JBoss Enterprise SOA Platform 5

JBPM Reference Guide

for JBoss Developers

Edition 5.3.1

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Legal Notice

Abstract

Read this guide to learn how to use the JBPM and JPDL on the JBoss Enterprise SOA Platform.

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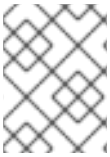
CHAPTER 1. INTRODUCTION

This *Guide* has been written for developers and administrators. Read on in order to learn how to use jBPM and JPDL in your corporate setting. Note that this book not only teaches how to use the software but explains, in significant detail, how it works.

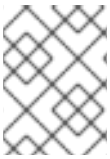


NOTE

This *Guide* contains a lot of terminology. Definitions for the key terms can be found in Section 6.1, " Some Helpful Definitions ".

The JBoss *Business Process Manager* (jBPM) is a flexible and extensible scaffolding for process languages. The *jBPM Process Definition Language* (JPDL) is one of the *process languages* that is built on top of this framework. It is an intuitive language, designed to enable the user to express business processes graphically. It does so by representing *tasks*, *wait states* (for asynchronous communication), *timers* and automated *actions*. To bind these operations together, the language has a powerful and extensible *control flow mechanism*.

The JPDL has few dependencies, making it is as easy to install as a Java library. To do so, deploy it on a *J2EE clustered application server*. One will find it particularly useful in environments in which extreme throughput is a crucial requirement.



NOTE

The JPDL can be configured for use with any database. It can also be deployed on any application server.

1.1. OVERVIEW

Read this section to gain an overview of the way in which the jBPM works.

The core workflow and business process management functionality is packaged as a simple Java library. This library includes a service that manages and executes JPDL database processes:

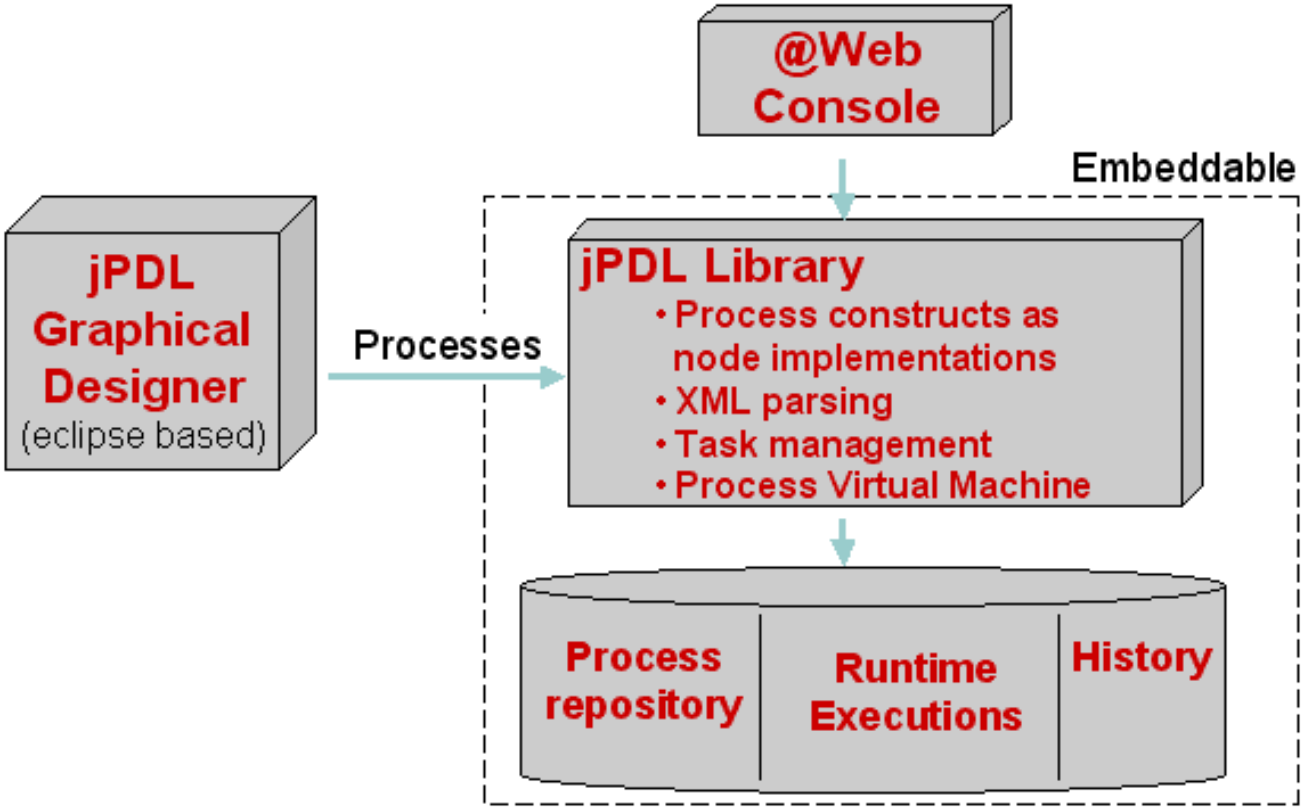


Figure 1.1. Overview of the jPDL components

1.2. THE JPDL SUITE

This suite contains all of the jBPM components and the following sub-directories:

- config
- database
- deploy
- designer
- examples
- lib
- src

The **JBoss Application Server** consists of the following components:

The jBPM Web Console

This is packaged as a web archive. Both *process participants* and jBPM administrators can use this console.

The jBPM Tables

These are contained in the default **Hypersonic** database. (It already contains a process.)

An Example Process

One example process is already deployed to the jBPM database.

Identity Component

The identity component libraries are part of the **Console Web Application**. It owns those tables found in the database which have the **`JBPM_ID_`** prefix.

1.3. THE JPDL GRAPHICAL PROCESS DESIGNER

The jPDL also includes the **Graphical Process Designer Tool**. Use it to design business processes. (It is an **Eclipse** plug-in and is included with the **JBoss Developer Studio** product.)

It facilitates a smooth transition from business process modeling to practical implementation, making it of use to both the business analyst and the technical developer.

1.4. THE JBPM CONSOLE WEB APPLICATION

The **Console Web Application** serves three purposes. Firstly, it functions as a central user interface, allowing one to interact with those run-time tasks that have been generated by the process executions. Secondly, it is an administrative and monitoring console that allows one to inspect and manipulate run-time instances. The third role of this software is that of business activity monitor. In this role, it presents statistics about the execution of processes. This information is of use to managers seeking to optimize performance as it allows them to find and eliminate bottlenecks.

1.5. THE JBPM CORE LIBRARY

The Business Process Manager has two core components. These are the "plain Java" (J2SE) library, which manages process definitions, and the run-time environment, which executes process instances.

The jBPM, itself, is a Java library. Consequently, it can be used in any Java environment, be it a web or **Swing** application, an **`Enterprise Java Bean`** or a web service.

One can also package and expose the jBPM library as a *stateless session* **`Enterprise Java Bean`**. Do this if there is a need to create a clustered deployment or provide scalability for extremely high throughput. (The stateless session **`Enterprise Java Bean`** adheres to the **`J2EE 1.3`** specifications, mearning that it can be deployed on any application server.)

Be aware that some parts of the **`jbpm-jpdl.jar`** file are dependent upon third-party libraries such as **Hibernate** and **Dom4J**.

Hibernate provides the jBPM with *persistence* functionality. Also, apart from providing traditional *O/R mapping*, **Hibernate** resolves the differences between the Structured Query Language dialects used by competing databases. This ability makes the jBPM highly portable.

The Business Process Manager's application programming interface can be accessed from any custom Java code in your project, whether it be a web application, an Enterprise Java Bean, a web service component or a message-driven bean.

1.6. THE IDENTITY COMPONENT

The jBPM can integrate with any company directory that contains user (and other organizational) data. (For those projects for which no organizational information component is available, use the *Identity Component*. This component has a "richer" model than those used by traditional servlets, Enterprise Java Beans and portlets.)

NOTE

Read Section 8.11, “ The Identity Component ” to learn more about this topic.

1.7. THE JBOSS JBPM JOB EXECUTOR

The *JBoss jBPM Job Executor* is a component designed for the purpose of monitoring and executing jobs in a standard Java environment. *Jobs* are used for timers and asynchronous messages. (In an enterprise environment, the Java Message Service and the Enterprise Java Bean **`TimerService`** might be used for this purpose; the Job Executor is best used in a "standard" environment.)

The Job Executor component is packaged in the core **`jbpm-jpdl`** library. It can only be deployed in one of the following two scenarios:

- if the **`JbpmThreadsServlet`** has been configured to start the Job Executor.
- if a separate Java Virtual Machine has been started so that the Job Executor thread can be run from within it

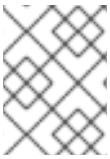
1.8. CONCLUSION

Having read this chapter, you have gained a broad overview of the jBPM and its constituent components.

CHAPTER 2. TUTORIAL

Study the following tutorial to learn how to use basic *process constructs* in the JPDL. The tutorial also demonstrates ways in which to manage run-time executions via the application programming interface.

The examples in this tutorial can be found in the JBPM download package (located in the **`src/java.examples`** sub-directory).



NOTE

Red Hat recommends creating a project at this point. You can then freely experiment and create variations of each of the examples.

First, download and install the JBPM.

jBPM includes a graphical designer tool for authoring the XML that is shown in the examples. You can find download instructions for the graphical designer in the Downloadables Overview section.. You don't need the graphical designer tool to complete this tutorial.

2.1. "HELLO WORLD" EXAMPLE

A *process definition* is a *directed graph*, made up of nodes and transitions. The **`Hello World`** process definition has three of these nodes. (It is best to learn how the pieces fit together by studying this simple process without using the **Designer Tool**.) The following diagram presents a graphical representation of the **`Hello World`** process:

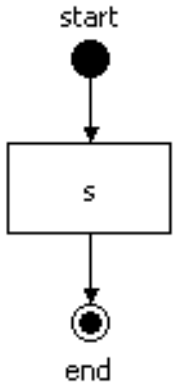


Figure 2.1. The Hello World Process Graph

```
public void testHelloWorldProcess() {
  // This method shows a process definition and one execution
  // of the process definition.  The process definition has
  // 3 nodes: an unnamed start-state, a state 's' and an
  // end-state named 'end'.
  // The next line parses a piece of xml text into a
  // ProcessDefinition.  A ProcessDefinition is the formal
  // description of a process represented as a java object.
  ProcessDefinition processDefinition = ProcessDefinition.parseXmlString(
      "<process-definition>" +
      "  <start-state>" +
      "    <transition to='s' />" +
      "  </start-state>" +
      "  <state name='s'>" +
```

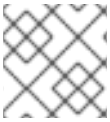
```
      "    <transition to='end' />" +
      "  </state>" +
      "  <end-state name='end' />" +
      "</process-definition>"
  );

    // The next line creates one execution of the process definition.
    // After construction, the process execution has one main path
    // of execution (=the root token) that is positioned in the
    // start-state.
    ProcessInstance processInstance =
      new ProcessInstance(processDefinition);

    // After construction, the process execution has one main path
    // of execution (=the root token).
    Token token = processInstance.getRootToken();

    // Also after construction, the main path of execution is positioned
    // in the start-state of the process definition.
    assertSame(processDefinition.getStartState(), token.getNode());

    // Let's start the process execution, leaving the start-state
    // over its default transition.
    token.signal();
    // The signal method will block until the process execution
    // enters a wait state.

    // The process execution will have entered the first wait state
    // in state 's'. So the main path of execution is now
    // positioned in state 's'
    assertSame(processDefinition.getNode("s"), token.getNode());

    // Let's send another signal.  This will resume execution by
    // leaving the state 's' over its default transition.
    token.signal();
    // Now the signal method returned because the process instance
    // has arrived in the end-state.

    assertSame(processDefinition.getNode("end"), token.getNode());
}
```

2.2. DATABASE EXAMPLE

One of the jBPM's basic features is the ability to make the execution of database processes persist while they are in a **`wait state`**. The next example demonstrates this ability, storing a process instance in the jBPM database.

It works by creating separate **`methods`** for different pieces of user code. For instance, a piece of user code in a web application starts a process and "persists" the execution in the database. Later, a message-driven bean loads that process instance and resumes the execution of it.

Here, separate **`methods`** are created for different pieces of user code. For instance, a piece of code in a web application starts a process and "persists" the execution in the database. Later, a *message-driven bean* loads the process instance and resumes executing it.



NOTE

More information about jBPM persistence can be found in Chapter 4, *Persistence* .

```
public class HelloWorldDbTest extends TestCase {

  static JbpmConfiguration jbpmConfiguration = null;

  static {
    // An example configuration file such as this can be found in
    // 'src/config.files'.  Typically the configuration information
    // is in the resource file 'jbpm.cfg.xml', but here we pass in
    // the configuration information as an XML string.

    // First we create a JbpmConfiguration statically.  One
    // JbpmConfiguration can be used for all threads in the system,
    // that is why we can safely make it static.

    jbpmConfiguration = JbpmConfiguration.parseXmlString(
      "<jbpm-configuration>" +

      // A jbpm-context mechanism separates the jbpm core
      // engine from the services that jbpm uses from
      // the environment.

      "<jbpm-context>"+
      "<service name='persistence' "+
      " factory='org.jbpm.persistence.db.DbPersistenceServiceFactory' />"
+
      "</jbpm-context>"+

      // Also all the resource files that are used by jbpm are
      // referenced from the jbpm.cfg.xml

      "<string name='resource.hibernate.cfg.xml' " +
      "  value='hibernate.cfg.xml' />" +
      "<string name='resource.business.calendar' " +
      "  value='org/jbpm/calendar/jbpm.business.calendar.properties' />" +
      "<string name='resource.default.modules' " +
      "  value='org/jbpm/graph/def/jbpm.default.modules.properties' />" +
      "<string name='resource.converter' " +
      "  value='org/jbpm/db/hibernate/jbpm.converter.properties' />" +
      "<string name='resource.action.types' " +
      "  value='org/jbpm/graph/action/action.types.xml' />" +
      "<string name='resource.node.types' " +
      "  value='org/jbpm/graph/node/node.types.xml' />" +
      "<string name='resource.varmapping' " +
      "  value='org/jbpm/context/exe/jbpm.varmapping.xml' />" +
      "</jbpm-configuration>"
    );
  }

  public void setUp() {
    jbpmConfiguration.createSchema();
  }
```

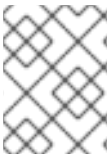
```
public void tearDown() {
  jbpmConfiguration.dropSchema();
}

public void testSimplePersistence() {
  // Between the 3 method calls below, all data is passed via the
  // database.  Here, in this unit test, these 3 methods are executed
  // right after each other because we want to test a complete process
  // scenario.  But in reality, these methods represent different
  // requests to a server.

  // Since we start with a clean, empty in-memory database, we have to
  // deploy the process first.  In reality, this is done once by the
  // process developer.
  deployProcessDefinition();

  // Suppose we want to start a process instance (=process execution)
  // when a user submits a form in a web application...
  processInstanceIsCreatedWhenUserSubmitsWebappForm();

  // Then, later, upon the arrival of an asynchronous message the
  // execution must continue.
  theProcessInstanceContinuesWhenAnAsyncMessageIsReceived();
}

public void deployProcessDefinition() {
  // This test shows a process definition and one execution
  // of the process definition.  The process definition has
  // 3 nodes: an unnamed start-state, a state 's' and an
  // end-state named 'end'.
  ProcessDefinition processDefinition =
      ProcessDefinition.parseXmlString(
    "<process-definition name='hello world'>" +
    "  <start-state name='start'>" +
    "    <transition to='s' />" +
    "  </start-state>" +
    "  <state name='s'>" +
    "    <transition to='end' />" +
    "  </state>" +
    "  <end-state name='end' />" +
    "</process-definition>"
  );

  //Lookup the pojo persistence context-builder that is configured above
  JbpmContext jbpmContext = jbpmConfiguration.createJbpmContext();
  try {
    // Deploy the process definition in the database
    jbpmContext.deployProcessDefinition(processDefinition);

  } finally {
    // Tear down the pojo persistence context.
    // This includes flush the SQL for inserting the process definition
    // to the database.
    jbpmContext.close();
  }
```

```
  }

  public void processInstanceIsCreatedWhenUserSubmitsWebappForm() {
    // The code in this method could be inside a struts-action
    // or a JSF managed bean.

    //Lookup the pojo persistence context-builder that is configured above
    JbpmContext jbpmContext = jbpmConfiguration.createJbpmContext();
    try {

      GraphSession graphSession = jbpmContext.getGraphSession();

      ProcessDefinition processDefinition =
          graphSession.findLatestProcessDefinition("hello world");

      //With the processDefinition that we retrieved from the database, we
      //can create an execution of the process definition just like in the
      //hello world example (which was without persistence).
      ProcessInstance processInstance =
          new ProcessInstance(processDefinition);

      Token token = processInstance.getRootToken();
      assertEquals("start", token.getNode().getName());
      // Let's start the process execution
      token.signal();
      // Now the process is in the state 's'.
      assertEquals("s", token.getNode().getName());

      // Now the processInstance is saved in the database.  So the
      // current state of the execution of the process is stored in the
      // database.
      jbpmContext.save(processInstance);
      // The method below will get the process instance back out
      // of the database and resume execution by providing another
      // external signal.

    } finally {
      // Tear down the pojo persistence context.
      jbpmContext.close();
    }
  }

  public void theProcessInstanceContinuesWhenAnAsyncMessageIsReceived() {
  //The code in this method could be the content of a message driven bean.

    // Lookup the pojo persistence context-builder that is configured
above
    JbpmContext jbpmContext = jbpmConfiguration.createJbpmContext();
    try {

      GraphSession graphSession = jbpmContext.getGraphSession();
      // First, we need to get the process instance back out of the
      // database.  There are several options to know what process
      // instance we are dealing  with here.  The easiest in this simple
      // test case is just to look for the full list of process instances.
      // That should give us only one result.  So let's look up the
```

```
      // process definition.

      ProcessDefinition processDefinition =
          graphSession.findLatestProcessDefinition("hello world");

      //Now search for all process instances of this process definition.
      List processInstances =
          graphSession.findProcessInstances(processDefinition.getId());

      // Because we know that in the context of this unit test, there is
      // only one execution.  In real life, the processInstanceId can be
      // extracted from the content of the message that arrived or from
      // the user making a choice.
      ProcessInstance processInstance =
          (ProcessInstance) processInstances.get(0);

      // Now we can continue the execution.  Note that the processInstance
      // delegates signals to the main path of execution (=the root
token).
      processInstance.signal();

      // After this signal, we know the process execution should have
      // arrived in the end-state.
      assertTrue(processInstance.hasEnded());

      // Now we can update the state of the execution in the database
      jbpmContext.save(processInstance);

    } finally {
      // Tear down the pojo persistence context.
      jbpmContext.close();
    }
  }
}
```

2.3. CONTEXTUAL EXAMPLE: PROCESS VARIABLES

Whilst processes are executed, the context information is held in *process variables*. These are similar to **`java.util.Map`** classes, in that they map variable names to values, the latter being Java objects. (The process variables are "persisted" as part of the process instance.)



NOTE

In order to keep the following example simple, only the application programming interface that is needed to work with variables is shown (without any persistence functionality.)

NOTE

Find out more about variables by reading Chapter 7, *The Context*

```
// This example also starts from the hello world process.
// This time even without modification.
ProcessDefinition processDefinition = ProcessDefinition.parseXmlString(
```

```
  "<process-definition>" +
  "  <start-state>" +
  "    <transition to='s' />" +
  "  </start-state>" +
  "  <state name='s'>" +
  "    <transition to='end' />" +
  "  </state>" +
  "  <end-state name='end' />" +
  "</process-definition>"
);

ProcessInstance processInstance =
  new ProcessInstance(processDefinition);

// Fetch the context instance from the process instance
// for working with the process variables.
ContextInstance contextInstance =
  processInstance.getContextInstance();

// Before the process has left the start-state,
// we are going to set some process variables in the
// context of the process instance.
contextInstance.setVariable("amount", new Integer(500));
contextInstance.setVariable("reason", "i met my deadline");

// From now on, these variables are associated with the
// process instance.  The process variables are now accessible
// by user code via the API shown here, but also in the actions
// and node implementations.  The process variables are also
// stored into the database as a part of the process instance.

processInstance.signal();

// The variables are accessible via the contextInstance.

assertEquals(new Integer(500),
             contextInstance.getVariable("amount"));
assertEquals("i met my deadline",
             contextInstance.getVariable("reason"));
```

2.4. TASK ASSIGNMENT EXAMPLE

The next example demonstrates how to assign a task to a user. Because of the separation between the jBPM workflow engine and the organizational model, expression languages will always be too limited to use to calculate actors. Instead, specify an implementation of **`AssignmentHandler`** and use it to include the calculation of actors for tasks.

```
public void testTaskAssignment() {
  // The process shown below is based on the hello world process.
  // The state node is replaced by a task-node.  The task-node
  // is a node in JPDL that represents a wait state and generates
  // task(s) to be completed before the process can continue to
  // execute.
  ProcessDefinition processDefinition = ProcessDefinition.parseXmlString(
    "<process-definition name='the baby process'>" +
```

```
    "  <start-state>" +
    "    <transition name='baby cries' to='t' />" +
    "  </start-state>" +
    "  <task-node name='t'>" +
    "    <task name='change nappy'>" +
    "      <assignment" +
    "       class='org.jbpm.tutorial.taskmgmt.NappyAssignmentHandler' />"
+
    "    </task>" +
    "    <transition to='end' />" +
    "  </task-node>" +
    "  <end-state name='end' />" +
    "</process-definition>"
  );

  // Create an execution of the process definition.
  ProcessInstance processInstance =
      new ProcessInstance(processDefinition);
  Token token = processInstance.getRootToken();

  // Let's start the process execution, leaving the start-state
  // over its default transition.
  token.signal();
  // The signal method will block until the process execution
  // enters a wait state.   In this case, that is the task-node.
  assertSame(processDefinition.getNode("t"), token.getNode());

  // When execution arrived in the task-node, a task 'change nappy'
  // was created and the NappyAssignmentHandler was called to determine
  // to whom the task should be assigned.  The NappyAssignmentHandler
  // returned 'papa'.

  // In a real environment, the tasks would be fetched from the
  // database with the methods in the org.jbpm.db.TaskMgmtSession.
  // Since we don't want to include the persistence complexity in
  // this example, we just take the first task-instance of this
  // process instance (we know there is only one in this test
  // scenario).
  TaskInstance taskInstance = (TaskInstance)
      processInstance
        .getTaskMgmtInstance()
        .getTaskInstances()
        .iterator().next();

  // Now, we check if the taskInstance was actually assigned to 'papa'.
  assertEquals("papa", taskInstance.getActorId() );

  // Now we suppose that 'papa' has done his duties and mark the task
  // as done.
  taskInstance.end();
  // Since this was the last (only) task to do, the completion of this
  // task triggered the continuation of the process instance execution.

  assertSame(processDefinition.getNode("end"), token.getNode());
}
```

2.5. EXAMPLE OF A CUSTOM ACTION

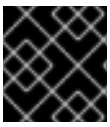
Actions are mechanisms designed to bind custom Java code to jBPM processes. They can be associated with their own nodes (if these are relevant to the graphical representation of the process.) Alternatively, actions can be "placed on" events (for instance, when taking a transition, or entering or leaving a node.) If they are placed on events, the actions are not treated as part of the graphical representation (but they are still run when the events are "fired" during a run-time process execution.)

Firstly, look at the action handler implementation to be used in the next example: **`MyActionHandler`**. It is not particularly impressive of itself: it merely sets the Boolean variable **`isExecuted`** to **`true`**. Note that this variable is static so one can access it from within the action handler (and from the action itself) to verify its value.

NOTE

More information about "actions" can be found in Section 6.5, “Actions”

```
// MyActionHandler represents a class that could execute
// some user code during the execution of a jBPM process.
public class MyActionHandler implements ActionHandler {

  // Before each test (in the setUp), the isExecuted member
  // will be set to false.
  public static boolean isExecuted = false;

  // The action will set the isExecuted to true so the
  // unit test will be able to show when the action
  // is being executed.
  public void execute(ExecutionContext executionContext) {
    isExecuted = true;
  }
}
```



IMPORTANT

Prior to each test, set the static field **`MyActionHandler.isExecuted`** to **`false`**.

```
  // Each test will start with setting the static isExecuted
  // member of MyActionHandler to false.
  public void setUp() {
    MyActionHandler.isExecuted = false;
  }
```

The first example illustrates an action on a transition:

```
public void testTransitionAction() {
    // The next process is a variant of the hello world process.
    // We have added an action on the transition from state 's'
    // to the end-state.  The purpose of this test is to show
    // how easy it is to integrate Java code in a jBPM process.
    ProcessDefinition processDefinition =
ProcessDefinition.parseXmlString(
      "<process-definition>" +
```

```
      "  <start-state>" +
      "    <transition to='s' />" +
      "  </start-state>" +
      "  <state name='s'>" +
      "    <transition to='end'>" +
      "      <action class='org.jbpm.tutorial.action.MyActionHandler' />"
+
      "    </transition>" +
      "  </state>" +
      "  <end-state name='end' />" +
      "</process-definition>"
    );

    // Let's start a new execution for the process definition.
    ProcessInstance processInstance =
      new ProcessInstance(processDefinition);

    // The next signal will cause the execution to leave the start
    // state and enter the state 's'
    processInstance.signal();

    // Here we show that MyActionHandler was not yet executed.
    assertFalse(MyActionHandler.isExecuted);
    // ... and that the main path of execution is positioned in
    // the state 's'
    assertSame(processDefinition.getNode("s"),
               processInstance.getRootToken().getNode());

    // The next signal will trigger the execution of the root
    // token.  The token will take the transition with the
    // action and the action will be executed during the
    // call to the signal method.
    processInstance.signal();

    // Here we can see that MyActionHandler was executed during
    // the call to the signal method.
    assertTrue(MyActionHandler.isExecuted);
  }
```

The next example shows the same action now being placed on both the **`enter-node`** and **`leave-node`** events. Note that a node has more than one event type. This is in contrast to a *transition*, which has only one event. Hence, when placing actions on a node, always put them in an event element.

```
ProcessDefinition processDefinition = ProcessDefinition.parseXmlString(
  "<process-definition>" +
  "  <start-state>" +
  "    <transition to='s' />" +
  "  </start-state>" +
  "  <state name='s'>" +
  "    <event type='node-enter'>" +
  "      <action class='org.jbpm.tutorial.action.MyActionHandler' />" +
  "    </event>" +
  "    <event type='node-leave'>" +
  "      <action class='org.jbpm.tutorial.action.MyActionHandler' />" +
  "    </event>" +
  "    <transition to='end'/>" +
```

```
  "  </state>" +
  "  <end-state name='end' />" +
  "</process-definition>"
);

ProcessInstance processInstance =
  new ProcessInstance(processDefinition);

assertFalse(MyActionHandler.isExecuted);
// The next signal will cause the execution to leave the start
// state and enter the state 's'.  So the state 's' is entered
// and hence the action is executed.
processInstance.signal();
assertTrue(MyActionHandler.isExecuted);

// Let's reset the MyActionHandler.isExecuted
MyActionHandler.isExecuted = false;

// The next signal will trigger execution to leave the
// state 's'.  So the action will be executed again.
processInstance.signal();
// Voila.
assertTrue(MyActionHandler.isExecuted);
```

CHAPTER 3. CONFIGURATION

Read this chapter and studied the examples to learn how to configure the jBPM.

The simplest way to configure the Business Process Manager is by putting the **`jbpm.cfg.xml`** configuration file into the root of the classpath. If the file is not available for use as a resource, the default minimal configuration will be used instead. This minimal configuration is included in the jBPM library (**`org/jbpm/default.jbpm.cfg.xml`**.) If a jBPM configuration file is provided, the values it contains will be used as the defaults. Hence, one only needs to specify the values that are to be different from those in the default configuration file.

