process. While the basic example simply shows tasks assigned to predefined users, the more advanced version shows data passing from the process to the task and back, group assignment, task delegation, etc.
- HumanTask: An advanced example when using human tasks. It shows how to do data passing between tasks, task forms, swimlanes, etc. This example can also be deployed to the Guvnor repository (including all the forms etc.) and executed on the jBPM console out-of-the-box.
- Request: An advanced example that shows various ways in which processes and rules can work together, like a rule task for invoking validation rules, rules as expression language for

constraints inside the process, rules for exception handling, event processing for monitoring, ad hoc rules for more flexible processes, etc.

8.3. Unit tests

The examples project contains a large number of simple BPMN2 processes for each of the different node types that are supported by jBPM5. In the junit folder under src/main/resources you can for example find process examples for constructs like a conditional start event, exclusive diverging gateways using default connections, etc. So if you're looking for a simple working example that shows the behavior of one specific element, you can probably find one here. The folder already contains well over 50 sample processes. Simply double-click them to open them in the graphical editor.

Each of those processes is also accompanied by a small junit test that tests the implementation of that construct. The org.jbpm.examples.junit.BPMN2JUnitTests class contains one test for each of the processes in the junit resources folder. You can execute these tests yourself by selecting the method you want to execute (or the entire class) and right-click and then Run as -> JUnit test.

Check out the chapter on testing and debugging if you want to learn more how to debug these example processes.

Chapter 9. Eclipse BPMN 2.0 Plugin

We are working on a new BPMN 2.0 Eclipse editor that allows you to specify business processes, choreographies, etc. using the BPMN 2.0 XML syntax (including BPMNDI for the graphical information). The editor itself is based on the Eclipse Graphiti framework and the Eclipse BPMN 2.0 model.

Features:

- It supports almost all BPMN 2.0 process constructs and attributes (including lanes and pools, annotations and all the BPMN2 node types).
- Support for the few custom attributes that jBPM5 introduces.
- Allows you to configure which elements and attributes you want use when modeling processes (so we can limit the constructs for example to the subset currently supported by jBPM5, which is a profile we will support by default, or even more if you like).

Many thanks go out to the people at Codehoop that did a great job in creating a first version of this editor.

9.1. Installation

Requirements

- Eclipse 3.6 or newer
- Graphiti framework, using update site *http://download.eclipse.org/graphiti/updates/0.7.1/*

To install, startup Eclipse and install Graphiti from the update site above (from menu Help -> Install new software and then add the update site in question and select and install the Graphiti runtime) and then use the following update site *http://codehoop.com/bpmn2* to install the latest version of the BPMN 2.0 editor in Eclipse. A screencast that shows all this in action can be found *here* [http://vimeo.com/22022128].

Sources can be found here: *https://github.com/droolsjbpm/bpmn2-eclipse-editor*

9.2. Creating your BPMN 2.0 processes

You can use a simple wizard to create a new BPMN 2.0 process (under File -> New - Other ... select BPMN - BPMN2 Diagram).

A video that shows some sample BPMN 2.0 processes from the examples that are part of the BPMN 2.0 specification:

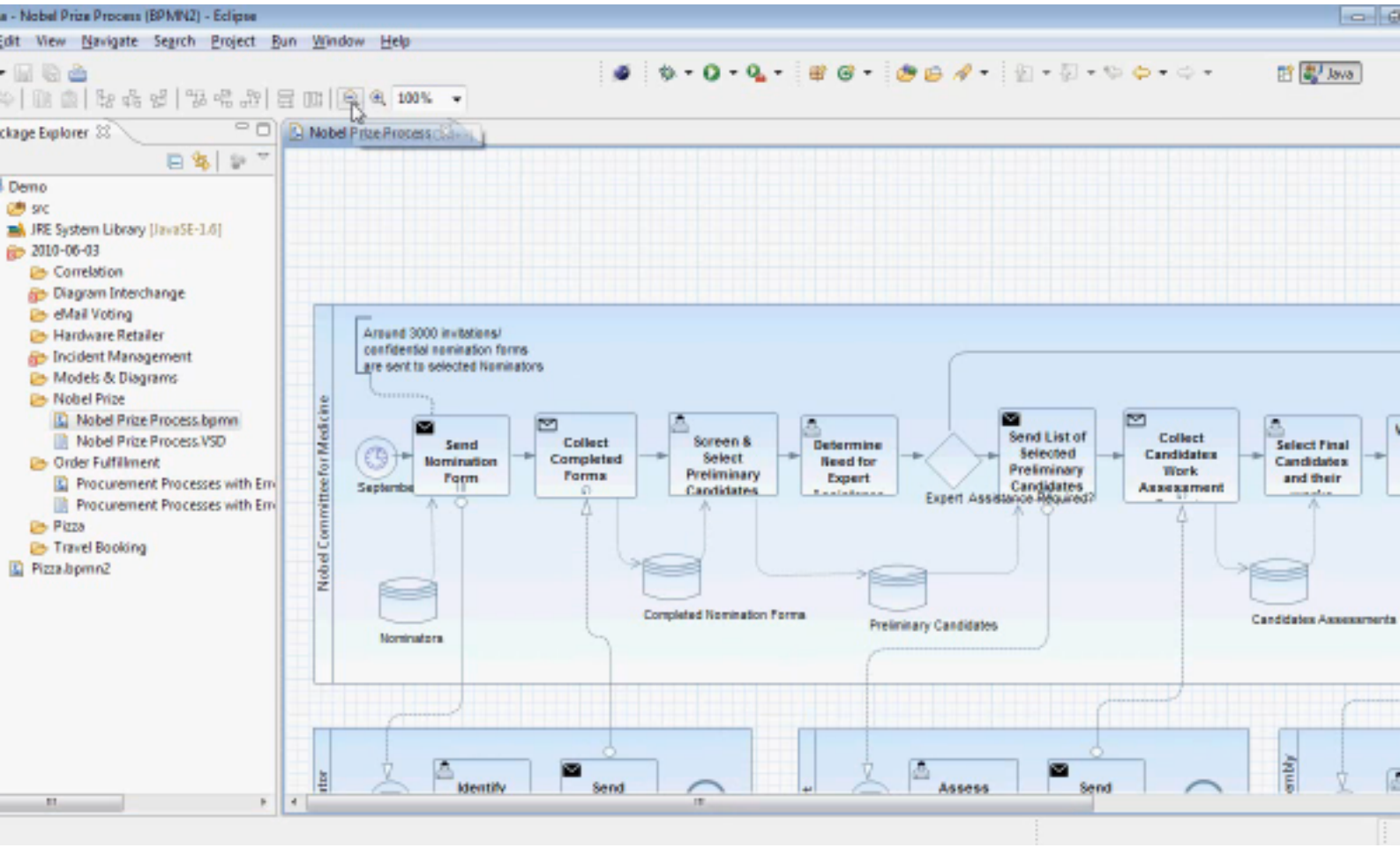


Figure 9.1.

[http://vimeo.com/22021856]

Here are some screenshots of the editor in action.

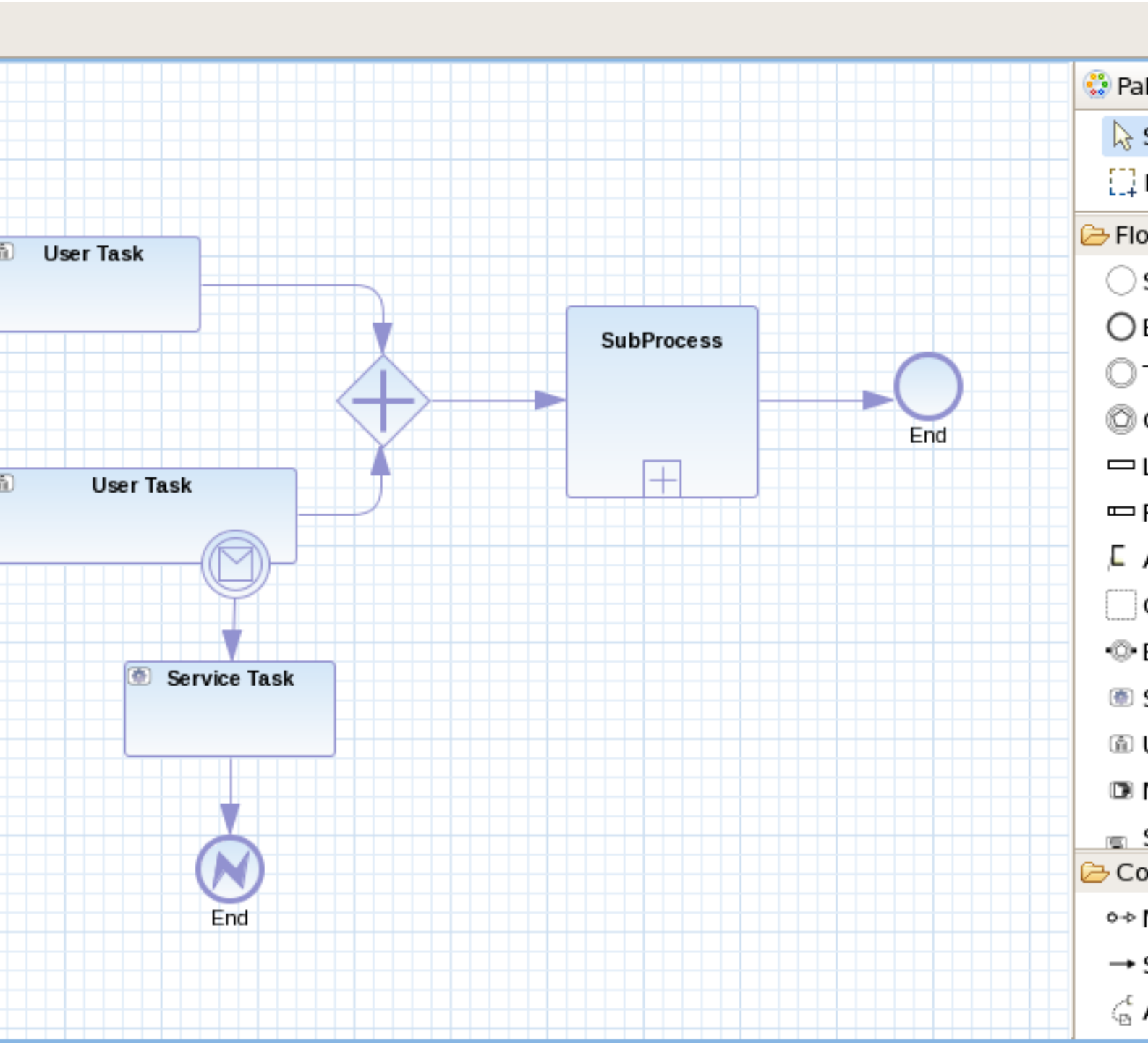


Figure 9.2.

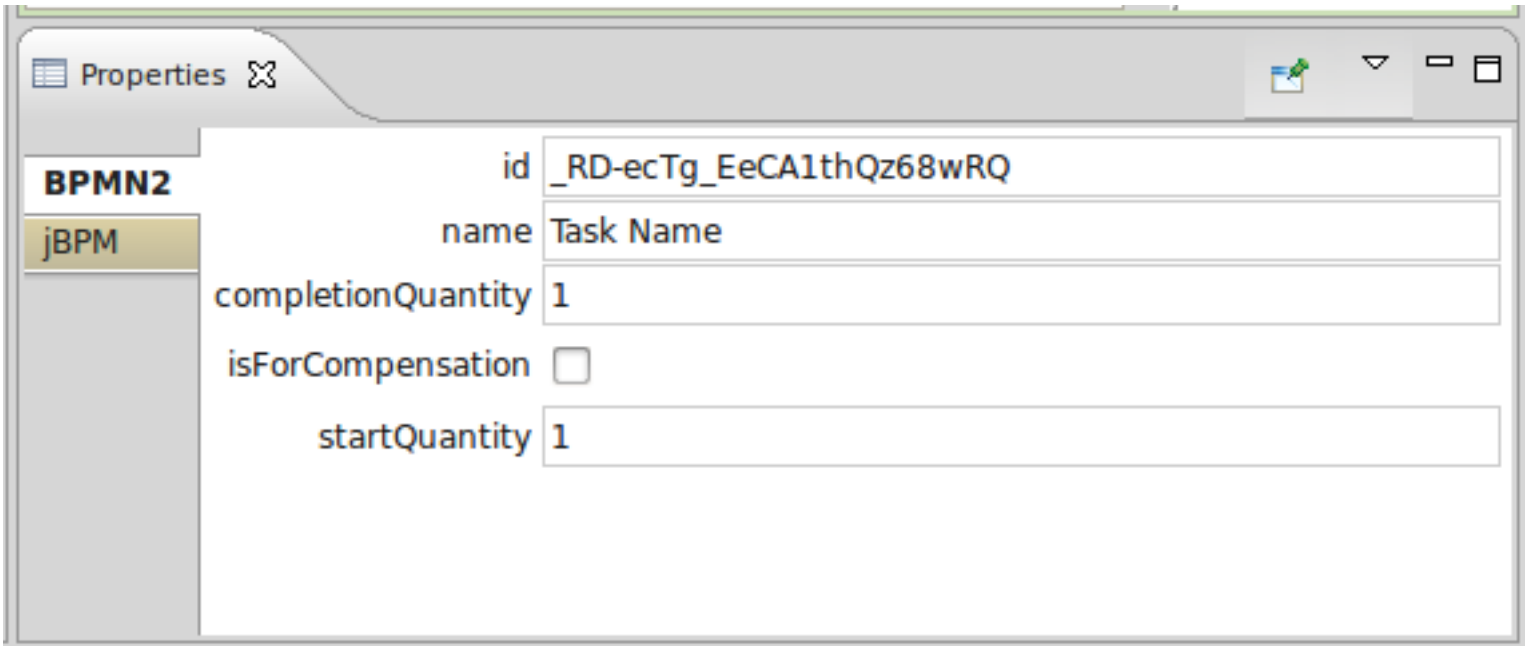

Properties
BPMN2
jBPM
id
_RD-ecTg_EeCA1thQz68wRQ
name
Task Name
completionQuantity
1
isForCompensation
startQuantity
1

Figure 9.3.

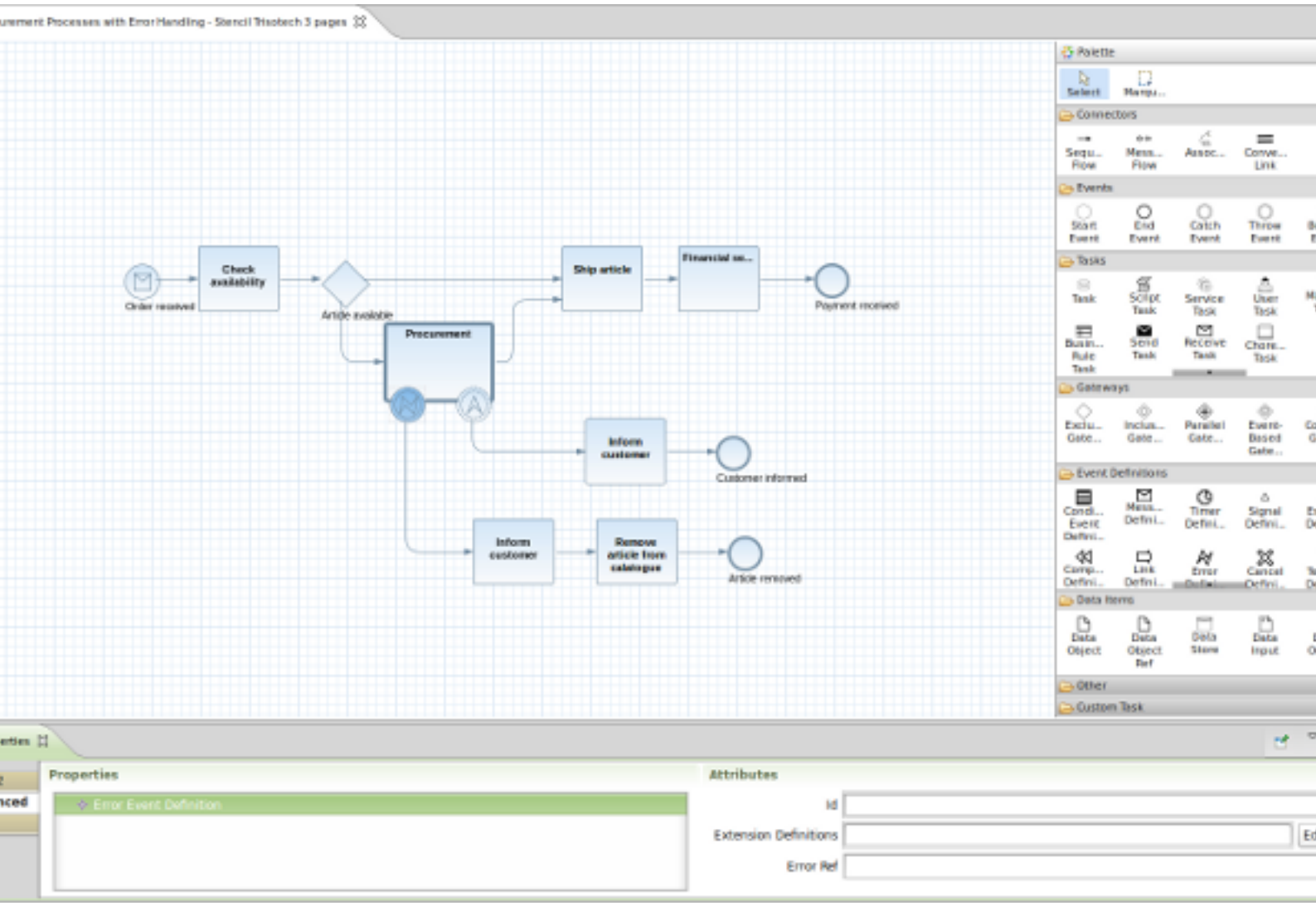

Palette
Connectors
Events
Tasks
Gateways
Event Definitions
Data Items
Other
Custom Task
Check availability
Order received
Article available
Procurement
Ship article
Payment received
Inform customer
Customer informed
Inform customer
Remove article from catalogue
Article removed
Properties
Error Event Definition
Attributes
Id
Extension Definitions
Error Ref

Figure 9.4.

