Living Systems® Process Suite

GO-BPMN Modeling Language

Living Systems Process Suite Documentation

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Chapter 1

GO-BPMN Modeling Language

The *Goal-Oriented Business Process Modeling Notation* is a visual modeling language used to design business models. It extends the BPMN specified by OMG and enables you to apply either a goal-driven approach or the classical BPMN approach in model design.

GO-BPMN Modeling Language as a conservative GO-BPMN extension and provides elements and mechanism for goal-oriented business modeling. The goal-extension of the language enables you to create models that separate the goal (WHAT you wish to achieve) from the way it is achieved (HOW to achieve it). The goals are defined by Goal elements and the ways they can be achieve by Plans.

Additionally, GO-BPMN defines elements for organizational models and data structures, which are not covered by the BPMN specification.

Chapter 2

Encapsulation

Encapsulation is a mechanisms for hiding content so as to present them as a single relatively self-contained container for other elements: In a model, all data is encapsulated in a Module–the highest level encapsulation construct. A module contains a plethora of elements, including processes, which encapsulate BPMN or GO-BPMN flows; these can include Sub-Processes, which encapsulate BPMN flows, etc. The encapsulation elements represent namespaces.

2.1 Namespaces

The elements that are encapsulation constructs represent namespaces. Namespace are the equivalent of the scope of a variable. Within a namespace, the elements with a semantic value are identified by a unique name.

The namespaces with their elements create a hierarchy, used to create the context hierarchy: at the top is the Module namespace, then the Process namespace, for goal processes Plan namespace and then Sub-Process namespaces. A higher namespace cannot access data in lower namespaces, while a lower namespace has access to data in higher namespaces: a global variable, which is defined in a module, cannot access local variables of processes, while you can access a global variable from a process variable.

As for access to the namespaces on the same level, the following applies:

- **Modules**: You can access elements in another module by using the name path to the target module in the form `<TARGET_MODULE>::<TARGET_ELEMENT>`. The target module has to be explicitly imported by the source module.
- **Processes**, **Plans**, **Sub-Processes**: It is not possible to access elements in another process, plan, or sub-process from each respectively.

2.2 Context

A *context* is a set of runtime data based on a context element. It is created when such an element is instantiated.

Every such element on runtime results in its own context or possibly multiple contexts: Typically, a model instance results in a model-instance context, a process results in a process instance context, a plan results in its own context, and every instance of a multi-instance sub-process takes place in its own context: Hierarchy of the contexts reflects the hierarchy of namespaces.

Lower contexts have access to higher contexts.

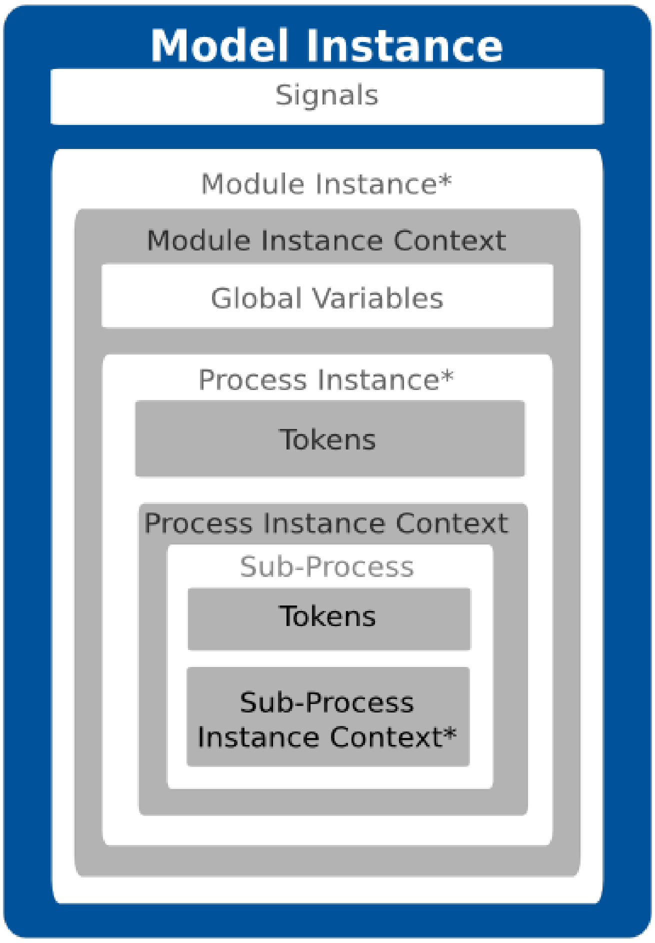


Figure 2.1 Context structure

Since a context holds all runtime data, it secures the persistence of execution data and status: In case of execution interruption, the stored context can be used to restore the execution status.