The jBPM configuration is represented by a Java class called **`org.jbpm.JbpmConfiguration`**. Obtain it by making use of the **`singleton`** instance method (**`JbpmConfiguration.getInstance()`**.)

NOTE

Use the **`JbpmConfiguration.parseXxxx`** methods to load a configuration from another source.

```
static JbpmConfinguration jbpmConfiguration =
JbpmConfinguration.parseResource("my.jbpm.cfg.xml");
```

The **`JbpmConfiguration`** is "thread safe" and, hence, can be kept in a *static member*.

Every thread can use a **`JbpmConfiguration`** as a *factory* for **`JbpmContext`** objects. A **`JbpmContext`** will usually represent one transaction. They make services available inside *context blocks* which looks like this:

```
JbpmContext jbpmContext = jbpmConfiguration.createJbpmContext();
try {
  // This is what we call a context block.
  // Here you can perform workflow operations

} finally {
  jbpmContext.close();
}
```

The **`JbpmContext`** makes both a set of services and the configuration settings available to the Business Process Manager. The services are configured by the values in the **`jbpm.cfg.xml`** file. They make it possible for the jBPM to run in any Java environment, using whatever services are available within said environment.

Here are the default configuration settings for the **`JbpmContext`**:

```
<jbpm-configuration>

<jbpm-context>
    <service name='persistence'
      factory='org.jbpm.persistence.db.DbPersistenceServiceFactory' />
    <service name='message'
      factory='org.jbpm.msg.db.DbMessageServiceFactory' />
    <service name='scheduler'
      factory='org.jbpm.scheduler.db.DbSchedulerServiceFactory' />
```

```
    <service name='logging'
      factory='org.jbpm.logging.db.DbLoggingServiceFactory' />
    <service name='authentication'
      factory=
'org.jbpm.security.authentication.DefaultAuthenticationServiceFactory' />
</jbpm-context>

<!-- configuration resource files pointing to default
     configuration files in jbpm-{version}.jar -->
<string name='resource.hibernate.cfg.xml' value='hibernate.cfg.xml' />

  <!-- <string name='resource.hibernate.properties'
       value='hibernate.properties' /> -->
  <string name='resource.business.calendar'
    value='org/jbpm/calendar/jbpm.business.calendar.properties' />
  <string name='resource.default.modules'
    value='org/jbpm/graph/def/jbpm.default.modules.properties' />
  <string name='resource.converter'
    value='org/jbpm/db/hibernate/jbpm.converter.properties' />
  <string name='resource.action.types'
    value='org/jbpm/graph/action/action.types.xml' />
  <string name='resource.node.types'
    value='org/jbpm/graph/node/node.types.xml' />
  <string name='resource.parsers'
    value='org/jbpm/jpdl/par/jbpm.parsers.xml' />
  <string name='resource.varmapping'
    value='org/jbpm/context/exe/jbpm.varmapping.xml' />
  <string name='resource.mail.templates'
    value='jbpm.mail.templates.xml' />

  <int name='jbpm.byte.block.size' value="1024" singleton="true" />
  <bean name='jbpm.task.instance.factory'
    class='org.jbpm.taskmgmt.impl.DefaultTaskInstanceFactoryImpl'
    singleton='true' />

  <bean name='jbpm.variable.resolver'
    class='org.jbpm.jpdl.el.impl.JbpmVariableResolver'
    singleton='true' />

    <string name='jbpm.mail.smtp.host' value='localhost' />

    <bean name='jbpm.mail.address.resolver'
        class='org.jbpm.identity.mail.IdentityAddressResolver'
        singleton='true' />
    <string name='jbpm.mail.from.address' value='jbpm@noreply' />

    <bean name='jbpm.job.executor'
        class='org.jbpm.job.executor.JobExecutor'>
      <field name='jbpmConfiguration'><ref bean='jbpmConfiguration' />
      </field>
      <field name='name'><string value='JbpmJobExecutor' /></field>
      <field name='nbrOfThreads'><int value='1' /></field>
      <field name='idleInterval'><int value='60000' /></field>
      <field name='retryInterval'><int value='4000' /></field>
      <!-- 1 hour -->
      <field name='maxIdleInterval'><int value='3600000' /></field>
```

```
      <field name='historyMaxSize'><int value='20' /></field>
      <!-- 10 minutes -->
      <field name='maxLockTime'><int value='600000' /></field>
      <!-- 1 minute -->
      <field name='lockMonitorInterval'><int value='60000' /></field>
       <!-- 5 seconds -->
      <field name='lockBufferTime'><int value='5000' /></field>
    </bean>
</jbpm-configuration>
```

The above file contains three parts:

1. a set of *service implementations* which configure the **`JbpmContext`**. (The possible configuration options are detailed in the chapters that cover specific service implementations.)

2. all of the mappings linking references to configuration resources. If one wishes to customize one of the configuration files, update these mappings. To do so, always back up the default configuration file (**`jbpm-3.x.jar`**) to another location on the classpath first. Then, update the reference in this file, pointing it to the customized version that the jBPM is to use.

3. miscellaneous configurations for use by the jBPM. (These are described in the chapters that cover the specific topics in question.)

The default configuration has been optimized for a simple web application environment which has minimal dependencies. The persistence service obtains a JDBC connection which is used by all of the other services. Hence, all of the workflow operations are centralized as they are placed in a single transaction on a JDBC connection (without the need for a transaction manager.)

`JbpmContext` contains *convenience methods* for most of the common process operations. They are demonstrated in this code sample:

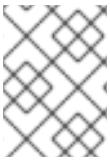
```
public void deployProcessDefinition(ProcessDefinition processDefinition)
public List getTaskList()
public List getTaskList(String actorId)
public List getGroupTaskList(List actorIds)
public TaskInstance loadTaskInstance(long taskInstanceId)
public TaskInstance loadTaskInstanceForUpdate(long taskInstanceId)
public Token loadToken(long tokenId)
public Token loadTokenForUpdate(long tokenId)
public ProcessInstance loadProcessInstance(long processInstanceId)
public ProcessInstance loadProcessInstanceForUpdate(long
processInstanceId)
public ProcessInstance newProcessInstance(String processDefinitionName)
public void save(ProcessInstance processInstance)
public void save(Token token)
public void save(TaskInstance taskInstance)
public void setRollbackOnly()
```

NOTE

There is no need to call any of the save methods explicitly because the **`XxxForUpdate`** methods are designed to register the loaded object for "auto-save."

It is possible to specify multiple **`jbpm-contexts`**. To do so, make sure that each of them is given a unique name attribute. (Retrieve named contexts by using **`JbpmConfiguration.createContext(String name);`**.)

A service element specifies its own name and associated *service factory*. The service will only be created when requested to do so by **`JbpmContext.getServices().getService(String name)`**.



NOTE

One can also specfy the **`factories`** as *elements* instead of attributes. This is necessary when injecting some configuration information into factory objects.

Note that the component responsible for creating and wiring the objects and parsing the XML is called the **`object factory`**.

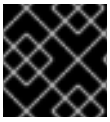
3.1. CUSTOMIZING FACTORIES

WARNING

A mistake commonly made by people when they are trying to customize factories is to mix long and short notation together. (Examples of the short notation can be seen in the default configuration file.)

Hibernate logs **`StateObjectStateException`** exceptions and generates a **`stack trace`**. In order to remove the latter, set **`org.hibernate.event.def.AbstractFlushingEventListener`** to **`FATAL`**. (Alternatively, if using **`log4j`**, set the following line in the configuration: for that: **`log4j.logger.org.hibernate.event.def.AbstractFlushingEventListener=FATAL`**

```
&lt;service name='persistence'
    factory='org.jbpm.persistence.db.DbPersistenceServiceFactory' /&gt;
```



IMPORTANT

If one needs to note specific properties on a service, only the long notation can be used.

```
<service name="persistence">
    <factory>
        <bean class="org.jbpm.persistence.db.DbPersistenceServiceFactory">
            <field name="dataSourceJndiName">
                <string value="java:/myDataSource"/>
            </field>
            <field name="isCurrentSessionEnabled"><true /></field>
            <field name="isTransactionEnabled"><false /></field>
        </bean>
    </factory>
</service>
```

3.2. CONFIGURATION PROPERTIES

jbpm.byte.block.size

File attachments and binary variables are stored in the database in the form of a list of fixed-sized, binary objects. (The aim of this is to improve portability amongst different databases. It also allows one to embed the jBPM more easily.) This parameter controls the size of those fixed-length chunks.

jbpm.task.instance.factory

To customize the way in which task instances are created, specify a fully-qualified classname against this property. (This is often necessary when one intends to customize, and add new properties to, the **`TaskInstance`** bean.) Ensure that the specified classname implements the **`org.jbpm.taskmgmt.TaskInstanceFactory`** interface. (Refer to Section 8.10, " Customizing Task Instances " for more information.)

jbpm.variable.resolver

Use this to customize the way in which jBPM looks for the first term in "JSF"-like expressions.

jbpm.class.loader

Use this property to load jBPM classes.

jbpm.sub.process.async

Use this property to allow for asynchronous signaling of sub-processes.

jbpm.job.retries

This configuration determines when a failed job is retired. If you examine the configuration file, you can set the entry so that it makes a specified number of attempts to process such a job before retiring it.

jbpm.mail.from.address

This property displays where a job has come from. The default is *jbpm@noreply*.

3.3. OTHER CONFIGURATION FILES

There are a number of configuration files in the jBPM which can be customized:

`hibernate.cfg.xml`

This contains references to, and configuration details for, the **Hibernate** mapping resource files.

To change the **`hibernate.cfg.xml`** file used by jBPM, set the following property in the **`jbpm.cfg.xml`** file:

```
<string name="resource.hibernate.cfg.xml" value="new.hibernate.cfg.xml"/>
```

The file jbpm.cfg.xml file is located in ${soa.home}/jboss-as/server/${server.config}/jbpm.esb

`org/jbpm/db/hibernate.queries.hbm.xml`

This file contains those **Hibernate** queries to be used in the jBPM sessions (**`org.jbpm.db.*Session`**.)

`org/jbpm/graph/node/node.types.xml`

This file is used to map XML node elements to **Node** implementation classes.

org/jbpm/graph/action/action.types.xml

This file is used to map XML action elements to **Action** implementation classes.

org/jbpm/calendar/jbpm.business.calendar.properties

This contains the definitions of "business hours" and "free time."

org/jbpm/context/exe/jbpm.varmapping.xml

This specifies the way in which the process variables values (Java objects) are converted to variable instances for storage in the jBPM database.

org/jbpm/db/hibernate/jbpm.converter.properties

This specifies the **id-to-classname** mappings. The ids are stored in the database. The **org.jbpm.db.hibernate.ConverterEnumType** class is used to map the identifiers to the **singleton** objects.

org/jbpm/graph/def/jbpm.default.modules.properties

This specifies which modules are to be added to a new **ProcessDefinition** by default.

org/jbpm/jpdl/par/jbpm.parsers.xml

This specifies the phases of *process archive parsing*.

3.4. LOGGING OPTIMISTIC CONCURRENCY EXCEPTIONS

When it is run in a cluster configuration, the jBPM synchronizes with the database by using *optimistic locking*. This means that each operation is performed in a transaction and if, at the end, a collision is detected, then the transaction in question is rolled back and has to be handled with a retry. This can cause **org.hibernate.StateObjectStateException** exceptions. If and when this happens, **Hibernate** will log the exceptions with a simple message,

```
optimistic locking
            failed
```

.

Hibernate can also log the **StateObjectStateException** with a stack trace. To remove these stack traces, set the **org.hibernate.event.def.AbstractFlushingEventListener** class to **FATAL**. Do so in **log4j** by using the following configuration:

```
log4j.logger.org.hibernate.event.def.AbstractFlushingEventListener=FATAL
```

In order to log jBPM stack traces, set the log category threshold above ERROR for the package.

3.5. OBJECT FACTORY

The *Object Factory* can build objects to the specification contained in a "beans-like" XML configuration file. This file dictates how objects are to be created, configured and wired together to form a complete object graph. Also use the Object Factory to inject configurations and other beans into a single bean.

In its most elementary form, the Object Factory is able to create both basic *types* and Java beans from such a configuration, as shown in the following examples:

```
<beans>
    <bean name="task" class="org.jbpm.taskmgmt.exe.TaskInstance"/>
    <string name="greeting">hello world</string>
    <int name="answer">42</int>
    <boolean name="javaisold">true</boolean>
    <float name="percentage">10.2</float>
    <double name="salary">100000000.32</double>
    <char name="java">j</char>
    <null name="dusttodust" />
</beans>
```

```
ObjectFactory of = ObjectFactory.parseXmlFromAbove();
assertEquals(TaskInstance.class, of.getNewObject("task").getClass());
assertEquals("hello world", of.getNewObject("greeting"));
assertEquals(new Integer(42), of.getNewObject("answer"));
assertEquals(Boolean.TRUE, of.getNewObject("javaisold"));
assertEquals(new Float(10.2), of.getNewObject("percentage"));
assertEquals(new Double(100000000.32), of.getNewObject("salary"));
assertEquals(new Character('j'), of.getNewObject("java"));
assertNull(of.getNewObject("dusttodust"));]]>
```

This code shows how to configure lists:

```
<beans>
    <list name="numbers">
        <string>one</string>
        <string>two</string>
        <string>three</string>
    </list>
</beans>
```

This code demonstrates how to configure maps:

```
<beans>
    <map name="numbers">
        <entry>
            <key><int>1</int></key>
            <value><string>one</string></value>
        </entry>
        <entry>
            <key><int>2</int></key>
            <value><string>two</string></value>
        </entry>
        <entry>
            <key><int>3</int></key>
            <value><string>three</string></value>
        </entry>
    </map>
</beans>
```

Use *direct field injection* and property **`setter`** methods to configure beans:

```
<beans>
    <bean name="task" class="org.jbpm.taskmgmt.exe.TaskInstance" >
        <field name="name"><string>do dishes</string></field>
        <property name="actorId"><string>theotherguy</string></property>
    </bean>
</beans>
```

You can refer to beans. The object referenced does not have to be a bean itself: it can be a string, an integer or anything you want.

```
<beans>
    <bean name="a" class="org.jbpm.A" />
    <ref name="b" bean="a" />
</beans>
```

Beans can be built with any constructor, as this code shows:

```
<beans>
    <bean name="task" class="org.jbpm.taskmgmt.exe.TaskInstance" >
        <constructor>
            <parameter class="java.lang.String">
                <string>do dishes</string>
            </parameter>
            <parameter class="java.lang.String">
                <string>theotherguy</string>
            </parameter>
        </constructor>
    </bean>
</beans>
```

Beans can be constructed using a **`factory`** method:

```
<beans>
    <bean name="taskFactory"
        class="org.jbpm.UnexistingTaskInstanceFactory"
        singleton="true"/>

    <bean name="task" class="org.jbpm.taskmgmt.exe.TaskInstance" >
        <constructor factory="taskFactory" method="createTask" >
            <parameter class="java.lang.String">
                <string>do dishes</string>
            </parameter>
            <parameter class="java.lang.String">
                <string>theotherguy</string>
            </parameter>
        </constructor>
    </bean>
</beans>
```

Beans can be constructed using a **`static factory`** method on a class:

```
<beans>
    <bean name="task" class="org.jbpm.taskmgmt.exe.TaskInstance" >
        <constructor
```

```
            factory-class="org.jbpm.UnexistingTaskInstanceFactory"
            method="createTask" >
            <parameter class="java.lang.String">
                <string>do dishes</string>
            </parameter>
            <parameter class="java.lang.String">
                <string>theotherguy</string>
            </parameter>
        </constructor>
    </bean>
</beans>
```

Use the attribute **`singleton="true"`** to mark each named object as a **`singleton`**. Doing so will ensure that a given **`object factory`** always returns the same object for each request.

NOTE

`Singletons` cannot be shared between different object factories.

The **`singleton`** feature causes differentiation between the methods named **`getObject`** and **`getNewObject`**. Normally, one should use **`getNewObject`** as this clears the **`object factory`**'s *object cache* before the new object graph is constructed.

During construction of the object graph, the *non-singleton objects* are stored in the **`object factory`**'s cache. This allows references to one object to be shared. Bear in mind that the **`singleton object cache`** is different from the **`plain object cache`**. The **`singleton`** cache is never cleared, whilst the plain one is cleared every time a **`getNewObject`** method is started.

Having studied this chapter, one now has a thorough knowledge of the many ways in which the jBPM can be configured.

CHAPTER 4. PERSISTENCE

This chapter provides the reader with detailed insight into the Business Process Manager's "persistence" functionality.

Most of the time, the jBPM is used to execute processes that span several transactions. The main purpose of the *persistence* functionality is to store process executions when *wait states* occur. It is helpful to think of the process executions as *state machines*. The intention is to move the process execution state machine from one state to the next within a single transaction.

A process definition can be represented in any of three different forms, namely XML, Java object or a jBPM database record. (Run-time data and log information can also be represented in either of the latter two formats.)

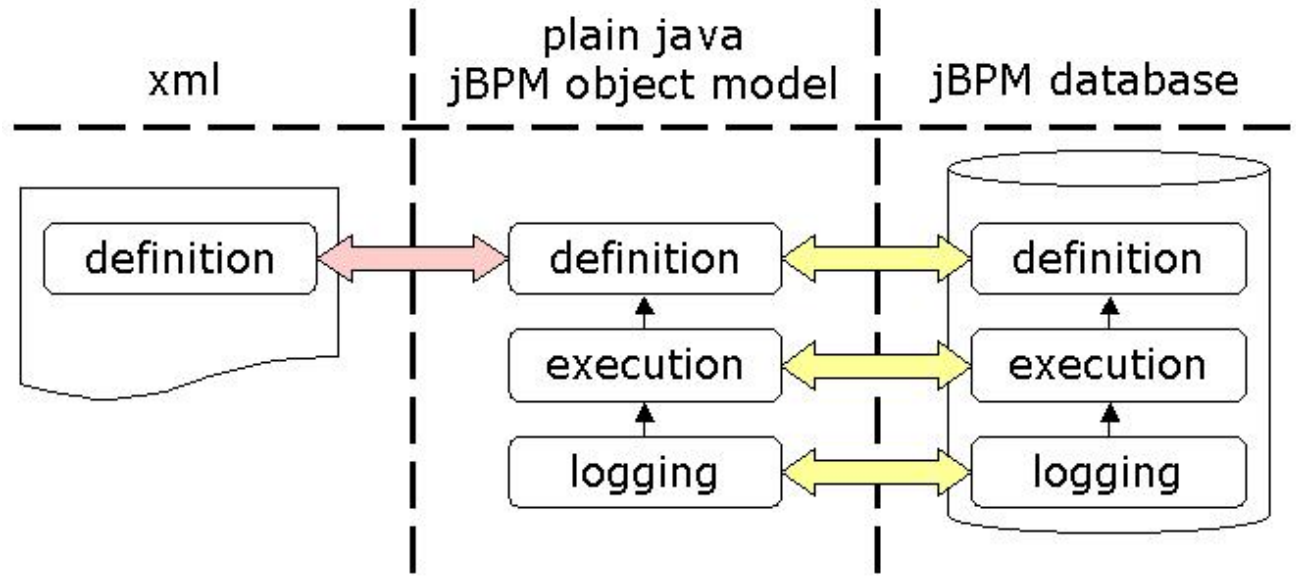
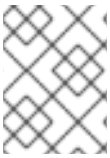


Figure 4.1. The Transformations and Different Forms



NOTE

To learn more about XML representations of process definitions and process archives, see Chapter 14, *jBPM Process Definition Language* .

NOTE

To learn more about how to deploy a process archive to the database, read Section 14.1.1, " Deploying a Process Archive " .

4.1. THE PERSISTENCE APPLICATION PROGRAMMING INTERFACE

4.1.1. Relationship with the Configuration Framework

The persistence application programming interface is integrated with the configuration framework, (see Chapter 3, *Configuration* .) This has been achieved by the exposure of some of the **`convenience persistence`** methods on the **`JbpmContext`**, allowing the jBPM **`context block`** to call persistence API operations.

```
JbpmContext jbpmContext = jbpmConfiguration.createJbpmContext();
```

```
try {
  // Invoke persistence operations here
} finally {
  jbpmContext.close();
}
```

4.1.2. Convenience Methods on JbpmContext

The three most commonly performed persistence operations are:

1. process. deployment
2. new process execution commencement
3. process execution continuation

Process deployment is normally undertaken directly from the **Graphical Process Designer** or from the **`deployprocess` ant** task. However, to do it directly from Java, use this code:

```
JbpmContext jbpmContext = jbpmConfiguration.createJbpmContext();
try {
  ProcessDefinition processDefinition = ...;
  jbpmContext.deployProcessDefinition(processDefinition);
} finally {
  jbpmContext.close();
}
```

Create a new process execution by specifying the process definition of which it will be an instance. The most common way to do this is by referring to the name of the process. The jBPM will then find the latest version of that process in the database. Here is some demonstration code:

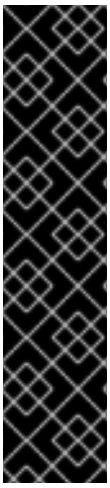
```
JbpmContext jbpmContext = jbpmConfiguration.createJbpmContext();
try {
 String processName = ...;
 ProcessInstance processInstance =
  jbpmContext.newProcessInstance(processName);
} finally {
 jbpmContext.close();
}
```

To continue a process execution, fetch the process instance, the token or the **`taskInstance`** from the database and invoke some methods on the POJO (*Plain Old Java Object*) jBPM objects. Afterwards, save the updates made to the **`processInstance`** into the database.

```
JbpmContext jbpmContext = jbpmConfiguration.createJbpmContext();
try {
 long processInstanceId = ...;
 ProcessInstance processInstance =
  jbpmContext.loadProcessInstance(processInstanceId);
  processInstance.signal();
  jbpmContext.save(processInstance);
} finally {
 jbpmContext.close();
}
```

Note that it is not necessary to explicitly invoke the **jbpmContext.save** method if the **ForUpdate** methods are used in the **JbpmContext** class. This is because the save process will run automatically when the **jbpmContext** class is closed. For example, one may wish to inform the jBPM that a **taskInstance** has completed. This can cause an execution to continue, so the **processInstance** related to the **taskInstance** must be saved. The most convenient way to do this is by using the **loadTaskInstanceForUpdate** method:

```
JbpmContext jbpmContext = jbpmConfiguration.createJbpmContext();
try {
 long taskInstanceId = ...;
 TaskInstance taskInstance =
  jbpmContext.loadTaskInstanceForUpdate(taskInstanceId);
 taskInstance.end();
 }
finally {
  jbpmContext.close();
}
```



IMPORTANT

Read the following explanation to learn how the jBPM manages the persistence feature and uses **Hibernate**'s functionality.

The **JbpmConfiguration** maintains a set of **ServiceFactories**. They are configured via the **jbpm.cfg.xml** file and instantiated as they are needed.

The **DbPersistenceServiceFactory** is only instantiated the first time that it is needed. After that, **ServiceFactory**s are maintained in the **JbpmConfiguration**.

A **DbPersistenceServiceFactory** manages a **Hibernate ServiceFactory** but this is only instantiated the first time that it is requested.

DbPersistenceServiceFactory parameters:

1. **isTransactionEnabled**
2. **sessionFactoryJndiName**
3. **dataSourceJndiName**
4. **isCurrentSessionEnabled**

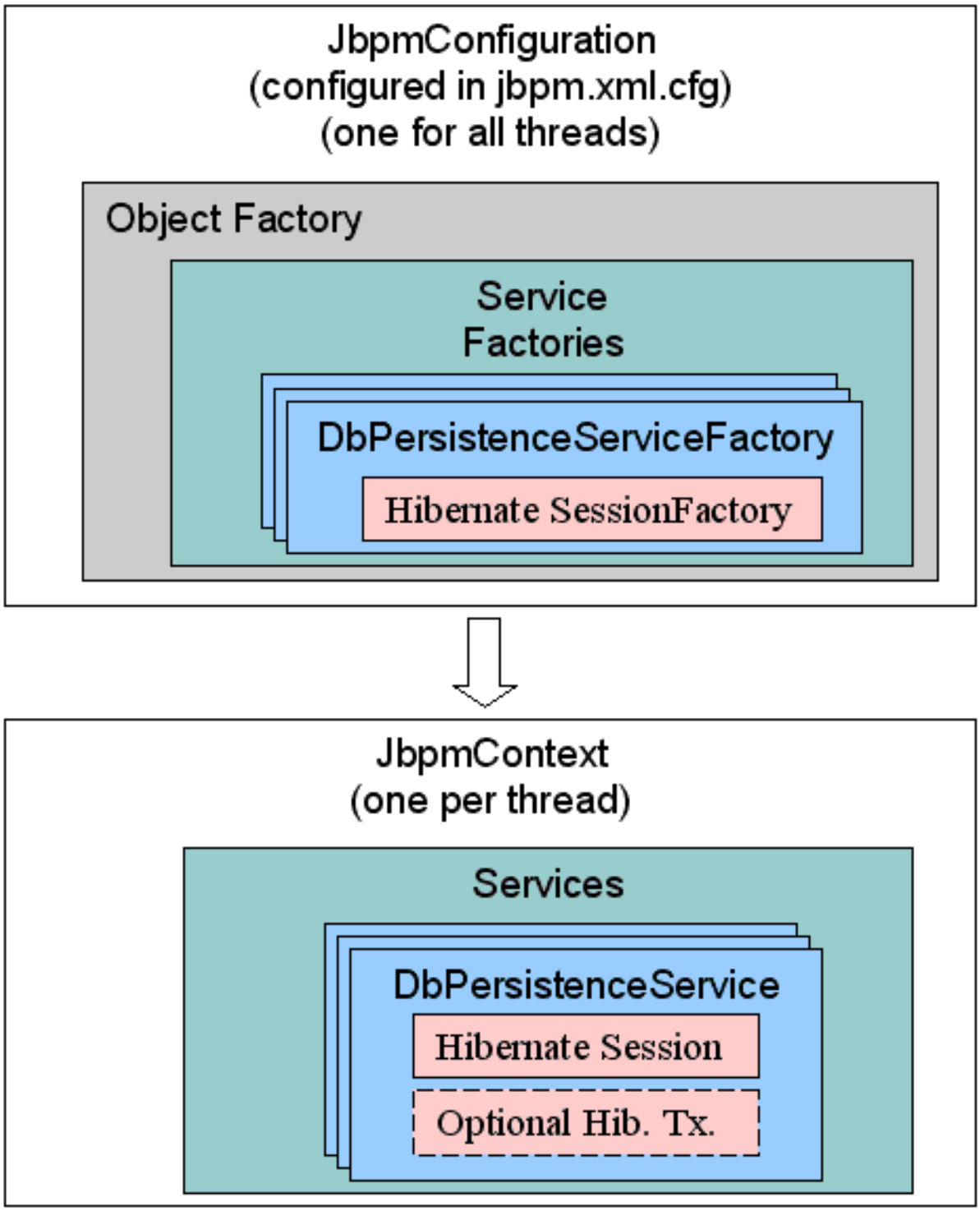


Figure 4.2. The Persistence-Related Classes

When the **`jbpmConfiguration.createJbpmContext()`** class is invoked, only the **`JbpmContext`** is created. No further persistence-related initializations occur at this time. The **`JbpmContext`** manages a **`DbPersistenceService`** class, which is instantiated when it is first requested. The **`DbPersistenceService`** class manages the **Hibernate** session, which is also only instantiated the first time it is required. (In other words, a **Hibernate** session will only be opened when the first operation that requires persistence is invoked.)