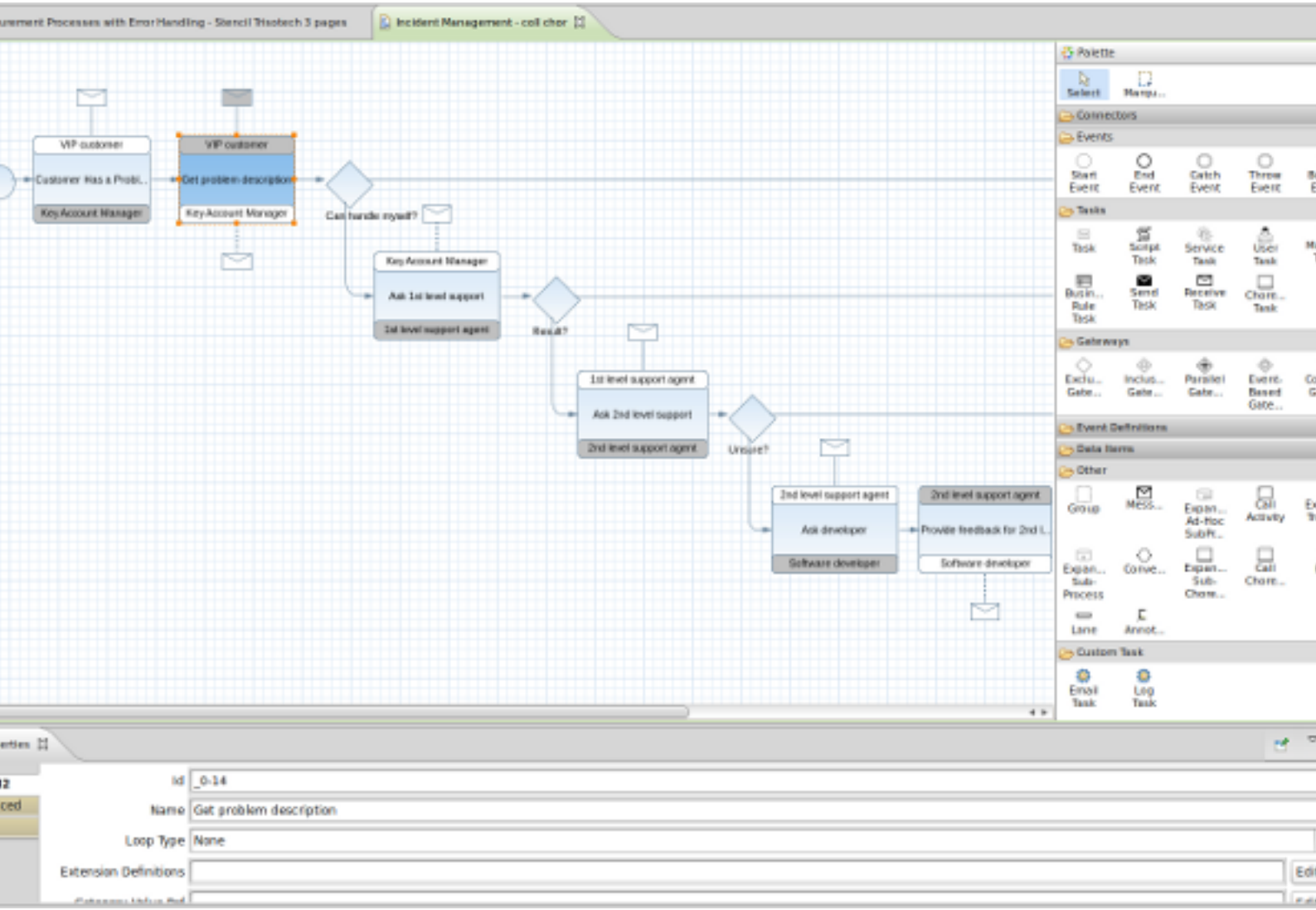


Figure 9.5.

9.3. Filtering elements and attributes

You can define which of the BPMN 2.0 elements and attributes you want to use when describing your BPMN 2.0 diagrams. Since the BPMN 2.0 specification is rather complex and includes a very large set of different node types and attributes for each of those nodes, you may not want to use all of these elements and attributes in your project. Elements and attributes can be enablement / disabled at the project level using the BPMN2 preferences category (right-click your project folder and select Properties ... which will open up a new dialog). The BPMN2 preferences contain an entry for all supported elements and attributes (per node type) and you can enable or disable each of those by (un)checking the box for each of those elements and attributes.

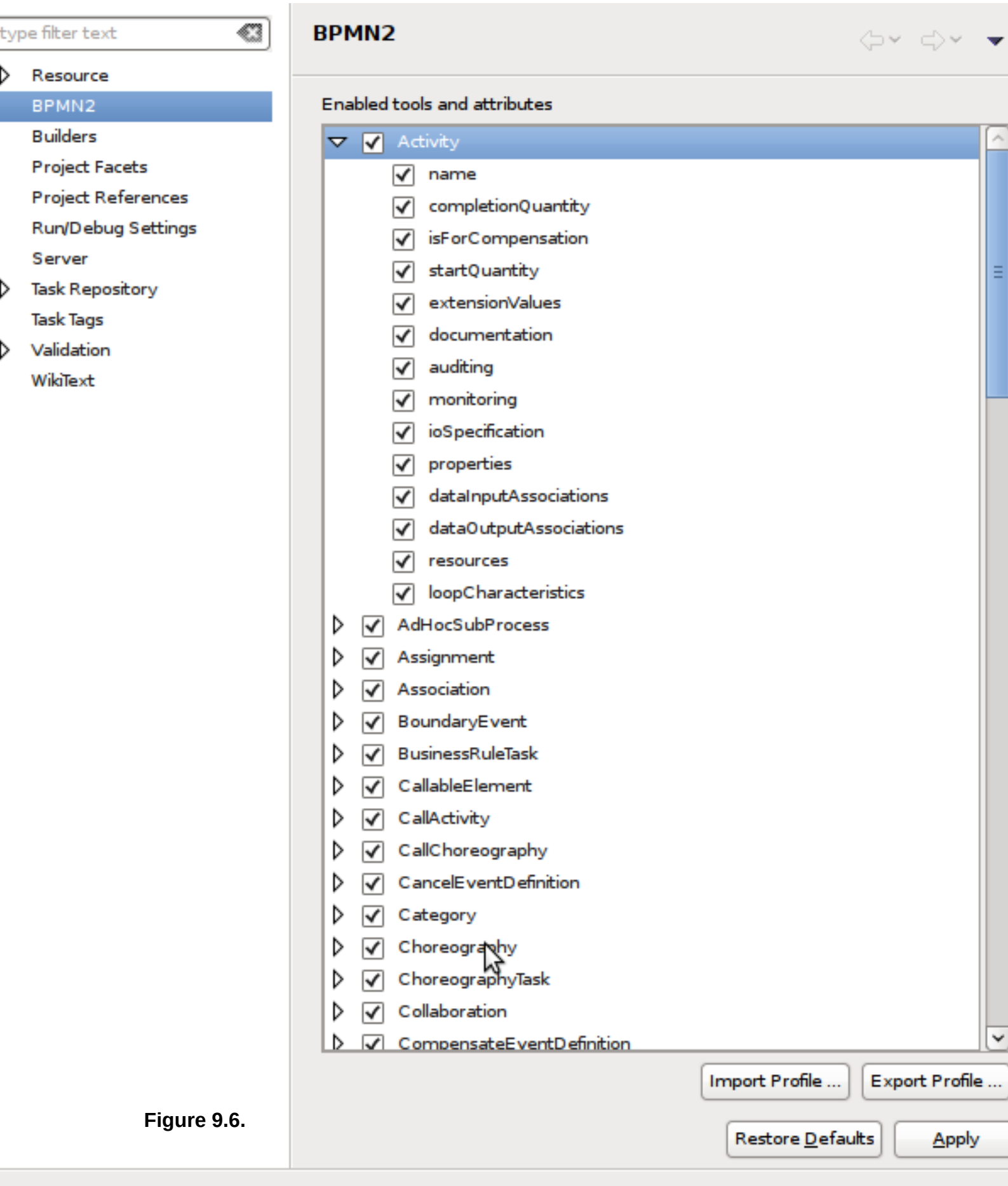

type filter text
Resource
BPMN2
Builders
Project Facets
Project References
Run/Debug Settings
Server
Task Repository
Task Tags
Validation
WikiText
BPMN2
Enabled tools and attributes
Activity
name
completionQuantity
isForCompensation
startQuantity
extensionValues
documentation
auditing
monitoring
ioSpecification
properties
dataInputAssociations
dataOutputAssociations
resources
loopCharacteristics
AdHocSubProcess
Assignment
Association
BoundaryEvent
BusinessRuleTask
CallableElement
CallActivity
CallChoreography
CancelEventDefinition
Category
Choreography
ChoreographyTask
Collaboration
CompensateEventDefinition
Import Profile ...
Export Profile ...
Restore Defaults
Apply
Cancel
OK

Figure 9.6.

Chapter 10. Designer

The designer is a web-based editor for viewing, creating and editing your business processes. It is very similar to the Eclipse-based designer and allows the creation of BPMN2 processes in a web context. There is a palette on the left and a properties panel on the right (make sure to click the arrows on the side of the canvas to make them visible if you cannot see them).

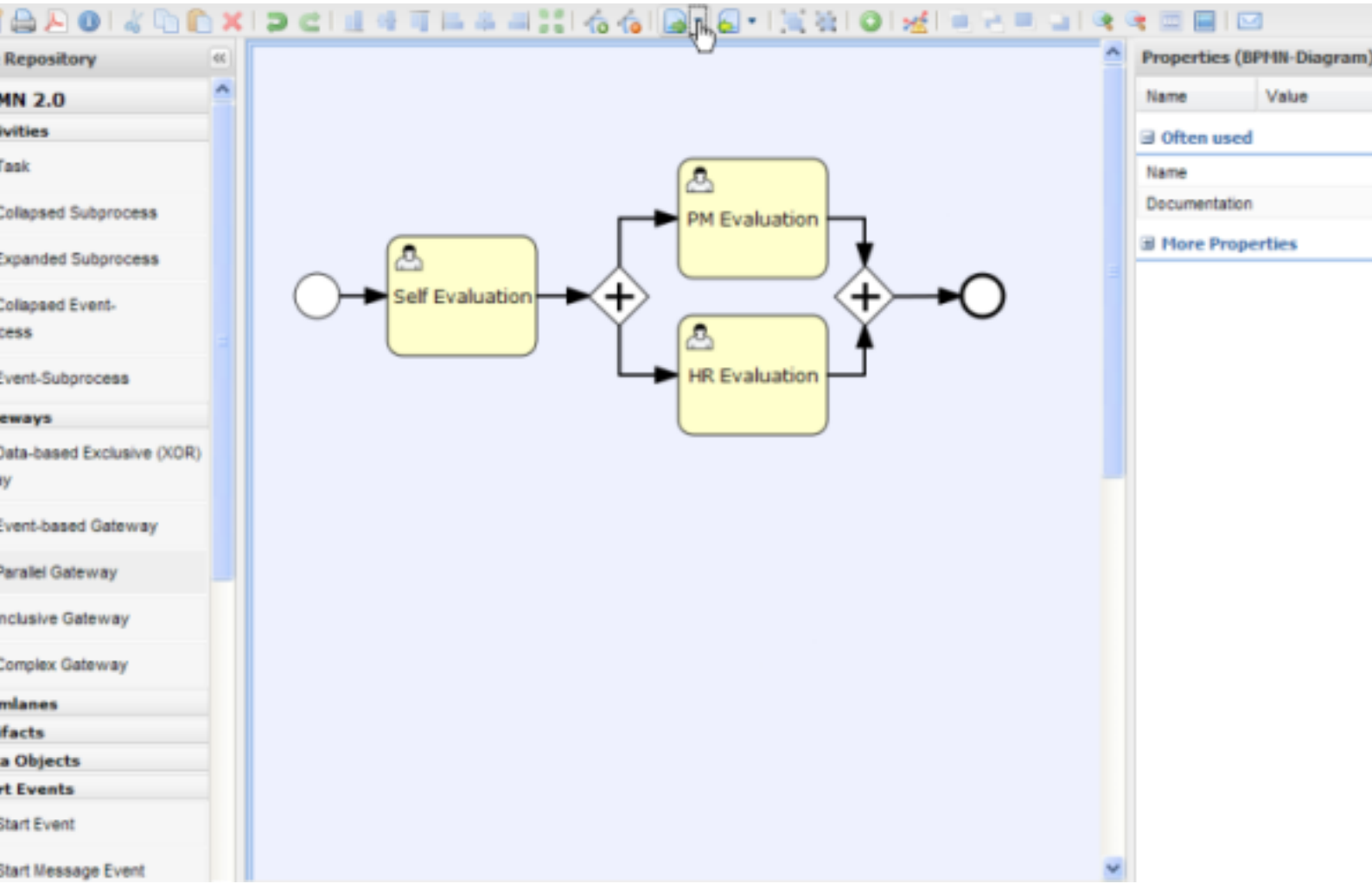


Figure 10.1.

The designer targets the following scenarios:

- View existing BPMN2 processes: The designer allows you to open existing BPMN2 processes (for example created using the BPMN2 Eclipse editor or any other tooling that exports BPMN 2.0 XML) in a web context.
- Prototyping new BPMN2 processes: A user can create a new BPMN2 process in the Designer and use the editing capabilities (drag and drop and filling in properties in the properties panel) to

fill in initial details. This for example allows business users to create a first prototype version of the business process that they want to create. This process could then for example be imported into Eclipse to add all the details to make it fully executable.

At this point, the designer does not yet support full roundtripping of your BPMN2 processes (due to limitations in the parser and the editor). We recommend you use the Eclipse plugin to add all the execution details (you can easily import a process from Guvnor there). The results can then be committed back to Guvnor so that the business user can see the resulting process. We are working hard to add full roundtripping support in the next version.

10.1. Installation

If you are using the jBPM installer, this should automatically download and install the latest version of the designer for you. To manually install the designer, simply drop the designer war into your application server deploy folder. This version that should deploy without any changes on JBoss AS 5.1.0. Note: If you want to deploy on other (versions of an) application server, you might have to adjust the dependencies inside the war based on the default libraries provided by your application server. The latest version of the designer can be found *here* [http://people.redhat.com/tsurdilo/oryx/1.0.0.051/].

To open up the designer, open up Guvnor (e.g. *http://localhost:8080/drools-guvnor* [http://localhost:8080/drools-guvnor]) and either open up an existing BPMN2 process or create a new one (under the "Knowledge Bases category on the left, select create new BPMN2 process"). This will open up the designer for the selected process in the center panel. You can use the palette on the left to drag and drop node types and the properties tab on the right to fill in the details (if either of these panels is not visible, click the arrow on the side of the editor to make them move forward).

The designer can also be opened stand-alone by using the following link: *http://localhost:8080/designer/editor?profile=jbpm&uuid=123456* (where 123456 should be replaced by the id of the process on guvnor). Note that running designer in this way allows you to only view existing processes, and not save any edits nor create new ones. Information on how to integrate designer into your own applications can be found here: http://blog.athico.com/2011/04/using-oryx-designer-and-guvnor-in-your.html.

10.2. Source code

The designer is based on the Oryx codebase. Oryx is a web-based editor for modeling different types of business processes hosted at Google Code. Oryx is also backed by Signavio, who provides a professionally maintained version.

jBPM integrates with the BPMN2 process designer based on an Oryx branch maintained by Intalio and JBoss. The goal of this branch is to apply upstream patches to the Oryx project where possible and it's latest version can be downloaded from github.

https://github.com/intalio/process-designer/

Chapter 11. Console

Business processes can be managed through a web console. This includes features like managing your process instances (starting/stopping/inspecting), inspecting your (human) task list and executing those tasks, and generating reports.

The jBPM console consists of two wars that must be deployed in your application server and contains the necessary libraries, the actual application, etc. One jar contains the server application, the other one the client.

11.1. Installation

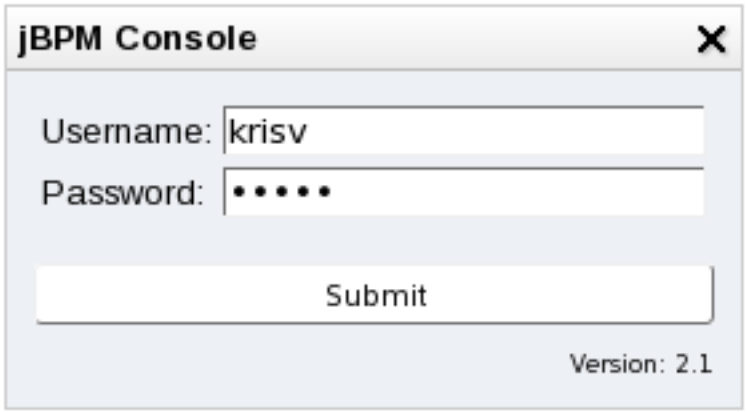
The easiest way to get started with the console is probably to use the installer. This will download, install and configure all the necessary components to get the console running, including an in-memory database, a human task service, etc. Check out the chapter on the installer for more information.

The console is a separate sub-project that is shared across different projects, like for example jBPM and RiftSaw. The source code of the version that jBPM5 is currently using can be found on SVN *here* [http://anonsvn.jboss.org/repos/soag/bpm-console/tags/bpm-console-2.1/]. The latest version of the console has been moved to Git and can be found *here* [https://github.com/bpmc].

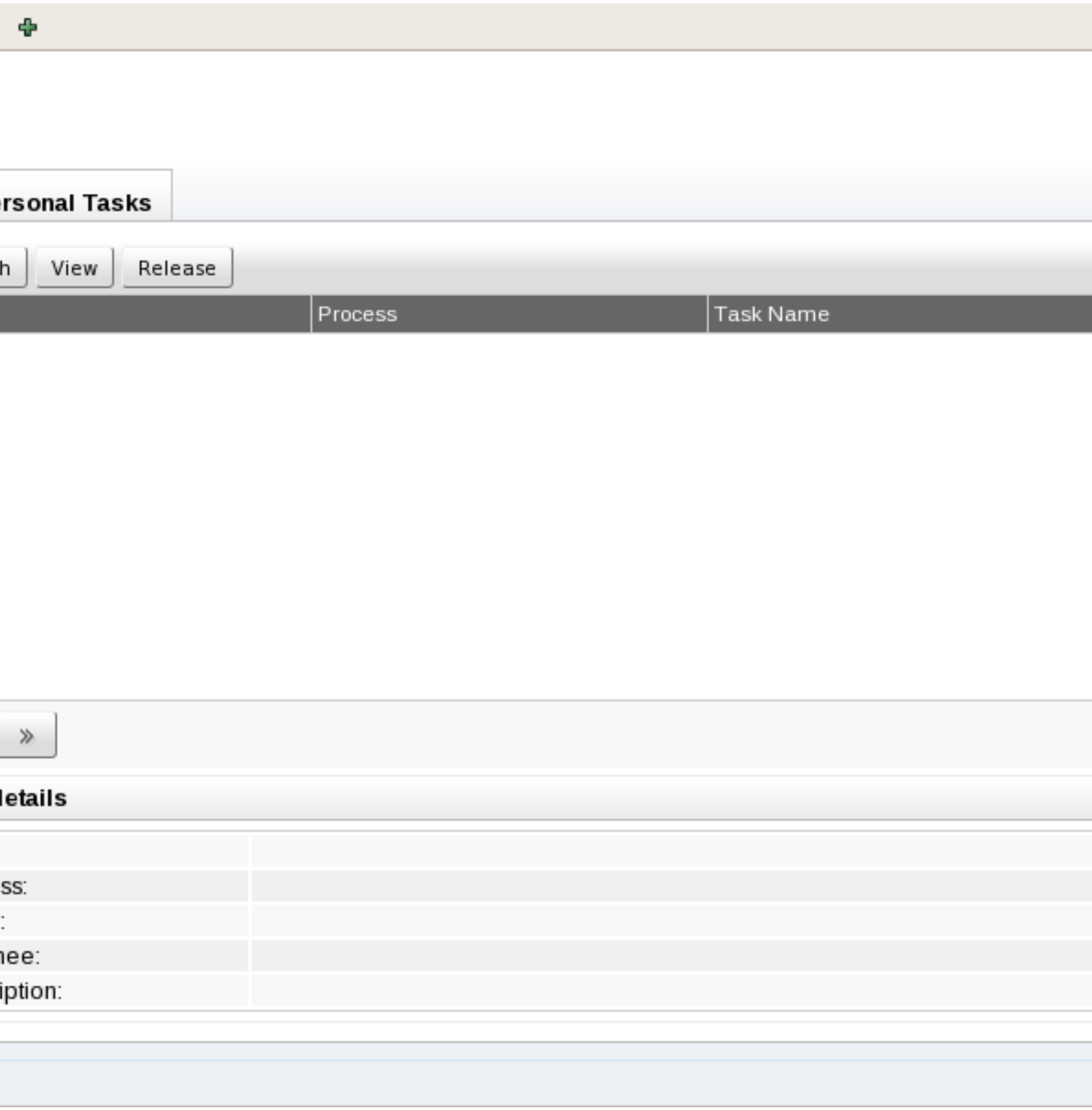
11.2. Running the process management console

Now navigate to the following URL (replace the host and/or port depending on how the application server is configured): *http://localhost:8080/jbpm-console*

A login screen should pop up, asking for your user name and password. By default, the following username/password configurations are supported: krisv/krisv, admin/admin, john/john and mary/mary.