A context can access and see its parent context, but not vice versa; for example, a process cannot see the context of its sub-process.

The visibility of a particular element can be determined by explicit accessibility rules: Elements can be `public` or `private`. A private element can be referred to only from its own context. In addition, record fields can be also `protected`: they are accessible only from within its data type hierarchy.

2.2.1 Metadata

Metadata are data pairs comprising a data key (name) and a data value, which provide additional data about a modeling element.

Metadata can be defined for any modeling element (element with execution semantics) with the exception of Modules. As providing background information, metadata are local to their owners and may contain *exclusively* constants.

Metadata are primarily meant for `development of your custom objects` and are not generally accessible from your model; the only metadata you can access are metadata of a process instance, for example, `thisProcessInstance().metadata`

2.3 Variables

Encapsulation elements with context can define variables, that will hold a value of a type on runtime, for these contexts; on runtime, such a variable is instantiated as part of the context: On context initialization, variables are assigned their initial value. Variables can use other variables of their own context or their parent contexts for their initialization.

Depending on the immediate parent context of a variable, we distinguish global variables defined in modules, and variables defined in processes, plans, and sub-processes.

A variable has the following properties:

- **Type**: data type of the value the variable can hold on runtime
- **Initial value**: value assigned to the variable when its context is created
- **Visibility**: access rules to the variable

If true, the Module can become a Model instance.

- **Monitoring**: property defining if the variable is used for monitoring purposes

Every variable must define its name and data type of the value it can hold.

> **Note:** In expressions, you can define `local variables`. The scope of these variables is the expression or the expression block.

2.4 Module

A *Module* is a bundle of resources, such as, BPMN processes, organization hierarchies, etc. that constitute a logical unit. It can include other Modules as its Module imports and resembles a jar file with dependencies.

Modules can be uploaded to the LSPS Server so the server can work with the module resources. An executable module can act as a model on runtime and be instantiated.

It represents a namespace; hence to reference its elements from another module, you need to include the module name in the element call, for example, `myModule::myVariable`.

A module defines the following properties:

- **Version**: version of the Module
- **Executable**: Boolean Attributes

  If true, the Module can become a Model instance. Note that if you import an executable module to another executable module, and you instantiate the importing module (the parent), the imported executable module will be instantiated as part of the model instance.
- **Module Imports**: imported Modules
- **Terminate condition**: Boolean condition defining if a module can be instantiated

  The condition is checked for the first time after the first transaction (module instance is created, process instances are created, process' start events fire). After that it is checked constantly during the entire life of a module instance. When evaluated to true, the Module instance is terminated.

> **Note:** Terminate conditions of imported Modules are not evaluated.

2.4.1 Module Import

A *Module import* allows you to reuse existing modules: it is include of a Module similar to dependencies of jar files: it allows a parent Module to use the resource of its Module imports, which are read-only includes of their Modules.

A Module can import one or several Modules, however, you can import a particular Module only once. Modules cannot be imported recursively (if moduleA imports moduleB, then moduleB cannot import moduleA).

> **Note:** To refer to the elements in Module imports from the importing module, you need to explicitly define the namespace of the referred Module; for example, `myModule::myVariable`.

2.4.2 Model

A *model* is an inclusion of an executable Module and its Module Imports. It is *not* explicitly represented by any component. On runtime, a model instance can created based on a model.

Chapter 3

Model Instance

On runtime, models can become model instances: The model, an executable module with all its imports, serves as a blueprint for the creation of its runtime version: a model instance.

The model instance holds data about its status and the module instances for each module: the parent executable module and any imported modules. Each module instance stores its runtime data, that is, the data about execution status, such as, whether the module instance is running, which processes are running, which task is being executed, values of variables, etc.