4.2. CONFIGURING THE PERSISTENCE SERVICE

4.2.1. The DbPersistenceServiceFactory

The **DbPersistenceServiceFactory** class has three more configuration properties: isTransactionEnabled, sessionFactoryJndiName, and dataSourceJndiName. To specify any of these properties in the **jbpm.cfg.xml** file, specify the Service Factory as a bean within the factory element. This sample code demonstrates how to do so:

```
<jbpm-context>
  <service name="persistence">
    <factory>
      <bean class="org.jbpm.persistence.db.DbPersistenceServiceFactory">
        <field name="isTransactionEnabled"><false /></field>
        <field name="sessionFactoryJndiName">
          <string value="java:/myHibSessFactJndiName" />
        </field>
        <field name="dataSourceJndiName">
          <string value="java:/myDataSourceJndiName" />
        </field>
      </bean>
    </factory>
  </service>
...
</jbpm-context>
```

IMPORTANT

Do not mix the short and long notation for configuring the factories. (See also Section 3.1, “ Customizing Factories ”.) If the factory is just a new instance of a class, use the factory attribute to refer to its factory class name but if properties in a factory require configuration, the long notation must be used and, furthermore, the factory and the bean must be combined as nested elements.

isTransactionEnabled

By default, jBPM will begin a **Hibernate** transaction when the session is retrieved for the first time and, if the **jbpmContext** is closed, the **Hibernate** transaction will be ended. The transaction is then committed or rolled back depending on whether or not **jbpmContext.setRollbackOnly** was called. (The isRollbackOnly property is maintained in the **TxService**.) To disable transactions and prohibit jBPM from managing them with **Hibernate**, set the isTransactionEnabled property value to **false**. (This property only controls the behaviour of the **jbpmContext**; the **DbPersistenceService.beginTransaction()** can still be called directly directly with the application programming interface, which ignores the isTransactionEnabled setting.) To learn more about transactions, please study Section 4.2.2, “ Hibernate Transactions ”.

sessionFactoryJndiName

By default, this is **null**, which means that the session factory will not be fetched from JNDI. If it is set and a session factory is needed in order to create a **Hibernate** session, it will be fetched from JNDI.

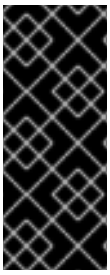
dataSourceJndiName

By default, this is **null**, resulting in creation of JDBC connections being delegated to **Hibernate**. By specifying a data-source, one makes the Business Process Manager fetch a JDBC connection from the data-source and provide it to **Hibernate** whilst opening a new session.

4.2.1.1. The Hibernate Session Factory

By default, the **DbPersistenceServiceFactory** uses the **hibernate.cfg.xml** file in the root of the classpath to create the **Hibernate** session factory. Note that the **Hibernate** configuration file resource is mapped in jbpm.hibernate.cfg.xml. Customise it by reconfiguring **jbpm.cfg.xml**.

```
<jbpm-configuration>
    <!-- configuration resource files pointing to default
         configuration files in jbpm-{version}.jar -->
    <string name='resource.hibernate.cfg.xml'
        value='hibernate.cfg.xml' />
    <!-- <string name='resource.hibernate.properties'
        value='hibernate.properties' /> -->
</jbpm-configuration>
```



IMPORTANT

When resource.hibernate.properties is specified, the properties in that resource file will overwrite all of those in **hibernate.cfg.xml**. Instead of updating the **hibernate.cfg.xml** to point to the database, use hibernate.properties to handle jBPM upgrades. The **hibernate.cfg.xml** file can then be copied without the need to reapply the changes.

4.2.1.2. Configuring a C3PO Connection Pool

Please refer to the Hibernate documentation at http://www.hibernate.org/214.html

4.2.1.3. Configuring an ehCache Provider

To learn how to configure jBPM with **JBossCache**, read http://wiki.jboss.org/wiki/Wiki.jsp?page=JbpmConfiguration

To learn how to configure a cache provider to work with **Hibernate**, study http://www.hibernate.org/hib_docs/reference/en/html/performance.html#performance-cache.

The **hibernate.cfg.xml** file that ships with jBPM includes the following line:

```
<property name="hibernate.cache.provider_class">
    org.hibernate.cache.HashtableCacheProvider
</property>
```

This is provided so that users do not have to concern themselves with configuring classpaths.

WARNING

Do not use **Hibernate**'s **`HashtableCacheProvider`** in a production environment.

To use **ehcache** instead of the **`HashtableCacheProvider`**, simply remove the relevant line from the classpath and substitute **`ehcache.jar`** instead. Note that one might have to search for the right **ehcache** library version that is compatible with one's environment.

4.2.2. Hibernate Transactions

By default, jBPM delegates transactions to **Hibernate** by using the *"session per transaction"* pattern. jBPM will begin a **Hibernate** transaction when a session is opened the first time when a persistent operation is invoked on the **`jbpmContext`**. The transaction will be committed right before the Hibernate session is closed. That will happen inside the **`jbpmContext.close()`**.

Use **`jbpmContext.setRollbackOnly()`** to mark a transaction for rollback. In doing so, the transaction will be rolled back imediately before the session is closed inside the **`jbpmContext.close()`** method.

To prohibit the Business Process Manager from invoking any of the transaction methods via the **Hibernate** application programming interface, set the isTransactionEnabled property to **`false`**, as explained in more detail in Section 4.2.1, “The DbPersistenceServiceFactory”.

4.2.3. JTA Transactions

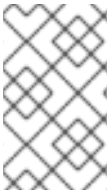
Managed transactions are most commonly found when jBPM is used in the JBoss Application Server. The following code sample shows a common way in which transactions are bound to JTA:

```
<jbpm-context>
  <service name="persistence">
    <factory>
      <bean class="org.jbpm.persistence.db.DbPersistenceServiceFactory">
        <field name="isTransactionEnabled"><false /></field>
        <field name="isCurrentSessionEnabled"><true /></field>
        <field name="sessionFactoryJndiName">
          <string value="java:/myHibSessFactJndiName" />
        </field>
      </bean>
    </factory>
  </service>
</jbpm-context>
```

Next, configure the **Hibernate** session factory to use a data-source and bind **Hibernate** itself to the Transaction Manager. If using more than one datasource, bind them to an **`XA datasource`**.

```
<hibernate-configuration>
    <session-factory>

        <!-- hibernate dialect -->
```

```
        <property name="hibernate.dialect">
            org.hibernate.dialect.HSQLDialect
        </property>

        <!-- DataSource properties (begin) -->
        <property name="hibernate.connection.datasource">
            java:/JbpmDS
        </property>

        <!-- JTA transaction properties (begin) -->
        <property name="hibernate.transaction.factory_class">
            org.hibernate.transaction.JTATransactionFactory
        </property>

        <property name="hibernate.transaction.manager_lookup_class">
            org.hibernate.transaction.JBossTransactionManagerLookup
        </property>

        <property name="jta.UserTransaction">
            java:comp/UserTransaction
        </property>

    </session-factory>
</hibernate-configuration>
```



NOTE

For more information about binding **Hibernate** to a Transaction Manager, please, refer to http://www.hibernate.org/hib_docs/v3/reference/en/html_single/#configuration-optional-transactionstrategy.

Next, configure Hibernate to use an **`XA datasource`**.

These configurations allow the enterprise beans to use CMT whilst the web console uses BMT. (This is why jta.UserTransaction is also specified.)

4.2.4. Customizing Queries

All of the SQL queries that jBPM uses are found in one central configuration file. That resource file is referenced in the **`hibernate.cfg.xml`** configuration file:

```
<hibernate-configuration>
    <!-- hql queries and type defs -->
    <mapping resource="org/jbpm/db/hibernate.queries.hbm.xml" />
</hibernate-configuration>
```

To customize one or more of those queries, make a back-up of the original file. Next, place the customized version somewhere on the classpath, then update the reference to **`org/jbpm/db/hibernate.queries.hbm.xml`** in the **`hibernate.cfg.xml`** to point to the customized version.

4.2.5. Database Compatibility

The jBPM runs on any database that is supported by **Hibernate**.

4.2.5.1. Isolation Level of the JDBC Connection

Set the database isolation level for the JDBC connection to at least **READ_COMMITTED**.

WARNING

If it is set to **READ_UNCOMMITTED**, (isolation level zero, the only isolation level supported by **Hypersonic**), race conditions might occur in the **job executor** .These might also appear when synchronization of multiple tokens is occurring.

4.2.5.2. Changing the Database

In order to reconfigure Business Process Manger to use a different database, follow these steps:

- put the JDBC driver library archive in the classpath.
- update the **Hibernate** configuration used by jBPM.
- create a schema in the new database.

4.2.5.3. The Database Schema

The **jbpm.db** sub-project contains drivers, instructions and scripts to help the user to start using the database of his or her choice. Refer to the **readme.html** (found in the root of the **jbpm.db** project) for more information.

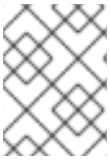
NOTE

Whilst the JBPM is capable of generating DDL scripts for any database, these schemas are not always as efficient as they could be. Consider asking your corporation's Database Administrator to review the generated DDL, so that he or she can optimise the column types and indexes.

The following **Hibernate** configuration option may be of use in a development environment: set hibernate.hbm2ddl.auto to **create-drop** and the schema will be created automatically the first time the database is used in an application. When the application closes down, the schema will be dropped.

4.2.5.3.1. Programmatic database schema operations

jBPM provides an API for creating and droping the database schema through the **org.jbpm.JbpmConfiguration** methods **createSchema** and **dropSchema**. Be aware that there is no constraint on invoking these methods other than the privileges of the configured database user.



NOTE

The aforementioned APIs constitute a facade to the broader functionality offered by class **org.jbpm.db.JbpmSchema**:

4.2.5.4. Combining Hibernate Classes

Combining **Hibernate** and jBPM persistent classes brings about two major benefits. Session, connection and transaction management become easier because, by combining them into one **Hibernate** session factory, there will be only one **Hibernate** session and one JDBC connection. Hence, the jBPM updates will be in the same transaction as the updates for the domain model. This eliminates the need for a transaction manager.

Secondly, it enables one to drop one's **Hibernate** persistence object into the process variables without any additional work.

To make this occur, create one central **`hibernate.cfg.xml`** file. It is easiest to use the default jBPM **`hibernate.cfg.xml`** as a starting point and add references to one's own **Hibernate** mapping files to customize it.

4.2.5.5. Customizing the jBPM Hibernate Mapping Files

Follow these steps to customize any of the jBPM **Hibernate** mapping files:

1. copy the jBPM **Hibernate** mapping files from the sources (**`src/jbpm-jpdl-sources.jar`**).
2. place the copy somewhere on the classpath, (ensuring that it is not the same location as they were in previously.
3. update the references to the customized mapping files in **`hibernate.cfg.xml`**

4.2.5.6. Second Level Cache

jBPM uses **Hibernate**'s *second level cache* to keep the process definitions in memory after loading they have been loaded once. The process definition classes and collections are configured in the **Hibernate** mapping files so that the cache element looks like this:

```
<cache usage="nonstrict-read-write"/>
```

Since process definitions will never change, it is acceptable to keep them in the second level cache. (See also Section 14.1.3, “ Changing Deployed Process Definitions ”.)

The default caching strategy is set to **`nonstrict-read-write`**. During run-time execution, the process definitions remain static, allowing maximum caching to be achieved. In theory, setting the caching strategy **`read-only`** would be even better for run-time execution but, that setting would not permit the deployment of new process definitions.

Having read this chapter, you have learned a great deal of theoretical information and practical advice relating to the topic of persistence in jBPM, including how to utilize **Hibernate** to its fullest potential.

CHAPTER 5. JAVA EE APPLICATION SERVER FACILITIES

Read this chapter to learn about the facilities offered by the jBPM to that can be used to leverage the Java EE infrastructure.

5.1. ENTERPRISE BEANS

The **CommandServiceBean** is a *stateless session bean* that runs Business Process Manager commands by calling its **execute** method within a separate jBPM context. The available environment entries and customizable resources are summarized in the following table:

Table 5.1. Command Service Bean Environment

Name	Type	Description
JbpmCfgResource	Environment Entry	This the classpath resource from which the jBPM configuration is read. Optional, defaults to **jbpm.cfg.xml**.
ejb/TimerEntityBean	EJB Reference	This is a link to the local entity bean that implements the scheduler service. Required for processes that contain timers.
jdbc/JbpmDataSource	Resource Manager Reference	This is the logical name of the data source that provides JDBC connections to the jBPM persistence service. Must match the hibernate.connection.datasource property in the Hibernate configuration file.
jms/JbpmConnectionFactory	Resource Manager Reference	This is the logical name of the factory that provides JMS connections to the jBPM message service. Required for processes that contain asynchronous continuations.
jms/JobQueue	Message Destination Reference	The jBPM message service sends job messages to this queue. To ensure this is the same queue from which the job listener bean receives messages, the **message-destination-link** points to a common logical destination, **JobQueue**.
jms/CommandQueue	Message Destination Reference	The command listener bean receives messages from this queue. To ensure this is the same queue to which command messages can be sent, the **message-destination-link element** points to a common logical destination, **CommandQueue**.

The **CommandListenerBean** is a message-driven bean that listens to the **CommandQueue** for command messages. It delegates command execution to the **CommandServiceBean**.

The body of the message must be a Java object that can implement the **org.jbpm.Command**

interface. (The message properties, if any, are ignored.) If the message is not of the expected format, it is forwarded to the **DeadLetterQueue** and will not be processed any further. The message will also be rejected if the destination reference is absent.

If a received message specifies a **replyTo** destination, the command execution result will be wrapped in an **object message** and sent there.

The **command connection factory environment reference** points to the resource manager being used to supply Java Message Service connections.

Conversely, **JobListenerBean** is a message-driven bean that listens to the **JbpmJobQueue** for job messages, in order to support *asynchronous continuations*.

NOTE

Be aware that the message must have a property called jobId of type **long**. This property must contain references to a pending Job in the database. The message body, if it exists, is ignored.

This bean extends the **CommandListenerBean**. It inherits the latter's environmental entries and those resource references that can be customized.

Table 5.2. Command/Job listener bean environment

Name	Type	Description
ejb/LocalCommandServiceBean	EJB Reference	This is a link to the local session bean that executes commands on a separate jBPM context.
jms/JbpmConnectionFactory	Resource Manager Reference	This is the logical name of the factory that provides Java Message Service connections for producing result messages. Required for command messages that indicate a reply destination.
jms/DeadLetterQueue	Message Destination Reference	Messages which do not contain a command are sent to the queue referenced here. It is optional. If it is absent, such messages are rejected, which may cause the container to redeliver.
-		

Name	Type	Description
Message Destination Reference	Messages which do not contain a command are sent to the queue referenced here. If it is absent, such messages are rejected, which may cause the container to redeliver.	

The **`TimerEntityBean`** is used by the *Enterprise Java Bean timer service* for scheduling. When the bean expires, timer execution is delegated to the **`command service`** bean.

The **`TimerEntityBean`** requires access to the Business Process Manager's data source. The Enterprise Java Bean deployment descriptor does not define how an entity bean is to map to a database. (This is left to the container provider.) In the **JBoss Application Server**, the jbosscmp-jdbc.xml descriptor defines the data source's JNDI name and relational mapping data (such as the table and column names).

NOTE

The JBoss CMP (*container-managed persistence*) descriptor uses a global JNDI name (**`java:JbpmDS`**), as opposed to a resource manager reference (**`java:comp/env/jdbc/JbpmDataSource`**).

NOTE

Earlier versions of the Business Process Manager used a stateless session bean called **`TimerServiceBean`** to interact with the Enterprise Java Bean timer service. The session approach had to be abandoned because it caused an unavoidable bottleneck for the **`cancelation`** methods. Because session beans have no identity, the timer service was forced to iterate through *all* the timers to find the ones it had to cancel.

The bean is still available for backwards compatibility purposes. It works in the same environment as the **`TimerEntityBean`**, so migration is easy.

Table 5.3. Timer Entity/Service Bean Environment

Name	Type	Description
`ejb/LocalCommandServiceBean`	EJB Reference	This is a link to the local session bean that executes timers on a separate jBPM context.

5.2. JBPM ENTERPRISE CONFIGURATION

The following configuration items are included in **`jbpm.cfg.xml`**:

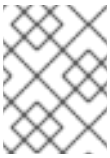
```
<jbpm-context>
  <service name="persistence"
    factory="org.jbpm.persistence.jta.JtaDbPersistenceServiceFactory" />
  <service name="message"
    factory="org.jbpm.msg.jms.JmsMessageServiceFactory" />
  <service name="scheduler"
    factory="org.jbpm.scheduler.ejbtimer.EntitySchedulerServiceFactory" />
</jbpm-context>
```

The **`JtaDbPersistenceServiceFactory`** allows the Business Process Manager to participate in JTA transactions. If an existing transaction is underway, the JTA persistence service "clings" to it; otherwise it starts a new transaction. The Business Process Manager's enterprise beans are configured to delegate transaction management to the container. However, a new one will be started automatically if one creates a JbpmContext in an environment in which no transaction is active (such as a web application.) The JTA **`persistence service factory`** contains the configurable fields described below.

isCurrentSessionEnabled

When this is set to **`true`**, the Business Process Manager will use the "current" **Hibernate** session associated with the ongoing JTA transaction. This is the default setting. (See http://www.hibernate.org/hib_docs/v3/reference/en/html/architecture.html#architecture-current-session for more information.)

Use the same session as by jBPM in other parts of the application by taking advantage of the contextual session mechanism. Do so through a call to **`SessionFactory.getCurrentSession()`**. Alternatively, supply a **Hibernate** session to jBPM by setting isCurrentSessionEnabled to **`false`** and injecting the session via the **`JbpmContext.setSession(session)`** method. This also ensures that jBPM uses the same **Hibernate** session as other parts of the application.



NOTE

The **Hibernate** session can be injected into a stateless session bean (via a persistence context, for example).

isTransactionEnabled

When this is set to **`true`**, jBPM will begin a transaction through **Hibernate**'s **`transaction API`**, using the **`JbpmConfiguration.createJbpmContext()`** method to commit it. (The **Hibernate** session is closed when **`JbpmContext.close()`** is called.)

WARNING

This is not the desired behavior when the Business Process Manager is deployed as an EAR and hence isTransactionEnabled is set to **`false`** by default. (See http://www.hibernate.org/hib_docs/v3/reference/en/html/transactions.html#transactions-demarcation for more details.)

`JmsMessageServiceFactory` delivers **`asynchronous continuation messages`** to the **`JobListenerBean`** by leveraging the reliable communication infrastructure exposed through the Java Message Service interfaces. The **`JmsMessageServiceFactory`** exposes the following configurable fields:

connectionFactoryJndiName

This is the name of the JMS connection factory in the JNDI initial context. It defaults to **`java:comp/env/jms/JbpmConnectionFactory`**.

destinationJndiName

This is the name of the JMS destination to which job messages will be sent. It must match the destination from which **`JobListenerBean`** receives messages. It defaults to **`java:comp/env/jms/JobQueue`**.

isCommitEnabled

This specifies whether the Business Process Manager should commit the Java Message Service session upon **`JbpmContext.close()`**. Messages produced by the JMS message service are never meant to be received before the current transaction commits; hence the sessions created by the service are always transacted. The default value is **`false`**, which is appropriate when the **`connection factory`** in use is XA-capable, as the messages produced by the Java Message Service session will be controlled by the overall JTA transaction. This field should be set to **`true`** if the JMS connection factory is not XA-capable so that the Business Process Manager explicitly commits the JMS session's local transaction.

The **`EntitySchedulerServiceFactory`** is used to schedule business process timers. It does so by building upon on the transactional notification service for timed events provided by the Enterprise Java Bean container. The EJB **`scheduler service factory`** has the configurable field described below.

timerEntityHomeJndiName

This is the name of the **`TimerEntityBean`**'s local home interface in the JNDI initial context. The default value is **`java:comp/env/ejb/TimerEntityBean`**.

5.3. HIBERNATE ENTERPRISE CONFIGURATION

The **`hibernate.cfg.xml`** file includes the following configuration items. Modify them to support other databases or application servers.

```
<!-- sql dialect -->
<property name="hibernate.dialect">
    org.hibernate.dialect.HSQLDialect
</property>

<property name="hibernate.cache.provider_class">
  org.hibernate.cache.HashtableCacheProvider
</property>

<!-- DataSource properties (begin) -->
<property name="hibernate.connection.datasource">
    java:comp/env/jdbc/JbpmDataSource
</property>
<!-- DataSource properties (end) -->

<!-- JTA transaction properties (begin) -->
<property name="hibernate.transaction.factory_class">
  org.hibernate.transaction.JTATransactionFactory
</property>
<property name="hibernate.transaction.manager_lookup_class">
  org.hibernate.transaction.JBossTransactionManagerLookup
</property>
<!-- JTA transaction properties (end) -->

<!-- CMT transaction properties (begin) ===
<property name="hibernate.transaction.factory_class">
  org.hibernate.transaction.CMTTransactionFactory
</property>
<property name="hibernate.transaction.manager_lookup_class">
  org.hibernate.transaction.JBossTransactionManagerLookup
</property>
==== CMT transaction properties (end) -->
```

Replace the **`hibernate.dialect`** setting with that which is appropriate for your database management system. (For more information, read http://www.hibernate.org/hib_docs/v3/reference/en/html/session-configuration.html#configuration-optional-dialects.)

The **`HashtableCacheProvider`** can be replaced with other supported cache providers. (Refer to http://www.hibernate.org/hib_docs/v3/reference/en/html/performance.html#performance-cache for more information.)

Out of the box, jBPM is configured to use the **`JTATransactionFactory`**. If an existing transaction is underway, the JTA transaction factory uses it; otherwise it creates a new transaction. The jBPM enterprise beans are configured to delegate transaction management to the container. However, if the jBPM APIs are being used in a context in which no transaction is active (such as a web application), one will be started automatically.

To prevent unintended transaction creations when using *container-managed transactions*, switch to the **`CMTTransactionFactory`**. This setting ensures that **Hibernate** will always look for an existing transaction and will report a problem if none is found.

5.4. CLIENT COMPONENTS

Ensure that the appropriate environmental references are in place for deployment descriptors for client components written directly against those Business Process Manager APIs that can leverage the enterprise services. The descriptor below can be regarded as typical for a client session bean:

```
<session>

  <ejb-name>MyClientBean</ejb-name>
  <home>org.example.RemoteClientHome</home>
  <remote>org.example.RemoteClient</remote>
  <local-home>org.example.LocalClientHome</local-home>
  <local>org.example.LocalClient</local>
  <ejb-class>org.example.ClientBean</ejb-class>
  <session-type>Stateless</session-type>
  <transaction-type>Container</transaction-type>

  <ejb-local-ref>
    <ejb-ref-name>ejb/TimerEntityBean</ejb-ref-name>
    <ejb-ref-type>Entity</ejb-ref-type>
    <local-home>org.jbpm.ejb.LocalTimerEntityHome</local-home>
    <local>org.jbpm.ejb.LocalTimerEntity</local>
  </ejb-local-ref>

  <resource-ref>
    <res-ref-name>jdbc/JbpmDataSource</res-ref-name>
    <res-type>javax.sql.DataSource</res-type>
    <res-auth>Container</res-auth>
  </resource-ref>

  <resource-ref>
    <res-ref-name>jms/JbpmConnectionFactory</res-ref-name>
    <res-type>javax.jms.ConnnectionFactory</res-type>
    <res-auth>Container</res-auth>
  </resource-ref>

  <message-destination-ref>
    <message-destination-ref-name>
        jms/JobQueue
    </message-destination-ref-name>
    <message-destination-type>javax.jms.Queue</message-destination-type>
    <message-destination-usage>Produces</message-destination-usage>
  </message-destination-ref>

</session>
```

The environmental references above can be bound to resources in the target operational environment as follows. Note that the JNDI names match the values used by the Business Process Manager enterprise beans.

```
<session>

  <ejb-name>MyClientBean</ejb-name>
  <jndi-name>ejb/MyClientBean</jndi-name>
  <local-jndi-name>java:ejb/MyClientBean</local-jndi-name>

  <ejb-local-ref>
    <ejb-ref-name>ejb/TimerEntityBean</ejb-ref-name>
```

```
    <local-jndi-name>java:ejb/TimerEntityBean</local-jndi-name>
  </ejb-local-ref>

  <resource-ref>
    <res-ref-name>jdbc/JbpmDataSource</res-ref-name>
    <jndi-name>java:JbpmDS</jndi-name>
  </resource-ref>

  <resource-ref>
    <res-ref-name>jms/JbpmConnectionFactory</res-ref-name>
    <jndi-name>java:JmsXA</jndi-name>
  </resource-ref>

  <message-destination-ref>
    <message-destination-ref-name>
        jms/JobQueue
    </message-destination-ref-name>
    <jndi-name>queue/JbpmJobQueue</jndi-name>
  </message-destination-ref>

</session>
```

If the client component is a web application, as opposed to an enterprise bean, the deployment descriptor will look like this:

```
<web-app>

  <servlet>
    <servlet-name>MyClientServlet</servlet-name>
    <servlet-class>org.example.ClientServlet</servlet-class>
  </servlet>

  <servlet-mapping>
    <servlet-name>MyClientServlet</servlet-name>
    <url-pattern>/client/servlet</url-pattern>
  </servlet-mapping>

  <ejb-local-ref>
    <ejb-ref-name>ejb/TimerEntityBean</ejb-ref-name>
    <ejb-ref-type>Entity</ejb-ref-type>
    <local-home>org.jbpm.ejb.LocalTimerEntityHome</local-home>
    <local>org.jbpm.ejb.LocalTimerEntity</local>
    <ejb-link>TimerEntityBean</ejb-link>
  </ejb-local-ref>

  <resource-ref>
    <res-ref-name>jdbc/JbpmDataSource</res-ref-name>
    <res-type>javax.sql.DataSource</res-type>
    <res-auth>Container</res-auth>
  </resource-ref>

  <resource-ref>
    <res-ref-name>jms/JbpmConnectionFactory</res-ref-name>
    <res-type>javax.jms.ConnectionFactory</res-type>
    <res-auth>Container</res-auth>
  </resource-ref>
```

```
  <message-destination-ref>
    <message-destination-ref-name>
        jms/JobQueue
    </message-destination-ref-name>
    <message-destination-type>javax.jms.Queue</message-destination-type>
    <message-destination-usage>Produces</message-destination-usage>
    <message-destination-link>JobQueue</message-destination-link>
  </message-destination-ref>

</web-app>
```

The above environmental references can also be bound to resources in the target operational environment, as per this code sample:

```
<jboss-web>

  <ejb-local-ref>
    <ejb-ref-name>ejb/TimerEntityBean</ejb-ref-name>
    <local-jndi-name>java:ejb/TimerEntityBean</local-jndi-name>
  </ejb-local-ref>

  <resource-ref>
    <res-ref-name>jdbc/JbpmDataSource</res-ref-name>
    <jndi-name>java:JbpmDS</jndi-name>
  </resource-ref>

  <resource-ref>
    <res-ref-name>jms/JbpmConnectionFactory</res-ref-name>
    <jndi-name>java:JmsXA</jndi-name>
  </resource-ref>

  <message-destination-ref>
    <message-destination-ref-name>
        jms/JobQueue
    </message-destination-ref-name>
    <jndi-name>queue/JbpmJobQueue</jndi-name>
  </message-destination-ref>

</jboss-web>
```

5.5. CONCLUSION

Having studied this chapter, you should now have a thorough understanding of the facilities offered by the jBPM that can be used to leverage the Java EE infrastructure and should be comfortable with testing some of these in your corporate environment.

CHAPTER 6. PROCESS MODELING

6.1. SOME HELPFUL DEFINITIONS

Read this section to learn the terminology that you will find used throughout the rest of this book.

A *process definition* represents a formal specification of a business process and is based on a *directed graph*. The graph is composed of nodes and transitions. Every node in the graph is of a specific type. The node type defines the run-time behavior. A process definition only has one start state.