After filling these in, the process management workbench should be opened, as shown in the screenshot below. On the right you will see several tabs, related to process instance management, human task lists and reporting, as explained in the following sections.

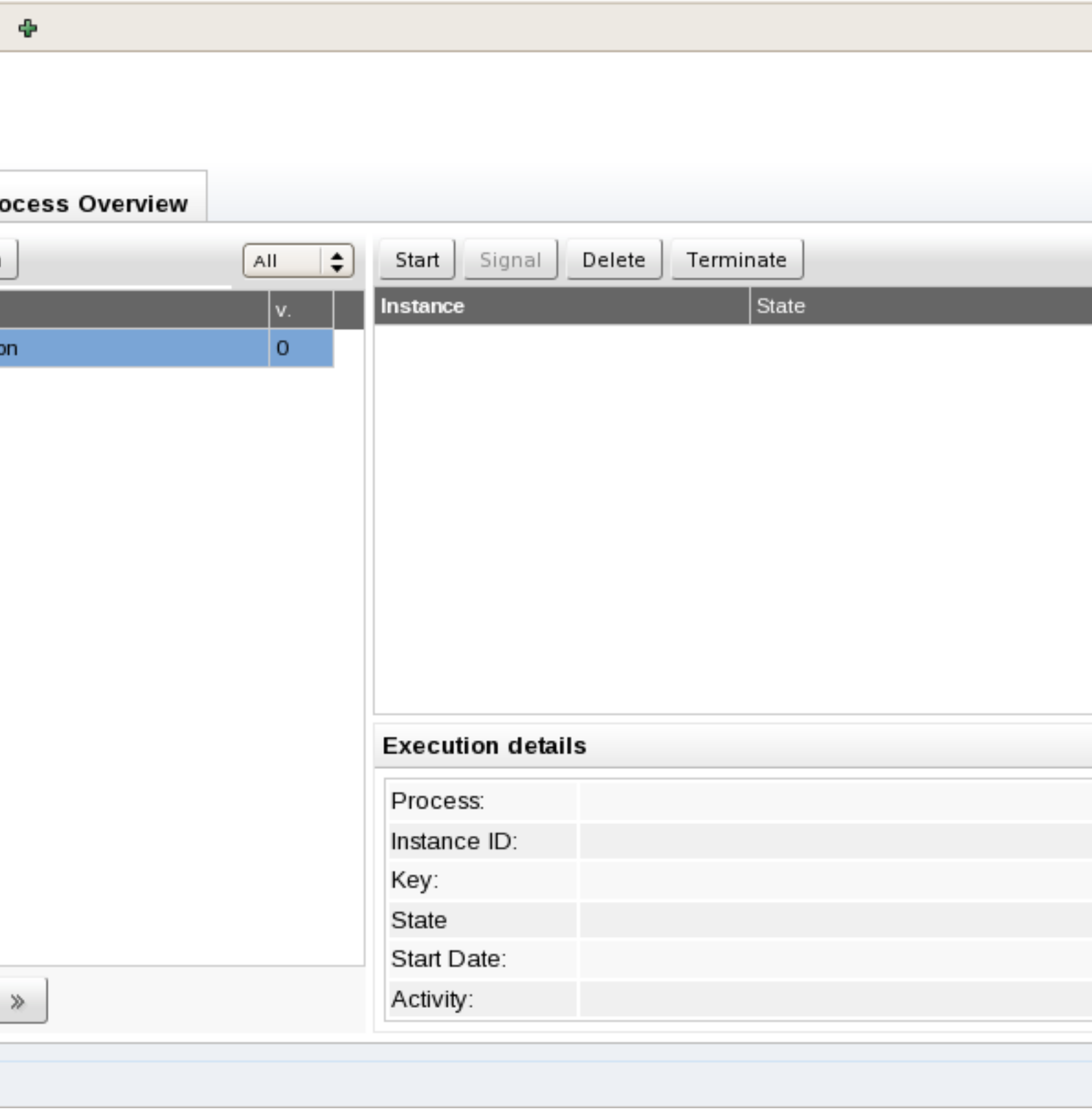

rsonal Tasks
h
View
Release
Process
Task Name
»
letails
ss:
:
nee:
iption:

11.2.1. Managing process instances

The "Processes" section allows you to inspect the process definitions that are currently part of the installed knowledge base, start new process instances and manage running process instances (which includes inspecting their state and data).

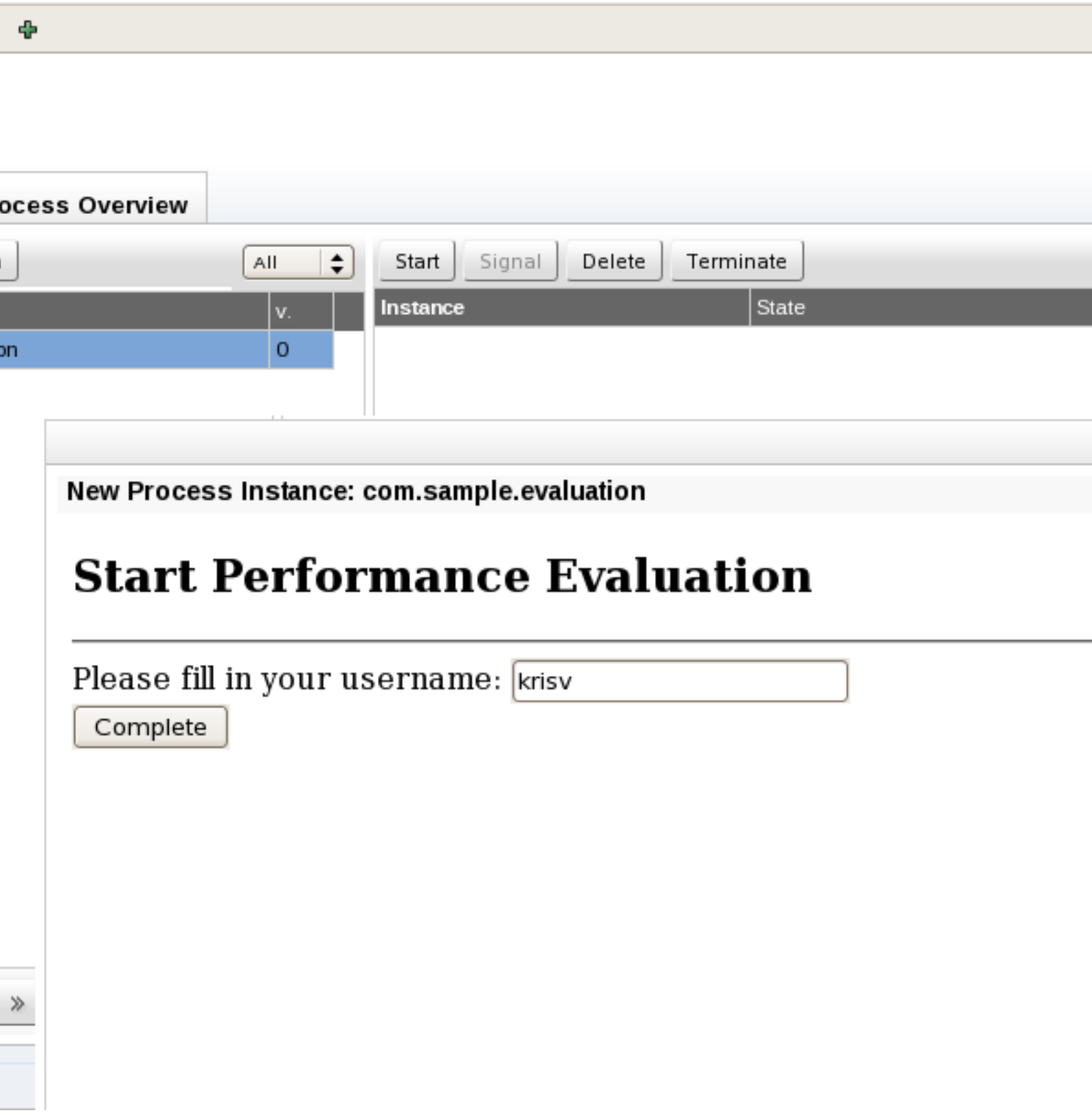
11.2.1.1. Inspecting process definitions

When you open the process definition list, all known process definitions are shown. You can then either inspect process instances for one specific process or start a new process instance.


ocess Overview
All
v.
0
Start
Signal
Delete
Terminate
Instance
State
Execution details
Process:
Instance ID:
Key:
State
Start Date:
Activity:

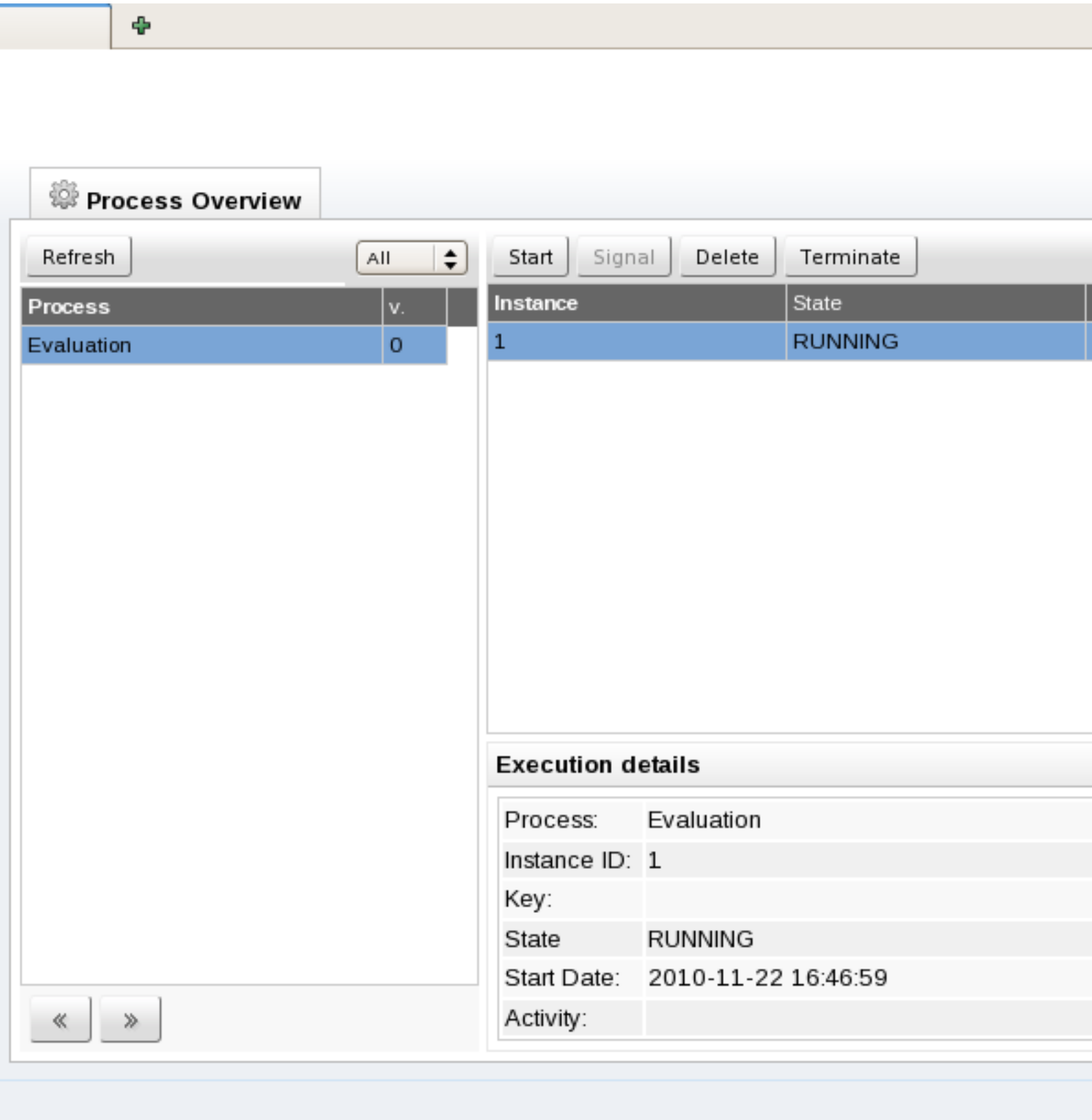
11.2.1.2. Starting new process instances

To start a new process instance for one specific process definition, select the process definition in the process definition list. Click on the "Start" button in the instances table to start a new instance of that specific process. When a form is associated with this particular process (to ask for additional information before starting the process), this form will be shown. After completing this form, the process will be started with the provided information.


ocess Overview
All
Start
Signal
Delete
Terminate
v.
Instance
State
0
New Process Instance: com.sample.evaluation
Start Performance Evaluation
Please fill in your username:
krisv
Complete

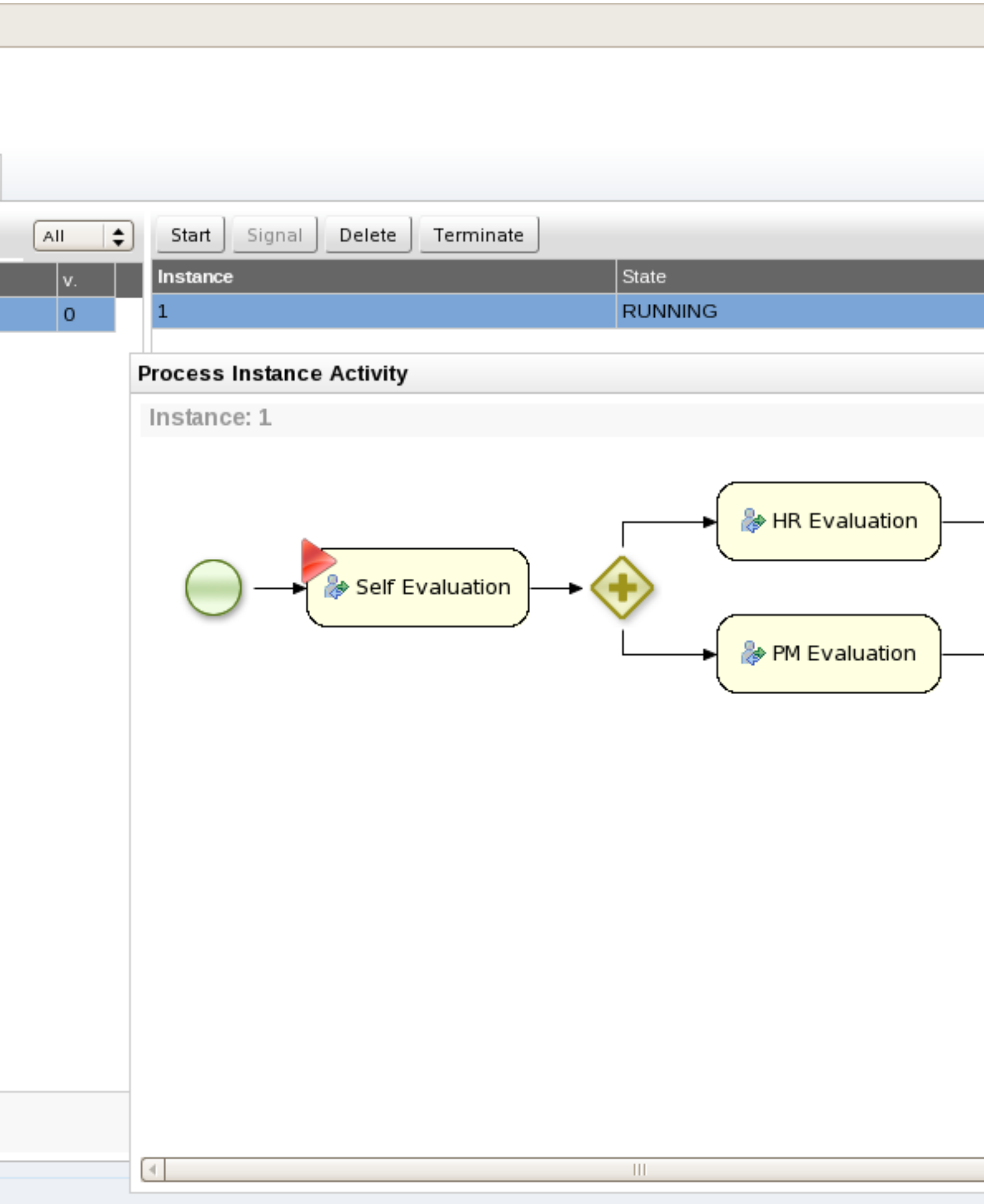
11.2.1.3. Managing process instances

The process instances table shows all running instances of that specific process definition. Select a process instance to show the details of that specific process instance.