A model instance can define initialization properties, key-value pairs with information about the model instance. By default, each instance is created with the *author* property, which is set to the person who created it. If the model instance has been initialized by another model instance, then the *Triggered by* property set with the model instance id that created the model instance is set instead. The properties can include the process entity with an ID of a shared record which the instance works with. Such instances are typically created with the `createModelInstance()` function from a document or a process with the process entity passed in the *processEntity* parameter.

A model instance can be primarily in the following states:

- **Created**: the model-instance context is created and the contexts of individual module instances are created.
- **Running**: the context data are initialized, initial values are assigned, and all BPMN-based and Goal-based Processes in all module instances are instantiated. The execution takes place in transactions as described in Transactions in Model Instances. This happens in a bottom-up manner: First the modules that are "lowest" in the hierarchy are initialized; if module A imports module B and module B imports module C, then C is initialized first, then B and only then A. Consequently, you use the data of C and B in A but not vice versa.

  A Running Model instance can be suspended: all its Process instances and their elements are suspended and no execution is taking place.

  > **Note:** If a Model instance attempts to perform an invalid action immediately when it becomes Running and an error occurs, the initialization is rolled back and the Model instance goes back to the Created status.

- **Finished**: Model instance becomes Finished, when all its Process instances are Finished.

While a model instance is **Running**, you can *suspend* or *finish* it:

- When you suspend a model instance, the execution is halted. To marked this state, the model instance and all running elements become **Suspended**. You can then resume the execution whenever required.
- When you finish a model instance, the execution of the model instance is halted and it instance becomes **Finished** immediately.

3.1 Suspend and Resume

A *Running* model instance can be suspended: on suspend, its execution is paused immediately so that no changes on runtime data can take place. Execution of all running elements is interrupted and all elements become *Suspended*. A suspended model instance is read-only.

Suspended model instances can be resumed: when resumed the execution of the model instance continues from the point when it was suspended. The model instance becomes *Running* and all asynchronous inputs received by the model instance while suspended (Signals, elapsing of time periods of Timer Events) are received and processed.

It is not possible to resume a model instance that is being `updated`.

> **Note:** If a Timer Event, either a Timer Start Event or a Timer Intermediate Event with a duration is suspended while Running, the duration is checked with regards to the time, when the Model instance was suspended. For example, a Timer Event with a duration of 60 minutes was triggered at 1 p.m.: if the Model instance is resumed at 1.30 p.m., the Timer Event continues running until 2 p.m.; if the Model instance is resumed at 3.00 p.m., the Timer Event is finished and the outgoing Flow is taken immediately. For cyclic events, only the last occurrence of the event is processed: For example, if a BPMN-based Process is to be instantiated every day at 12 p.m. and the model instance is resumed after three days at 1 p.m., only one process instance is triggered.

3.2 Finish

When a model instance receives a request to finish, the following happens:

- Active activities (Tasks and Sub-Processes) fail and become *terminated* immediately.
- Processes become *finished*:
  - In Goal Processes, all Achieve Goals become *deactivated* immediately while Maintain Goals finish their current cycle and then become *deactivated*.
  - In BPMN Processes, all active Activities its BPMN-based Process instances are terminated (fail).
- All *alive* to-dos become *interrupted* so they cannot be submitted.
- As a result, the model becomes *finished* since all process instances are *finished*.

3.3 Transactions in Model Instances

When a Model instance is executed, its execution takes place in transactions. The status of the model instance is persisted always when such a transaction is committed (it finishes).

To understand what comprises a transaction, let's go through model execution:

1. All modules are instantiated.
2. The first database transaction for the model instance is created.
3. All BPMN and Goal processes are instantiated.
4. On Goal processes, all top goals are triggered and become either *ready* or *running* depending on their precondition. The running Goals trigger their sub-goals or plans.

5. Tokens are generated on all start events of the relevant process instances and on activities with no incoming flows. Every token is moved as far ahead as possible, that is, until it hits a wait point. A wait point is considered the following:
   - asynchronous task (user task, web service task, etc.)
   - intermediate event that requires the execution to stop, such as a delay (timer; signal, if the signal has not yet been received, etc.)
   - parallel *join* gateways that wait for a token
6. If no token can be moved further, the transaction ends and is committed or rolled back in case of an error and the status of the model instance is persisted: if a token move fails with an exception, the branch execution on the branch is no longer invoked.