A *token* is one path of execution. A token is the runtime concept that maintains a pointer to a node in the graph.

A *process instance* is one execution of a process definition. When a process instance is created, a token is generated for the main path of execution. This token is called the *root token* of the process instance and it is positioned in the *start state* of the process definition.

A signal instructs a token to continue to execute the graph. When it receives an unnamed signal, the token will leave its current node over the default *leaving transition*. When a *transition-name* is specified in the signal, the token will leave its node over the specified transition. A signal given to the process instance is delegated to the root token.

After the token has entered a node, the node is executed. Nodes themselves are responsible for making the graph execution continue. Continuation of graph execution is achieved by making the token leave the node. Each type of node can implement a different behavior for the continuation of the graph execution. A node that does not pass on the execution will behave as a *state*.

Actions are pieces of Java code that are executed upon events during the process execution. The *graph* is an important instrument in the communication of software requirements but it is just one view (*projection*) of the software being produced. It hides many technical details. Actions are a mechanism used to add technical details beyond those of the graphical representation. Once the graph is put in place, it can be decorated with actions. The main *event types* are **`entering a node`**, **`leaving a node`** and **`taking a transition`**.

Having learned these definitions, read on to find out how process modelling works.

6.2. PROCESS GRAPH

A process definition is a graph that is made up of nodes and transitions. This information is expressed in XML and found in a file called **`processdefinition.xml`**. Each node must have a *type* (examples being **`state`**, **`decision`**, **`fork`** and **`join`**.) Each node has a set of *leaving transitions*. Names can be given to the transitions that leave a node in order to make them distinct from each other. For example, the following diagram shows a process graph for an auction process.

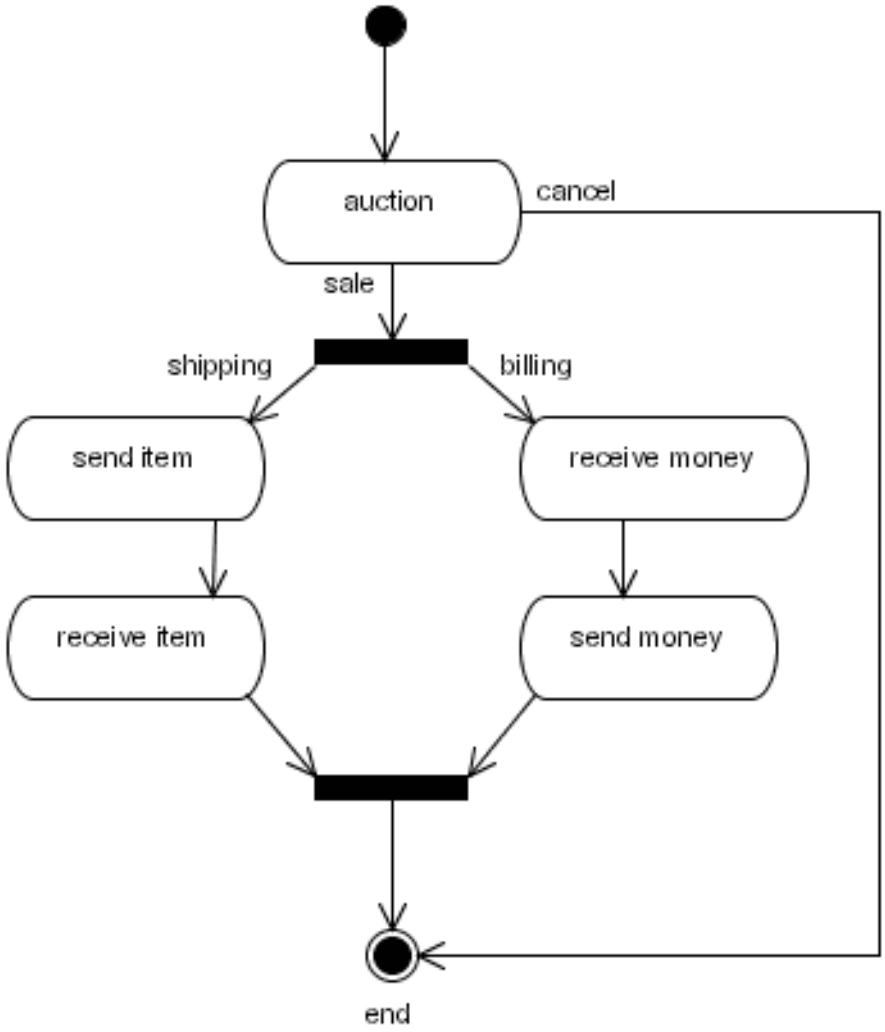


Figure 6.1. The auction process graph

Below is the process graph for the same auction process represented in XML:

```
<process-definition>

  <start-state>
    <transition to="auction" />
  </start-state>

  <state name="auction">
    <transition name="auction ends" to="salefork" />
    <transition name="cancel" to="end" />
  </state>

  <fork name="salefork">
    <transition name="shipping" to="send item" />
    <transition name="billing" to="receive money" />
  </fork>

  <state name="send item">
    <transition to="receive item" />
  </state>

  <state name="receive item">
```

```
    <transition to="salejoin" />
  </state>

  <state name="receive money">
    <transition to="send money" />
  </state>

  <state name="send money">
    <transition to="salejoin" />
  </state>

  <join name="salejoin">
    <transition to="end" />
  </join>

  <end-state name="end" />

</process-definition>
```

6.3. NODES

A process graph is made up of nodes and transitions. Each node is of a specific type. The node type determines what will happen when an execution arrives in the node at run-time. The Business Process Manager provides a set of node types to use. Alternatively, you can write custom codes to implement a specific node behavior.

6.3.1. Node Responsibilities

Each node has two main responsibilities: firstly, it can execute plain Java code, code which will normally relate to the function of the node. Its second responsibility is to pass on the process execution.

A node may face the following options when it attempts to pass the process execution on. It will follow that course which is most applicable:

1. it can not propagate the execution. (The node behaves as a **`wait state`**.)
2. it can propagate the execution over one of the node's **`leaving transitions`**. (This means that the token that originally arrived in the node is passed over one of the **`leaving transitions`** with the API call **`executionContext.leaveNode(String)`**.) The node will now act automatically in the sense that it will execute some custom programming logic and then continue the process execution automatically without waiting.
3. a node can "decide" to create new tokens, each of which will represent a new path of execution. Each of these new tokens can be launched over the node's **`leaving transitions`**. A good example of this kind of behavior is the **`fork node`**.
4. it can end the path of execution. This means that the token has concluded.
5. it can modify the whole *run-time structure* of the process instance. The run-time structure is a process instance that contains a tree of tokens, each of which represents a path of execution. A node can create and end tokens, put each token in a node of the graph and launch tokens over transitions.

The Business Process Manager contains a set of pre-implemented node types, each of which has a specific configuration and behavior. However, you can also write your own node behavior and use it in a process.

6.3.2. Node Type: Task Node

A *task node* represents one or more tasks that are to be performed manually. Thus, when the execution process arrives in a node, task instances will be created in the lists belonging to the workflow participants. After that, the node will enter a **`wait state`**. When the users complete their tasks, the execution will be triggered, making it resume.

6.3.3. Node Type: State

A *state* is a "bare bones" **`wait state`**. It differs from a task node in that no task instances will be created for any task list. This can be useful if the process is waiting for an external system. After that, the process will go into a wait state. When the external system send a response message, a **`token.signal()`** is normally invoked, triggering the resumption of the process execution.

6.3.4. Node Type: Decision

There are two ways in which one can model a decision, the choice as to which to use being left to the discretion of the user. The options are:

1. the decision is made by the process, and is therefore specified in the process definition,
2. an external entity decides.

When the decision is to be undertaken by the process, use a **`decision node`**. Specify the decision criteria in one of two ways, the simplest being to add condition elements to the transitions. (Conditions are EL expressions or beanshell scripts that return a Boolean value.)

At run-time, the decision node will loop over those **`leaving transitions`** which have conditions have been specified. It will evaluate those transitions first in the order specified in the XML. The first transition for which the condition resolves to **`true`** will be taken. If the conditions for all transitions resolve to **`false`**, the default transition, (the first in the XML), will taken instead. If no default transition is found, a JbpmException is thrown.

The second approach is to use an expression that returns the name of the transition to take. Use the expression attribute to specify an expression on the decision. This will need to resolve to one of the decision node's **`leaving transitions`**.

One can also use the handler element on the decision, as this element can be used to specify an implementation of the **`DecisionHandler`** interface that can be specified on the decision node. In this scenario, the decision is calculated by a Java class and the selected **`leaving transition`** is returned by the **`decide`** method, which belongs to the **`DecisionHandler`** implementation.

When the decision is undertaken by an external party, always use multiple transitions that will leave a **`state`** or **`wait state`** node. The leaving transition can then be provided in the external trigger that resumes execution after the **`wait state`** is finished (these might, for example, be **`Token.signal(String transitionName)`** or **`TaskInstance.end(String transitionName)`**.)

6.3.5. Node Type: Fork

A fork splits a single path of execution into multiple concurrent ones. By default, the fork creates a child token for each transition that leaves it, (thereby creating a parent-child relation between the tokens that arrives in the fork.)

6.3.6. Node Type: Join

By default, the join assumes that all tokens that arrive within itself are children of the same parent. (This situation occurs when using the fork as mentioned above and when all tokens created by a fork arrive in the same join.)

A join will end every token that enters it. It will then examine the parent-child relation of those tokens. When all sibling tokens have arrived in the join, the parent token will be passed through to the **`leaving transition`**. When there are still sibling tokens active, the join will behave as a **`wait state`**.

6.3.7. Node Type: Node

Use this node to avoid writing custom code. It expects only one sub-element action, which will be run when the execution arrives in the node. Custom code written in **`actionhandler`** can do anything but be aware that it is also responsible for passing on the execution. (See Section 6.3.1, " Node Responsibilities " for more information.)

This node can also be used when one is utilizing a Java API to implement some functional logic for a corporate business analyst. It is advantageous to do so this way because the node remains visible in the graphical representation of the process. (Use actions to add code that is invisible in the graphical representation of the process.)

6.4. TRANSITIONS

Transitions have both source and destination nodes. The source node is represented by the property from and the destination is represented by to.

A transition can, optionally, be given a name. (Most features of the Business Process Manager depend on transitions being given unique names.) If more than one transition has the same name, the first of these will be taken. (In case duplicate transition names occur in a node, the **`Map getLeavingTransitionsMap()`** method will return less elements than **`List getLeavingTransitions()`**.)

6.5. ACTIONS

Actions are pieces of java code that are executed upon events in the process execution. The graph is an important instrument in the communication about software requirements. But the graph is just one view (projection) of the software being produced. It hides many technical details. Actions are a mechanism to add technical details outside of the graphical representation. Once the graph is put in place, it can be decorated with actions. This means that java code can be associated with the graph without changing the structure of the graph. The main event types are entering a node, leaving a node and taking a transition.

IMPORTANT

There is a difference between an action that is placed on an event and an action that is placed in a node. Actions that are put in events are executed when the event fires. They have no way to influence the flow of control of the process. (It is similar to the *observer pattern*.) By contrast, an action placed on a node has the responsibility of passing on the execution.

Read this section to study an example of an action on an event. It demonstrates how to undertake a database update on a given transition. (The database update is technically vital but it is not of importance to the business analyst.)

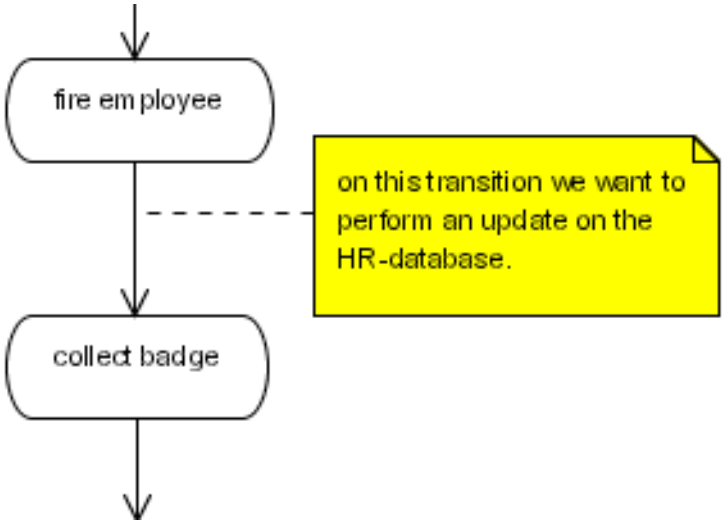


Figure 6.2. A database update action

```
public class RemoveEmployeeUpdate implements ActionHandler {
  public void execute(ExecutionContext ctx) throws Exception {
    // get the fired employee from the process variables.
    String firedEmployee =
      (String) ctx.getContextInstance().getVariable("fired employee");

    // by taking the same database connection as used for the jbpm
    // updates, we reuse the jbpm transaction for our database update.
    Connection connection =

ctx.getProcessInstance().getJbpmSession().getSession().getConnection();
    Statement statement = connection.createStatement();
    statement.execute("DELETE FROM EMPLOYEE WHERE ...");
    statement.execute();
    statement.close();
  }
}
```

```
<process-definition name="yearly evaluation">
  <state name="fire employee">
    <transition to="collect badge">
      <action class="com.nomercy.hr.RemoveEmployeeUpdate" />
    </transition>
  </state>

  <state name="collect badge">

</process-definition>
```

6.5.1. Action References

Actions can be given names. This allows for them be referenced from other locations in which actions are specified. Named actions can also be added to the process definition as *child elements*.

Use this feature to limit duplication of action configurations. (This is particularly helpful when the action has complicated configurations or when run-time actions have to be scheduled or executed.)

6.5.2. Events

Events are specific moments in the execution of the process. The Business Process Manager's engine will "fire" events during *graph execution*, which occurs when the software calculates the next state, (in other words, when it processes a signal.) An event is always relative to an element in the process definition.

Most process elements can fire different types of events. A node, for example, can fire both **`node-enter`** and **`node-leave`** events. (Events are the "hooks" for actions. Each event has a list of actions. When the jBPM engine fires an event, the list of actions is executed.)

6.5.3. Passing On Events

A *super-state* creates a parent-child relation in the elements of a process definition. (Nodes and transitions contained in a super-state will have that superstate as a parent. Top-level elements have the process definition as their parent which, itself, does not have a further parent.) When an event is fired, the event will be passed up the parent hierarchy. This allows it both to capture all transition events in a process and to associate actions with these events via a centralized location.

6.5.4. Scripts

A *script* is an action that executes a **Beanshell** script. (For more information about **Beanshell**, see http://www.beanshell.org/.) By default, all process variables are available as script variables but no script variables will be written to the process variables. The following script-variables are available:

- executionContext
- token
- node
- task
- taskInstance

```
<process-definition>
  <event type="node-enter">
    <script>
      System.out.println("this script is entering node "+node);
    </script>
  </event>
  ...
</process-definition>
```

To customize the default behavior of loading and storing variables into the script, use the variable element as a sub-element of script. If doing so, also place the script expression into the script as a sub-element: expression.

```
<process-definition>
  <event type="process-end">
    <script>
      <expression>
```

```
        a = b + c;
      </expression>
      <variable name='XXX' access='write' mapped-name='a' />
      <variable name='YYY' access='read' mapped-name='b' />
      <variable name='ZZZ' access='read' mapped-name='c' />
    </script>
  </event>
  ...
</process-definition>
```

Before the script starts, the process variables **YYY** and **ZZZ** will be made available to the script as script-variables **b** and **c** respectively. After the script is finished, the value of script-variable **a** is stored into the process variable **XXX**.

If the variable's access attribute contains **`read`**, the process variable will be loaded as a script variable before the script is evaluated. If the access attribute contains **`write`**, the script variable will be stored as a process variable after evaluation. The mapped-name attribute can make the process variable available under another name in the script. Use this when the process variable names contain spaces or other invalid characters.

6.5.5. Custom Events

Run custom events at will during the execution of a process by calling the **`GraphElement.fireEvent(String eventType, ExecutionContext executionContext);`** method. Choose the names of the event types freely.

6.6. SUPER-STATES

A super-state is a group of nodes. They can be nested recursively and are used to add a hierarchy to the process definition. For example, this functionality is useful to group the nodes belonging to a process in phases.

Actions can be associated with super-state events. Events fired by tokens in nested nodes bubble up the super-state hierarchy up to the process definition. The token therefore acts as being in every node in the hierarchy at the same time. This can be convenient when checking if a process execution is in, for example, the start-up phase.

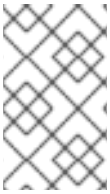
6.6.1. Super-State Transitions

Any transition leaving a super-state can be taken by a token positioned in any node within that super-state. One use case for this feature is to model a *cancel* transition which can be taken at any time.

Transitions can also arrive in super-states, in which case the token will be redirected to the first node in document order. Furthermore, nodes which are outside the super-state can have transitions directly to nodes that are inside it and vice versa. Finally, as any other node, super-states can also self-transition.

6.6.2. Super-State Events

Two events are unique to super-states, these being **`superstate-enter`** and **`superstate-leave`**. They will be fired irrespective of which transitions the node has entered or left. As long as a token takes transitions within the super-state, these events will not be fired.



NOTE

There are separate event types for states and super-states. The software was designed this way in order to make it easy to distinguish between actual super-state events and node events which have been passed from within the super-state.

6.6.3. Hierarchical Names

Node names have to be unique within their *scope*. The scope of the node is its *node-collection*. Both the process definition and the super-state are node collections. To refer to nodes in super-states, specify the relative, slash (`/`) separated name. The slash separates the node names. Use `..` to refer to an upper level. The next example shows how to refer to a node in a super-state:

```
<process-definition>
  <state name="preparation">
    <transition to="phase one/invite murphy"/>
  </state>
  <super-state name="phase one">
    <state name="invite murphy"/>
  </super-state>
</process-definition>
```

The next example shows how to travel up the super-state hierarchy:

```
<process-definition>
  <super-state name="phase one">
    <state name="preparation">
      <transition to="../phase two/invite murphy"/>
    </state>
  </super-state>
  <super-state name="phase two">
    <state name="invite murphy"/>
  </super-state>
</process-definition>
```

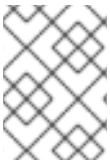
6.7. EXCEPTION HANDLING

The Business Process Manager's exception handling mechanism only works for Java exceptions. Graph execution cannot, of itself, result in problems. It is only when *delegation classes* are executed that exceptions can occur.

A list of **`exception-handler`**s can be specified on **`process-definition`**s, **`node`**s and **`transition`**s. Each of these exception handlers has a list of actions. When an exception occurs in a delegation class, the process element's parent hierarchy is searched for an appropriate **`exception-handler`**, the actions for which are executed.

IMPORTANT

The Business Process Manager's exception handling differs in some ways from the Java exception handling. In Java, a caught exception can have an influence on the *control flow*. In the case of jBPM, control flow cannot be changed by the exception handling mechanism. The exception is either caught or it is not. Exceptions which have not been caught are thrown to the client that called the **`token.signal()`** method. For those exceptions that are caught, the graph execution continues as if nothing had occurred.



NOTE

Use **`Token.setNode(Node node)`** to put the token in an arbitrary node within the graph of an exception-handling **`action`**.

6.8. PROCESS COMPOSITION

The Business Process Manager supports *process composition* by means of the **`process-state`**. This is a state that is associated with another process definition. When graph execution arrives in the **`process-state`**, a new instance of the sub-process is created. This sub-process is then associated with the path of execution that arrived in the process state. The super-process' path of execution will wait until the sub-process has ended and then leave the process state and continue graph execution in the super-process.

```
<process-definition name="hire">
  <start-state>
    <transition to="initial interview" />
  </start-state>
  <process-state name="initial interview">
    <sub-process name="interview" />
    <variable name="a" access="read,write" mapped-name="aa" />
    <variable name="b" access="read" mapped-name="bb" />
    <transition to="..." />
  </process-state>
  ...
</process-definition>
```

In the example above, the **`hire`** process contains a **`process-state`** that spawns an **`interview`** process. When execution arrives in the **`first interview`**, a new execution (that is, process instance) of the **`interview`** process is created. If a version is not explicitly specified, the latest version of the sub-process is used. To make the Business Process Manager instantiate a specific version, specify the optional version attribute. To postpone binding the specified or latest version until the sub-process is actually created, set the optional binding attribute to **`late`**.

Next, **`hire`** process variable **`a`** is copied into **`interview`** process variable **`aa`**. In the same way, **`hire`** variable **`b`** is copied into interview variable **`bb`**. When the interview process finishes, only variable **`aa`** is copied back into the **`a`** variable.

In general, when a sub-process is started, all of the variables with read access are read from the super-process and fed into the newly created sub-process. This occurs before the signal is given to leave the start state. When the sub-process instances are finished, all of the variables with write access will be copied from the sub-process to the super-process. Use the variable's mapped-name attribute to specify the variable name that should be used in the sub-process.

6.9. CUSTOM NODE BEHAVIOR

Create custom nodes by using a special implementation of the **`ActionHandler`** that can execute any business logic, but also has the responsibility to pass on the graph execution. Here is an example that reads a value from an ERP system, adds an amount (from the process variables) and stores the result back in the ERP system. Based on the size of the amount, use either the **`small amounts`** or the **`large amounts`** transition to exit.

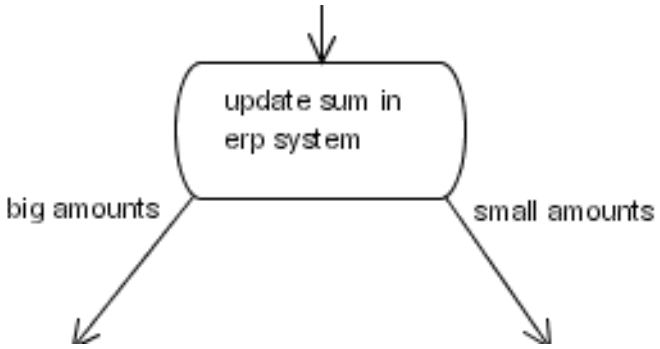


Figure 6.3. Process Snippet for Updating ERP Example

```
public class AmountUpdate implements ActionHandler {
  public void execute(ExecutionContext ctx) throws Exception {
    // business logic
    Float erpAmount = ...get amount from erp-system...;
    Float processAmount = (Float)
ctx.getContextInstance().getVariable("amount");
    float result = erpAmount.floatValue() + processAmount.floatValue();
    ...update erp-system with the result...;

    // graph execution propagation
    if (result > 5000) {
      ctx.leaveNode(ctx, "big amounts");
    } else {
      ctx.leaveNode(ctx, "small amounts");
    }
  }
}
```

NOTE

One can also create and join tokens in custom node implementations. To learn how to do this, study the Fork and Join node implementation in the jBPM source code.

6.10. GRAPH EXECUTION

The Business Process Manager's graph execution model is based on an interpretation of the process definition and the "chain of command" pattern.

The process definition data is stored in the database and is used during process execution.

NOTE

Be aware that **Hibernate**'s second level cache is used so as to avoid loading definition information at run-time. Since the process definitions do not change, **Hibernate** can cache them in memory.

The "chain of command pattern" makes each node in the graph responsible for passing on the process execution. If a node does not pass it on, it behaves as though it were a **`wait state`**.

Let the execution start on process instances and it will continue until it enters a **`wait state`**.

A token represents a path of execution. It has a pointer to a node in the process graph. During **`wait state`**, the tokens can be made to persist in the database.

This algorithm is used to calculate the execution of a token. Execution starts when a signal is sent to the tokenand it is then passed over the transitions and nodes via the chain of command pattern. These are the relevant methods:

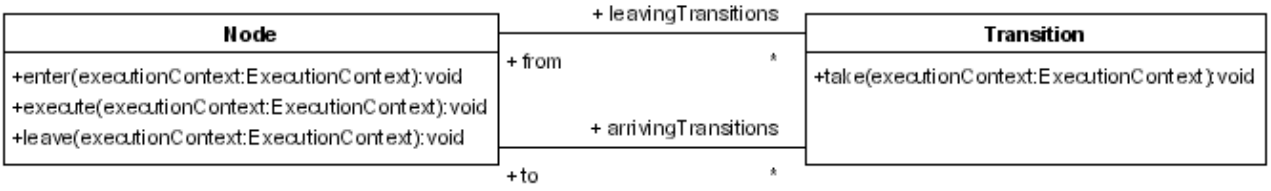
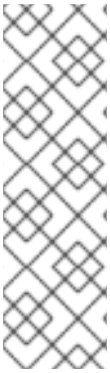


Figure 6.4. The graph execution-related methods

When a token is in a node, signals can be sent to it. A signal is treated as an instruction to start execution and must, therefore, specify a **`leaving transition`** from the token's current node. The first transition is the default. In a signal to a token, it takes its current node and calls the **`Node.leave(ExecutionContext,Transition)`** method. (It is best to think of the **`ExecutionContext`** as a token because the main object in it is a token.) The **`Node.leave(ExecutionContext,Transition)`** method will fire the **`node-leave`** event and call the **`Transition.take(ExecutionContext)`**. That method will then run the transition event and call the **`Node.enter(ExecutionContext)`** on the transition's destination node. That method will then fire the **`node-enter`** event and call the **`Node.execute(ExecutionContext)`**.

Every type of node has its own behaviour, these being implemented via the **`execute`** method. Each node is responsible for passing on the graph execution by calling the **`Node.leave(ExecutionContext,Transition)`** again. In summary:

- **`Token.signal(Transition)`**
- **`Node.leave(ExecutionContext,Transition)`**
- **`Transition.take(ExecutionContext)`**
- **`Node.enter(ExecutionContext)`**
- **`Node.execute(ExecutionContext)`**

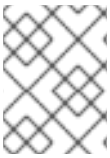


NOTE

The next state, including the invocation of the actions, is calculated via the client's thread. A common misconception is that all calculations must be undertaken in this way. Rather, as is the case with any *asynchronous invocation*, one can use *asynchronous messaging* (via Java Message Service) for that. When the message is sent in the same transaction as the process instance update, all synchronization issues are handled correctly. Some workflow systems use asynchronous messaging between all nodes in the graph but, in high throughput environments, this algorithm gives much more control and flexibility to those wishing to maximise business process performance.

6.11. TRANSACTION DEMARCATION

As explained in Section 6.10, " Graph Execution ", the Business Process Manager runs the process in the thread of the client and is, by nature, synchronous. In practice, this means that the **`token.signal()`** or **`taskInstance.end()`** will only return when the process has entered a new **`wait state`**.



NOTE

To learn more about the jPDL feature being described in this section, read Chapter 10, *Asynchronous Continuations* .

In most situations this is the most straightforward approach because one can easily bind the the process execution to server-side transactions: the process moves from one state to the next in the space of one transaction.

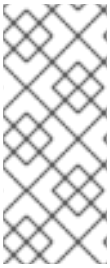
Sometimes, in-process calculations take a lot of time, so this behavior might be undesirable. To cope with this issue, the Business Process Manager includes an asynchronous messaging system that allows it to continue a process in a manner, which is, as the name implies, asynchronous. (Of course, in a Java enterprise environment, jBPM can be configured to use a Java Message Service broker instead of the in-built messaging system.)

jPDL supports the **`async="true"`** attribute in every node. Asynchronous nodes will not be executed in the thread of the client. Instead, a message is sent over the asynchronous messaging system and the thread is returned to the client (in other words, **`token.signal()`** or **`taskInstance.end()`** will be returned.)

The Business Process Manager's client code can now commit the transaction. Send messages in the same transaction as that containing the process updates. (The overall result of such a transaction will be that the token is moved to the next node (which has not yet been executed) and a **`org.jbpm.command.ExecuteNodeCommand`** message will be sent from the asynchronous messaging system to the **`jBPM Command Executor`**. This reads the commands from the queue and executes them. In the case of the **`org.jbpm.command.ExecuteNodeCommand`**, the process will be continued when the node is executed. (Each command is executed in a separate transaction.)