Process Overview
Refresh
All
Start
Signal
Delete
Terminate
Process
v.
Evaluation
0
Instance
State
1
RUNNING
Execution details
Process:
Evaluation
Instance ID:
1
Key:
State
RUNNING
Start Date:
2010-11-22 16:46:59
Activity:

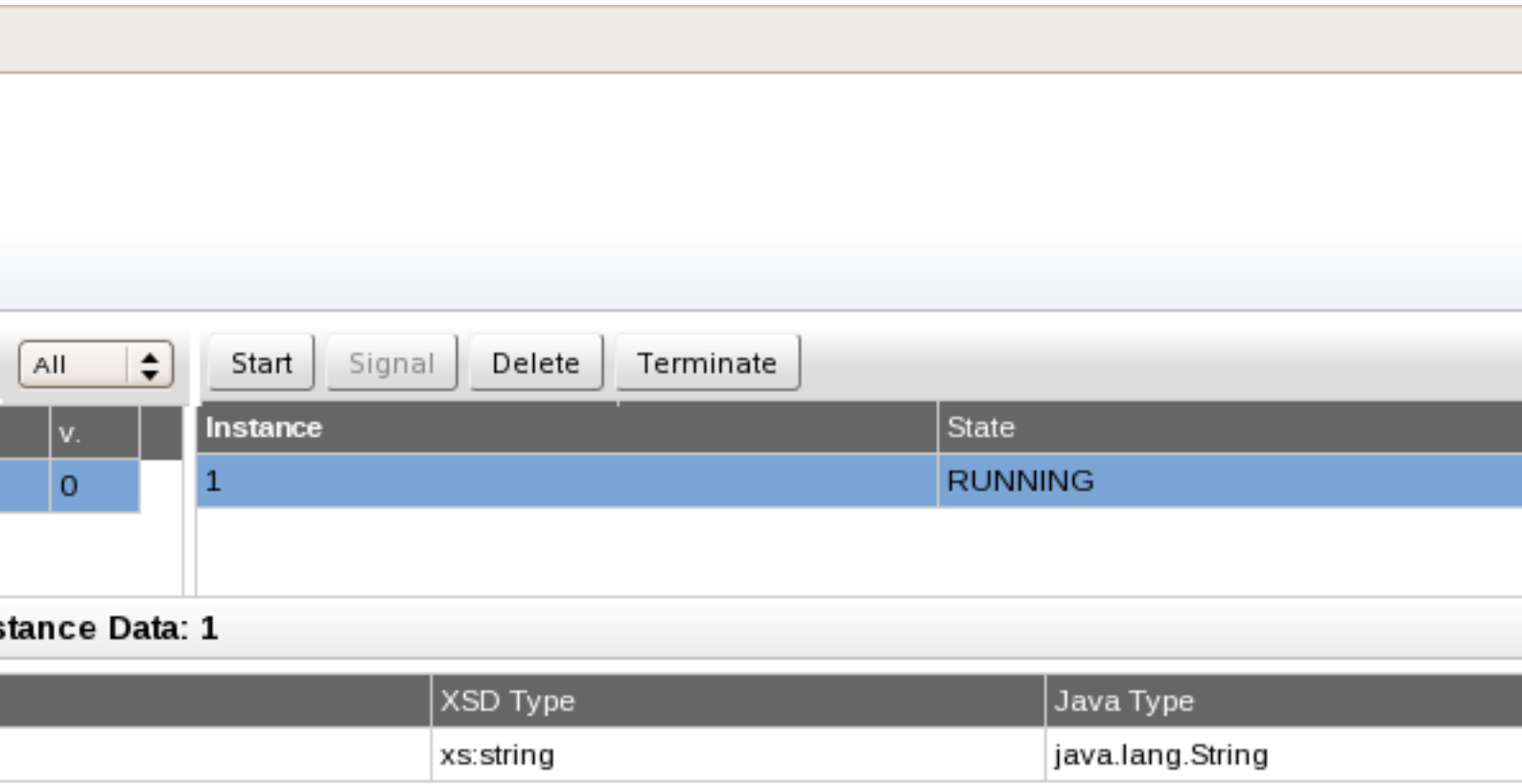
11.2.1.4. Inspecting process instance state

You can inspect the state of a specific process instance by clicking on the "Diagram" button. This will show you the process flow chart, where a red traingle is shown at each node that is currently active (like for example a human task node waiting for the task to be completed or a join node waiting for more incoming connections before continuing). [Note that multiple instances of one node could be executing simultaneously. They will still be shown using only one red triangle.]


All
Start
Signal
Delete
Terminate
V.
0
Instance
State
1
RUNNING
Process Instance Activity
Instance: 1
Self Evaluation
HR Evaluation
PM Evaluation

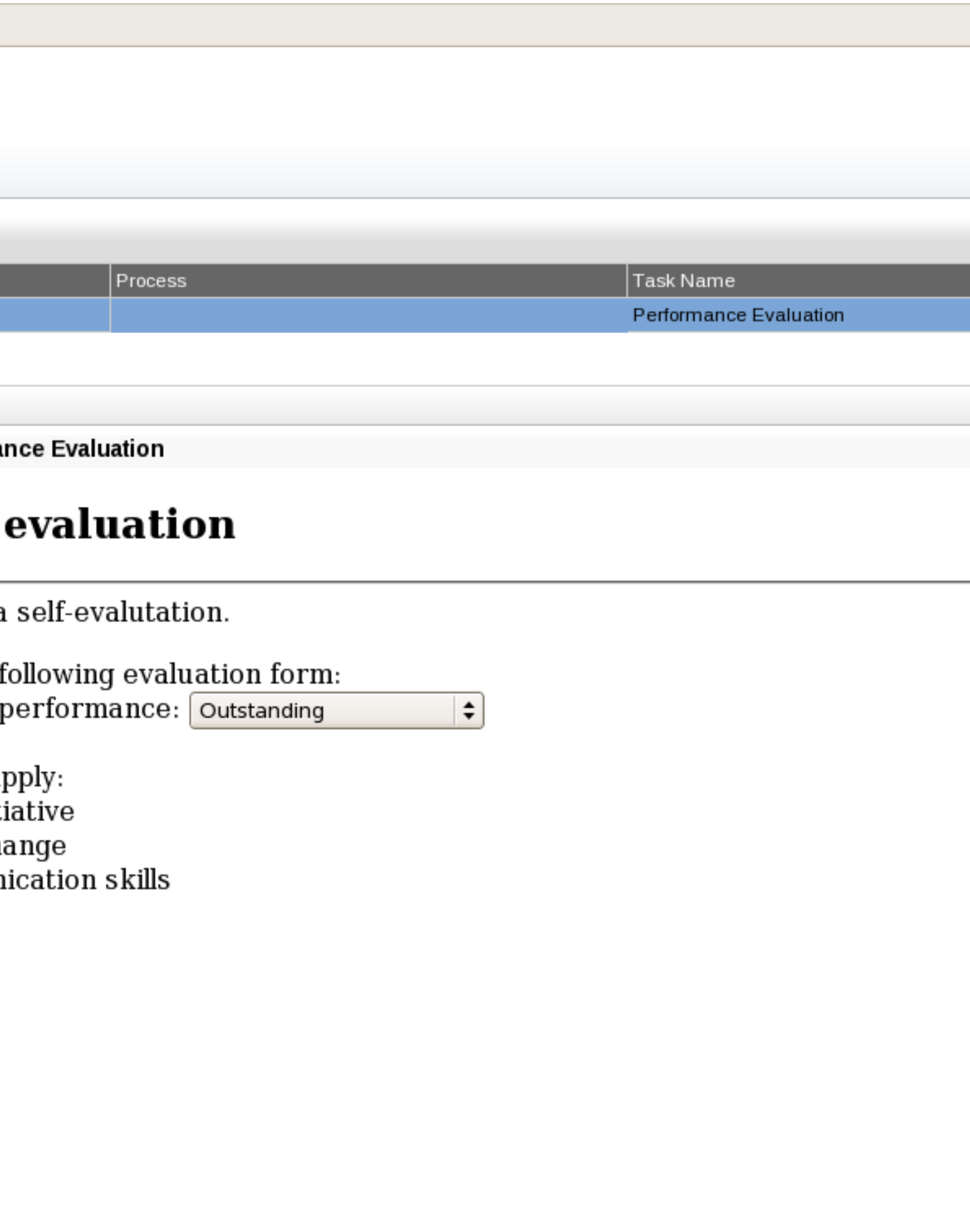
11.2.1.5. Inspecting process instance variables

You can inspect the (top-level) variables of a specific process instance by clicking on the "Instance Data" button. This will show you how each variable defined in the process maps to it's corresponding value for that specific process instance.


All
Start
Signal
Delete
Terminate
v.
0
Instance
State
1
RUNNING
stance Data: 1
XSD Type
Java Type
xs:string
java.lang.String

11.2.2. Human task lists

The task management section allows a user to see his/her current task list. The group task list shows all the tasks that are not yet assigned to one specific user but that the currently logged in user could claim. The personal task list shows all tasks that are assigned to the currently logged in user. To execute a task, select it in your personal task list and select "View". If a form is associated with the selected task (for example to ask for additional information), this form will be shown. After completing the form, the task will also be completed.


Process
Task Name
Performance Evaluation
ance Evaluation
evaluation
a self-evalutation.
following evaluation form:
performance:
Outstanding
pply:
iative
ange
nication skills

11.2.3. Reporting

The reporting section allows you to view reports about the execution of processes. This includes an overall report showing an overview of all processes, as shown below.

This report doesn't require any paramters.

Business Activity Monitori

Instances / Hour

A report regarding one specific process instance can also be generated.

Please enter a process definition id

com.sampl

Business Activity Monitori

Process com.sample.evaluatio

com.sample.evaluation
1
1
1

ocess Instances

com.sample.evaluation

jBPM provides some sample reports that could be used to visualize some generic execution characteristics like the number of active process instances per process etc. But custom reports could be generated to show the information your company thinks is important, by replacing the report templates in the report directory.

11.3. Adding new process / task forms

Forms can be used to (1) start a new process or (2) complete a human task. We use freemarker templates to dynamically create forms. To create a form for a specific process definition, create a freemarker template with the name {processId}.ftl. The template itself should use HTML code to model the form. For example, the form to start the evaluation process shown above is defined in the com.sample.evaluation.ftl file:

```
<html>
<body>
<h2>Start Performance Evaluation</h2>
<hr>
<form action="complete" method="POST" enctype="multipart/form-data">
Please fill in your username: <input type="text" name="employee" /></BR>
<input type="submit" value="Complete">
</form>
</body>
</html>
```

Similarly, task forms for a specific type of human task (uniquely identified by its task name) can be linked to that human task by creating a freemarker template with the name {taskName}.ftl. The form has access to a "task" parameter that represents the current human task, so it allows you to dynamically adjust the task form based on the task input. The task parameter is a Task model object as defined in the jbpm-human-task module. This for example allows you to customize the task form based on the description or input data related to that task. For example, the evaluation form shown earlier uses the task parameter to access the description of the task and show that in the task form:

```
<html>
<body>
<h2>Employee evaluation</h2>
<hr>
${task.descriptions[0].text}<br/>
<br/>
Please fill in the following evaluation form:
<form action="complete" method="POST" enctype="multipart/form-data">
```

```
Rate the overall performance: <select name="performance">
<option value="outstanding">Outstanding</option>
<option value="exceeding">Exceeding expectations</option>
<option value="acceptable">Acceptable</option>
<option value="below">Below average</option>
</select><br/>
<br/>
Check any that apply:<br/>
<input type="checkbox" name="initiative" value="initiative">Displaying initiative<br/>
<input type="checkbox" name="change" value="change">Thriving on change<br/>
<input type="checkbox" name="communication" value="communication">Good communication
 skills<br/>
<br/>
<input type="submit" value="Complete">
</form>
</body>
</html>
```

Data that is provided by the user when filling in the task form will be added as parameters when completing the task. For example, when completing the task above, the Map of outcome parameters will include result variables called "performance", "initiative", "change" and "communication". The result parameters can be accessed in the related process by mapping these parameters to process variables.

Forms should be included in the jbpm-gwt-form.jar in the server war.

11.4. REST interface

The console also offers a REST interface for the functionality it exposes. This for example allows easy integration with the process engine for features like starting process instances, retrieving task lists, etc.

The list URLS that the REST interface exposes can be inspected if you navigate to the following URL (after installing and starting the console):

http://localhost:8080/gwt-console-server/rs/server/resources

For example, this allows you to close a task using

/gwt-console-server/rs/task/{taskId}/close

or starting a new process instances using

/gwt-console-server/rs/process/definition/{id}/new_instance

Chapter 12. Human Tasks

An important aspect of work flow and BPM is human task management. While some of the work performed in a process can be executed automatically, some tasks need to be executed with the interaction of human actors. jBPM supports the use of human tasks inside processes using a special user task node that will represent this interaction. This node allows process designers to define the type of task, the actor(s), the data associated with the task, etc. We also have implemented a task service that can be used to manage these user tasks. Users are however open to integrate any other solution if they want to, as this is fully pluggable.

To start using human tasks inside your processes, you first need to (1) include user task nodes inside your process, (2) integrate a task management component of your choice (e.g. the WS-HT implementation provided by us) and (3) have end users interact with the human task management component using some kind of user interface. These elements will be discussed in more detail in the next sections.

12.1. Human tasks inside processes

jBPM supports the use of human tasks inside processes using a special user task node (as shown in the figure above). A user task node represents an atomic task that needs to be executed by a human actor. Although jBPM has a special user task node for including human tasks inside a process, human tasks are simply considered as any other kind of external service that needs to be invoked and are therefore simply implemented as a special kind of work item. The only thing that is special about the user task node is that we have added support for swimlanes, making it easier to assign tasks to users (see below). A user task node contains the following properties:

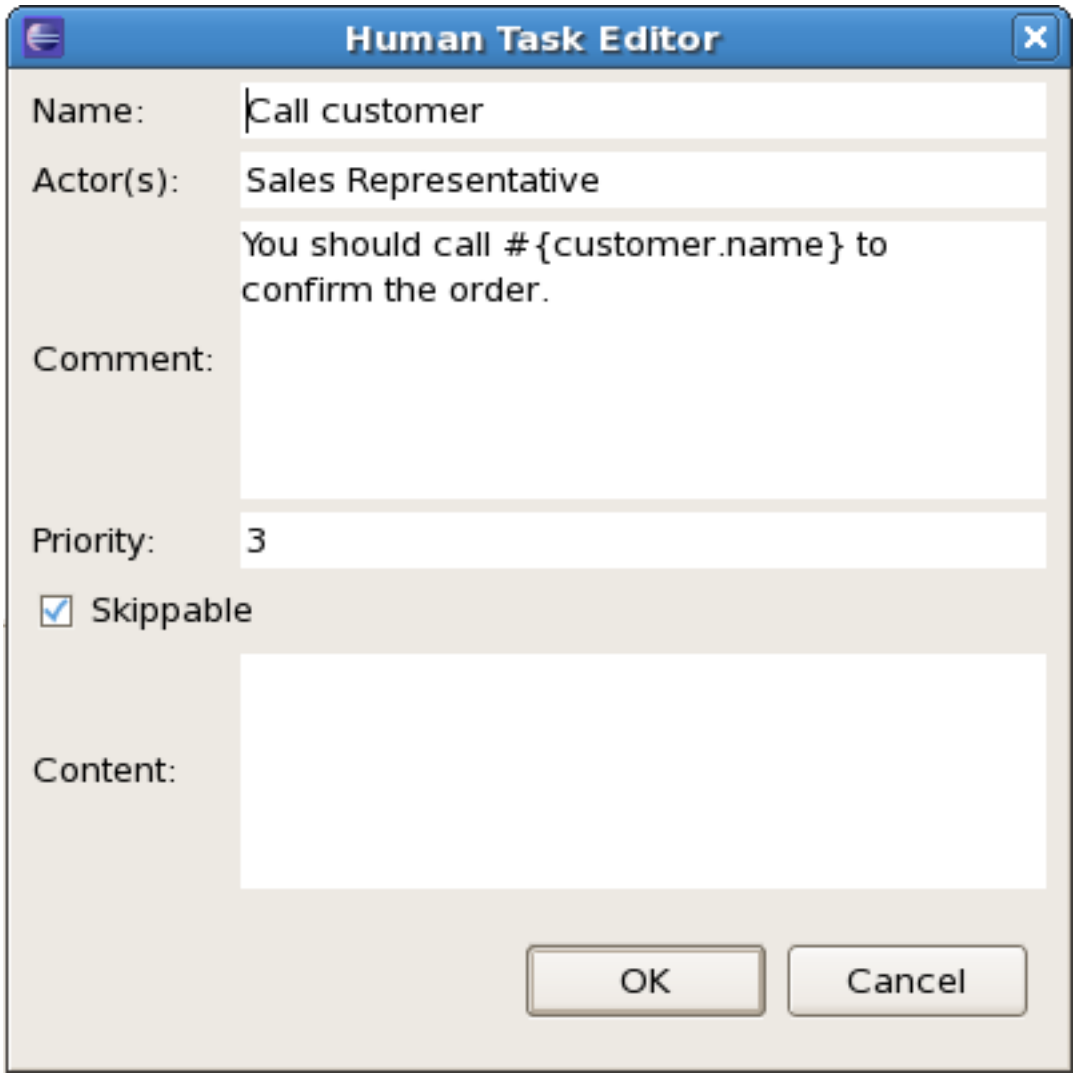
- *Id*: The id of the node (which is unique within one node container).
- *Name*: The display name of the node.
- *TaskName*: The name of the human task.
- *Priority*: An integer indicating the priority of the human task.
- *Comment*: A comment associated with the human task.
- *ActorId*: The actor id that is responsible for executing the human task. A list of actor id's can be specified using a comma (',') as separator.
- *Skippable*: Specifies whether the human task can be skipped (i.e. the actor decides not to execute the human task).

- *Content*: The data associated with this task.
- *Swimlane*: The swimlane this human task node is part of. Swimlanes make it easy to assign multiple human tasks to the same actor. See below for more detail on how to use swimlanes.
- *Wait for completion*: If this property is true, the human task node will only continue if the human task has been terminated (i.e. completed or any other terminal state); otherwise it will continue immediately after creating the human task.
- *On-entry and on-exit actions*: Actions that are executed upon entry and exit of this node.
- *Parameter mapping*: Allows copying the value of process variables to parameters of the human task. Upon creation of the human tasks, the values will be copied.
- *Result mapping*: Allows copying the value of result parameters of the human task to a process variable. Upon completion of the human task, the values will be copied. Note that can only use result mappings when "Wait for completion" is set to true. A human task has a result variable "Result" that contains the data returned by the human actor. The variable "ActorId" contains the id of the actor that actually executed the task.
- *Timers*: Timers that are linked to this node (see the 'timers' section for more details).
- *ParentId*: Allows to specify the parent task id, in the case that this task is a sub task of another. (see the 'sub task' section for more details)

You can edit these variables in the properties view (see below) when selecting the user task node, or the most important properties can also be edited by double-clicking the user task node, after which a custom user task node editor is opened, as shown below as well.

Properties

Property	Value
ActorId	Sales Representative
Comment	You should call #{customer.name} to confirm the order.
Content	
Id	4
Name	Human Task
On Entry Actions	
On Exit Actions	
Parameter Mapping	{}
Priority	3
Result Mapping	{}
Skippable	true
Swimlane	
TaskName	Call customer
Timers	
Wait for completion	true



Note that you could either specify the values of the different parameters (actorId, priority, content, etc.) directly (in which case they will be the same for each execution of this process), or make them context-specific, based on the data inside the process instance. For example, parameters of type String can use #{expression} to embed a value in the String. The value will be retrieved when creating the work item and the #{...} will be replaced by the toString() value of the variable. The expression could simply be the name of a variable (in which case it will be resolved to the value of the variable), but more advanced MVEL expressions are possible as well, like #{person.name.firstname}. For example, when sending an email, the body of the email could contain something like "Dear #{customer.name}, ...". For other types of variables, it is possible to map the value of a variable to a parameter using the parameter mapping.

12.1.1. Swimlanes

User task nodes can be used in combination with swimlanes to assign multiple human tasks to the similar actors. Tasks in the same swimlane will be assigned to the same actor. Whenever the first task in a swimlane is created, and that task has an actorId specified, that actorId will be assigned

to the swimlane as well. All other tasks that will be created in that swimlane will use that actorId as well, even if an actorId has been specified for the task as well.

Whenever a human task that is part of a swimlane is completed, the actorId of that swimlane is set to the actorId that executed that human task. This allows for example to assign a human task to a group of users, and to assign future tasks of that swimlame to the user that claimed the first task. This will also automatically change the assignment of tasks if at some point one of the tasks is reassigned to another user.

To add a human task to a swimlane, simply specify the name of the swimlane as the value of the "Swimlane" parameter of the user task node. A process must also define all the swimlanes that it contains. To do so, open the process properties by clicking on the background of the process and click on the "Swimlanes" property. You can add new swimlanes there.