   Important: Instances of shared Records are persisted in the Model instance using their primary key and record type: however, the value is stored in a database table. In every new transaction, the system fetches the values of the shared Records it requires from the database. This can potentially slow down the execution when working with large amounts of shared-record instances across multiple transactions.

A model instance with tokens remains in the RUNNING state and is invoked (woken up) whenever one of the following happens:

- A human task is submitted.
- A Timer is triggered.
- A condition that uses a shared record is met.
- A signal is received.
- A web service request/response is received.
- An asynchronous task is triggered.
- An Admin action occurs (an expression is evaluated, a context value changed, etc.).

On invocation, the following happens:

1. A new transaction and session are created based on the persisted model instance data. The persisted model instance data includes:
   - tokens with their positions
   - execution context (variables, referenced values, shared records)
2. Every token is "moved" as far ahead as possible until it hits a wait point.
3. Signals are handled, goals activated and deactivated, values changed, etc.
4. Every token is "moved" as far ahead as possible.

That means that an invocation is in general identical with one transaction; however, if a transaction can include a custom object, such as, a function, which can create its own transaction. Such a transaction is still part of the same invocation.

The transaction is committed or rolled back and closed along with the session (the status of the model instance is persisted).

3.3.1 Example Transactions in a Model instance with Two Process Instances

The order of the transactions is an example order and depends on the order in which the asynchronous tasks are accomplished.

- 1st transaction: None Start Events produce a token each; the tokens are moved as far as possible:
  - In process instance A, the token is moved to the Timer Intermediate Event with a delay (had it defined a point in time which has already occurred, the token would be moved further).
  - In process instance B, the token is moved to the first split gateway, which splits it into 2 tokens; The first token moves to the asynchronous task and waits for the task to be accomplished; the second token passed through the synchronous task and enters the join gateway, which holds it and waits for the first token to arrive.

  At this point, the tokens cannot move further and the transaction ends.
- 2nd transaction: we assume the delay period on the timer in A has elapsed;
  - In process instance A, the token is moved to the asynchronous task.
  - In process instance B, the token remains on the asynchronous task and the gateway keeps waiting for it.
- 3rd transaction: we assume that asynchronous tasks in both processes have been accomplished.
  - In process instance A, the token is moved to the first gateway and split in two:
    - The first token continues until the Timer Intermediate Event with a delay;
    - The second token continues until to the join gateway.
  - In process instance B, the token is enters the second join gateway. Since both tokens originally produced by the split gateway have arrived, the join gateway produces a token, which then continues to the asynchronous task.
- 4th transaction: we assume the delay set in the timer event in A has elapsed.
  - In process instance A, the token is moved to the second join gateway which has now received both tokens produced by the split gateway and hence produces a token. The token continues to the None Start Event, which consumes it and the process instance finishes.
- 5th transaction: we assume the asynchronous task in B has been accomplished.
  - In process instance B, the token is moved to the None Start Event, which consumes it and the process instance finishes.