IMPORTANT

Ensure that a **`jBPM Command Executor`** is running so that asynchronous processes can continue. Do so by configuring the web application's **`CommandExecutionServlet`**.



NOTE

Process modelers do not need to be excessively concerned with asynchronous messaging. The main point to remember is transaction demarcation: by default, the Business Process Manager will operate in the client transaction, undertaking the whole calculation until the process enters a **`wait state`**. (Use **`async="true"`** to demarcate a transaction in the process.)

Here is an example:

```
<start-state>
  <transition to="one" />
</start-state>
<node async="true" name="one">
  <action class="com...MyAutomaticAction" />
  <transition to="two" />
</node>
<node async="true" name="two">
  <action class="com...MyAutomaticAction" />
  <transition to="three" />
</node>
<node async="true" name="three">
  <action class="com...MyAutomaticAction" />
  <transition to="end" />
</node>
<end-state name="end" />
...
```

The client code needed to both start and resume process executions is exactly the same as that needed for normal synchronous processes.

```
//start a transaction
JbpmContext jbpmContext = jbpmConfiguration.createContext();
try {
  ProcessInstance processInstance =
    jbpmContext.newProcessInstance("my async process");
  processInstance.signal();
  jbpmContext.save(processInstance);
} finally {
  jbpmContext.close();
}
```

After this first transaction occurs, the process execution's **`root token`** will point to **`node one`** and an **`ExecuteNodeCommand`** message is sent to the command executor.

In a subsequent transaction, the command executor will read the message from the queue and execute **`node one`**. The action can decide to pass the execution on or enter a **`wait state`**. If it chooses to pass it on, the transaction will be ended when the execution arrives at **`node two`**.

CHAPTER 7. THE CONTEXT

Read this chapter to learn about *process variables*. Process variables are key-value pairs that maintain process instance-related information.

NOTE

To be able to store the *context* in a database, some minor limitations apply.

7.1. ACCESSING PROCESS VARIABLES

`org.jbpm.context.exe.ContextInstance` serves as the central interface for process variables. Obtain the **`ContextInstance`** from a process instance in this manner:

```
ProcessInstance processInstance = ...;
ContextInstance contextInstance =
 (ContextInstance) processInstance.getInstance(ContextInstance.class);
```

These are the basic operations:

```
void ContextInstance.setVariable(String variableName, Object value);
void ContextInstance.setVariable(
 String variableName, Object value, Token token);

Object ContextInstance.getVariable(String variableName);
Object ContextInstance.getVariable(String variableName, Token token);
```

The variable name is **`java.lang.String`**. By default, the Business Process Manager supports the following value types. (It also supports any other class that can be persisted with **Hibernate**.)

`java.lang.String`	**`java.lang.Boolean`**
`java.lang.Character`	**`java.lang.Float`**
`java.lang.Double`	**`java.lang.Long`**
`java.lang.Byte`	**`java.lang.Integer`**
`java.util.Date`	**`byte[]`**
`java.io.Serializable`	

NOTE

Untyped null values can also be stored persistently.

WARNING

Do not save a process instance if there are any other types stored in the process variables as this will cause an exception error.

7.2. LIVES OF VARIABLES

Variables do not have to be declared in the process archive. At run-time, simply put any Java object in the variables. If a variable did not exist, it will be created, in the same way as a plain **`java.util.Map`**. Note that variables can also be deleted.

```
ContextInstance.deleteVariable(String variableName);
ContextInstance.deleteVariable(String variableName, Token token);
```

Types can change automatically. This means that a type is allowed to overwrite a variable with a value of a different type. It is important to always try to limit the number of type changes since this generates more communications with the database than a plain column update.

7.3. VARIABLE PERSISTENCE

The variables are part of the process instance. Saving the process instance in the database will synchronise the database with the process instance. (The variables are created, updated and deleted by doing this.) For more information, see Chapter 4, *Persistence* .

7.4. VARIABLE SCOPES

Each path of execution (also known as a *token*) has its own set of process variables. Variables are always requested on a path of execution. Process instances have a tree of these paths. If a variable is requested but no path is specified, the **`root token`** will be used by default.

The variable look-up occurs recursively. It runs over the parents of the given path of execution. (This is similar to the way in which variables are scoped in programming languages.)

When a non-existent variable is set on a path of execution, the variable is created on the **`root token`**. (Hence, each variable has, by default, a process scope.) To make a variable token "local", create it explicitly, as per this example:

```
ContextInstance.createVariable(String name, Object value, Token token);
```

7.4.1. Variable Overloading

Variable overloading means that each path of execution can have its own copy of a variable with the same name. These copies are all treated independently of each other and can be of different types. Variable overloading can be interesting if one is launching multiple concurrent paths of execution over the same transition. This is because the only thing that will distinguish these paths will be their respective set of variables.

7.4.2. Variable Overriding

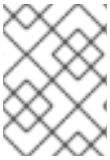
Variable overriding simply means that variables in *nested paths of execution* over-ride variables in more global paths of execution. Generally, "nested paths of execution" relates to concurrency: the paths of execution between a fork and a join are children (nested) of the path of execution that arrived in the fork. For example, you can override a variable named **`contact`** in the process instance scope with this variable in the nested paths of execution **`shipping`** and **`billing`**.

7.4.3. Task Instance Variable Scope

To learn about task instance variables, read Section 8.4, “ Task Instance Variables ”.

7.5. TRANSIENT VARIABLES

When a process instance is persisted in the database, so too are normal variables. However, at times one might want to use a variable in a delegation class without storing it in the database. This can be achieved with *transient variables*.



NOTE

The lifespan of a transient variable is the same as that of a **`ProcessInstance`** Java object.

NOTE

Because of their nature, transient variables are not related to paths of execution. Therefore, a process instance object will have only one map of them.

The transient variables are accessible through their own set of methods in the context instance. They do not need to be declared in the **`processdefinition.xml`** file.

```
Object ContextInstance.getTransientVariable(String name);
void ContextInstance.setTransientVariable(String name, Object value);
```

This chapter has covered process variables in great detail. The reader should now be confident that he or she understands this topic.

CHAPTER 8. TASK MANAGEMENT

The jBPM's core role is to *persist* the execution of a process. This feature is extremely useful when one is seeking to manage tasks and task-lists for people. The jBPM allows one to specify a piece of software that describes an overall process. Such a piece of software can have *wait states* for human tasks.

8.1. TASKS

Tasks are part of the process definition. They define how task instances will be created and assigned during process executions.

Define tasks in **`task-node`**s and in the **`process-definition`**. The most common way is to define one or more **`task`**s in a **`task-node`**. In that case the **`task-node`** represents a task to be undertaken by the user and the process execution should wait until the actor completes the task. When the actor completes the task, process execution continues. When more tasks are specified in a **`task-node`**, the default behaviour is to wait until all the tasks have ended.

One can also specify tasks on the **`process-definition`**. Tasks specified in this way can be found by searching for their names. One can also reference them from within **`task-node`**s or use them from within actions. In fact, every task (or **`task-node`**) that is given a name can be found in the **`process-definition`**.

Ensure that each task name is unique. Also, give the task a **`priority`**. This will be used as the initial priority for each task instance created for this task. (This initial priority can be changed by the task instance afterwards.)

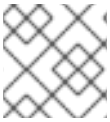
8.2. TASK INSTANCES

It is possible to assign a task instance to an **`actorId`** (**`java.lang.String`**). Every task instance is stored in one table (**`JBPM_TASKINSTANCE`**.) Query this table for every task instances for a given actorId, in order to obtain the task list for that particular user.

Use the jBPM task list mechanism to combine jBPM tasks with other tasks, even when those other tasks are unrelated to a process execution. In this way, one can easily combine jBPM-process-tasks with other application's tasks in one centralised repository.

8.2.1. Task Instance Life-Cycle

The task instance life-cycle is straightforward: after creation, one can start the instances. They can then be ended, which means that they will be marked as completed.



NOTE

For the sake of flexibility, *assignment* is not part of the life-cycle.

1. Task instances are normally created when the process execution enters a **`task-node`** (via the **`TaskMgmtInstance.createTaskInstance(...)`** method.)

2. A user interface component then queries the database for the task lists. It does so by using the **`TaskMgmtSession.findTaskInstancesByActorId(...)`** method.

3. Then, after collecting input from the user, the UI component calls **`TaskInstance.assign(String)`**, **`TaskInstance.start()`** or **`TaskInstance.end(...)`**.

A task instance maintains its state by means of three date-properties:

1. **`create`**
2. **`start`**
3. **`end`**

Access these properties via their respective "getters", which can be found on the **`TaskInstance`**.

Completed task instances are marked with an end date so that they are not fetched when subsequent queries search for tasks lists. The completed tasks do, however, remain in the **`JBPM_TASKINSTANCE`** table.

8.2.2. Task Instances and Graph Executions

Task instances are the items in an actor's task list. A signalling task instance is a task instance that, when completed, sends a signal to its token to continue the process execution. Blocking task instances are those that the related token (the path of execution) is not allowed to leave the **`task-node`** before the task instance is completed. By default, task instances are configured to be signalling and non-blocking.

If more than one task instance is associated with a **`task-node`**, the process developer can specify the way in which completion of the task instances affects continuation of the process. Give any of these values to the **`task-node`**'s **`signal-property`**:

last

This is the default. It proceeds execution when the last task instance has been completed. When no tasks are created on entrance of this node, execution is continued.

last-wait

This proceeds execution when the last task instance has been completed. When no tasks are created on entrance of this node, execution waits in the task node until tasks are created.

first

This proceeds execution when the first task instance has been completed. When no tasks are created upon the entry of this node, execution is continued.

first-wait

This proceeds execution when the first task instance has been completed. When no tasks are created on entrance of this node, execution waits in the task node until tasks are created.

unsynchronized

In this case, execution always continues, regardless of whether tasks are created or still unfinished.

never

In this case, execution never continues, regardless whether tasks are created or still unfinished.

Task instance creation can be based upon a run-time calculation. In these cases, add an **`ActionHandler`** to the **`task-node`**'s **`node-enter`** event and set **`create-tasks="false"`**. Here is an example:

```
public class CreateTasks implements ActionHandler {
  public void execute(ExecutionContext executionContext) throws Exception
{
    Token token = executionContext.getToken();
    TaskMgmtInstance tmi = executionContext.getTaskMgmtInstance();

    TaskNode taskNode = (TaskNode) executionContext.getNode();
    Task changeNappy = taskNode.getTask("change nappy");

    // now, 2 task instances are created for the same task.
    tmi.createTaskInstance(changeNappy, token);
    tmi.createTaskInstance(changeNappy, token);
  }
}
```

Here, the tasks to be created are specified in the **`task-node`**. They could also be specified in the **`process-definition`** and fetched from the **`TaskMgmtDefinition`**. (**`TaskMgmtDefinition`** extends the process definition by adding task management information.)

The **`TaskInstance.end()`** method is used to mark task instances as completed. One can optionally specify a transition in the end method. In case the completion of this task instance triggers continuation of the execution, the **`task-node`** is left over the specified transition.

8.3. ASSIGNMENT

A process definition contains task nodes. A **`task-node`** contains zero or more tasks. Tasks are static descriptions of part of the process definition. At run-time, executing tasks result in the creation of task instances. A task instance corresponds to one entry in a person's task list.

With the jBPM, one can apply the push (personal task list) and pull (group task list) models of task assignment in combination. The process determines those responsible for a task and push it to their task lists. A task can also be assigned to a pool of actors, in which case each of the actors pull the task and put it in their personal task lists.

8.3.1. Assignment Interfaces

Assign task instances via the **`AssignmentHandler`** interface:

```
public interface AssignmentHandler extends Serializable {
  void assign( Assignable assignable, ExecutionContext executionContext );
}
```

An assignment handler implementation is called when a task instance is created. At that time, the task instance is assigned to one or more actors. The **`AssignmentHandler`** implementation calls the assignable methods (**`setActorId`** or **`setPooledActors`**) to assign a task. The assignable item is either a **`TaskInstance`** or a **`SwimlaneInstance`** (that is, a process role).

```
public interface Assignable {
  public void setActorId(String actorId);
  public void setPooledActors(String[] pooledActors);
```

```
}
```

Both **`TaskInstance`**s and **`SwimlaneInstance`**s can be assigned to a specific user or to a pool of actors. To assign a **`TaskInstance`** to a user, call **`Assignable.setActorId(String actorId)`**. To assign a **`TaskInstance`** to a pool of candidate actors, call **`Assignable.setPooledActors(String[] actorIds)`**.

One can associate each task in the process definition with an handler implementation to perform the assignment at run-time.

When more than one task in a process should be assigned to the same person or group of actors, consider the usage of a swimlane, see Section 8.6, " Swimlanes ".

To create reusable **`AssignmentHandler`**s, configure each one via the **`processdefinition.xml`** file. (See Section 14.2, "Delegation" for more information on how to add configuration to assignment handlers.)

8.3.2. The Assignment Data Model

The data model for managing assignments of task instances and swimlane instances to actors is the following. Each **`TaskInstance`** has an **`actorId`** and a set of pooled actors.

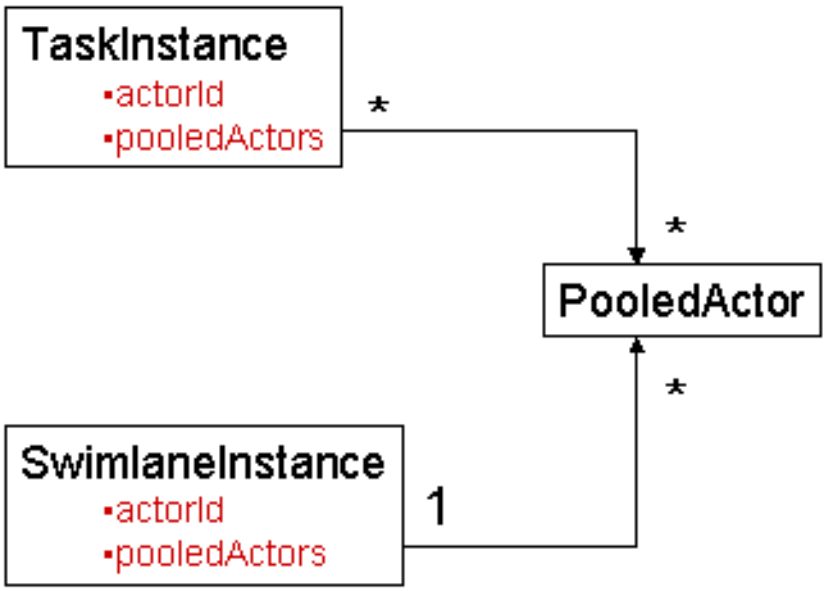


Figure 8.1. The assignment model class diagram

The **`actorId`** is the responsible for the task, while the set of pooled actors represents a collection of candidates one of whom will become responsible if they take the task. Both **`actorId`** and **`pooledActors`** are optional and can also be combined.

8.3.3. The Personal Task List

The personal task list denotes all the task instances that are assigned to a specific individual. This is indicated by the presence of the actorId property on a **`TaskInstance`**. Put a **`TaskInstance`** in someone's task list in one of these ways:

- specify an expression in the task element's **`actor-id`** attribute

- use the **`TaskInstance.setActorId(String)`** method from anywhere in the code
- use the **`assignable.setActorId(String)`** in an **`AssignmentHandler`**

To fetch the personal task list for a given user, use **`TaskMgmtSession.findTaskInstances(String actorId)`**.

8.3.4. The Group Task List

The pooled actors are the group of candidates to whom the task is offered. One candidate has to accept it. Users can not start working on tasks immediately as that would, potentially, result in a conflict if many people commenced work on the same task. To prevent this, users can only take task instances from the group task list and move these into their personal task lists. It is only when a task is placed on the user's personal task list that her or she can commence working on it.

To put a **`taskInstance`** in someone's group task list, add the user's actorId or one of the user's **`groupIds`** to the **`pooledActorIds`**. To specify the pooled actors, use one of the following methods:

- specify an expression in the attribute **`pooled-actor-ids`** of the task element in the process
- use **`TaskInstance.setPooledActorIds(String[])`** from anywhere in your code
- use **`assignable.setPooledActorIds(String[])`** in an AssignmentHandler

To fetch the group task list for a given user, make a collection that includes the user's actorId and those of all the groups to which the user belongs. Use **`TaskMgmtSession.findPooledTaskInstances(String actorId)`** or **`TaskMgmtSession.findPooledTaskInstances(List actorIds)`** to search for task instances that are not in a personal task list (**`actorId==null`**) and for which there is a match amongst the pooled actorId.

NOTE

The software was designed this way in order to separate the identity component from jBPM task assignment. The jBPM only stores strings as actorIds. It does not understand the relationships between the users and groups or any other identity information.

The actorId always overrides pooled actors. Hence, a taskInstance that has an actorId and a list of **`pooledActorId`**s will only show up in the actor's personal task list. Retain the **`pooledActorId`**s in order to put a task instance back into the group by simply setting the **`taskInstance`**'s actorId property to **`null`**.

8.4. TASK INSTANCE VARIABLES

A task instance can have its own set of variables and can also "see" the process variables. Task instances are usually created in an execution path (a token). This creates a parent-child relation between the token and the task instance, which is similar to the parent-child relation between the tokens themselves. Note that the normal scoping rules apply.

Use the *controller* to create, populate and submit variables between the task instance scope and the process scoped variables.

This means that a task instance can 'see' its own variables plus all the variables of its related token.

The controller can be used to create populate and submit variables between the task instance scope and the process scoped variables.

8.5. TASK CONTROLLERS

When task instances are created, one can use task controllers populate the task instance variables. When the task instances terminate, one can use task controllers to submit the data belonging to them to the process variables.

NOTE

Use of task controllers is optional. Task instances also are able to "see" the process variables related to its token. Use task controllers to undertake these tasks:

- create copies of task instance variables so that intermediate updates to them do not affect the process variables until the process is finished. At this time, the copies are submitted back into the process variables.
- the task instance variables do not have a one-to-one relationship with the process variables. For instance, if the process has variables named **`sales in January`** **`sales in February`** and **`sales in March`**, then the task instance form might need to show the average sales for those three months.

Tasks collect input from users. But there are many user interfaces which could be used to present the tasks to the users. E.g. a web application, a swing application, an instant messenger, an email form,... So the task controllers make the bridge between the process variables (=process context) and the user interface application. The task controllers provide a view of process variables to the user interface application.

When a task instance is created, the task controller translates process variables, if there are any, into task variables. The task variables serve as the input for the user interface form. The user input itself is stored in the task variables. When the user ends the task, the task controller updates the process variables based on the task instance data.

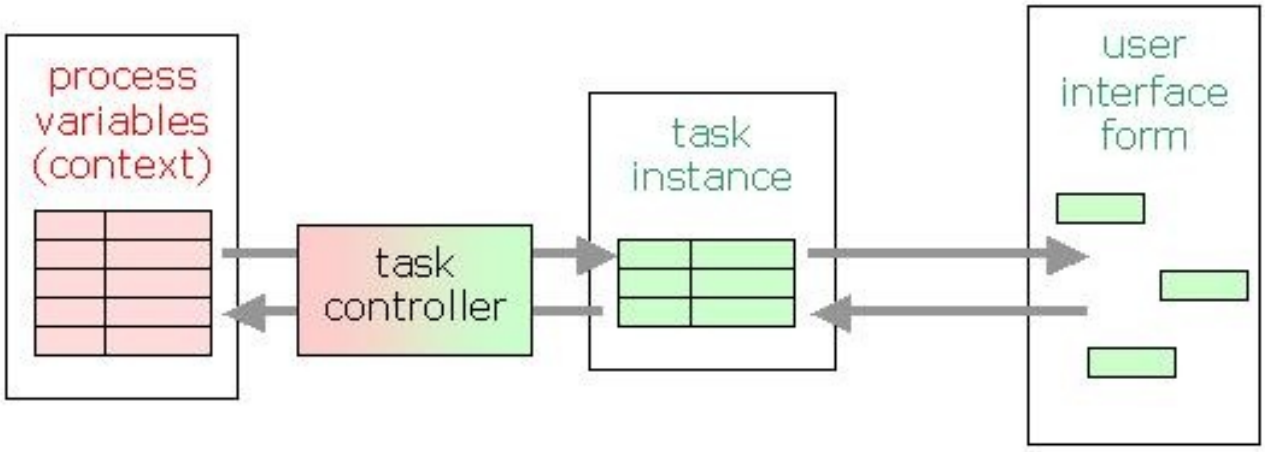


Figure 8.2. The task controllers

In a simple scenario, there is a one-on-one mapping between process variables and the form parameters. Specify task controllers in a task element. In this case, the default JBPM task controller can be used. It takes a list of **`variable`** elementswhich express how the process variables are copied in the task variables.

The next example demonstrates how to create separate copies of task instance variable, based on the process variables:

```
<task name="clean ceiling">
  <controller>
    <variable name="a" access="read" mapped-name="x" />
    <variable name="b" access="read,write,required" mapped-name="y" />
    <variable name="c" access="read,write" />
  </controller>
</task>
```

The name attribute refers to the name of the process variable. The mapped-name is optional and refers to the name of the task instance variable. If the mapped-name attribute is omitted, mapped-name defaults to the name. Note that the mapped-name is also used as the label for the fields in the web application's task instance form.

Use the access attribute to specify as to whether or not the variable copied at task instance creation, will be written back to the process variables at task instance conclusion. (This information can be used by the user interface to generate the proper form controls.) The access attribute is optional and the default access is **`read,write`**.

A **`task-node`** can have many tasks whilst a **`start-state`** has one task.

If the simple one-to-one mapping between process variables and form parameters is too limiting, create a custom **`TaskControllerHandler`** implementation. Here is the interface for it:.

```
public interface TaskControllerHandler extends Serializable {
  void initializeTaskVariables(TaskInstance taskInstance, ContextInstance
contextInstance, Token token);
  void submitTaskVariables(TaskInstance taskInstance, ContextInstance
contextInstance, Token token);
}
```

This code sample demonstrates how to configure it:

```
<task name="clean ceiling">
  <controller class="com.yourcom.CleanCeilingTaskControllerHandler">
    -- here goes your task controller handler configuration --
  </controller>
</task>
```

8.6. SWIMLANES

A *swimlane* is a process role. Use this mechanism to specify that multiple tasks in the process are to be undertaken by the same actor. After the first task instance for a given swimlane is created, the actor is "remembered" for every subsequent task in the same swimlane. A swimlane therefore has one **`assignment`**. Study Section 8.3, “ Assignment ” to learn more.

When the first task in a given swimlane is created, the **`AssignmentHandler`** is called. The **`Assignable`** item that is passed to the **`AssignmentHandler`** is **`SwimlaneInstance`**. Every assignment undertaken on the task instances in a given swimlane will propagate to the swimlane instance. This is the default behaviour because the person that takes a task will have a knowledge of that particular process. Hence, ever subsequent task instances in that swimlane is automatically assigned to that user.

8.7. SWIMLANE IN START TASK

It is possible to associate a swimlane with the start task. One does this to capture the process initiator.

A task can be specified in a start-state, which will associate it with a swimlane. When a new task instance is created, the current authenticated actor is captured via the **`Authentication.getAuthenticatedActorId()`** method. The actor is stored in the start task's swimlane.

```
<process-definition>
  <swimlane name='initiator' />
  <start-state>
    <task swimlane='initiator' />
    <transition to='...' />
  </start-state>
  ...
</process-definition>
```

Add variables to the start task using the normal method. Do so to define the form associated with the task. See Section 8.5, “ Task Controllers ” for more information.

8.8. TASK EVENTS

One can associate actions with tasks. There are four standard event types:

1. **`task-create`**, which is fired when a task instance is created.
2. **`task-assign`**, which is fired when a task instance is being assigned. Note that in actions that are executed on this event, one can access the previous actor with the **`executionContext.getTaskInstance().getPreviousActorId();`** method.
3. **`task-start`**, which is fired when the **`TaskInstance.start()`** method is called. Use this optional feature to indicate that the user is actually starting work on the task instance.
4. **`task-end`**, which is fired when **`TaskInstance.end(...)`** is called. This marks the completion of the task. If the task is related to a process execution, this call might trigger the resumption of the process execution.

NOTE

Exception handlers can be associated with tasks, For more information about this, read Section 6.7, “ Exception Handling ”.

8.9. TASK TIMERS

One can specify timers on tasks. See Section 9.1, “ Timers ”.

It is possible to customise cancel-event for task timers. By default, a task timer cancels when the task is ended but with the cancel-event attribute on the timer, one can customise that totask-assign or task-start. The cancel-event supports multiple events. To combine cancel-event types, specify them in a comma-separated list in the attribute.

8.10. CUSTOMIZING TASK INSTANCES

To customise a task instance, follow these steps:

1. create a sub-class of **`TaskInstance`**
2. create a **`org.jbpm.taskmgmt.TaskInstanceFactory`** implementation
3. configure the implementation by setting the jbpm.task.instance.factory configuration property to the fully qualified class name in the **`jbpm.cfg.xml`** file.
4. if using a sub-class of **`TaskInstance`**, create a **Hibernate** mapping file for the sub-class (using **`extends="org.jbpm.taskmgmt.exe.TaskInstance"`**
5. add that mapping file to the list in **`hibernate.cfg.xml`**.

8.11. THE IDENTITY COMPONENT

Management of users, groups and permissions is termed *identity management*. The jBPM includes an optional identity component. One can easily replace it with one's company's own data store.

The jBPM identity management component holds knowledge of the organisational model and uses this to assign tasks. This model describes the users, groups, systems and the relationships between these. Optionally, permissions and roles can also be included.

The jBPM handles this by defining an actor as an actual participant in a process. An actor is identified by its ID called an actorId. The jBPM has only knowledge about actorIds and they are represented as **`java.lang.String`**s for maximum flexibility. So any knowledge about the organizational model and the structure of that data is outside the scope of the jBPM's core engine.

As an extension to jBPM we will provide (in the future) a component to manage that simple user-roles model. This many to many relation between users and roles is the same model as is defined in the J2EE and the servlet specs and it could serve as a starting point in new developments.

Note that the user-roles model as it is used in the servlet, ejb and portlet specifications, is not sufficiently powerful for handling task assignments. That model is a many-to-many relation between users and roles. This doesn't include information about the teams and the organizational structure of users involved in a process.