12.2. Human task management component

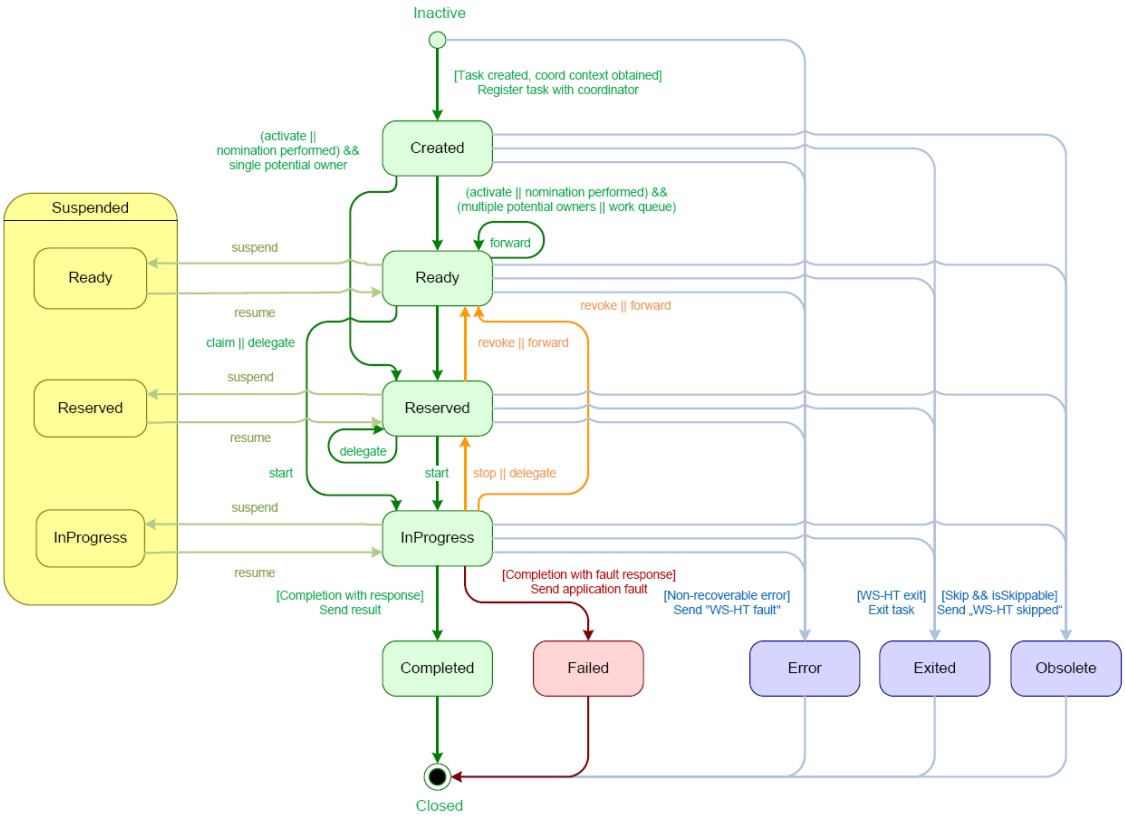
As far as the jBPM engine is concerned, human tasks are similar to any other external service that needs to be invoked and are implemented as an extension of normal work items. As a result, the process itself only contains an abstract description of the human tasks that need to be executed, and a work item handler is responsible for binding this abstract tasks to a specific implementation. Using our pluggable work item handler approach (see the chapter on domain-specific processes for more details), users can plug in any back-end implementation.

We do however provide an implementation of such a human task management component based on the WS-HumanTask specification. If you do not have the requirement to integrate a specific human task component yourself, you can use this service. It manages the task life cycle of the tasks (creation, claiming, completion, etc.) and stores the state of the task persistently. It also supports features like internationalization, calendar integration, different types of assignments, delegation, deadlines, etc.

Because we did not want to implement a custom solution when a standard is available, we chose to implement our service based on the WS-HumanTask (WS-HT) specification. This specification defines in detail the model of the tasks, the life cycle, and a lot of other features as the ones mentioned above. It is pretty comprehensive and can be found *here* [http://download.boulder.ibm.com/ibmdl/pub/software/dw/specs/ws-bpel4people/WS-HumanTask_v1.pdf].

12.2.1. Task life cycle

Looking from the perspective of the process, whenever a user task node is triggered during the execution of a process instance, a human task is created. The process will only continue from that point when that human task has been completed or aborted (unless of course you specify that the process does not need to wait for the human task to complete, by setting the "Wait for completion" property to true). However, the human task usually has a separate life cycle itself. We will now shortly introduce this life cycle, as shown in the figure below. For more details, check out the WS-HumanTask specification.



Whenever a task is created, it starts in the "Created" stage. It usually automatically transfers to the "Ready" state, at which point the task will show up on the task list of all the actors that are allowed to execute the task. There, it is waiting for one of these actors to claim the task, indicating that he or she will be executing the task. Once a user has claimed a task, the status is changed to "Reserved". Note that a task that only has one potential actor will automatically be assigned to that actor upon creation of that task. After claiming the task, that user can then at some point decide to start executing the task, in which case the task status is changed to "InProgress". Finally, once the task has been performed, the user must complete the task (and can specify the result data related to the task), in which case the status is changed to "Completed". If the task could not be completed, the user can also indicate this using a fault response (possibly with fault data associated), in which case the status is changed to "Failed".

The life cycle explained above is the normal life cycle. The service also allows a lot of other life cycle methods, like:

- Delegating or forwarding a task, in which case it is assigned to another actor
- Revoking a task, so it is no longer claimed by one specific actor but reappears on the task list of all potential actors
- Temporarly suspending and resuming a task
- Stopping a task in progress

- Skipping a task (if the task has been marked as skippable), in which case the task will not be executed

12.2.2. Linking the task component to the jBPM engine

The task management component needs to be integrated with the jBPM engine just like any other external service, by registering a work item handler that is responsible for translating the abstract work item (in this case a human task) to a specific invocation. We have implemented such a work item handler (org.jbpm.process.workitem.wsht.WSHumanTaskHandler in the jbpm-human-task module) so you can easily link this work item handler like this:

```
StatefulKnowledgeSession ksession = ...;
ksession.getWorkItemManager().registerWorkItemHandler("Human
 Task", new WSHumanTaskHandler());
```

By default, this handler will connect to the human task management component on the local machine on port 9123, but you can easily change that by invoking the setConnection(ipAddress, port) method on the WSHumanTaskHandler.

If you are using persistence for the session (check out the chapter on persistence for more information), you should use the org.jbpm.process.workitem.wsht.CommandBasedWSHumanTaskHandler as that makes sure that the state of the process instances is persisted correctly after interacting with the process engine.

The communication between the human task service and the process engine, or any task client, is done using messages being sent between the client and the server. The implementation allows different transport mechanisms being plugged in, but by default, Mina *(http://mina.apache.org/)* [http://mina.apache.org/] is used for client/server communication. An alternative implementation using HornetQ is also available.

A task client offers the following methods for managing the life cycle of human tasks:

```
public void start( long taskId, String userId, TaskOperationResponseHandler responseHandler )
public void stop( long taskId, String userId, TaskOperationResponseHandler responseHandler )
public void release( long taskId, String userId, TaskOperationResponseHandler responseHandler )
public void suspend( long taskId, String userId, TaskOperationResponseHandler responseHandler )
public void resume( long taskId, String userId, TaskOperationResponseHandler responseHandler )
public void skip( long taskId, String userId, TaskOperationResponseHandler responseHandler )
public void delegate( long taskId, String userId, String targetUserId,
                      TaskOperationResponseHandler responseHandler )
public void complete( long taskId, String userId, ContentData outputData,
                      TaskOperationResponseHandler responseHandler )
```

```
...
```

You can either use these methods directly, or probably use some kind of GUI that the end user will use to lookup and execute the tasks that are assigned to them. If you take a look a the method signatures you will notice that almost all of this method takes the following arguments:

- **taskId**: The id of the task that we are working with. This is usually extract from the currently selected task in the user task list in the user interface.
- **userId**: The id of the user that is executing the action. This is usually the id of the user that is logged in into the application.
- **responseHandler**: Communication with the task service is usually asynchronous, so you should use a response handler that will be notified when the results are available.

As you can imagine all the methods create a message that will be sent to the server, and the server will execute the logic that implements the correct action.

12.2.3. Starting the Task Management Component

The task management component is a completely independent service that the process engine communicates with. We therefore recommend to start it as a separate service as well. The installer contains a command to start the task server (in this case using Mina as transport protocol), or you can use the following code fragment:

```
EntityManagerFactory emf = Persistence.createEntityManagerFactory("org.jbpm.task");
TaskService taskService = new TaskService(emf, SystemEventListenerFactory.getSystemEventListener());
MinaTaskServer server = new MinaTaskServer( taskService );
Thread thread = new Thread( server );
thread.start();
```

The task management component uses the Java Persistence API (JPA) to store all task information in a persistent manner. To configure the persistence, you need to modify the persistence.xml configuration file accordingly. We refer to the JPA documentation on how to do that. The following fragment shows for example how to use the task management component with hibernate and an in-memory H2 database:

```
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<persistence
   version="1.0"
   xsi:schemaLocation=
    "http://java.sun.com/xml/ns/persistence
     http://java.sun.com/xml/ns/persistence/persistence_1_0.xsd
     http://java.sun.com/xml/ns/persistence/orm
```

```
    http://java.sun.com/xml/ns/persistence/orm_1_0.xsd"
  xmlns:orm="http://java.sun.com/xml/ns/persistence/orm"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xmlns="http://java.sun.com/xml/ns/persistence">

<persistence-unit name="org.jbpm.task">
  <provider>org.hibernate.ejb.HibernatePersistence</provider>
  <class>org.jbpm.task.Attachment</class>
  <class>org.jbpm.task.Content</class>
  <class>org.jbpm.task.BooleanExpression</class>
  <class>org.jbpm.task.Comment</class>
  <class>org.jbpm.task.Deadline</class>
  <class>org.jbpm.task.Comment</class>
  <class>org.jbpm.task.Deadline</class>
  <class>org.jbpm.task.Delegation</class>
  <class>org.jbpm.task.Escalation</class>
  <class>org.jbpm.task.Group</class>
  <class>org.jbpm.task.I18NText</class>
  <class>org.jbpm.task.Notification</class>
  <class>org.jbpm.task.EmailNotification</class>
  <class>org.jbpm.task.EmailNotificationHeader</class>
  <class>org.jbpm.task.PeopleAssignments</class>
  <class>org.jbpm.task.Reassignment</class>
  <class>org.jbpm.task.Status</class>
  <class>org.jbpm.task.Task</class>
  <class>org.jbpm.task.TaskData</class>
  <class>org.jbpm.task.SubTasksStrategy</class>
  <class>org.jbpm.task.OnParentAbortAllSubTasksEndStrategy</class>
  <class>org.jbpm.task.OnAllSubTasksEndParentEndStrategy</class>
  <class>org.jbpm.task.User</class>

  <properties>
    <property name="hibernate.dialect" value="org.hibernate.dialect.H2Dialect"/>
    <property name="hibernate.connection.driver_class" value="org.h2.Driver"/>
    <property name="hibernate.connection.url" value="jdbc:h2:mem:mydb" />
    <property name="hibernate.connection.username" value="sa"/>
    <property name="hibernate.connection.password" value="sasa"/>
    <property name="hibernate.connection.autocommit" value="false" />
    <property name="hibernate.max_fetch_depth" value="3"/>
    <property name="hibernate.hbm2ddl.auto" value="create" />
    <property name="hibernate.show_sql" value="true" />
  </properties>
</persistence-unit>
```

```
</persistence>
```

The first time you start the task management component, you need to make sure that all the necessary users and groups are added to the database. Our implementation requires all users and groups to be predefined before trying to assign a task to that user or group. So you need to make sure you add the necessary users and group to the database using the taskSession.addUser(user) and taskSession.addGroup(group) methods. Note that you at least need an "Administrator" user as all tasks are automatically assigned to this user as the administrator role.

The jbpm-human-task module contains a org.jbpm.task.RunTaskService class in the src/test/java source folder that can be used to start a task server. It automatically adds users and groups as defined in LoadUsers.mvel and LoadGroups.mvel configuration files.

12.2.4. Interacting With the Task Management Component

The task management component exposes various methods to manage the life cycle of the tasks through a Java API. This allows clients to integrate (at a low level) with the task management component. Note that end users should probably not interact with this low-level API directly but rather use one of the task list clients (see below). These clients interact with the task management component using this API. The following code sample shows how to create a task client and interact with the task service to create, start and complete a task.

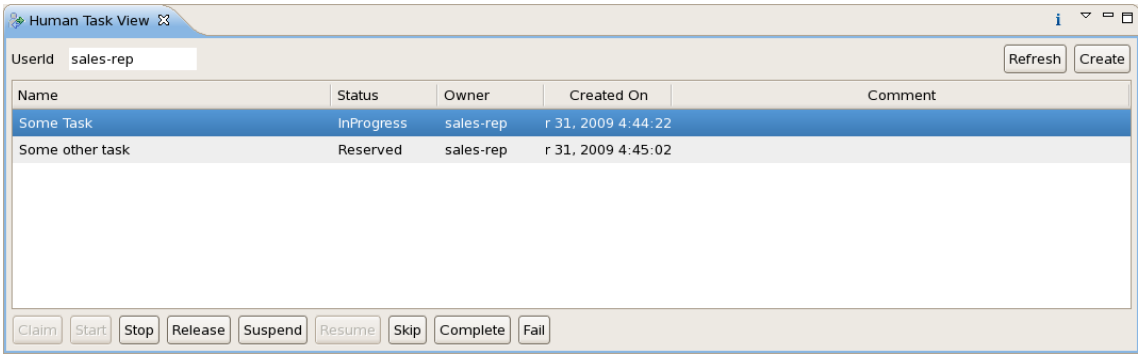
```
TaskClient client = new TaskClient(new MinaTaskClientConnector("client 1",
    new MinaTaskClientHandler(SystemEventListenerFactory.getSystemEventListener())));
client.connect("127.0.0.1", 9123);

// adding a task
BlockingAddTaskResponseHandler addTaskResponseHandler = new BlockingAddTaskResponseHandler();
Task task = ...;
client.addTask( task, null, addTaskResponseHandler );
long taskId = addTaskResponseHandler.getTaskId();

// getting tasks for user "bobba"
BlockingTaskSummaryResponseHandler taskSummaryResponseHandler =
    new BlockingTaskSummaryResponseHandler();
client.getTasksAssignedAsPotentialOwner("bobba", "en-UK", taskSummaryResponseHandler);
List<TaskSummary> tasks = taskSummaryResponseHandler.getResults();

// starting a task
BlockingTaskOperationResponseHandler responseHandler =
    new BlockingTaskOperationResponseHandler();
client.start( taskId, "bobba", responseHandler );

// completing a task
```

```
responseHandler = new BlockingTaskOperationResponseHandler();
client.complete( taskId, users.get( "bobba" ).getId(), null, responseHandler );
```

12.3. Human Task Management Interface

12.3.1. Eclipse integration

The Drools IDE contains a org.drools.eclipse.task plugin that allows you to test and/or debug processes using human tasks. In contains a Human Task View that can connect to a running task management component, request the relevant tasks for a particular user (i.e. the tasks where the user is either a potential owner or the tasks that the user already claimed and is executing). The life cycle of these tasks can then be executed, i.e. claiming or releasing a task, starting or stopping the execution of a task, completing a task, etc. A screenshot of this Human Task View is shown below. You can configure which task management component to connect to in the Drools Task preference page (select Window -> Preferences and select Drools Task). Here you can specify the url and port (default = 127.0.0.1:9123).



12.3.2. Web-based Task View

The jBPM console also contains a task view for looking up task lists and managing the life cycle of tasks. See the chapter on the jBPM console for more information.

Chapter 13. Domain-specific processes

13.1. Introduction

One of the goals of jBPM is to allow users to extend the default process constructs with domain-specific extensions that simplify development in a particular application domain. This tutorial describes how to take your first steps towards domain-specific processes. Note that you don't need to be a jBPM expert to define your own domain-specific nodes, this should be considered integration code that a normal developer with some experience in jBPM can do himself.

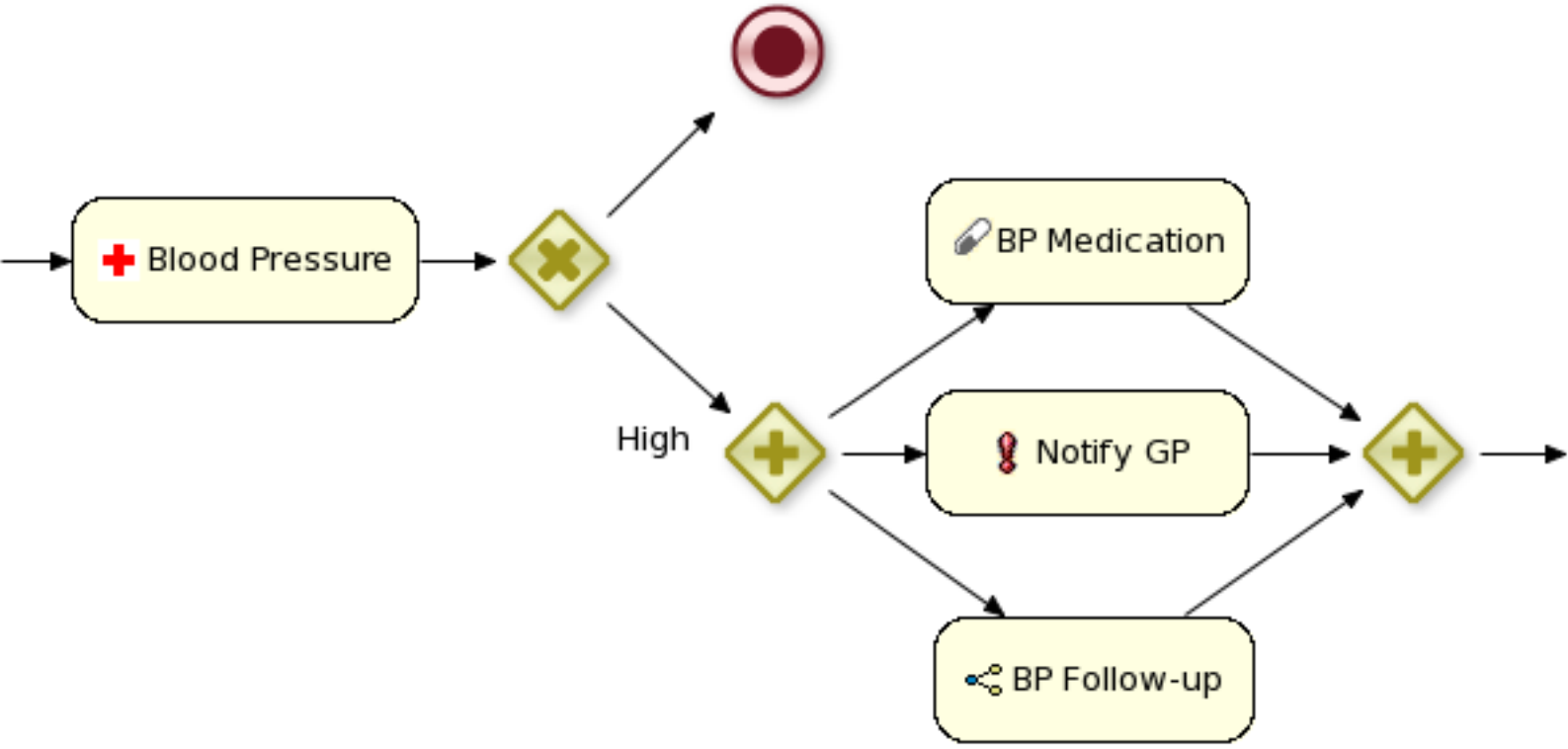
Most process languages offer some generic action (node) construct that allows plugging in custum user actions. However, these actions are usually low-level, where the user is required to write custom code to implement the work that should be incorporated in the process. The code is also closely linked to a specific target environment, making it difficult to reuse the process in different contexts.