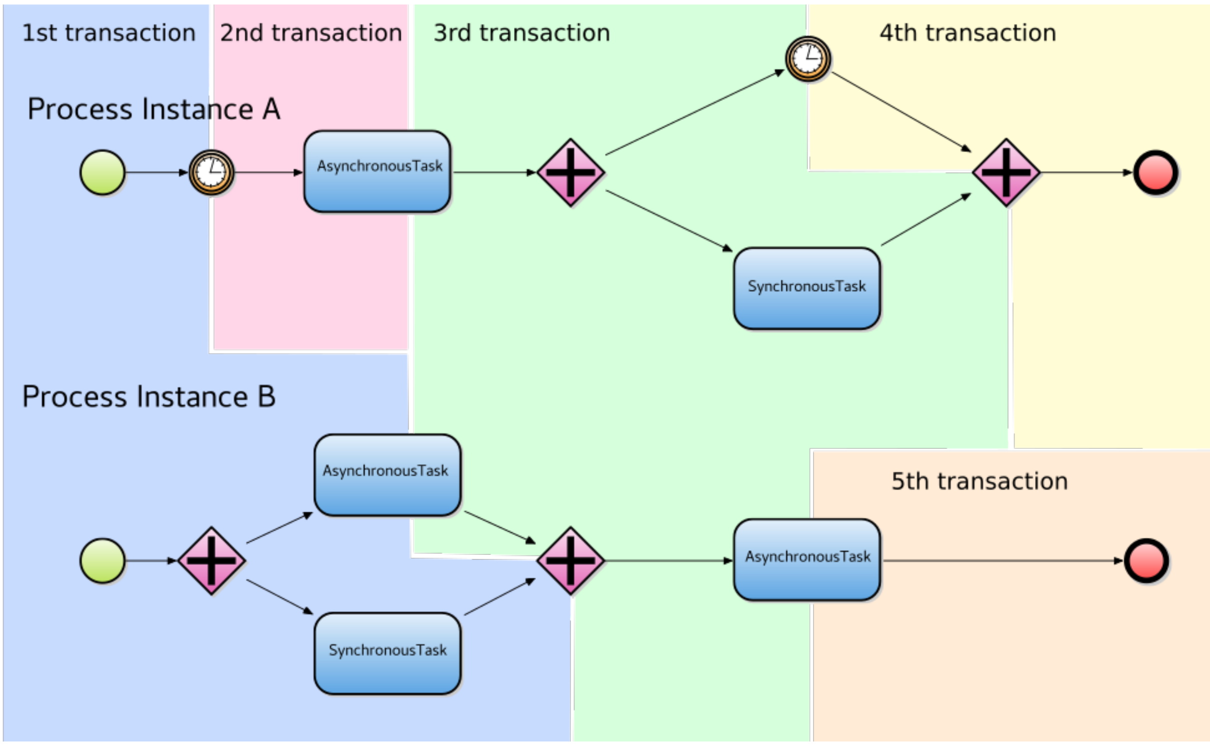


Figure 3.1 Example transactions in a single model instance with two process instances

Chapter 4

Process Model

The *process model* comprises all *processes* within a model: the process is a container element for Goal or BPMN process workflows and is always part of a module. Just like a Module, a Process represents a namespace which, on runtime, results in a local process context and a process instance.

A process can contain other elements that create further nested namespaces and therefore result in further local contexts in the process instance context, such as, Sub-Process contexts.

Depending on the requirements, a process can be

- Goal-based defined in GO-BPMN with the Goal extension
- BPMN-based defined in BPMN.

When a model is instantiated it instantiates its process model: it attempts to create instances of each process in the process model including processes in module imports. For each process it firs checks whether the process is executable and whether it can be instantiated automatically. If the Process is not executable, no instance is created. If it is executable, instantiation takes place:

1. A process instance based on the process is created.
2. A process context is created.
3. The process instance becomes **Running**. What happens when the process instance becomes running depends on whether it is a BPMN Processes and Goal Processes.
4. On execution finish, the Process instance becomes **Finished**.

Process Attributes

- **Executable** defines whether a process can run. When false, the process never runs: when a model instance is triggering processes, either on start automatically or with another mechanism, such as, signals, the process is ignored.
- **Visibility** defines the access rules to the process.
- **Create activity reflection type** creates a record that reflects the process. The Record is the subtype of the Activity record and can then be used as a parameter of the Execute task. For further information, refer to the `Standard Library documentation`.

4.1 Goal Processes

The Goal-based process is a process that defines its logic in a goal hierarchy. On execution, after the parent model instance becomes *running* and one process instance based on the process is created, the goal hierarchy is activated:

1. Context data are created and initialized (initial values are assigned).
2. All top Goals are triggered: they become Ready and, if their conditions are fulfilled, they become running.
3. The Process instance becomes *Running*.
4. When no Achieve Goal is Active (Ready or Running) and no Plan is running, the Goal-based Process instance becomes *Finished*.

4.2 BPMN Processes

The BPMN-based process is a process that encapsulates a BPMN workflow.

It is instantiated when the parent model instance is instantiated, and that possibly multiple times by different start events. It also can be used as a Reusable Process and be instantiated as a sub-process instances.

When a BPMN-based process is instantiated, the following happens:

1. Context data are created and initialized (initial values are assigned).
2. The process instance becomes *Running* and its Start Event, and Activities without incoming Flow are triggered and produce tokens (the token marks the currently executed step).
3. The token leaves the start event or activity through the outgoing flows.
4. When no process element is active (there is no token in the workflow), the process instance becomes Finished.