8.11.1. The identity model

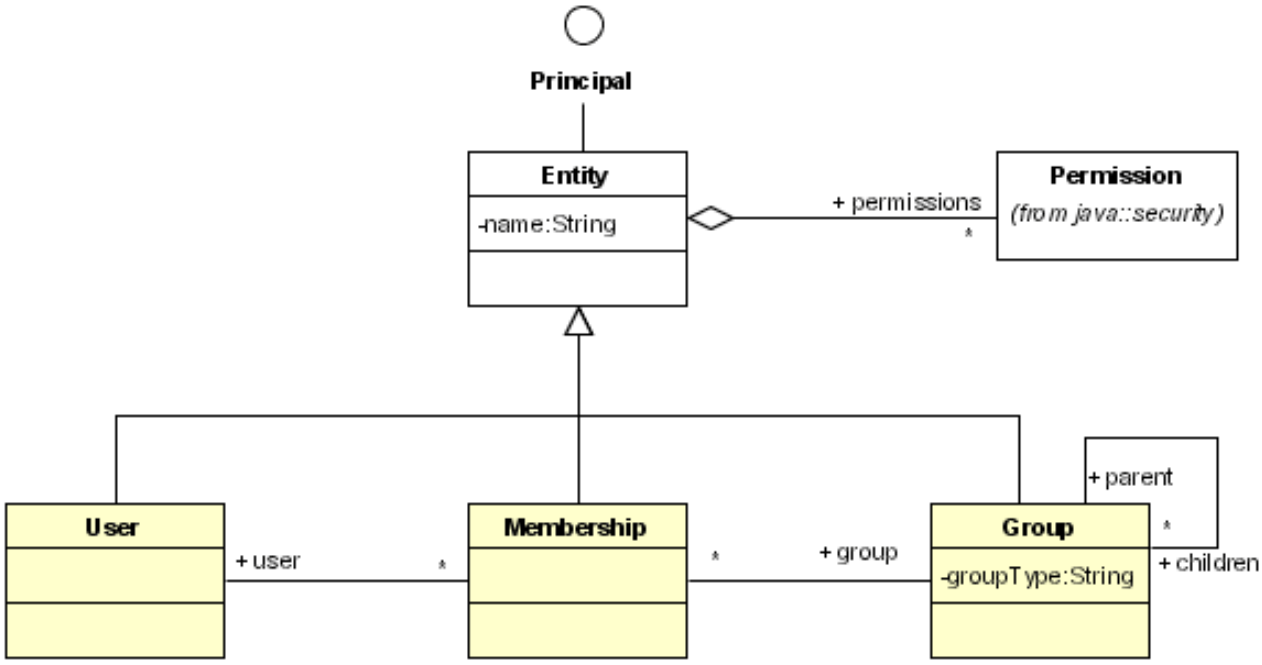


Figure 8.3. The identity model class diagram

The classes in yellow are those which pertain to the expression assignment handler discussed next.

A **`User`** represents a user or a service. A **`Group`** is any kind of group of users. Groups can be nested to model the relation between a team, a business unit and the whole company. Groups have a type to differentiate between the hierarchical groups and e.g. hair color groups. **`Membership`**s represent the many-to-many relation between users and groups. A membership can be used to represent a position in a company. The name of the membership can be used to indicate the role that the user fulfills in the group.

8.11.2. Assignment expressions

The identity component comes with one implementation that evaluates an expression for the calculation of actors during assignment of tasks. Here's an example of using the assignment expression in a process definition:

```
<process-definition>
  <task-node name='a'>
    <task name='laundry'>
      <assignment expression='previous --> group(hierarchy) -->
member(boss)' />
    </task>
    <transition to='b' />
  </task-node>

      <para>Syntax of the assignment expression is like this:</para>
      first-term --> next-term --> next-term --> ... --> next-term

where

first-term ::= previous |
               swimlane(swimlane-name) |
               variable(variable-name) |
               user(user-name) |
```

```
                group(group-name)

and

next-term ::= group(group-type) |
              member(role-name)
</programlisting>
```

8.11.2.1. First terms

An expression is resolved from left to right. The first-term specifies a **`User`** or **`Group`** in the identity model. Subsequent terms calculate the next term from the intermediate user or group.

`previous` means the task is assigned to the current authenticated actor. This means the actor that performed the previous step in the process.

`swimlane(swimlane-name)` means the user or group is taken from the specified swimlane instance.

`variable(variable-name)` means the user or group is taken from the specified variable instance. The variable instance can contain a **`java.lang.String`**, in which case that user or group is fetched from the identity component. Or the variable instance contains a **`User`** or **`Group`** object.

`user(user-name)` means the given user is taken from the identity component.

`group(group-name)` means the given group is taken from the identity component.

8.11.2.2. Next terms

`group(group-type)` gets the group for a user. Meaning that previous terms must have resulted in a **`User`**. It searches for the the group with the given group-type in all the memberships for the user.

`member(role-name)` gets the user that performs a given role for a group. The previous terms must have resulted in a **`Group`**. This term searches for the user with a membership to the group for which the name of the membership matches the given role-name.

8.11.3. Removing the identity component

When you want to use your own datasource for organizational information such as your company's user database or LDAP system, you can remove the jBPM identity component. The only thing you need to do is make sure that you delete the following lines from the **`hibernate.cfg.xml`**.

```
<mapping resource="org/jbpm/identity/User.hbm.xml"/>
<mapping resource="org/jbpm/identity/Group.hbm.xml"/>
<mapping resource="org/jbpm/identity/Membership.hbm.xml"/>
```

The **`ExpressionAssignmentHandler`** is dependent on the identity component so you will not be able to use it as is. In case you want to reuse the **`ExpressionAssignmentHandler`** and bind it to your user data store, you can extend from the **`ExpressionAssignmentHandler`** and override the method **`getExpressionSession`**.

```
protected ExpressionSession getExpressionSession(AssignmentContext
assignmentContext);
```

CHAPTER 9. SCHEDULER

Read this chapter to learn about the role of *timers* in the Business Process Manager.

Timers can be created upon events in the process. Set them to trigger either action executions or event transitions.

9.1. TIMERS

The easiest way to set a timer is by adding a *timer element* to the node. This sample code shows how to do so:

```
<state name='catch crooks'>
  <timer name='reminder'
         duedate='3 business hours'
         repeat='10 business minutes'
         transition='time-out-transition' >
    <action class='the-remainder-action-class-name' />
  </timer>
  <transition name='time-out-transition' to='...' />
</state>
```

A timer specified on a node is not executed after that node is exited. Both the transition and the action are optional. When a timer is executed, the following events occur in sequence:

1. an event of type **`timer`** is fired
2. if an action is specified, it executes
3. a signal is to resume execution over any specified transition

Every timer must have a unique name. If no name is specified in the **`timer`** element, the name of the node is used by default.

Use the timer action to support any action element (such as **`action`** or **`script`**.)

Timers are created and canceled by actions. The two pertinent **`action-elements`** are **`create-timer`** and **`cancel-timer`**. In actual fact, the timer element shown above is just short-hand notation for a **`create-timer`** action on **`node-enter`** and a **`cancel-timer`** action on **`node-leave`**.

9.2. SCHEDULER DEPLOYMENT

Process executions create and cancel timers, storing them in a *timer store*. A separate **`timer runner`** checks this store and execute each timers at the due moment.

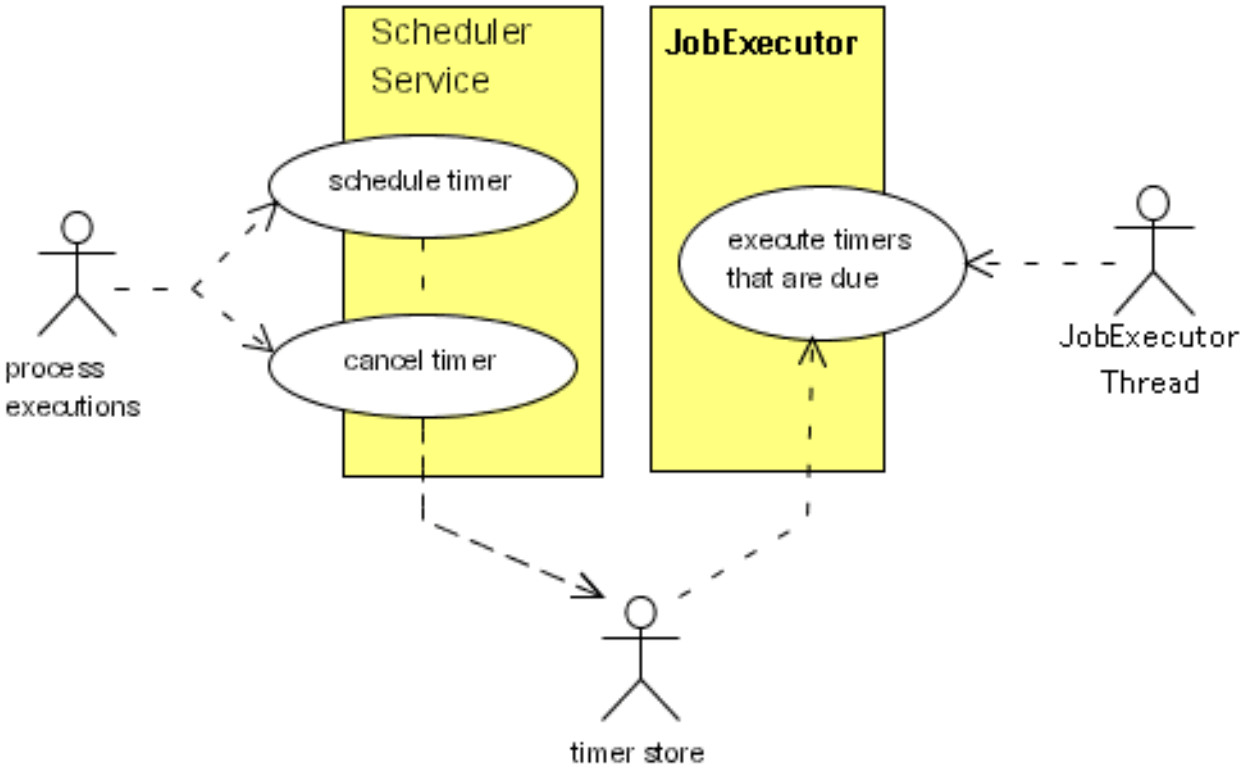


Figure 9.1. Scheduler Components Overview

CHAPTER 10. ASYNCHRONOUS CONTINUATIONS

10.1. THE CONCEPT

jBPM is based on *Graph-Oriented Programming* (GOP). Basically, GOP specifies a simple-state machine that can handle concurrent paths of execution but, in the specified execution algorithm, all state transitions are undertaken in a single thread client operation. By default, it is a good approach to perform state transitions in the thread of the client because it fits naturally with server-side transactions. The process execution moves from one "wait" state to another in the space of one transaction.

In some situations, a developer might want to fine-tune the transaction demarcation in the process definition. In jPDL, it is possible to specify that the process execution should continue asynchronously with the attribute **`async="true"`**. **`async="true"`** is supported only when it is triggered in an event but can be specified on all node types and all action types.

10.2. EXAMPLE

Normally, a node is always executed after a token has entered it. Hence, the node is executed in the client's thread. One will explore asynchronous continuations by looking at two examples. The first example is part of a process with three nodes. Node 'a' is a wait state, node 'b' is an automated step and node 'c' is, again, a wait state. This process does not contain any asynchronous behavior and it is represented in the diagram below.

The first frame shows the starting situation. The token points to node 'a', meaning that the path of execution is waiting for an external trigger. That trigger must be given by sending a signal to the token. When the signal arrives, the token will be passed from node 'a' over the transition to node 'b'. After the token arrived in node 'b', node 'b' is executed. Recall that node 'b' is an automated step that does not behave as a wait state (e.g. sending an email). So the second frame is a snapshot taken when node 'b' is being executed. Since node 'b' is an automated step in the process, the execute of node 'b' will include the propagation of the token over the transition to node 'c'. Node 'c' is a wait state so the third frame shows the final situation after the signal method returns.

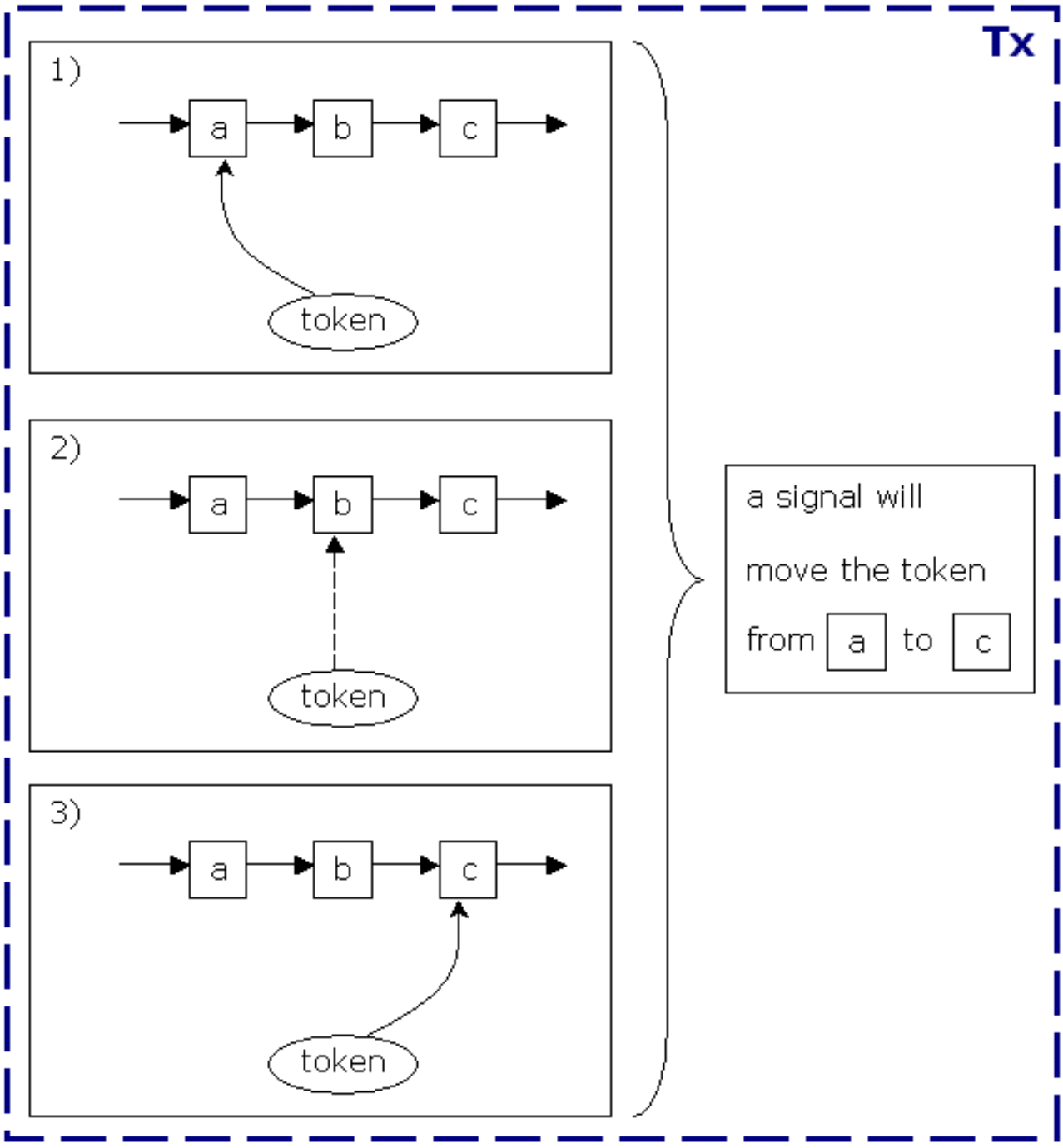


Figure 10.1. Example One: Process without Asynchronous Continuation

Whilst "persistence" is not mandatory in jBPM, most commonly a signal will be called within a transaction. Look at the updates of that transaction. Initially, the token is updated to point to node 'c'. These updates are generated by **Hibernate** as a result of the **`GraphSession.saveProcessInstance`** on a JDBC connection. Secondly, in case the automated action accesses and updates some transactional resources, such updates should be combined or made part of the same transaction.

The second example is a variant of the first and introduces an asynchronous continuation in node 'b'. Nodes 'a' and 'c' behave the same as in the first example, namely they behave as wait states. In jPDL a node is marked as asynchronous by setting the attribute **`async="true"`**.

The result of adding **`async="true"`** to node 'b' is that the process execution will be split into two parts. The first of these will execute the process up to the point at which node 'b' is to be executed. The second part will execute node 'b.' That execution will stop in wait state 'c'.

The transaction will hence be split into two separate transactions, one for each part. While it requires an external trigger (the invocation of the **`Token.signal`** method) to leave node 'a' in the first transaction, jBPM will automatically trigger and perform the second transaction.

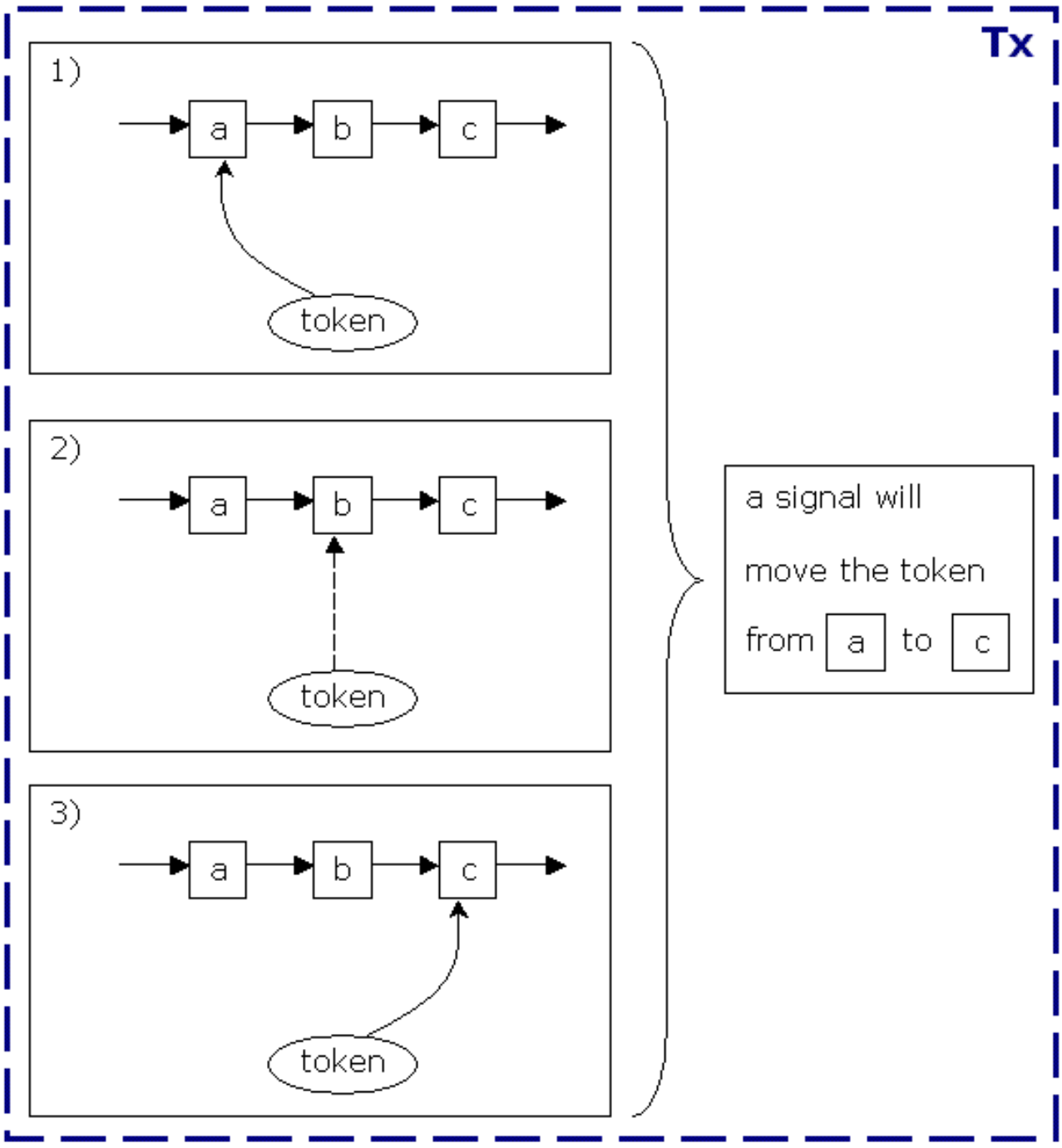


Figure 10.2. A Process with Asynchronous Continuations

For actions, the principle is similar. Actions that are marked with the attribute **`async="true"`** are executed outside of the thread that executes the process. If persistence is configured (it is by default), the actions will be executed in a separate transaction.

In jBPM, asynchronous continuations are realized by using an asynchronous messaging system. When the process execution arrives at a point that should be executed asynchronously, jBPM will suspend the execution, produces a command message and send it to the command executor. The command executor is a separate component that, upon receipt of a message, will resume the execution of the process where it got suspended.

jBPM can be configured to use a JMS provider or its built-in asynchronous messaging system. The built-in messaging system is quite limited in functionality, but allows this feature to be supported on environments where JMS is unavailable.

10.3. THE JOB EXECUTOR

The *job executor* is the component that resumes process executions asynchronously. It waits for job messages to arrive over an asynchronous messaging system and executes them. The two job messages used for asynchronous continuations are **`ExecuteNodeJob`** and **`ExecuteActionJob`**.

These job messages are produced by the process execution. During process execution, for each node or action that has to be executed asynchronously, a **`Job`** (Plain Old Java Object) will be dispatched to the **`MessageService`**. The message service is associated with the **`JbpmContext`** and it just collects all the messages that have to be sent.

The messages will be sent as part of **`JbpmContext.close()`**. That method cascades the **`close()`** invocation to all of the associated services. The actual services can be configured in **`jbpm.cfg.xml`**. One of the services, **`JmsMessageService`**, is configured by default and will notify the job executor that new job messages are available.

The graph execution mechanism uses the interfaces **`MessageServiceFactory`** and **`MessageService`** to send messages. This is to make the asynchronous messaging service configurable (also in **`jbpm.cfg.xml`**). In Java EE environments, the **`DbMessageService`** can be replaced with the **`JmsMessageService`** to leverage the application server's capabilities.

The following is a brief summary of the way in which the job executor works.

"Jobs" are records in the database. Furthermore, they are objects and can be executed. Both timers and asynchronous messages are jobs. For asynchronous messages, the dueDate is simply set to the current time when they are inserted. The job executor must execute the jobs. This is done in two phases.

- The dispatcher thread must acquire a job
- An executor thread must execute the job

Acquiring a job and executing the job are done in 2 separate transactions. The dispatcher thread acquires jobs from the database on behalf of all the executor threads on this node. When the executor thread takes the job, it adds its name into the owner field of the job. Each thread has a unique name based on IP address and sequence number.

A thread could fail between acquisition and execution of a job. To clean-up after those situations, there is one lock-monitor thread per job executor that checks the lock times. The lock monitor thread will unlock any jobs that have been locked for more than 10 minutes, so that they can be executed by another job executor thread.

The isolation level must be set to **`REPEATABLE_READ`** for Hibernate's optimistic locking to work correctly. **`REPEATABLE_READ`** guarantees that this query will only update one row in exactly one of the competing transactions.

```
update JBPM_JOB job
set job.version = 2
    job.lockOwner = '192.168.1.3:2'
where
    job.version = 1
```

Non-Repeatable Reads can lead to the following anomaly. A transaction re-reads data it has previously read and finds that data has been modified by another transaction, one that has been committed since the transaction's previous read.

Non-Repeatable reads are a problem for optimistic locking and therefore, isolation level **`READ_COMMITTED`** is not enough because it allows for Non-Repeatable reads to occur. So **`REPEATABLE_READ`** is required if you configure more than one job executor thread.

Configuration properties related to the job executor are:

jbpmConfiguration

The bean from which configuration is retrieved.

name

The name of this executor.

IMPORTANT

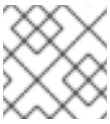
This name should be unique for each node, when more than one jBPM instance is started on a single machine.

nbrOfThreads

The number of executor threads that are started.

idleInterval

The interval that the dispatcher thread will wait before checking the job queue, if there are no jobs pending.

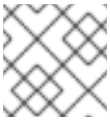


NOTE

The dispatcher thread is automatically notifed when jobs are added to the queue.

retryInterval

The interval that a job will wait between retries, if it fails during execution. The default value for this is 3 times.



NOTE

The maximum number of retries is configured by jbpm.job.retries.

maxIdleInterval

The maximum period for idleInterval.

historyMaxSize

This property is deprecated and has no effect.

maxLockTime

The maximum time that a job can be locked before the lock-monitor thread will unlock it.

lockMonitorInterval

The period for which the lock-monitor thread will sleep between checking for locked jobs.

lockBufferTime

This property is deprecated, and has no affect.

10.4. JBPM'S BUILT-IN ASYNCHRONOUS MESSAGING

When using jBPM's built-in asynchronous messaging, job messages will be sent by persisting them to the database. This message persisting can be done in the same transaction or JDBC connection as the jBPM process updates.

The job messages will be stored in the **`JBPM_JOB`** table.

The POJO command executor (**`org.jbpm.msg.command.CommandExecutor`**) will read the messages from the database table and execute them. The typical transaction of the POJO command executor looks like this:

1. Read next command message
2. Execute command message
3. Delete command message

If execution of a command message fails, the transaction will be rolled back. After that, a new transaction will be started that adds the error message to the message in the database. The command executor filters out all messages that contain an exception.

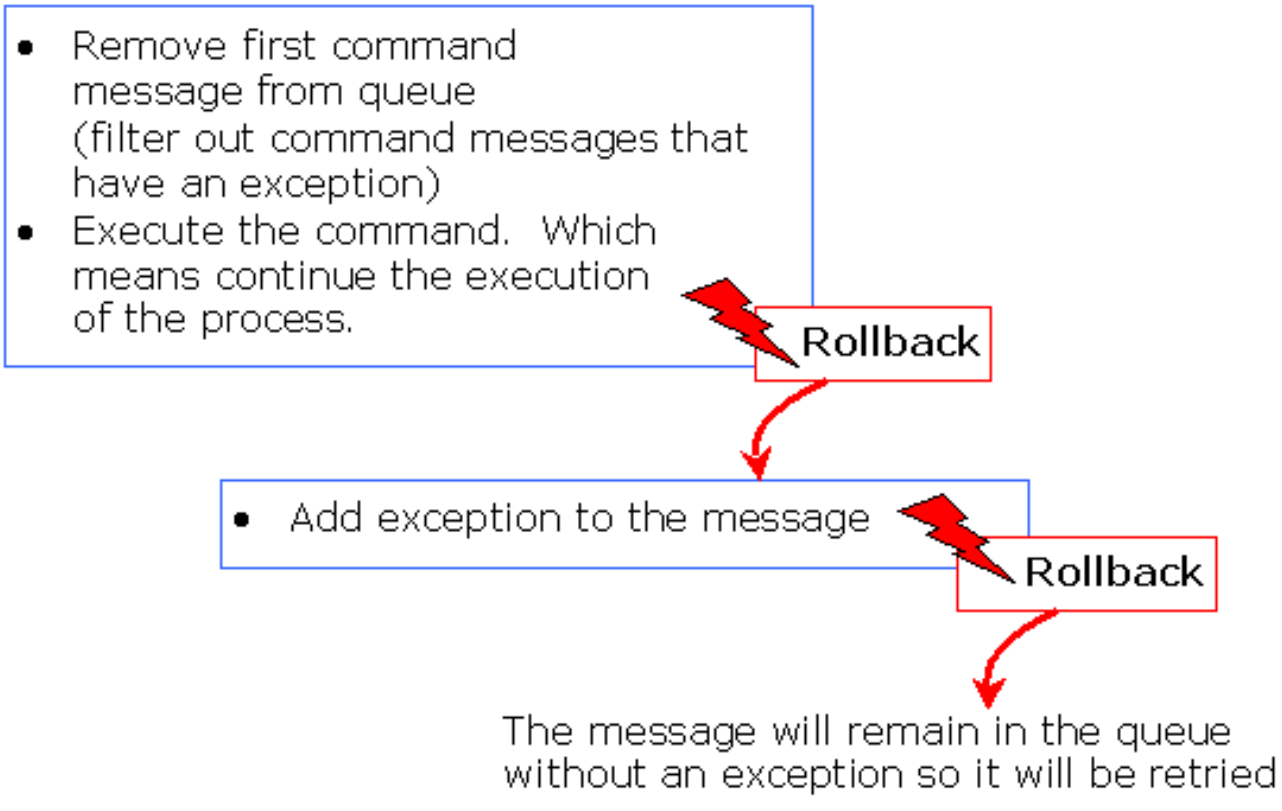


Figure 10.3. POJO command executor transactions

If the transaction that adds the exception to the command message fails, it is rolled back. The message will remain in the queue without an exception and will be retried later.