Domain-specific languages are targeted to one particular application domain and therefore can offer constructs that are closely related to the problem the user is trying to solve. This makes the processes and easier to understand and self-documenting. We will show you how to define domain-specific work items (also called service nodes), which represent atomic units of work that need to be executed. These service nodes specify the work that should be executed in the context of a process in a declarative manner, i.e. specifying what should be executed (and not how) on a higher level (no code) and hiding implementation details.

So we want service nodes that are:

1. domain-specific
2. declarative (what, not how)
3. high-level (no code)
4. customizable to the context

Users can easily define their own set of domain-specific service nodes and integrate them in our process language. For example, the next figure shows an example of a process in a healthcare context. The process includes domain-specific service nodes for ordering nursing tasks (e.g. measuring blood pressure), prescribing medication and notifying care providers.



13.2. Example: Notifications

Let's start by showing you how to include a simple work item for sending notifications. A work item represent an atomic unit of work in a declarative way. It is defined by a unique name and additional parameters that can be used to describe the work in more detail. Work items can also return information after they have been executed, specified as results. Our notification work item could thus be defined using a work definition with four parameters and no results:

```
Name: "Notification"
Parameters
From [String]
To [String]
Message [String]
Priority [String]
```

13.2.1. Creating the work definition

All work definitions must be specified in one or more configuration files in the project classpath, where all the properties are specified as name-value pairs. Parameters and results are maps where each parameter name is also mapped to the expected data type. Note that this configuration

file also includes some additional user interface information, like the icon and the display name of the work item.

In our example we will use MVEL for reading in the configuration file, which allows us to do more advanced configuration files. This file must be placed in the project classpath in a directory called META-INF. Our MyWorkDefinitions.wid file looks like this:

```
import org.drools.process.core.datatype.impl.type.StringDataType;
[
  // the Notification work item
  [
    "name" : "Notification",
    "parameters" : [
      "Message" : new StringDataType(),
      "From" : new StringDataType(),
      "To" : new StringDataType(),
      "Priority" : new StringDataType(),
    ],
    "displayName" : "Notification",
    "icon" : "icons/notification.gif"
  ]

]
```

The project directory structure could then look something like this:

```
project/src/main/resources/META-INF/MyWorkDefinitions.wid
```

You might now want to create your own icons to go along with your new work definition. To add these you will need .gif or .png images with a pixel size of 16x16. Place them in a directory outside of the META-INF directory, for example as follows:

```
project/src/main/resources/icons/notification.gif
```

13.2.2. Registering the work definition

The configuration API can be used to register work definition files for your project using the drools.workDefinitions property, which represents a list of files containing work definitions

(separated usings spaces). For example, include a drools.rulebase.conf file in the META-INF directory of your project and add the following line:

```
drools.workDefinitions = MyWorkDefinitions.wid
```

This will replace the default domain specific node types EMAIL and LOG with the newly defined NOTIFICATION node in the process editor. Should you wish to just add a newly created node definition to the existing palette nodes, adjust the drools.workDefinitions property as follows including the default set configuration file:

```
drools.workDefinitions = MyWorkDefinitions.conf WorkDefinitions.conf
```

13.2.3. Using your new work item in your processes

Once our work definition has been created and registered, we can start using it in our processes. The process editor contains a separate section in the palette where the different service nodes that have been defined for the project appear.

Using drag and drop, a notification node can be created inside your process. The properties can be filled in using the properties view.

Apart from the properties defined by for this work item, all work items also have these three properties:

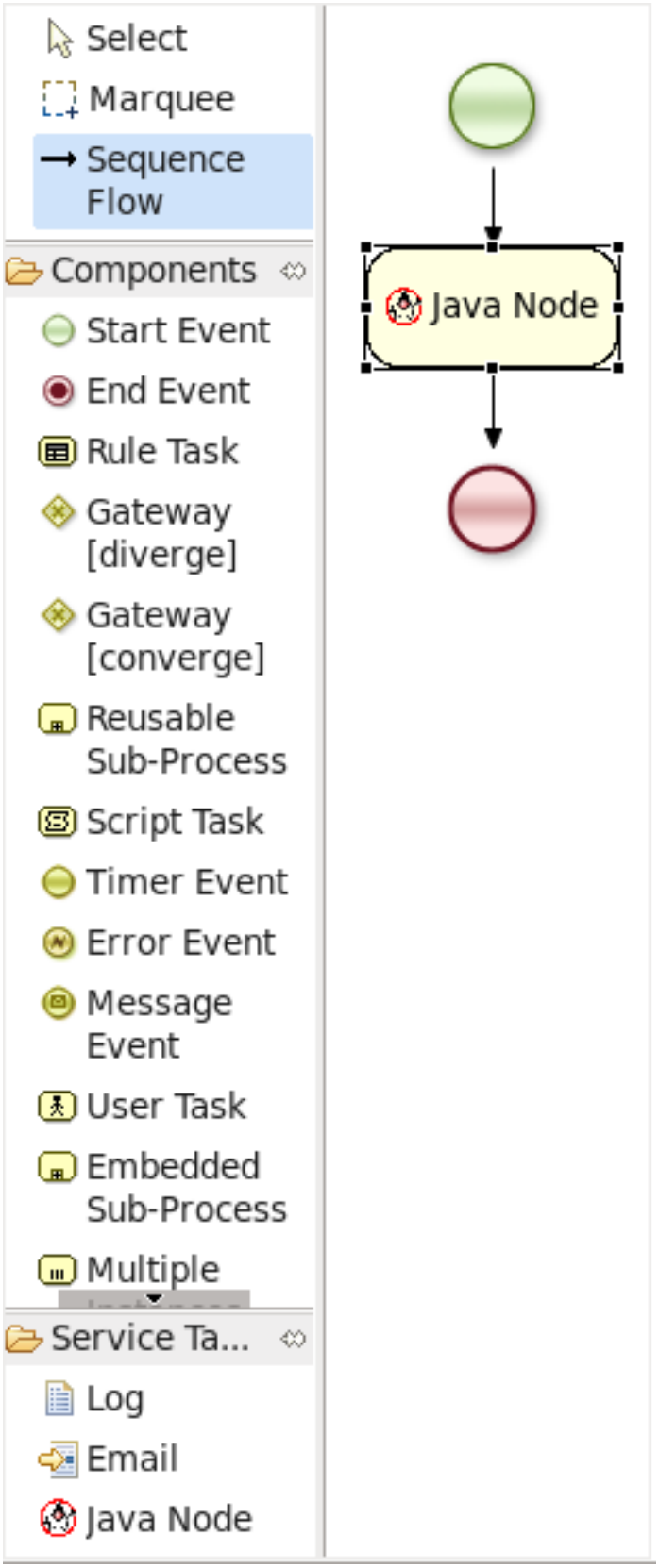
1. Parameter Mapping: Allows you map the value of a variable in the process to a parameter of the work item. This allows you to customize the work item based on the current state of the actual process instance (for example, the priority of the notification could be dependent of some process-specific information).
2. Result Mapping: Allows you to map a result (returned once a work item has been executed) to a variable of the process. This allows you to use results in the remainder of the process.

3. Wait for completion: By default, the process waits until the requested work item has been completed before continuing with the process. It is also possible to continue immediately after the work item has been requested (and not waiting for the results) by setting "wait for completion" to false.

Here is an example that creates a domain specific node to execute Java, asking for the class and method parameters. It includes a custom java.gif icon and consists of the following files and resulting screenshot:

```
import org.drools.process.core.datatype.impl.type.StringDataType;
[
  // the Java Node work item located in:
  // project/src/main/resources/META-INF/JavaNodeDefinition.conf
  [
    "name" : "JavaNode",
    "parameters" : [
      "class" : new StringDataType(),
      "method" : new StringDataType(),
    ],
    "displayName" : "Java Node",
    "icon" : "icons/java.gif"
  ]

]
```

```
// located in: project/src/main/resources/META-INF/drools.rulebase.conf
//
  drools.workDefinitions = JavaNodeDefinition.conf WorkDefinitions.conf

// icon for java.gif located in:
// project/src/main/resources/icons/java.gif
```


Select
Marquee
Sequence Flow
Components
Start Event
End Event
Rule Task
Gateway [diverge]
Gateway [converge]
Reusable Sub-Process
Script Task
Timer Event
Error Event
Message Event
User Task
Embedded Sub-Process
Multiple
Service Ta...
Log
Email
Java Node
Java Node

13.2.4. Executing service nodes

The jBPM engine contains a WorkItemManager that is responsible for executing work items whenever necessary. The WorkItemManager is responsible for delegating the work items to WorkItemHandlers that execute the work item and notify the WorkItemManager when the work item has been completed. For executing notification work items, a NotificationWorkItemHandler should be created (implementing the WorkItemHandler interface):

```
package com.sample;

import org.drools.runtime.process.WorkItem;
import org.drools.runtime.process.WorkItemHandler;
import org.drools.runtime.process.WorkItemManager;

public class NotificationWorkItemHandler implements WorkItemHandler {

  public void executeWorkItem(WorkItem workItem, WorkItemManager manager) {
    // extract parameters
    String from = (String) workItem.getParameter("From");
    String to = (String) workItem.getParameter("To");
    String message = (String) workItem.getParameter("Message");
    String priority = (String) workItem.getParameter("Priority");
    // send email
    EmailService service = ServiceRegistry.getInstance().getEmailService();
    service.sendEmail(from, to, "Notification", message);
    // notify manager that work item has been completed
    manager.completeWorkItem(workItem.getId(), null);
  }

  public void abortWorkItem(WorkItem workItem, WorkItemManager manager) {
    // Do nothing, notifications cannot be aborted
  }

}
```

This WorkItemHandler sends a notification as an email and then immediate notifies the WorkItemManager that the work item has been completed. Note that not all work items can be completed directly. In cases where executing a work item takes some time, execution can continue asynchronously and the work item manager can be notified later. In these situations, it might also be possible that a work item is being aborted before it has been completed. The abort method can be used to specify how to abort such work items.

WorkItemHandlers should be registered at the WorkItemManager, using the following API:

```
ksession.getWorkItemManager().registerWorkItemHandler(
    "Notification", new NotificationWorkItemHandler());
```

Decoupling the execution of work items from the process itself has the following advantages:

1. The process is more declarative, specifying what should be executed, not how.
2. Changes to the environment can be implemented by adapting the work item handler. The process itself should not be changed. It is also possible to use the same process in different environments, where the work item handler is responsible for integrating with the right services.
3. It is easy to share work item handlers across processes and projects (which would be more difficult if the code would be embedded in the process itself).
4. Different work item handlers could be used depending on the context. For example, during testing or simulation, it might not be necessary to actually execute the work items. In this case specialized dummy work item handlers could be used during testing.

Chapter 14. Testing and debugging

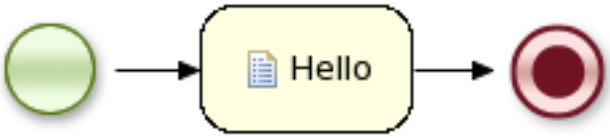
Even though business processes aren't code (we even recommend you to make them as high-level as possible and to avoid adding implementation details), they also have a life cycle like other development artefacts. And since business processes can be updated dynamically, testing them (so that you don't break any use cases when doing a modification) is really important as well.

14.1. Unit testing

When unit testing your process, you test whether the process behaves as expected in specific use cases, for example test the output based on the existing input. To simplify unit testing, jBPM includes a helper class called JbpmJUnitTestCase (in the jbpm-bpmn2 test module) that you can use to greatly simplify your junit testing, by offering:

- helper methods to create a new knowledge base and session for a given (set of) process(es)
  - you can select whether you want to use persistence or not
- assert statements to check
  - the state of a process instance (active, completed, aborted)
  - which node instances are currently active
  - which nodes have been triggered (to check the path that has been followed)
  - get the value of variables
  - etc.

For example, conside the following hello world process containing a start event, a script task and an end event. The following junit test will create a new session, start the process and then verify whether the process instance completed successfully and whether these three nodes have been executed.




```
public class MyProcessTest extends JbpmJUnitTestCase {

  public void testProcess() {
    // create your session and load the given process(es)
    StatefulKnowledgeSession ksession = createKnowledgeSession("sample.bpmn");
```

```
        // start the process
        ProcessInstance processInstance = ksession.startProcess("com.sample.bpmn.hello");
        // check whether the process instance has completed successfully
        assertProcessInstanceCompleted(processInstance.getId(), ksession);
        // check whether the given nodes were executed during the process execution
        assertNodeTriggered(processInstance.getId(), "StartProcess", "Hello", "EndProcess");
    }
}
```

14.1.1. Helper methods to create your session

Several methods are provided to simplify the creation of a knowledge base and a session to interact with the engine.

- *createKnowledgeBase(String... process)*: Returns a new knowledge base containing all the processes in the given filenames (loaded from classpath)
- *createKnowledgeBase(Map<String, ResourceType> resources)* :Returns a new knowledge base containing all the resources (not limited to processes but possibly also including other resource types like rules, decision tables, etc.) from the given filenames (loaded from classpath)
- *createKnowledgeBaseGuvnor(String... packages)*: Returns a new knowledge base containing all the processes loaded from Guvnor (the process repository) from the given packages
- *createKnowledgeSession(KnowledgeBase kbase)*: Creates a new statefull knowledge session from the given knowledge base
- *restoreSession(StatefulKnowledgeSession ksession, boolean noCache)* : completely restores this session from database, can be used to recreate a session to simulate a critical failure and to test recovery, if noCache is true, the existing persistence cache will not be used to restore the data

14.1.2. Assertions

The following assertions are added to simplify testing the current state of a process instance:

- *assertProcessInstanceActive(long processInstanceId, StatefulKnowledgeSession ksession)*: check whether the process instance with the given id is still active
- *assertProcessInstanceCompleted(long processInstanceId, StatefulKnowledgeSession ksession)*: check whether the process instance with the given id has completed successfully
- *assertProcessInstanceAborted(long processInstanceId, StatefulKnowledgeSession ksession)*: check whether the process instance with the given id was aborted

- *assertNodeActive(long processInstanceId, StatefulKnowledgeSession ksession, String... name)*: check whether the process instance with the given id contains at least one active node with the given node name (for each of the given names)

- *assertNodeTriggered(long processInstanceId, String... nodeNames)* : check for each given node name whether a node instance was triggered (but not necessarily active anymore) during the execution of the process instance with the given

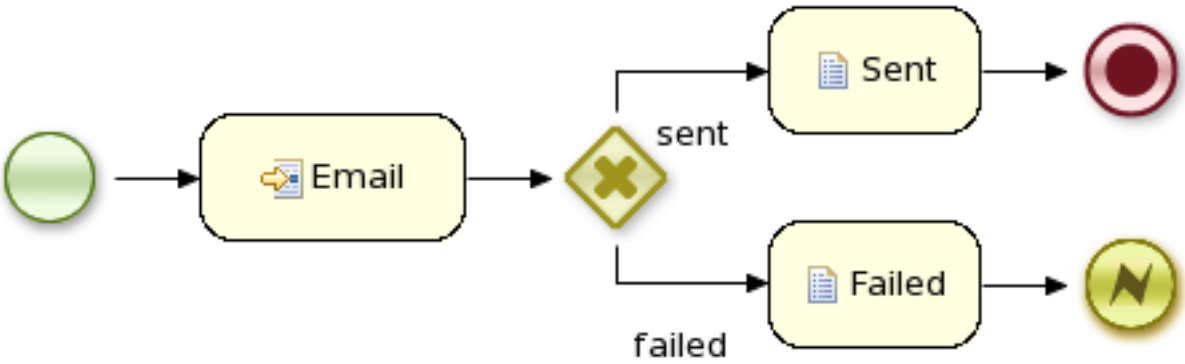
- *getVariableValue(String name, long processInstanceId, StatefulKnowledgeSession ksession)*: retrieves the value of the variable with the given name from the given process instance, can then be used to check the value of process variables

14.1.3. Testing integration with external services

Real-life business processes typically include the invocation of external services (like for example a human task service, an email server or your own domain-specific services). One of the advantages of our domain-specific process approach is that you can specify yourself how to actually execute your own domain-specific nodes, by registering a handler. And this handler can be different depending on your context, allowing you to use testing handlers for unit testing your process. When you are unit testing your business process, you can register test handlers that then verify whether specific services are requested correctly, and provide test responses for those services. For example, imagine you have an email node or a human task as part of your process. When unit testing, you don't want to send out an actual email but rather test whether the email that is requested contains the correct information (for example the right to email, a personalized body, etc.).

A TestWorkItemHandler is provided by default that can be registered to collect all work items (a work item represents one unit of work, like for example sending one specific email or invoking one specific service and contains all the data related to that task) for a given type. This test handler can then be queried during unit testing to check whether specific work was actually requested during the execution of the process and that the data associcated with the work was correct.

The following example describes how a process that sends out an email could be tested. This test case in particular will test whether an exception is raised when the email could not be sent (which is simulated by notifying the engine that the sending the email could not be completed). The test case uses a test handler that simply registers when an email was requested (and allows you to test the data related to the email like from, to, etc.). Once the engine has been notified the email could not be sent (using abortWorkItem(..)), the unit test verifies that the process handles this case successfully by logging this and generating an error, which aborts the process instance in this case.




```
public void testProcess2() {
    // create your session and load the given process(es)
    StatefulKnowledgeSession ksession = createKnowledgeSession("sample2.bpmn");
    // register a test handler for "Email"
    TestWorkItemHandler testHandler = new TestWorkItemHandler();
    ksession.getWorkItemManager().registerWorkItemHandler("Email", testHandler);
    // start the process
    ProcessInstance processInstance = ksession.startProcess("com.sample.bpmn.hello2");
    assertProcessInstanceActive(processInstance.getId(), ksession);
    assertNodeTriggered(processInstance.getId(), "StartProcess", "Email");
    // check whether the email has been requested
    WorkItem workItem = testHandler.getWorkItem();
    assertNotNull(workItem);
    assertEquals("Email", workItem.getName());
    assertEquals("me@mail.com", workItem.getParameter("From"));
    assertEquals("you@mail.com", workItem.getParameter("To"));
    // notify the engine the email has been sent
    ksession.getWorkItemManager().abortWorkItem(workItem.getId());
    assertProcessInstanceAborted(processInstance.getId(), ksession);
    assertNodeTriggered(processInstance.getId(), "Gateway", "Failed", "Error");
}
```

14.1.4. Configuring persistence

You can configure whether you want to execute the junit tests using persistence or not. By default, the junit tests will use persistence, meaning that the state of all process instances will be stored in a (in-memory H2) database (which is started by the junit test during setup) and a history log will be used to check assertions related to execution history. When persistence is not used, process instances will only live in memory and an in-memory logger is used for history assertions.