A BPMN-based Process defines the following specific properties:

- **Instantiate automatically**: if false, the Process can be triggered only as a Reusable Sub-Process
- **Parameters**: an arbitrary number of parameters

4.3 Reusable Processes

Any BPMN-based process that starts with a None Start Event can be reused by another process by the means of the reusable subprocess activity. The activity defines the referenced process and is used in a workflow just like any other activity. However, on runtime, the entire workflow of the referenced process is executed providing a convenient mechanism for reuse of the existing workflow.

When a BPMN-based process is used exclusive as a reusable sub-process, it can be parametric.

Process Modeling

4.4 Process Modeling

A process contains workflows consisting of modeling elements with execution semantics, which define how it is executed; this includes processes themselves, goals and plans, process body elements with semantics, such as, gateways, intermediate events, start events, activities, etc.

Every modeling element has at least the following properties:

- **Name**: optional identifier of an element in its namespace
- **Description**: free-text description
- **Assignments and Monitoring**: set of expressions executed at a certain point of the element's life

4.4.1 Assignments

Assignments serve to define expressions that are executed when an element *changes to a life-cycle status* from another named status. They are execution hooks where you can define the actions taken for the life-cycle status: You can define what should happen when an Achieve Goal becomes *running*, when a Task is *accomplished*, etc.

- On workflow elements, some or all of the following assignments can be defined depending on the element:
  - **Start assignment** is performed when the token enters the element.
  - **End assignment** is performed always when *a token leaves* the element or *is removed* from the element, for example, due to failure, termination, or restart.
  - **Accomplish assignment** is performed when a token when the flow element finishes "successfully" and the token leaves using the outgoing flow. The Accomplish assignment is performed always before the End assignment.
- Goals and Plans can define assignment for individual life-cycle statuses.

4.4.2 Monitoring an Element

To define monitoring related activities, modeling elements can define

- monitoring assignments: a special type of Assignment intended to implement the monitoring logic

  Monitoring assignments are available on modeling elements with execution semantics. It is identical to the Assignment mechanism and is executed right after assignments.
- monitoring flags: an indicator that a variable or a Record is used for monitoring purposes

4.4.3 Signal

A *signal* is a means of communication within a model instance or with other model instances, the recipients of a signal.

A signal is targeted at particular model instances: when sent, it is either consumed by at least one Signal Catch Event or added to the signal queue of the model instances: If multiple Signal Catch Events can consume the Signal, then all of them consumed the Signal one time (Signal Start Events and Catch Signal Events). If the signal is not consumed by at least one event in a target model instance, it remains in its signal queue.

Depending on the transaction that adds the signal to the signal queue of the target model instance, we distinguish synchronous and asynchronous signals:

- **Synchronous signals** are added to the signal queue of the target model instance in the same transaction that produced them. As a result, the signal can be caught and processed in the same transaction.
- **Asynchronous signals** are added to the signal queue of the target model instance only in the next transaction.

Signals are produced by Throw Signal Events or using the `sendSignal()` function. and can be any object that is not and does not recursively contain a reference, closure, Goal, Plan, or Process instance.