IMPORTANT

jBPM's built-in asynchronous messaging system does not support multi-node locking. You cannot deploy the POJO command executor multiple times and have them configured to use the same database.

CHAPTER 11. BUSINESS CALENDAR

Read this chapter to learn about the Business Process Manager's calendar functionality, which is used to calculate due dates for tasks and timers.

It does so by adding or subtracting a duration with a base date. (If the base date is omitted, the current date is used by default.)

11.1. DUE DATE

The due date is comprised of a duration and a base date. The formula used is: **`duedate ::= [<basedate> +/-] <duration>`**

11.1.1. Duration

A duration is specified in either absolute or business hours by use of this formula: **`duration ::= <quantity> [business] <unit>`**

In the calculation above, **`<quantity>`** must be a piece of text that is parsable with **`Double.parseDouble(quantity)`**. **`<unit>`** will be one of: second, seconds, minute, minutes, hour, hours, day, days, week, weeks, month, months, year or years. Adding the optional **`business`** flag will mean that only business hours will be taken into account for this duration. (Without it, the duration will be interpreted as an absolute time period.)

11.1.2. Base Date

The base date is calculated in this way: **`basedate ::= <EL>`**.

In the formula above, **`<EL>`** can be any Java Expression Language expression that resolves to a **`Java Date`** or **`Calendar`** object.

WARNING

Do not reference variables of any other object types, as this will result in a **`JbpmException`** error.

The base date is supported in a number of places, these being a plain timer's duedate attributes, on a task reminder and the timer within a task. However, it is not supported on the repeat attributes of these elements.

11.1.3. Due Date Examples

The following uses are all valid:

```
<timer name="daysBeforeHoliday" duedate="5 business days">...</timer>
<timer name="pensionDate" duedate="#{dateOfBirth} + 65 years" >...</timer>
<timer name="pensionReminder" duedate="#{dateOfPension} - 1 year"
>...</timer>
```

```
<timer name="fireWorks" duedate="#{chineseNewYear} repeat="1 year"
>...</timer>
<reminder name="hitBoss" duedate="#{payRaiseDay} + 3 days" repeat="1 week"
/>
```

11.2. CALENDAR CONFIGURATION

Define the business hours in the **org/jbpm/calendar/jbpm.business.calendar.properties** file. (To customize this configuration file, place a modified copy in the root of the classpath.)

This is the default business hour specification found in **jbpm.business.calendar.properties**:

```
hour.format=HH:mm
#weekday ::= [<daypart> [&amp; <daypart>]*]
#daypart ::= <start-hour>-<to-hour>
#start-hour and to-hour must be in the hour.format
#dayparts have to be ordered
weekday.monday=    9:00-12:00 &amp; 12:30-17:00
weekday.tuesday=   9:00-12:00 &amp; 12:30-17:00
weekday.wednesday= 9:00-12:00 &amp; 12:30-17:00
weekday.thursday=  9:00-12:00 &amp; 12:30-17:00
weekday.friday=    9:00-12:00 &amp; 12:30-17:00
weekday.saturday=
weekday.sunday=

day.format=dd/MM/yyyy
# holiday syntax: <holiday>
# holiday period syntax: <start-day>-<end-day>
# below are the belgian official holidays
holiday.1=  01/01/2005 # nieuwjaar
holiday.2=  27/3/2005  # pasen
holiday.3=  28/3/2005  # paasmaandag
holiday.4=  1/5/2005   # feest van de arbeid
holiday.5=  5/5/2005   # hemelvaart
holiday.6=  15/5/2005  # pinksteren
holiday.7=  16/5/2005  # pinkstermaandag
holiday.8=  21/7/2005  # my birthday
holiday.9=  15/8/2005  # moederkesdag
holiday.10= 1/11/2005  # allerheiligen
holiday.11= 11/11/2005 # wapenstilstand
holiday.12= 25/12/2005 # kerstmis

business.day.expressed.in.hours=             8
business.week.expressed.in.hours=           40
business.month.expressed.in.business.days=  21
business.year.expressed.in.business.days=  220
```

11.3. EXAMPLES

The following examples demonstrate different ways in which it can be used:

```
<timer name="daysBeforeHoliday" duedate="5 business days">...</timer>

<timer name="pensionDate" duedate="#{dateOfBirth} + 65 years" >...</timer>
```

```
<timer name="pensionReminder" duedate="#{dateOfPension} - 1 year" >...
</timer>

<timer name="fireWorks" duedate="#{chineseNewYear} repeat="1 year" >...
</timer>

<reminder name="hitBoss" duedate="#{payRaiseDay} + 3 days" repeat="1 week"
/>
```

```
hour.format=HH:mm
#weekday ::= [<daypart> [&amp; <daypart>]*]
#daypart ::= <start-hour>-<to-hour>
#start-hour and to-hour must be in the hour.format
#dayparts have to be ordered
weekday.monday=    9:00-12:00 &amp; 12:30-17:00
weekday.tuesday=   9:00-12:00 &amp; 12:30-17:00
weekday.wednesday= 9:00-12:00 &amp; 12:30-17:00
weekday.thursday=  9:00-12:00 &amp; 12:30-17:00
weekday.friday=    9:00-12:00 &amp; 12:30-17:00
weekday.saturday=
weekday.sunday=

day.format=dd/MM/yyyy
# holiday syntax: <holiday>
# holiday period syntax: <start-day>-<end-day>
# below are the belgian official holidays
holiday.1=  01/01/2005 # nieuwjaar
holiday.2=  27/3/2005  # pasen
holiday.3=  28/3/2005  # paasmaandag
holiday.4=  1/5/2005   # feest van de arbeid
holiday.5=  5/5/2005   # hemelvaart
holiday.6=  15/5/2005  # pinksteren
holiday.7=  16/5/2005  # pinkstermaandag
holiday.8=  21/7/2005  # my birthday
holiday.9=  15/8/2005  # moederkesdag
holiday.10= 1/11/2005  # allerheiligen
holiday.11= 11/11/2005 # wapenstilstand
holiday.12= 25/12/2005 # kerstmis

business.day.expressed.in.hours=             8
business.week.expressed.in.hours=           40
business.month.expressed.in.business.days=  21
business.year.expressed.in.business.days=  220
```

Having studied this chapter, you now understand how the Business Calendar works.

CHAPTER 12. E-MAIL SUPPORT

This chapter describes the "out-of-the-box" e-mail support available in the JPDL. Read this information to learn how to configure different aspects of the mail functionality.

12.1. MAIL IN JPDL

There are four ways in which one can specify the point in time at which e-mails are to be sent from a process.

12.1.1. Mail Action

Use a *mail action* if there is a reason not to show the e-mail as a node in the process graph.

NOTE

A mail action can be added to the process anywhere that a normal action can be added.

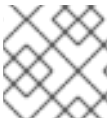
```
&lt;mail actors="#{president}" subject="readmylips" text="nomoretaxes"
/&gt;
```

Specify the subject and text attributes as an element like this:

```
<mail actors="#{president}" >
    <subject>readmylips</subject>
    <text>nomoretaxes</text>
</mail>
```

Each of the fields can contain JSF-like expressions:

```
<mail
    to='#{initiator}'
    subject='websale'
    text='your websale of #{quantity} #{item} was approved' />
```

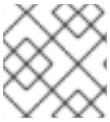


NOTE

To learn more about expressions, see Section 14.3, “ Expressions ”.

Two attribute specify the recipients: actors and to. The to attribute should "resolve" to a semi-colon separated list of e-mail addresses. The actors attribute should resolve to a semi-colon separated list of actorIds. These actorIds will, in turn, resolve to e-mail addresses. (Refer to Section 12.3.3, “ Address Resolving ” for more details.)

```
<mail
    to='admin@mycompany.com'
    subject='urgent'
    text='the mailserver is down :-)' />
```



NOTE

To learn how to specify recipients, read Section 12.3, " Specifying E-Mail Recipients "

e-Mails can be defined by the use of templates. Overwrite template properties in this way:

```
<mail template='sillystatement' actors="#{president}" />
```

NOTE

Learn more about templates by reading Section 12.4, " E-Mail Templates "

12.1.2. Mail Node

As with mail actions, the action of sending an e-mail can be modeled as a node. In this case, the run-time behavior will be identical but the e-mail will display as a node in the *process graph*.

Mail nodes support exactly the same attributes and elements as the **`mail action`**. (See Section 12.1.1, " Mail Action " to find out more.)

```
<mail-node  name="send email"
            to="#{president}"
            subject="readmylips"
            text="nomoretaxes">
    <transition to="the next node" />
</mail-node>
```

IMPORTANT

Always ensure that mail nodes have exactly one *leaving* transition.

12.1.3. "Task Assigned" E-Mail

A notification e-mail can be sent when a task is assigned to an actor. To configure this feature, add the **`notify="yes"`** attribute to a task in the following manner:

```
<task-node name='a'>
    <task name='laundry' swimlane="grandma" notify='yes' />
    <transition to='b' />
</task-node>
```

Set notify to **`yes`**, **`true`** or **`on`** to make the Business Process Manager send an e- mail to the actor being assigned to the task. (Note that this e- mail is based on a template and contains a link to the web application's task page.)

12.1.4. "Task Reminder" E-Mail

e-Mails can be sent as task reminders. The JPDL's reminder element utilizes the timer. The most commonly used attributes are duedate and repeat. Note that actions do not have to be specified.

```
<task-node name='a'>
```

```
    <task name='laundry' swimlane="grandma" notify='yes'>
        <reminder duedate="2 business days" repeat="2 business hours"/>
    </task>
    <transition to='b' />
</task-node>
```

12.2. EXPRESSIONS IN MAIL

The fields **to**, **recipients**, **subject** and **text** can contain JSF-like expressions. (For more information about expressions, see Section 14.3, " Expressions ".)

One can use the following variables in expressions: swimlanes, process variables and transient variables beans. Configure them via the **jbpm.cfg.xml** file.

Expressions can be combined with *address resolving* functionality. (Refer to Section 12.3.3, " Address Resolving ". for more information.)

This example pre-supposes the existence of a swimlane called **president**:

```
<mail   actors="#{president}"
        subject="readmylips"
        text="nomoretaxes" />
```

The code will send an e-mail to the person that acts as the **president** for that particular process execution.

12.3. SPECIFYING E-MAIL RECIPIENTS

12.3.1. Multiple Recipients

Multiple recipients can be listed in the actors and to fields. Separate items in the list with either a colon or a semi-colon.

12.3.2. Sending E-Mail to a BCC Address

In order to send messages to a *Blind Carbon Copy* (BCC) recipient, use either the bccActors or the bcc attribute in the process definition.

```
<mail to='#{initiator}'
      bcc='bcc@mycompany.com'
      subject='websale'
      text='your websale of #{quantity} #{item} was approved' />
```

An alternative approach is to always send BCC messages to some location that has been centrally configured in **jbpm.cfg.xml**. This example demonstrates how to do so:

```
<jbpm-configuration>
    ...
    <string name="jbpm.mail.bcc.address" value="bcc@mycompany.com" />
</jbpm-configuration>
```

12.3.3. Address Resolving

Throughout the Business Process Manager, actors are referenced by **actorIds**. These are strings that serves to identify process participants. An *address resolver* translates **actorIds** into e-mail addresses.

Use the attribute actors to apply address resolving. Conversely, use the to attribute if adding addresses directly as it will not run apply address resolving.

Make sure the address resolver implements the following interface:

```
public interface AddressResolver extends Serializable {
 Object resolveAddress(String actorId);
}
```

An address resolver will return one of the following three types: a string, a collection of strings or an array of strings. (Strings must always represent e-mail addresses for the given **actorId**.)

Ensure that the address resolver implementation is a bean. This bean must be configured in the **jbpm.cfg.xml** file with name **jbpm.mail.address.resolver**, as per this example:

```
<jbpm-configuration>
    <bean name='jbpm.mail.address.resolver'
        class='org.jbpm.identity.mail.IdentityAddressResolver'
        singleton='true' />
</jbpm-configuration>
```

The Business Process Manager's **identity** component includes an address resolver. This address resolver will look for the given **actorId**'s user. If the user exists, their e-mail address will be returned. If not, null will be returned.

NOTE

To learn more about the identity component, read Section 8.11, “ The Identity Component ”.

12.4. E-MAIL TEMPLATES

Instead of using the **processdefinition.xml** file to specify e-mails, one can use a template. In this case, each of the fields can still be overwritten by **processdefinition.xml**. Specify a templates like this:

```
<mail-templates>
    <variable name="BaseTaskListURL"
        value="http://localhost:8080/jbpm/task?id=" />

    <mail-template name='task-assign'>
        <actors>#{taskInstance.actorId}</actors>
        <subject>Task '#{taskInstance.name}'</subject>
        <text><![CDATA[Hi,
Task '#{taskInstance.name}' has been assigned to you.
Go for it: #{BaseTaskListURL}#{taskInstance.id}
Thanks.
---powered by JBoss jBPM---]]></text>
    </mail-template>

    <mail-template name='task-reminder'>
```

```
        <actors>#{taskInstance.actorId}</actors>
        <subject>Task '#{taskInstance.name}' !</subject>
        <text><![CDATA[Hey,
Don't forget about #{BaseTaskListURL}#{taskInstance.id}
Get going !
---powered by JBoss jBPM---]]></text>
    </mail-template>

</mail-templates>
```

Extra variables can be defined in the mail templates and these will be available in the expressions.

Configure the resource that contains the templates via the **jbpm.cfg.xml** like this:

```
<jbpm-configuration>
  <string name="resource.mail.templates" value="jbpm.mail.templates.xml"
/>
</jbpm-configuration>
```

12.5. MAIL SERVER CONFIGURATION

Configure the mail server by setting the jbpm.mail.smtp.host property in the **jbpm.cfg.xml** file, as per this example code:

```
<jbpm-configuration>
    <string name="jbpm.mail.smtp.host" value="localhost" />
</jbpm-configuration>
```

Alternatively, when more properties need to be specified, give a resource reference to a properties file in this way:

```
<jbpm-configuration>
   <string name='resource.mail.properties' value='jbpm.mail.properties' />
</jbpm-configuration>
```

12.6. EMAIL AUTHENTICATION

12.6.1. Email authentication configuration

The following settings can be used to enable (SMTP) authentication when sending email.

Table 12.1. jBPM mail authentication properties

Property	Type	Description
jbpm.mail.user	string	The email address of the user
jbpm.mail.password	string	The password for that email address

Property	Type	Description
jbpm.mail.smtp.starttls	boolean	Whether or not to use the STARTTLS protocol with the SMTP server
jbpm.mail.smtp.auth	boolean	Whether or not to use the SMTP authentication protocol
jbpm.mail.debug	boolean	Whether or not to set the javax.mail.Session instance to debug mode

12.6.2. Email authentication logic

The following logic is applied with regards to the above properties:

If neither the jbpm.mail.user nor the jbpm.mail.password property is set, authentication is not used regardless of other settings set.

If the jbpm.mail.user property is set, then the following is done:

- The mail.smtp.submitter property is set with the value of the jbpm.mail.user property
- The jbpm engine will try to login into the smtp server when sending email.

If the jbpm.mail.user property and the jbpm.mail.password property are set, then the following is done:

- Everything that is done when at least the jbpm.mail.user is set, is also done in this case
- The mail.smtp.auth property is set to true, regardless of the value of the jbpm.mail.smtp.auth property

12.7. "FROM" ADDRESS CONFIGURATION

The default value for the **From** address field **jbpm@noreply**. Configure it via the **jbpm.xfg.xml** file with key **jbpm.mail.from.address** like this:

```
<jbpm-configuration>
    <string name='jbpm.mail.from.address' value='jbpm@yourcompany.com' />
</jbpm-configuration>
```

12.8. CUSTOMIZING E-MAIL SUPPORT

All of the Business Process Manager's e-mail support is centralized in one class, namely **org.jbpm.mail.Mail**. This class is an **ActionHandler** implementation. Whenever an e-mail is specified in the **process** XML, a delegation to the **mail** class will result. It is possible to inherit from the **mail** class and customize certain behavior for specific needs. To configure a class to be used for mail delegations, specify a **jbpm.mail.class.name** configuration string in the **jbpm.cfg.xml** like this:

```
<jbpm-configuration>
  <string name='jbpm.mail.class.name'
  value='com.your.specific.CustomMail' />
```

```
</jbpm-configuration>
```

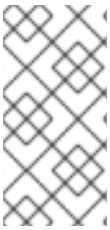
The customized mail class will be read during parsing. Actions will be configured in the process that reference the configured (or the default) mail classname. Hence, if the property is changed, all the processes that were already deployed will still refer to the old mail classname. Alter them simply by sending an update statement directed at the jBPM database.

This chapter has provided detailed information on how to configure various e-mail settings. You can now practice configuring your own environment

CHAPTER 13. LOGGING

Read this chapter to learn about the logging functionality present in the Business Process Manager and the various ways in which it can be utilized.

The purpose of logging is to record the history of a process execution. As the run-time data of each process execution alters, the changes are stored in the logs.



NOTE

Process logging, which is covered in this chapter, is not to be confused with *software logging*. Software logging traces the execution of a software program (usually for the purpose of debugging it). Process logging, by contast, traces the execution of process instances.

There are many ways in which process logging information can be useful. Most obvious of these is the consulting of the process history by process execution participants.

Another use case is that of *Business Activity Monitoring* (BAM). This can be used to query or analyze the logs of process executions to find useful statistical information about the business process. This information is key to implementing "real" business process management in an organization. (Real business process management is about how an organization manages its processes, how these processes are supported by information technology and how these two can be used improve each other in an iterative process.)

Process logs can also be used to implement "undos". Since the logs contain a record of all run-time information changes, they can be "played" in reverse order to bring a process back into a previous state.

13.1. LOG CREATION

Business Process Manager modules produce logs when they run process executions. But also users can insert process logs. (A log entry is a Java object that inherits from **`org.jbpm.logging.log.ProcessLog`**.) Process log entries are added to the **`LoggingInstance`**, which is an optional extension of the **`ProcessInstance`**.

The Business Process Manager generates many different kinds of log, these being graph execution logs, context logs and task management logs. A good starting point is **`org.jbpm.logging.log.ProcessLog`** since one can use that to navigate down the **`inheritance tree`**.

The **`LoggingInstance`** collects all log entries. When the **`ProcessInstance`** is saved, they are flushed from here to the database. (The **`ProcessInstance`**'s logs field is not mapped to **Hibernate**. This is so as to avoid those logs that are retrieved from the database in each transaction.)

Each **`ProcessInstance`** is made in the context of a path of execution and hence, the**`ProcessLog`** refers to that token, which also serves as an *index sequence generator* it. (This is important for log retrieval as it means that logs produced in subsequent transactions shall have sequential sequence numbers.)

Use this API method to add process logs:

```
public class LoggingInstance extends ModuleInstance {
  ...
  public void addLog(ProcessLog processLog) {...}
```

```
  ...
}
```

This is the UML diagram for information logging:

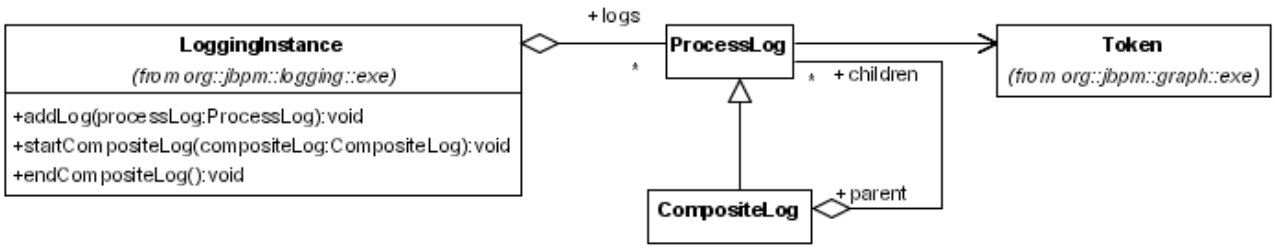


Figure 13.1. The jBPM logging information class diagram

A *CompositeLog* is a special case. It serves as the parent log for a number of children, thereby creating the means for a hierarchical structure to be applied. The following application programming interface is used to insert a log:

```
public class LoggingInstance extends ModuleInstance {
  ...
  public void startCompositeLog(CompositeLog compositeLog) {...}
  public void endCompositeLog() {...}
  ...
}
```

The **`CompositeLog`**s should always be called in a **`try-finally-block`** to make sure that the hierarchical structure is consistent. For example:

```
startCompositeLog(new MyCompositeLog());
try {
  ...
} finally {
  endCompositeLog();
}
```

13.2. LOG CONFIGURATIONS

If logs are not important for a particular deployment, simply remove the logging line from the jbpm-context section of the **`jbpm.cfg.xml`** configuration file:

```
<service name='logging'
    factory='org.jbpm.logging.db.DbLoggingServiceFactory' />
```

In order to filter the logs, write a custom implementation of the **`LoggingService`** (this is a subclass of **`DbLoggingService`**). Having done so, create a custom **`ServiceFactory`** for logging and specify it in the **`factory`** attribute.

13.3. LOG RETRIEVAL

Process instance logs must always be retrieved via database queries. There are two methods to achieve this through **`LoggingSession`**.

The first method retrieves all logs for a process instance. These logs will be grouped by token in a map. This map will associate a list of **`ProcessLogs`** with every token in the process instance. The list will contain the **`ProcessLogs`** in the same order as that in which they were created.

```
public class LoggingSession {
  ...
  public Map findLogsByProcessInstance(long processInstanceId) {...}
  ...
}
```

The second method retrieves the logs for a specific token. The list will contain the **`ProcessLogs`** in the same order as that in which they were created.

```
public class LoggingSession {
  public List findLogsByToken(long tokenId) {...}
  ...
}
```

Having read this chapter, you now know how logging works in jBPM and has some idea of the various uses to which it can be put.

CHAPTER 14. JBPM PROCESS DEFINITION LANGUAGE

The *jBPM Process Definition Language* (jPDL) is the notation to define business processes recognized by the jBPM framework and expressed as an XML schema. Process definitions often require support files in addition to the jPDL document. All these files are packaged into a *process archive* for deployment.

14.1. PROCESS ARCHIVE

The process archive is just a ZIP archive with a specific content layout. The central file in the process archive is called **`processdefinition.xml`** This file defines the business process in the jPDL notation and provides information about automated actions and human tasks. The process archive also contains other files related to the process, such as action handler classes and user interface task forms.

14.1.1. Deploying a Process Archive

You can deploy a **`process archive`** in any of these ways:

- via the **Process Designer Tool**
- with an **`ant`** task
- programatically

To deploy a process archive with the **Process Designer Tool**, right-click on the process archive folder and select the **Deploy process archive** option.

The jBPM application server integration modules include the **gpd-deployer** web application, which has a servlet to upload process archives, called **`GPD Deployer Servlet`**. This servlet is capable of receiving process archives and deploying them to the configured database.

To deploy a process archive with an **`ant`** task, define and call the task as follows.

```
<target name="deploy-process">
  <taskdef name="deployproc" classname="org.jbpm.ant.DeployProcessTask">
    <classpath location="jbpm-jpdl.jar" />
  </taskdef>
  <deployproc process="build/myprocess.par" />
</target>
```

To deploy more process archives at once, use nested fileset elements. Here are the **`DeployProcessTask`** attributes.

Table 14.1. `DeployProcessTask` Attributes

Attribute	Description	Required?
process	Path to process archive.	Yes, unless a nested resource collection element is used.
jbpmcfg	jBPM configuration resource to load during deployment.	No; defaults to **`jbpm.cfg.xml`**

Attribute	Description	Required?
failonerror	If false, log a warning message, but do not stop the build, when the process definition fails to deploy.	No; defaults to true

To deploy process archives programmatically, use one of the **`parseXXX`** methods of the **`org.jbpm.graph.def.ProcessDefinition`** class.

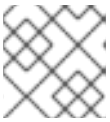
14.1.2. Process Versioning

Process instances always execute on the same process definition as that in which they were started. However, the **jBPM** allows multiple process definitions of the same name to co-exist in the database. Typically, a process instance is started in the latest version available at that time and it will keep on executing in that same process definition for its complete lifetime. When a newer version is deployed, newly created instances will be started in the newest version, while older process instances keep on executing in the older process definitions.

If the process includes references to Java classes, these can be made available to the jBPM runtime environment in one of two ways:

- by making sure these classes are visible to the jBPM class-loader.

  To do so, put the delegation classes in a **`.jar`** file "next to" **`jbpm-jpdl.jar`** so that all of the process definitions will see that class file. The Java classes can also be included in the process archive. When you include your delegation classes in the process archive (and they are not visible to the jbpm classloader), the **jBPM** will also version these classes inside the process definition.



NOTE

Learn more about process classloading by reading Section 14.2, “Delegation”

When a process archive is deployed, a *process definition* is created in the jBPM database. Version process definitions on the basis of their names. When a named process archive is deployed, the deployer assigns it a version number. It does so by searching for the highest number assigned to a process definition of the same name and then adds one to that value. (Unnamed process definitions will always be versioned as **`-1`**.)

14.1.3. Changing Deployed Process Definitions

WARNING

Changing process definitions after they are deployed is not a recommended practice. It is better to migrate process instances to a new version of the process definition.

Consider these factors before undertaking this process:

- There is no restriction on updating a process definition loaded through the **`org.jbpm.db.GraphSession`** methods **`loadProcessDefinition`**, **`findProcessDefinition`** or reached through association traversal. Nonetheless, it is *very* easy to mess up the process with a few calls such as **`setStartState(null)`**!
- Because processs definitions are not supposed to change, the shipped Hibernate configuration specifies the **`nonstrict-read-write`** caching strategy for definition classes and collections. This strategy can make uncommitted updates visible to other transactions.

14.1.4. Migrating Process Instances

An alternative approach to changing a process definition is to migrate each process instance to a new version. Please consider that migration is not trivial due to the long-lived nature of business processes.

NOTE

This is an experimental feature.

There is a clear distinction between definition data, execution data and logging data. Because of this distinction, a new version of the process has to be deployed first, and then process instances are migrated to the new version. Migration involves a translation if tokens or task instances point to nodes or task definitions that have been removed in the target process definition. Be aware that logging data ends up spread over two process definitions. This can present challenges when developing tools and making statistics calculations.

To migrate a process instance to a new version, execute the **`ChangeProcessInstanceVersionCommand`** as shown below.

```
new ChangeProcessInstanceVersionCommand()
  .processName("commute")
  .nodeNameMappingAdd("drive to destination", "ride bike to destination")
  .execute(jbpmContext);
```

14.2. DELEGATION

Use the *delegation* mechanism to include custom code in process executions.

14.2.1. jBPM Class Loader

The jBPM class loader is the one that loads the jBPM classes. To make classes visible to the jBPM class loader, pack them in a JAR file and co-locate the JAR with **`jbpm-jpdl.jar`**. In the case of web applications, place the custom JAR file in **`WEB-INF/lib`** alongside **`jbpm-jpdl.jar`**.

14.2.2. Process Class Loader

Delegation classes are loaded through their respective *process class loader*. The process class loader has the jBPM class loader as its parent. It adds the classes deployed with one particular process definition. To add classes to a process definition, put them in the **`classes`** directory of the process archive. Note that this is only useful when you want to version the classes that have been added to the process definition. If versioning is not required, make the classes available to the jBPM class loader instead.

If the resource name does not start with a slash, resources are also loaded from the process archive's **`classes`** directory. To load resources that reside outside this directory, start the path with a double forward slash (`//`). For example, to load **`data.xml`**, located in the process archive root, call **`class.getResource("//data.xml")`**.

14.2.3. Configuring Delegations

Delegation classes contain user code that is called from within a process execution, the most common example being an *action*. In the case of action, an implementation of the**`ActionHandler`** interface can be called on an event in the process. Delegations are specified in the **`processdefinition.xml`** file. You can supply any of these three pieces of data when specifying a delegation:

1. the class name (required): this is the delegation class' fully-qualified name.
2. configuration type (optional): this specifies the way in which to instantiate and configure the delegation object. By default, the constructor is used and the configuration information is ignored.
3. configuration (optional): this is the configuration of the delegation object, which must be in the format required by the configuration type.