By default, persistence is turned on. To turn off persistence, simply pass a boolean to the super constructor when creating your test case, as shown below:

```
public class MyProcessTest extends JbpmJUnitTestCase {

  public MyProcessTest() {
    // configure this tests to not use persistence in this case
    super(false);
  }

  ...
```

14.2. Debugging

This section describes how to debug processes using the Eclipse plugin. This means that the current state of your running processes can be inspected and visualized during the execution. Note that we currently don't allow you to put breakpoints on the nodes within a process directly. You can however put breakpoints inside any Java code you might have (i.e. your application code that is invoking the engine or invoked by the engine, listeners, etc.) or inside rules (that could be evaluated in the context of a process). At these breakpoints, you can then inspect the internal state of all your process instances.

When debugging the application, you can use the following debug views to track the execution of the process:

1. The process instances view, showing all running process instances (and their state). When double-clicking a process instance, the process instance view visually shows the current state of that process instance at that point in time.

2. The human task view, showing the task list of the given user (fill in the user id of the actor and click refresh to view all the tasks for the given actor), where you can then control the life cycle of the task, for example start and complete it.

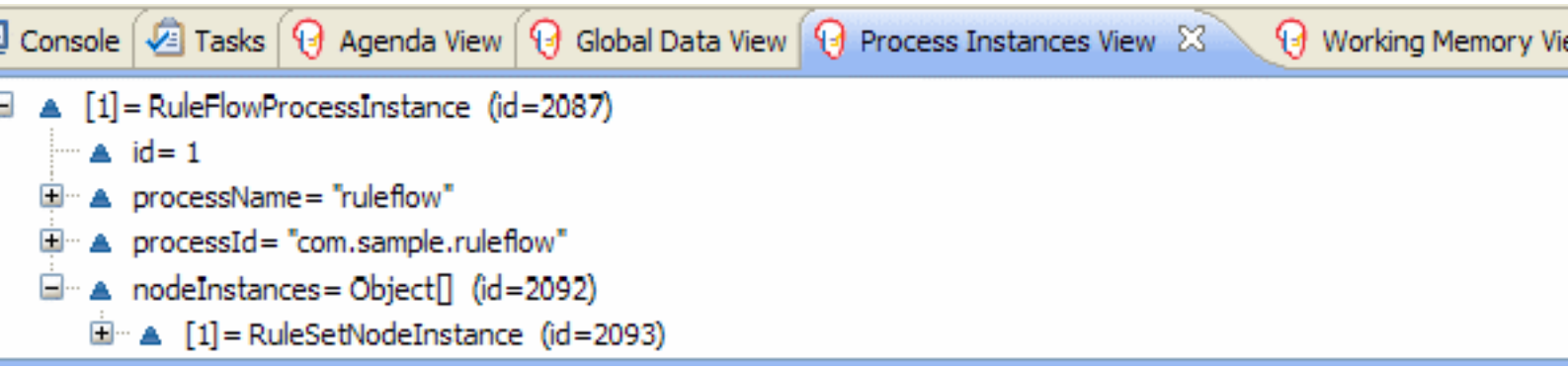
3. The audit view, showing the audit log (note that you should probably use a threaded file logger if you want to session to save the audit event to the file system on regular intervals, so the audit view can be update to show the latest state).

4. The global data view, showing the globals.

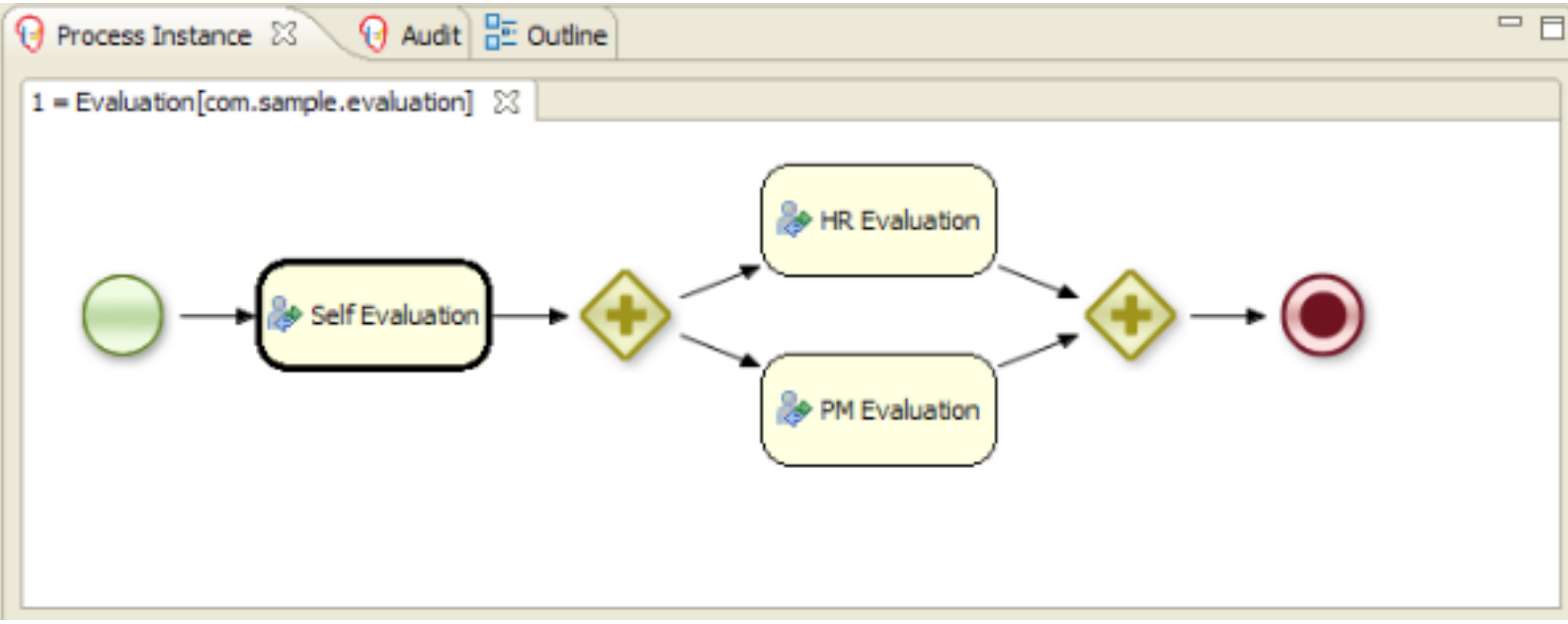
5. Other views related to rule execution like the working memory view (showing the contents (data) in the working memory related to rule execution), the agenda view (showing all activated rules), etc.

14.2.1. The Process Instances View

The process instances view shows the currently running process instances. The example shows that there is currently one running process (instance), currently executing one node instance, i.e. business rule task. When double-clicking a process instance, the process instance viewer will graphically show the progress of the process instance. An example where the process instance is waiting for a human actor to perform a self-evaluation task is shown below.



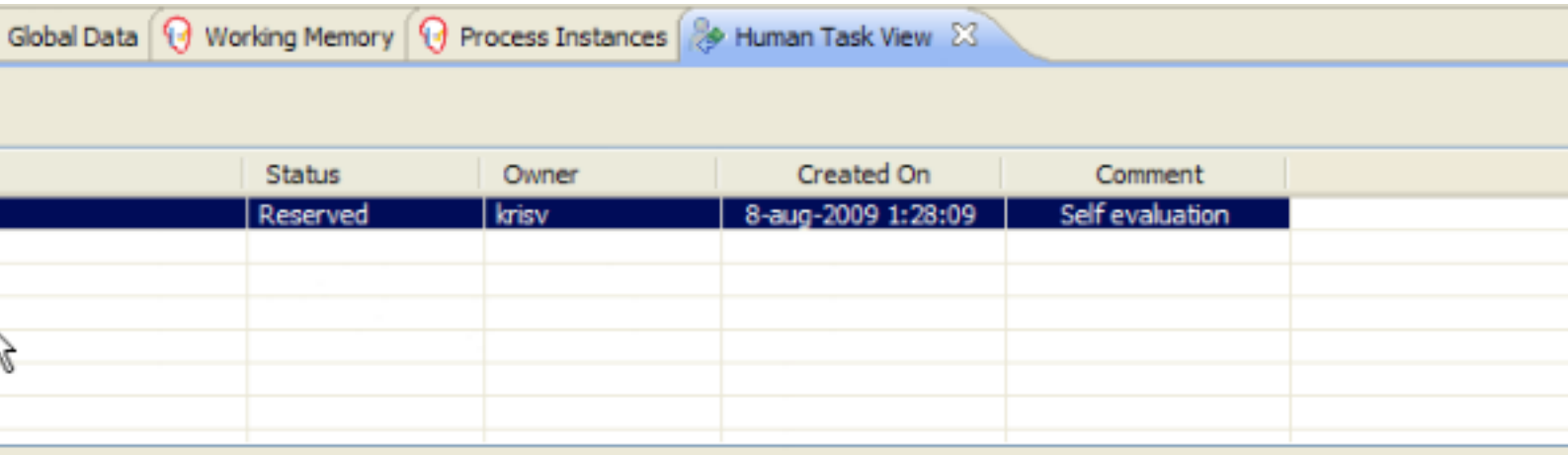
When you double-click a process instance in the process instances view and the process instance view complains that it cannot find the process, this means that the plugin wasn't able to find the process definition of the selected process instance in the cache of parsed process definitions. To solve this, simply change the process definition in question and save again (so it will be parsed) or rebuild the project that contains the process definition in question.



14.2.2. The Human Task View

The Human Task View can connect to a running human task service and request the relevant tasks for a particular user (i.e. the tasks where the user is either a potential owner or the tasks that the user already claimed and is executing). The life cycle of these tasks can then be executed, i.e. claiming or releasing a task, starting or stopping the execution of a task, completing a task, etc.

A screenshot of this Human Task View is shown below. You can configure which task service to connect to in the Drools Task preference page (select Window -> Preferences and select Drools Task). Here you can specify the url and port (default = 127.0.0.1:9123).

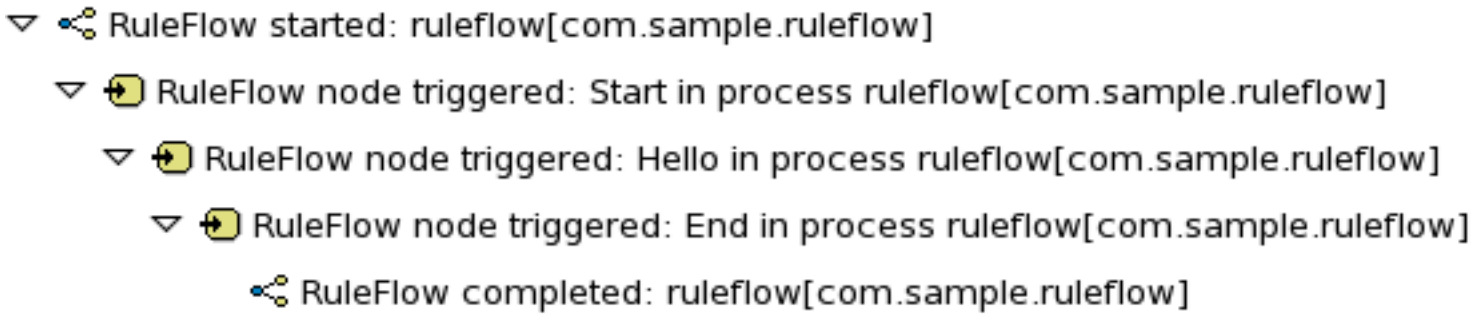


14.2.3. The Audit View

The audit view, showing the audit log, which is a log of all events that were logged from the session. To create a logger, use the KnowledgeRuntimeLoggerFactory to create a new logger and attach it to a session. Note that you should probably use a threaded file logger if you want to session to save the audit event to the file system on regular intervals, so the audit view can be update to show the latest state. When creating a threaded file logger, you can specify the name of the file where the audit log should be created and the interval after which event should be saved to the file (in milliseconds). Be sure to close the logger after usage.

```
KnowledgeRuntimeLogger logger = KnowledgeRuntimeLoggerFactory
  .newThreadedFileLogger(ksession, "logdir/mylogfile", 1000);
// do something with the session here
logger.close();
```

To open up an audit tree in the audit view, open the selected log file in the audit view or simply drag the file into the audit view. A tree-based view is generated based on the audit log. An event is shown as a subnode of another event if the child event is caused by (a direct consequence of) the parent event. An example is shown below.


RuleFlow started: ruleflow[com.sample.ruleflow]
RuleFlow node triggered: Start in process ruleflow[com.sample.ruleflow]
RuleFlow node triggered: Hello in process ruleflow[com.sample.ruleflow]
RuleFlow node triggered: End in process ruleflow[com.sample.ruleflow]
RuleFlow completed: ruleflow[com.sample.ruleflow]

Chapter 15. Process Repository

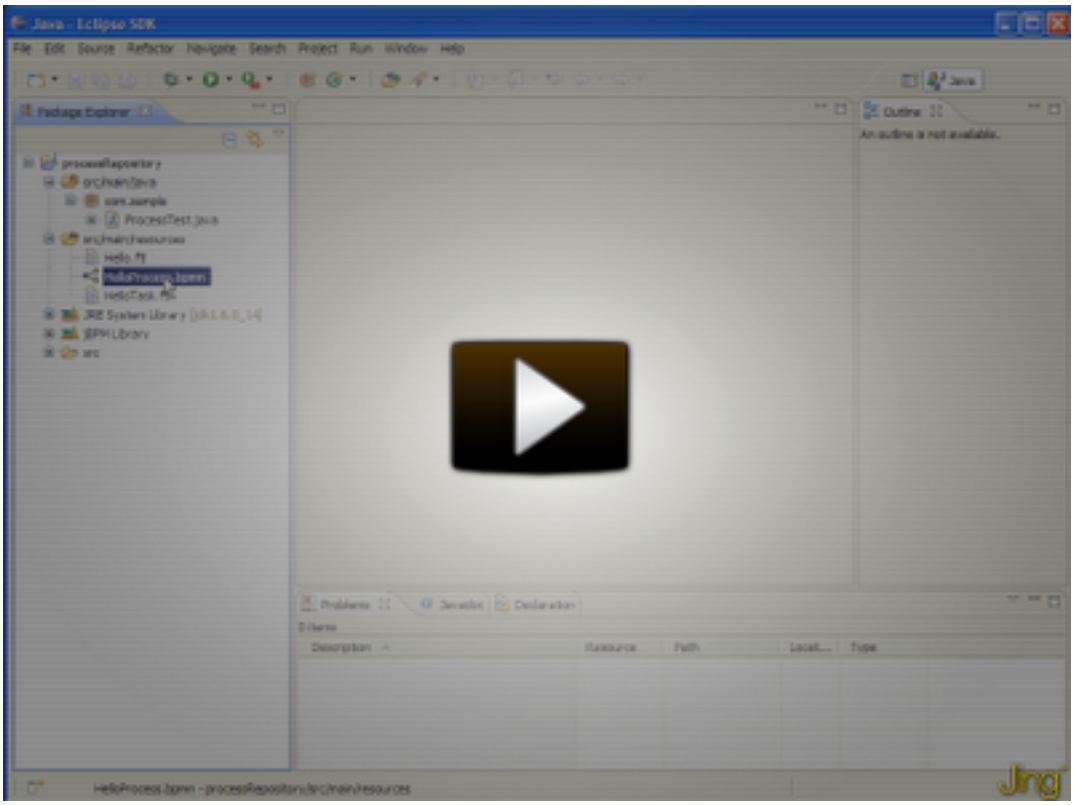
A process repository is an important part of your BPM architecture if you start using more and more business processes in your applications and especially if you want to have the ability to dynamically update them. The process repository is the location where you store and manage your business processes. Because they are not deployed as part of your application, they have their own life cycle, meaning you can update your business processes dynamically, without having to change the application code.

Note that a process repository is a lot more than simply a database to store your process definitions. It almost acts as a combination of a source code management system, content management system, collaboration suite and development and testing environment. These are the kind of features you can expect from a process repository:

- Persistent storage of your processes so the latest version can always easily be accessed from anywhere, including versioning
- Build and deploy selected processes
- User-friendly (web-based) interface to manage, update and deploy your processes (targeted to business users, not just developers)
- Authentication / authorization to make sure only people that have the right role can see and/or edit your processes
- Categorization and searching
- Scenario testing to make sure you don't break anything when you change your process
- Collaboration and other social features like comments, notifications on change, etc.
- Synchronization with your development environment

Actually, it would be better to talk about a knowledge repository, as the repository will not only store your process definitions, but possibly also other related artefacts like task forms, your domain model, associated business rules, etc. Luckily, we don't have to reinvent the wheel for this, as the Guvnor project acts as a generic knowledge repository to store any type of artefacts and already supports most of these features.

The following screencast shows how you can upload your process definition to Guvnor, along with the process form (that is used when you try to start a new instance of that process to collect the necessary data), task forms (for the human tasks inside the process), and the process image (that can be annotated to show runtime progress). The jbpm-console is configured to get all this information from Guvnor whenever necessary and show them in the console.



[http://people.redhat.com/kverlaen/jBPM5-guvnor-integration.swf]

Figure 15.1.

If you use the installer, that should automatically download and install the latest version of Guvnor as well. So simply deploy your assets (for example using the Guvnor Eclipse integration as shown in the screencast, also automatically installed) to Guvnor (taking some naming conventions into account, as explained below), build the package and start up the console.

The current integration with the jbpm-console uses the following naming conventions to find the artefacts it needs (though we hope to update this to something more flexible in the near future):

- All artefacts should be deployed to the "defaultPackage" on Guvnor (as that is where the jbpm-console will be looking)
- A process should define "defaultPackage" as the package name (otherwise you won't be able to build your package on Guvnor)
- Don't forget to build the package on Guvnor before opening the console, as Guvnor will only publish the latest version of your processes once you build the package
- Currently, the console will load the process definitions the first time the list of processes is requested in the console. At this point, automatic updating from guvnor when the package is rebuilt is turned off by default, so you will have to either configure this or restart the application server to get the latest versions.

- Task forms that should be associated with a specific process definition should have the name "{processDefinitionId}.ftl"
- Task forms for a specific human task should have the name "{taskName}.ftl"
- The process diagram for a specific process should have the name "{processDefinitionId}-image.png"

If you follow these rules, your processes, forms and images should show up without any issues in the jbpm-console.

Chapter 16. Business Activity Monitoring

You need to actively monitor your processes to make sure you can detect any anomalies and react to unexpected events as soon as possible. Business Activity Monitoring (BAM) is concerned with real-time monitoring of your processes and the option of intervening directly, possibly even automatically, based on the analysis of these events.

jBPM allows users to define reports based on the events generated by the process engine, and possibly direct intervention in specific situations using complex event processing rules (Drools Fusion), as described in the next two sections. Future releases of the jBPM platform will include support for all requirements of Business Activity Monitoring, including a web-based application that can be used to more easily interact with a running process engine, inspect its state, generate reports, etc.

16.1. Reporting

By adding a history logger to the process engine, all relevent events are stored in the database. This history log can be used to monitor and analyze the execution of your processes. We are using the Eclipse BIRT (Business Intelligence Reporting Tool) to create reports that show the key performance indicators. Its easy to define your own reports yourself, using the predefined data sets containing all process history information, and any other data sources you might want to add yourself.

The Eclipse BIRT framework allows you to define data sets, create reports, include charts, preview your reports, and export them on web pages. (Consult the Eclipse BIRT documentation on how to define your own reports.) The following screen shot shows a sample on how to create such a chart.

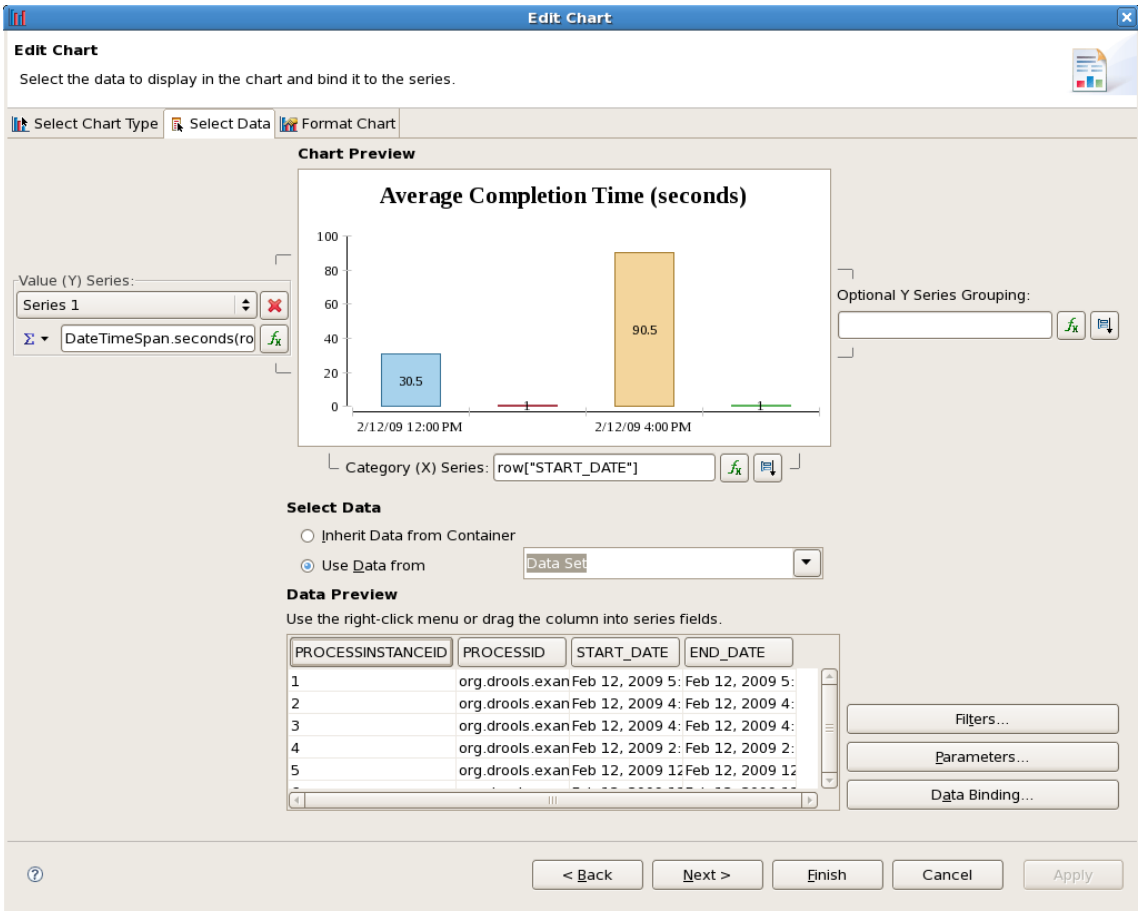


Figure 16.1. Creating a report using Eclipse BIRT

The next figure displays a simple report based on some history data, showing the number of requests per hour and the average completion time of the request during that hour. These charts could be used to check for an unexpected drop or rise of requests, an increase in the average processing time, etc. These charts could signal possible problems before the situation really gets out of hand.

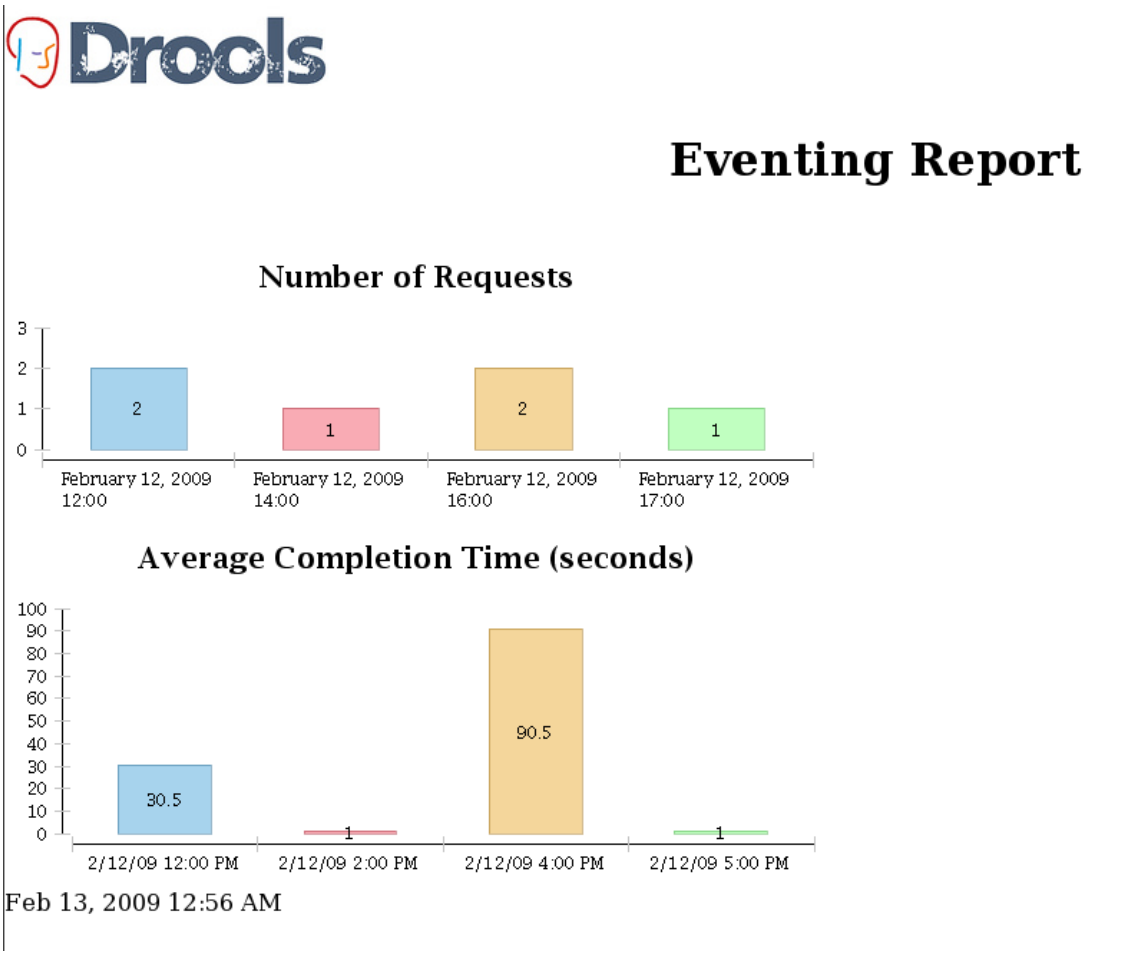


Figure 16.2. The eventing report

16.2. Direct Intervention

Reports can be used to visualize an overview of the current state of your processes, but they rely on a human actor to take action based on the information in these charts. However, we allow users to define automatic responses to specific circumstances.

Drools Fusion provides numerous features that make it easy to process large sets of events. This can be used to monitor the process engine itself. This can be achieved by adding a listener to the engine that forwards all related process events, such as the start and completion of a process instance, or the triggering of a specific node, to a session responsible for processing these events. This could be the same session as the one executing the processes, or an independent session as well. Complex Event Processing (CEP) rules could then be used to specify how to process these events. For example, these rules could generate higher-level business events based on a specific occurrence of low-level process events. The rules could also specify how to respond to specific situations.

The next section shows a sample rule that accumulates all start process events for one specific order process over the last hour, using the "sliding window" support. This rule prints out an error

message if more than 1000 process instances were started in the last hour (e.g., to detect a possible overload of the server). Note that, in a realistic setting, this would probably be replaced by sending an email or other form of notification to the responsible instead of the simple logging.

```
declare ProcessStartedEvent
    @role( event )
end

dialect "mvel"

rule "Number of process instances above threshold"
when
  Number( nbProcesses : intValue > 1000 )
    from accumulate(
      e: ProcessStartedEvent( processInstance.processId == "com.sample.order.OrderProcess" )
      over window:size(1h),
      count(e) )
then
  System.err.println( "WARNING: Number of order processes in the last hour above 1000: " +
                      nbProcesses );
end
```

These rules could even be used to alter the behavior of a process automatically at runtime, based on the events generated by the engine. For example, whenever a specific situation is detected, additional rules could be added to the Knowledge Base to modify process behavior. For instance, whenever a large amount of user requests within a specific time frame are detected, an additional validation could be added to the process, enforcing some sort of flow control to reduce the frequency of incoming requests. There is also the possibility of deploying additional logging rules as the consequence of detecting problems. As soon as the situtation reverts back to normal, such rules would be removed again.

Chapter 17. Flexible Processes

Case management and its relation to BPM is a hot topic nowadays. There definitely seems to be a growing need amongst end users for more flexible and adaptive business processes, without ending up with overly complex solutions. Everyone seems to agree that using a process-centric approach only in many cases leads to complex solutions that are hard to maintain. The "knowledge workers" no longer want to be locked into rigid processes but wants to have the power and flexibility to regain more control over the process themselves.

The term case management is often used in that context. Without trying to give a precise definition of what it might or might not mean, as this has been a hot topic for discussion, it refers to the basic idea that many applications in the real world cannot really be described completely from start to finish (including all possible paths, deviations, exceptions, etc.). Case management takes a different approach: instead of trying to model what should happen from start to finish, let's give the end user the flexibility to decide what should happen at runtime. In its most extreme form for example, case management doesn't even require any process definition at all. Whenever a new case comes in, the end user can decide what to do next based on all the case data.

A typical example can be found in healthcare (clinical decision support to be more precise), where care plans can be used to describe how patients should be treated in specific circumstances, but people like general practitioners still need to have the flexibility to add additional steps and deviate from the proposed plan, as each case is unique. And there are similar examples in claim management, helpdesk support, etc.

So, should we just throw away our BPM system then? No! Even at its most extreme form (where we don't model any process up front), you still need a lot of the other features a BPM system (usually) provides: there still is a clear need for audit logs, monitoring, coordinating various services, human interaction (e.g. using task forms), analysis, etc. And, more importantly, many cases are somewhere in between, or might even evolve from case management to more structured business process over time (when we for example try to extract common approaches from many cases). If we can offer flexibility as part of our processes, can't we let the users decide how and where they would like to apply it?

Let me give you two examples that show how you can add more and more flexibility to your processes. The first example shows a care plan that shows the tasks that should be performed when a patient has high blood pressure. While a large part of the process is still well-structured, the general practitioner can decide himself which tasks should be performed as part of the sub-process. And he also has the ability to add new tasks during that period, tasks that were not defined as part of the process, or repeat tasks multiple times, etc. The process uses an ad-hoc sub-process to model this kind of flexibility, possibly augmented with rules or event processing to help in deciding which fragments to execute.

Figure 17.1.

The second example actually goes a lot further than that. In this example, an internet provider could define how cases about internet connectivity problems will be handled by the internet provider. There are a number of actions the case worker can select from, but those are simply small process fragments. The case worker is responsible for selecting what to do next and can even add new tasks dynamically. As you can see, there is not process from start to finish anymore, but the user is responsible for selecting which process fragments to execute.

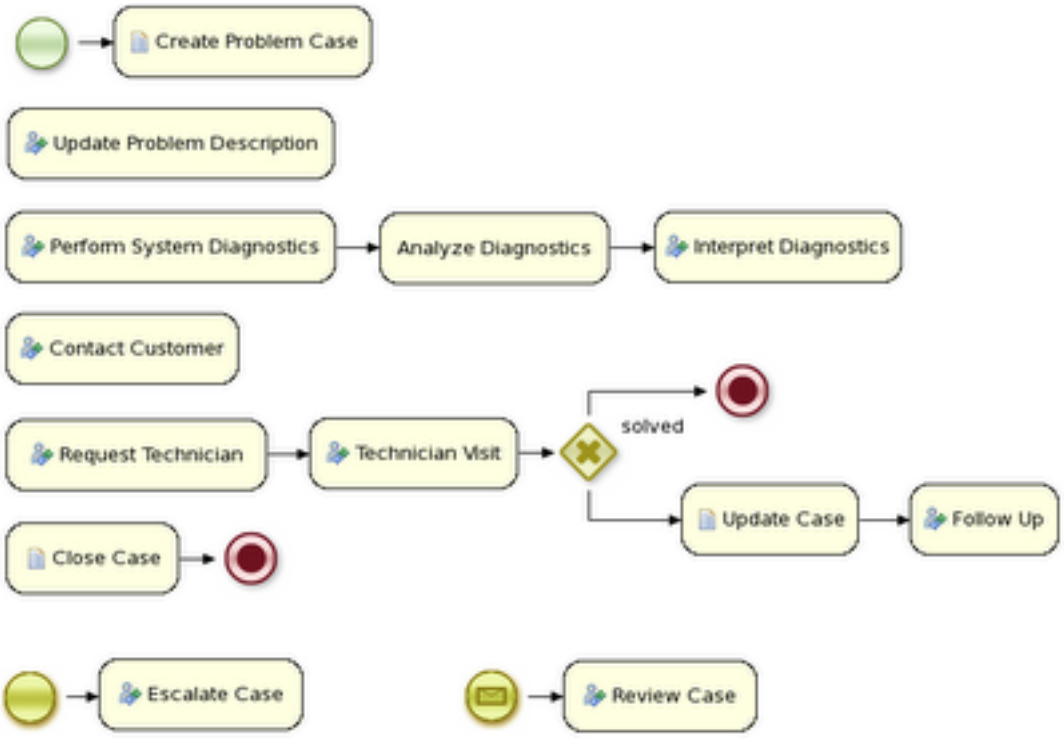


Figure 17.2.

And in its most extreme form, we even allow you to create case instances without a process definition, where what needs to be performed is selected purely at runtime. This however doesn't mean you can't figure out anymore what 's actually happening. For example, meetings can be very adhoc and dynamic, but we usually want a log of what was actually discussed. The following screenshot shows how our regular audit view can still be used in this case, and the end user could then for example get a lot more info about what actually happened by looking at the data associated with each of those steps. And maybe, over time, we can even automate part of that by using a semi-structured process.

Figure 17.3.

Chapter 18. Integration with Maven, OSGi, Spring, etc.

jBPM can be integrated with a lot of other technologies. This chapter gives an overview of a few of those that are supported out-of-the-box. Most of these modules are developed as part of the droolsjbpm-integration module, so they work not only for your business processes but also for business rules and complex event processing.

18.1. Maven

By using a Maven pom.xml to define your project dependencies, you can let maven get your dependencies for you. The following pom.xml is an example that could for example be used to create a new Maven project that is capable of executing a BPMN2 process:

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

  <modelVersion>4.0.0</modelVersion>
  <groupId>org.jbpm</groupId>
  <artifactId>jbpm-maven-example</artifactId>
  <name>jBPM Maven Project</name>
  <version>1.0-SNAPSHOT</version>

  <repositories>
    <!--  use this repository for stable releases -->
    <repository>
      <id>jboss-public-repository-group</id>
      <name>JBoss Public Maven Repository Group</name>
      <url>https://repository.jboss.org/nexus/content/groups/public/</url>
      <layout>default</layout>
      <releases>
        <enabled>true</enabled>
        <updatePolicy>never</updatePolicy>
      </releases>
      <snapshots>
        <enabled>false</enabled>
      </snapshots>
```

```
    </repository>
    <!-- use this repository for snapshot releases -->
    <repository>
      <id>jboss-snapshot-repository-group</id>
      <name>JBoss SNAPSHOT Maven Repository Group</name>
      <url>https://repository.jboss.org/nexus/content/repositories/snapshots/</url>
      <layout>default</layout>
      <releases>
        <enabled>false</enabled>
      </releases>
      <snapshots>
        <enabled>true</enabled>
        <updatePolicy>never</updatePolicy>
      </snapshots>
    </repository>

  </repositories>

  <dependencies>
    <dependency>
      <groupId>org.jbpm</groupId>
      <artifactId>jbpm-bpmn2</artifactId>
      <version>5.0.0</version>
    </dependency>
  </dependencies>

</project>
```

To use this as the basis for your project in Eclipse, either use M2Eclipse or use "mvn eclipse:eclipse" to generate eclipse .project and .classpath files based on this pom.

18.2. OSGi

All core jbpm jars (and core dependencies) are OSGi-enabled. That means that they contain MANIFEST.MF files (in the META-INF directory) that describe their dependencies etc. These manifest files are automatically generated by the build. You can plug these jars directly into an OSGi environment.

OSGi is a dynamic module system for declarative services. So what does that mean? Each jar in OSGi is called a bundle and has it's own Classloader. Each bundle specifies the packages it exports (makes publicly available) and which packages it imports (external dependencies). OSGi will use this information to wire the classloaders of different bundles together; the key distinction is you don't specify what bundle you depend on, or have a single monolithic classpath, instead you specify your package import and version and OSGi attempts to satisfy this from available bundles.

It also supports side by side versioning, so you can have multiple versions of a bundle installed and it'll wire up the correct one. Further to this Bundles can register services for other bundles to use. These services need initialisation, which can cause ordering problems - how do you make sure you don't consume a service before its registered? OSGi has a number of features to help with service composition and ordering. The two main ones are the programmatic ServiceTracker and the xml based Declarative Services. There are also other projects that help with this; Spring DM, iPOJO, Gravity.

The following jBPM jars are OGSi-enabled:

- jbpm-flow
- jbpm-flow-builder
- jbpm-bpmn2

For example, the following code example shows how you can look up the necessary services in an OSGi environment using the service registry and create a session that can then be used to start processes, signal events, etc.

```
ServiceReference serviceRef =
 bundleContext.getServiceReference( ServiceRegistry.class.getName() );
ServiceRegistry registry = (ServiceRegistry) bundleContext.getService( serviceRef );

KnowledgeBuilderFactoryService knowledgeBuilderFactoryService =
 registry.get( KnowledgeBuilderFactoryService.class );
KnowledgeBaseFactoryService knowledgeBaseFactoryService =
 registry.get( KnowledgeBaseFactoryService.class );
ResourceFactoryService resourceFactoryService = registry.get( ResourceFactoryService.class );

KnowledgeBaseConfiguration kbaseConf =
                    knowledgeBaseFactoryService.newKnowledgeBaseConfiguration(
 getClass().getClassLoader() );

KnowledgeBuilderConfiguration kbConf =
                    knowledgeBuilderFactoryService.newKnowledgeBuilderConfiguration( nul
 getClass().getClassLoader() );
KnowledgeBuilder kbuilder = knowledgeBuilderFactoryService.newKnowledgeBuilder( kbConf );
kbuilder.add( resourceFactoryService.newClassPathResource( "MyProcess.bpmn",
 Dummy.class ), ResourceType.BPMN2 );

kbaseConf = knowledgeBaseFactoryService.newKnowledgeBaseConfiguration( null,
 getClass().getClassLoader() );
KnowledgeBase kbase = knowledgeBaseFactoryService.newKnowledgeBase( kbaseConf );
kbase.addKnowledgePackages( kbuilder.getKnowledgePackages() );
```

```
StatefulKnowledgeSession ksession = kbase.newStatefulKnowledgeSession();
```

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