Here are descriptions of every type of configuration:

14.2.3.1. config-type field

This is the default configuration type. The config-type field first instantiates an object of the delegation class and then set values in those object fields specified in the configuration. The configuration is stored in an XML file. In this file, the element names have to correspond to the class' field names. The element's content text is put in the corresponding field. If both necessary and possible to do, the element's content text is converted to the field type.

These are the supported type conversions:

- string is trimmed but not converted.
- primitive types such as int, long, float, double, ...
- the basic wrapper classes for the primitive types.
- lists, sets and collections. In these cases, each element of the xml-content is considered an element of the collection and is parsed recursively, applying the conversions. If the element types differ from **`java.lang.String`** indicate this by specifying a type attribute with the fully-qualified type name. For example, this code injects an **`ArrayList`** of strings into numbers field:

  ```
  <numbers>
    <element>one</element>
    <element>two</element>
    <element>three</element>
  </numbers>
  ```

  You can convert the text in the elements to any object that has a string constructor. To use a type other than a string, specify the element-type in the field (numbers in this case).

  Here is another example of a map:

```
<numbers>
  <entry><key>one</key><value>1</value></entry>
  <entry><key>two</key><value>2</value></entry>
  <entry><key>three</key><value>3</value></entry>
</numbers>
```

- In this case, each of the field elements is expected to have one key and one value sub-element. Parse both of these by using the conversion rules recursively. As with collections, it will be assumed that a conversion to **`java.lang.String`** is intended if you do not specify a type attribute.
- **`org.dom4j.Element`**
- for any other type, the string constructor is used.

Look at this class:

```
public class MyAction implements ActionHandler {
  // access specifiers can be private, default, protected or public
  private String city;
  Integer rounds;
  ...
}
```

This is a valid configuration for that class:

```
...
<action class="org.test.MyAction">
  <city>Atlanta</city>
  <rounds>5</rounds>
</action>
...
```

14.2.3.2. config-type bean

This is the same as the config-type field but, in that case, the properties are configured via "setter" methods. Here they are set directly on the fields. The same conversions are applied.

14.2.3.3. config-type constructor

This method takes the complete contents of the delegation XML element and passes them as text to the delegation class constructor.

14.2.3.4. config-type configuration-property

If you use the default constructor, this method will take the complete contents of the delegation XML element and pass it as text in the **`void configure(String);`** method.

14.3. EXPRESSIONS

There is limited support for a JSP/JSF EL-like expression language. In actions, assignments and decision conditions, you can write this kind of expression: **`expression="#{myVar.handler[assignments].assign}"`**

NOTE

To learn about this expression language, study this tutorial: http://java.sun.com/j2ee/1.4/docs/tutorial/doc/JSPIntro7.html.

The jPDL and JSF expression languages are similar. jPDL EL is based on JSF EL but, in contrast to the latter, it employs **`#{...}`** notation and includes support for method-binding.

Depending on the context, the process and task instance variables can be used as starting variables, as can the the following implicit objects:

- taskInstance (**`org.jbpm.taskmgmt.exe.TaskInstance`**)
- processInstance (**`org.jbpm.graph.exe.ProcessInstance`**)
- processDefinition (**`org.jbpm.graph.def.ProcessDefinition`**)
- token (**`org.jbpm.graph.exe.Token`**)
- taskMgmtInstance (**`org.jbpm.taskmgmt.exe.TaskMgmtInstance`**)
- contextInstance (**`org.jbpm.context.exe.ContextInstance`**)

This feature becomes powerful when used in a **JBoss SEAM** environment (http://www.jboss.com/products/seam). Because of the integration between the JBPM and SEAM, every *backed bean*, Enterprise Java Bean and so forth becomes accessible from within the process definition.

14.4. JPDL XML SCHEMA

The jPDL schema is the schema used in the process archive's **`processdefinition.xml`** file.

14.4.1. Validation

When parsing a jPDL XML document, jBPM will validate it against the schema when these two conditions are met:

1. The schema is referenced in the XML document:

```
<process-definition xmlns="urn:jbpm.org:jpdl-3.2">
  ...
</process-definition>
```

2. The **Xerces** parser is on the class-path.

NOTE

Find the jPDL schema at **`${jbpm.home}/src/java.jbpm/org/jbpm/jpdl/xml/jpdl-3.2.xsd`** or at http://jbpm.org/jpdl-3.2.xsd.

14.4.2. process-definition

Table 14.2. Process Definition Schema

Name	Type	Multiplicity	Description
name	attribute	optional	This is the name of the process
swimlane	element	[0..*]	These are the *swim-lanes* used in the process. The swim-lanes represent process roles and are used for task assignments.
start-state	element	[0..1]	This is the process' start state. Note that a process without a start-state is valid, but cannot be executed.
{end-state|state|node|task-node|process-state|super-state|fork|join|decision}	element	[0..*]	These are the process definition's nodes. Note that a process without nodes is valid, but cannot be executed.
event	element	[0..*]	These serve as a container for actions
{action|script|create-timer|cancel-timer}	element	[0..*]	These are globally-defined actions that can be referenced from events and transitions. Note that these actions must specify a name in order to be referenced.
task	element	[0..*]	These are globally-defined tasks that can be used in e.g. actions.
exception-handler	element	[0..*]	This is a list of those exception handlers that applies to all errors thrown by delegation classes in this process definition.

14.4.3. node

Table 14.3. Node Schema

Name	Type	Multiplicity	Description
{action|script|create-timer|cancel-timer}	element	1	This is a custom action that represents the behaviour for this node
common node elements			Section 14.4.4, “common node elements”

14.4.4. common node elements

Table 14.4. Common Node Schema

Name	Type	Multiplicity	Description
name	attribute	required	This is the name of the node
async	attribute	{ true | false }, false is the default	If set to true, this node will be executed asynchronously. See also Chapter 10, *Asynchronous Continuations*
transition	element	[0..*]	These are the leaving transitions. Each transition leaving a node *must* have a distinct name. A maximum of one of the leaving transitions is allowed to have no name. The first transition that is specified is called the default transition. The default transition is taken when the node is left without specifying a transition.
event	element	[0..*]	There are two supported event types: **`{node-enter|node-leave}`**
exception-handler	element	[0..*]	This is a list of exception handlers that applies to every bug thrown by a delegation class from within this process node.
timer	element	[0..*]	This specifies a timer that monitors the duration of an execution in this node.

14.4.5. start-state

Table 14.5. Start State Schema

Name	Type	Multiplicity	Description
name	attribute	optional	This is the name of the node
task	element	[0..1]	This is the task used to start a new instance for this process or to capture the process initiator. See Section 8.7, " Swimlane in Start Task "
event	element	[0..*]	This is the supported event type: **`{node-leave}`**
transition	element	[0..*]	These are the leaving transitions. Each transition leaving a node must have a distinct name.
exception-handler	element	[0..*]	This is a list of exception handlers that applies to every bug thrown by a delegation class from within this process node.

14.4.6. end-state

Table 14.6. End State Schema

Name	Type	Multiplicity	Description
name	attribute	required	This is the name of the end-state
end-complete-process	attribute	optional	If the **`end-complete-process`** is set to **`false`**, only the token concluding this end-state is finished. If this token was the last child to end, the parent token is ended recursively. Set this property to **`true`**, to ensure that the full process instance is ended.
event	element	[0..*]	The supported event type is **`{node-enter}`**
exception-handler	element	[0..*]	This is a list of exception handlers that applies to every bug thrown by a delegation class from within this process node.

14.4.7. state

Table 14.7. State Schema

Name	Type	Multiplicity	Description
common node elements			See Section 14.4.4, “common node elements”

14.4.8. task-node

Table 14.8. Task Node Schema

Name	Type	Multiplicity	Description
signal	attribute	optional	This can be **`{unsynchronized|never|first|first-wait|last|last-wait}`**, the default being **`last`**. It specifies the way in which task completion affects *process execution continuation*.
create-tasks	attribute	optional	This can be **`{yes|no|true|false}`**, with the default being **`true`**. Set it to **`false`** when a run-time calculation has to determine which of the tasks have to be created. In that case, add an action on node-enter, create the tasks in the action and set create-tasks to **`false`**.

Name	Type	Multiplicity	Description
end-tasks	attribute	optional	This can be **{yes|no|true|false}**, with the default being **false**. If remove-tasks is set to **true** on node-leave, every open task is ended.
task	element	[0..*]	These are the tasks that are created when execution arrives in this task node.
common node elements			See Section 14.4.4, “common node elements”

14.4.9. process-state

Table 14.9. Process State Schema

Name	Type	Multiplicity	Description
sub-process	element	1	This is the sub-process that is associated with this node.
variable	element	[0..*]	This specifies how data should be copied from the super-process to the sub-process at the commencement, and from the sub-process to the super-process upon completion of the sub-process.
common node elements			See Section 14.4.4, “common node elements”

14.4.10. super-state

Table 14.10. Super State Schema

Name	Type	Multiplicity	Description
{end-state|state|node|task-node|process-state|super-state|fork|join|decision}	element	[0..*]	These are the super-state's nodes. Super-states can be nested.
common node elements			See Section 14.4.4, “common node elements”

14.4.11. fork

Table 14.11. Fork Schema

Name	Type	Multiplicity	Description
common node elements			See Section 14.4.4, “common node elements”

14.4.12. join

Table 14.12. Join Schema

Name	Type	Multiplicity	Description
common node elements			See Section 14.4.4, “common node elements”

14.4.13. decision

Table 14.13. Decision Schema

Name	Type	Multiplicity	Description
handler	element	either a 'handler' element or conditions on the transitions should be specified	the name of a `org.jbpm.jpdl.Def.DecisionHandler` implementation
transition conditions	attribute or element text on the transitions leaving a decision		Every transition may have a guard condition. The decision node examines the leaving transitions having a condition, and selects the first transition whose condition is true. In case no condition is met, the *default* transition is taken. The default transition is the first unconditional transition if there is one, or else the first conditional transition. Transitions are considered in document order. If only conditional ("guarded") transitions are available, and *none* of the conditions on the transitions evaluate to true, an exception will be thrown.
common node elements			See Section 14.4.4, “common node elements”

14.4.14. event

Table 14.14. Event Schema

Name	Type	Multiplicity	Description
type	attribute	required	This is the event type that is expressed relative to the element on which the event is placed
{action|script|create-timer|cancel-timer}	element	[0..*]	This is the list of actions that should be executed on this event

14.4.15. transition

Table 14.15. Transition Schema

Name	Type	Multiplicity	Description
name	attribute	optional	This is the name of the transition. Note that each transition leaving a node *must* have a distinct name.
to	attribute	required	This is the destination node's hierarchical name. For more information about hierarchical names, see Section 6.6.3, “ Hierarchical Names ”
condition	attribute or element text	optional	This is a *guard condition* expression. Use these condition attributes (or child elements) in decision nodes, or to calculate the available transitions on a token at run-time. Conditions are only allowed on transitions leaving decision nodes.
{action|script|create-timer|cancel-timer}	element	[0..*]	These are the actions that will execute when this transition occurs. Note that a transition's actions do not need to be put in an event (because there is only one).
exception-handler	element	[0..*]	This is a list of exception handlers that applies to every bug thrown by a delegation class from within this process node.

14.4.16. action

Table 14.16. Action Schema

Name	Type	Multiplicity	Description

Name	Type	Multiplicity	Description
name	attribute	optional	This is the name of the action. When actions are given names, they can be looked up from the process definition. This can be useful for runtime actions and declaring actions only once.
class	attibute	either, a ref-name or an expression	This is the fully-qualified class name of the class that implements the **`org.jbpm.graph.def.ActionHandler`** interface.
ref-name	attibute	either this or class	This is the name of the referenced action. The content of this action is not processed further if a referenced action is specified.
expression	attribute	either this, a class or a ref-name	This is a jPDL expression that resolves to a method. See also Section 14.3, " Expressions "
accept-propagated-events	attribute	optional	The options are **`{yes|no|true|false}`**. The default is **`yes|true`**. If set to **`false`**, the action will only be executed on events that were fired on this action's element. For more information, read Section 6.5.3, " Passing On Events "
config-type	attribute	optional	The options are **`{field|bean|constructor|configuration-property}`**. This specifies how the action-object should be constructed and how the content of this element should be used as configuration information for that action-object.
async	attribute	{true|false}	**`'async="true"`** is only supported in **`action`** when it is triggered in an event. The default value is **`false`**, which means that the **`action`** is executed in the thread of the execution. If set to **`true`**, a message will be sent to the command executor and that component will execute the action asynchronously in a separate transaction.
	{content}	optional	The action's content can be used as the configuration information for custom action implementations. This allows to create reusable delegation classes.

14.4.17. script

Table 14.17. Script Schema

Name	Type	Multiplicity	Description
name	attribute	optional	This is the name of the script-action. When actions are given names, they can be looked up from the process definition. This can be useful for runtime actions and declaring actions only once.
accept-propagated-events	attribute	optional [0..*]	{yes|no|true|false}. Default is yes|true. If set to false, the action will only be executed on events that were fired on this action's element. for more information, see Section 6.5.3, " Passing On Events "
expression	element	[0..1]	the beanshell script. If you don't specify variable elements, you can write the expression as the content of the script element (omitting the expression element tag).
variable	element	[0..*]	in variable for the script. If no in variables are specified, all the variables of the current token will be loaded into the script evaluation. Use the in variables if you want to limit the number of variables loaded into the script evaluation.

14.4.18. expression

Table 14.18. Expression Schema

Name	Type	Multiplicity	Description
	{content}		a bean shell script.

14.4.19. variable

Table 14.19. Variable Schema

Name	Type	Multiplicity	Description
name	attribute	required	the process variable name
access	attribute	optional	default is **`read,write`**. It is a comma separated list of access specifiers. The only access specifiers used so far are **`read`**, **`write`** and **`required`**. "required" is only relevant when you are submitting a task variable to a process variable.

Name	Type	Multiplicity	Description
mapped-name	attribute	optional	this defaults to the variable name. it specifies a name to which the variable name is mapped. the meaning of the mapped-name is dependent on the context in which this element is used. For a script, this will be the script-variable-name. For a task controller, this will be the label of the task form parameter. For a process-state, this will be the variable name used in the sub-process.

14.4.20. handler

Table 14.20. Handler Schema

Name	Type	Multiplicity	Description
expression	attribute	either this or a class	A jPDL expression. The returned result is transformed to a string with the toString() method. The resulting string should match one of the leaving transitions. See also Section 14.3, " Expressions ".
class	attribute	either this or ref-name	the fully qualified class name of the class that implements the **`org.jbpm.graph.node.DecisionHandler`** interface.
config-type	attribute	optional	{field|bean|constructor|configuration-property}. Specifies how the action-object should be constructed and how the content of this element should be used as configuration information for that action-object.
	{content}	optional	the content of the handler can be used as configuration information for your custom handler implementations. This allows the creation of reusable delegation classes.

14.4.21. timer

Table 14.21. Timer Schema

Name	Type	Multiplicity	Description
name	attribute	optional	the name of the timer. If no name is specified, the name of the enclosing node is taken. Note that every timer should have a unique name.

Name	Type	Multiplicity	Description
duedate	attribute	required	the duration (optionally expressed in business hours) that specifies the time period between the creation of the timer and the execution of the timer. See Section 11.1.1, “ Duration ” for the syntax.
repeat	attribute	optional	{duration | 'yes' | 'true'}after a timer has been executed on the duedate, 'repeat' optionally specifies duration between repeating timer executions until the node is left. If **`yes`** or **`true`** is specified, the same duration as for the due date is taken for the repeat. See Section 11.1.1, “ Duration ” for the syntax.
transition	attribute	optional	a transition-name to be taken when the timer executes, after firing the timer event and executing the action (if any).
cancel-event	attribute	optional	this attribute is only to be used in timers of tasks. it specifies the event on which the timer should be cancelled. by default, this is the **`task-end`** event, but it can be set to e.g. **`task-assign`** or **`task-start`**. The **`cancel-event`** types can be combined by specifying them in a comma separated list in the attribute.
{action|script|create-timer|cancel-timer}	element	[0..1]	an action that should be executed when this timer fires

14.4.22. create-timer

Table 14.22. Create Timer Schema

Name	Type	Multiplicity	Description
name	attribute	optional	the name of the timer. The name can be used for cancelling the timer with a cancel-timer action.
duedate	attribute	required	the duration (optionally expressed in business hours) that specifies the the time period between the creation of the timer and the execution of the timer. See Section 11.1.1, “ Duration ” for the syntax.

Name	Type	Multiplicity	Description
repeat	attribute	optional	{duration | 'yes' | 'true'}after a timer has been executed on the duedate, 'repeat' optionally specifies duration between repeating timer executions until the node is left. If **`yes`** of **`true`** is specified, the same duration as for the due date is taken for the repeat. See Section 11.1.1, " Duration " for the syntax.
transition	attribute	optional	a transition-name to be taken when the timer executes, after firing the the timer event and executing the action (if any).

14.4.23. cancel-timer

Table 14.23. Cancel Timer Schema

Name	Type	Multiplicity	Description
name	attribute	optional	the name of the timer to be cancelled.

14.4.24. task

Table 14.24. Task Schema

Name	Type	Multiplicity	Description
name	attribute	optional	the name of the task. Named tasks can be referenced and looked up via the **`TaskMgmtDefinition`**
blocking	attribute	optional	{yes|no|true|false}, default is false. If blocking is set to true, the node cannot be left when the task is not finished. If set to false (default) a signal on the token is allowed to continue execution and leave the node. The default is set to false, because blocking is normally forced by the user interface.
signalling	attribute	optional	{yes|no|true|false}, default is true. If signalling is set to false, this task will never have the capability of trigering the continuation of the token.
duedate	attribute	optional	is a duration expressed in absolute or business hours as explained in Chapter 11, *Business Calendar*

Name	Type	Multiplicity	Description
swimlane	attribute	optional	reference to a swimlane. If a swimlane is specified on a task, the assignment is ignored.
priority	attribute	optional	one of {highest, high, normal, low, lowest}. alternatively, any integer number can be specified for the priority. FYI: (highest=1, lowest=5)
assignment	element	optional	describes a delegation that will assign the task to an actor when the task is created.
event	element	[0..*]	supported event types: {task-create|task-start|task-assign|task-end}. Especially for the **`task-assign`** we have added a non-persisted property **`previousActorId`** to the **`TaskInstance`**
exception-handler	element	[0..*]	a list of exception handlers that applies to all exceptions thrown by delegation classes thrown in this process node.
timer	element	[0..*]	specifies a timer that monitors the duration of an execution in this task. special for task timers, the **`cancel-event`** can be specified. by default the **`cancel-event`** is **`task-end`**, but it can be customized to e.g. **`task-assign`** or **`task-start`**.
controller	element	[0..1]	specifies how the process variables are transformed into task form parameters. the task form paramaters are used by the user interface to render a task form to the user.

14.4.25. Swimlane

Table 14.25. Swimlane Schema

Name	Type	Multiplicity	Description
name	attribute	required	the name of the swimlane. Swimlanes can be referenced and looked up via the **`TaskMgmtDefinition`**
assignment	element	[1..1]	specifies a the assignment of this swimlane. the assignment will be performed when the first task instance is created in this swimlane.

14.4.26. Assignment

Table 14.26. Assignment Schema

Name	Type	Multiplicity	Description
expression	attribute	optional	For historical reasons, this attribute expression does *not* refer to the jPDL expression, but instead, it is an assignment expression for the jBPM identity component. For more information on how to write jBPM identity component expressions, see Section 8.11.2, “Assignment expressions”. Note that this implementation has a dependency on the jbpm identity component.
actor-id	attribute	optional	An actorId. Can be used in conjunction with pooled-actors. The actor-id is resolved as an expression. So you can refer to a fixed actorId like this **`actor-id="bobthebuilder"`**. Or you can refer to a property or method that returns a String like this: **`actor-id="myVar.actorId"`**, which will invoke the getActorId method on the task instance variable "myVar".
pooled-actors	attribute	optional	A comma separated list of actorIds. Can be used in conjunction with actor-id. A fixed set of pooled actors can be specified like this: **`pooled-actors="chicagobulls, pointersisters"`**. The pooled-actors will be resolved as an expression. So you can also refer to a property or method that has to return, a String[], a Collection or a comma separated list of pooled actors.
class	attribute	optional	the fully qualified classname of an implementation of **`org.jbpm.taskmgmt.def.AssignmentHandler`**
config-type	attribute	optional	{field|bean|constructor|configuration-property}. Specifies how the assignment-handler-object should be constructed and how the content of this element should be used as configuration information for that assignment-handler-object.
	{content}	optional	the content of the assignment-element can be used as configuration information for your AssignmentHandler implementations. This allows the creation of reusable delegation classes.

14.4.27. Controller

Table 14.27. Controller Schema

Name	Type	Multiplicity	Description
class	attribute	optional	the fully qualified classname of an implementation of **`org.jbpm.taskmgmt.def.TaskControllerHandler`**
config-type	attribute	optional	{field|bean|constructor|configuration-property}. This specifies how the assignment-handler-object should be constructed and how the content of this element should be used as configuration information for that assignment-handler-object.
	{content}		This is either the content of the controller is the configuration of the specified task controller handler (if the class attribute is specified. if no task controller handler is specified, the content must be a list of variable elements.
variable	element	[0..*]	When no task controller handler is specified by the class attribute, the content of the controller element must be a list of variables.

14.4.28. sub-process

Table 14.28. Sub Process Schema

Name	Type	Multiplicity	Description
name	attribute	required	Name of the sub-process to call. Can be an EL expression which must evaluate to **`String`**.
version	attribute	optional	Version of the sub-process to call. If version is not specified, the **`process-state`** takes the latest version of the given process.
binding	attribute	optional	Defines the moment when the sub-process is resolved. The options are: **`{early|late}`**. The default is to resolve **`early`**, that is, at deployment time. If binding is defined as **`late`**, the **`process-state`** resolves the latest version of the given process at each execution. Late binding is senseless in combination with a fixed version; therefore, the version attribute is ignored if **`binding="late"`**.

14.4.29. condition

Table 14.29. Condition Schema

Name	Type	Multiplicity	Description
	The option is **{content}**. For backwards compatibility, the condition can also be entered with the expression attribute, but that attribute has been deprecated since Version 3.2	required	The contents of the condition element is a jPDL expression that should evaluate to a Boolean. A decision takes the first transition (as ordered in the **processdefinition.xml** file) for which the expression resolves to **true**. If none of the conditions resolve to **true**, the default leaving transition (the first one) will be taken. Conditions are only allowed on transitions leaving decision nodes.

14.4.30. exception-handler

Table 14.30. Exception Handler Schema

Name	Type	Multiplicity	Description
exception-class	attribute	optional	This specifies the Java "throwable" class' fully-qualified name which should match this exception handler. If this attribute is not specified, it matches all exceptions (**java.lang.Throwable**).
action	element	[1..*]	This is a list of actions to be executed when an error is being handled by this exception handler.

CHAPTER 15. TEST DRIVEN DEVELOPMENT FOR WORKFLOW

15.1. INTRODUCING TEST DRIVEN DEVELOPMENT FOR WORKFLOW

Read this chapter to learn how to use **JUnit** without any extensions to unit test custom process definitions.

Keep the development cycle as short as possible. Verify all changes to software source code immediately, (preferably, without any intermediate build steps.) The following examples demonstrate how to develop and test jBPM processes in this way.

Most process definition unit tests are execution-based. Each scenario is executed in one JUnit test method and this feeds the external triggers (signals) into a process execution. It then verifies after each signal to confirm that the process is in the expected state.

Here is an example graphical representation of such a test. It takes a simplified version of the auction process:

Figure 15.1. The auction test process

Next, write a test that executes the main scenario:

```
public class AuctionTest extends TestCase {

  // parse the process definition
  static ProcessDefinition auctionProcess =
      ProcessDefinition.parseParResource("org/jbpm/tdd/auction.par");

  // get the nodes for easy asserting
  static StartState start = auctionProcess.getStartState();
  static State auction = (State) auctionProcess.getNode("auction");
  static EndState end = (EndState) auctionProcess.getNode("end");

  // the process instance
  ProcessInstance processInstance;

  // the main path of execution
  Token token;

  public void setUp() {
```

```
    // create a new process instance for the given process definition
    processInstance = new ProcessInstance(auctionProcess);

    // the main path of execution is the root token
    token = processInstance.getRootToken();
  }

  public void testMainScenario() {
    // after process instance creation, the main path of
    // execution is positioned in the start state.
    assertSame(start, token.getNode());

    token.signal();

    // after the signal, the main path of execution has
    // moved to the auction state
    assertSame(auction, token.getNode());

    token.signal();

    // after the signal, the main path of execution has
    // moved to the end state and the process has ended
    assertSame(end, token.getNode());
    assertTrue(processInstance.hasEnded());
  }
}
```

15.2. XML SOURCES

Before writing execution scenarios, you must compose a **`ProcessDefinition`**. The easiest way to obtain a **`ProcessDefinition`** object is by parsing XML. With code completion switched on, type **`ProcessDefinition.parse`**. The various parsing methods will be displayed. There are three ways in which to write XML that can be parsed to a **`ProcessDefinition`** object:

15.2.1. Parsing a Process Archive

A *process archive* is a ZIP file that contains the process XML file, namely **`processdefinition.xml`**. The **jBPM Process Designer** plug-in reads and writes process archives.

```
static ProcessDefinition auctionProcess =
    ProcessDefinition.parseParResource("org/jbpm/tdd/auction.par");
```

15.2.2. Parsing an XML File

To write the **`processdefinition.xml`** file by hand, use the **`JpdlXmlReader`**. Use an **`ant`** script to package the resulting ZIP file.

```
static ProcessDefinition auctionProcess =
    ProcessDefinition.parseXmlResource("org/jbpm/tdd/auction.xml");
```

15.2.3. Parsing an XML String

Parse the XML in the unit test inline from a plain string:

```
static ProcessDefinition auctionProcess =
    ProcessDefinition.parseXmlString(
  "<process-definition>" +
  "  <start-state name='start'>" +
  "    <transition to='auction'/>" +
  "  </start-state>" +
  "  <state name='auction'>" +
  "    <transition to='end'/>" +
  "  </state>" +
  "  <end-state name='end'/>" +
  "</process-definition>");
```

APPENDIX A. GNU LESSER GENERAL PUBLIC LICENSE 2.1

GNU LESSER GENERAL PUBLIC LICENSE
Version 2.1, February 1999

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```
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Hacker.

  <signature of Ty Coon>, 1 April 1990
  Ty Coon, President of Vice

That's all there is to it!
```

APPENDIX B. REVISION HISTORY

Revision 5.3.1-0.402 Rebuild with Publican 4.0.0	**Fri Oct 25 2013**	**Rüdiger Landmann**
Revision 5.3.1-0 Updated for SOA 5.3.1	**Thu Jan 10 2013**	**Suzanne Dorfield**
Revision 5.3.0-0 Updated for SOA 5.3	**Thu Mar 29 2012**	**Suzanne Dorfield**
Revision 5.2.0-0 Updated for SOA 5.2	**Wed Jun 29 2011**	**David Le Sage**
Revision 5.1.0-0 Updated for SOA 5.1	**Fri Feb 18 2011**	**David Le Sage**
Revision 5.0.2-0 Updated for SOA 5.0.2	**Wed May 26 2010**	**David Le Sage**
Revision 5.0.1-0 Updated for SOA 5.0.1	**Tue Apr 20 2010**	**David Le Sage**
Revision 5.0.0-0 Created.	**Sat Jan 30 2010**	**David Le Sage**