4.4.4 Errors

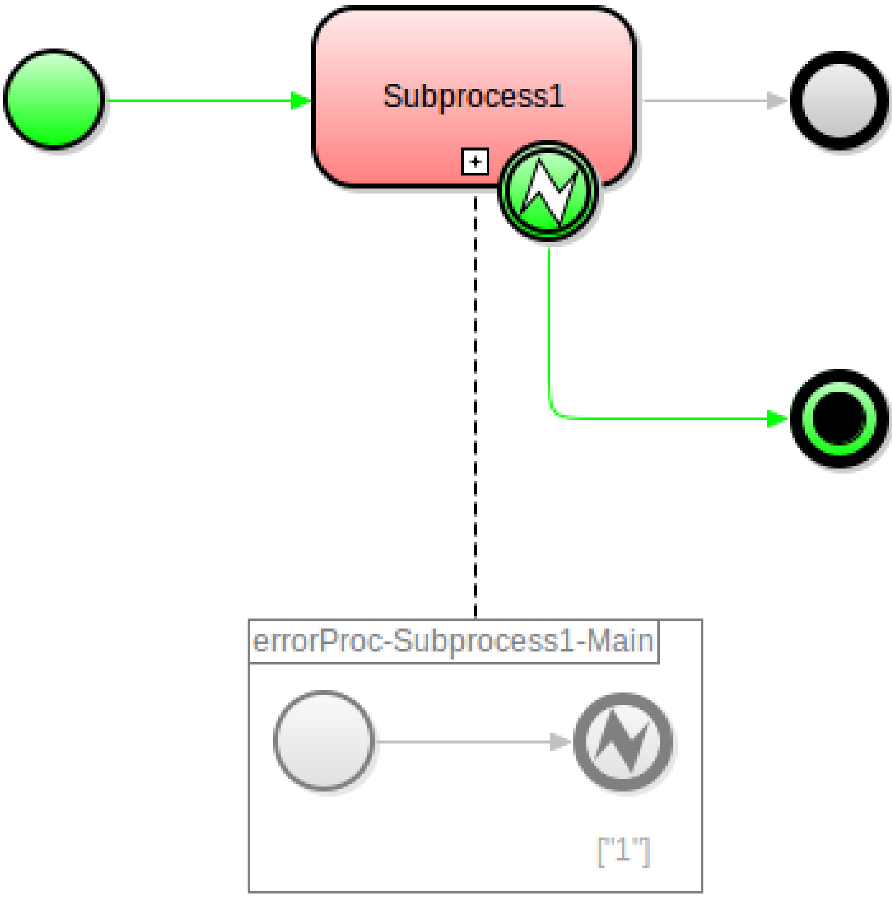
An *error* represents a critical problem in execution of your process, which stops the execution immediately unless explicitly handled and corrected.

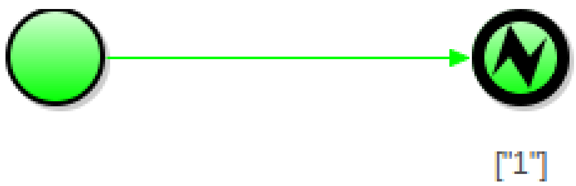
Once generated, the error is gradually propagated through its immediate context. If the error is not consumed in the this context, it is gradually propagated throughout higher contexts. If not consumed within its process instance, an exception is thrown and the last model transaction which caused the error is rolled back.

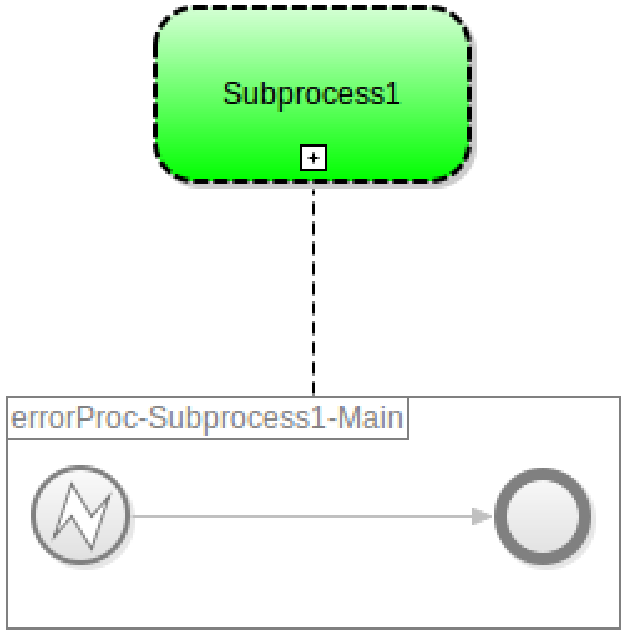
An error can be thrown by an Activity or an Error End Event.

> **Note:** Additionally, you can throw an error with the `error()` function of the Standard Library or from your custom implementations as `com.whitestein.lsps.common.ErrorException`.

An error can be caught and consumed by a Error Intermediate Event or by Plans.







4.4.5 Escalation

The *escalation* mechanism resembles the signal mechanism; however, while signals can be consumed by multiple elements in the model instance, an escalation signal is consumed by a single element within its model instance.

Similarly to signals, to perform escalation, you need to create an escalation object with the Throw Escalation Event or Escalation End Event positioned at the appropriate location in your workflow. When the workflow enters a Throw Escalation Event or Escalation End Event event, the event produces an Escalation object, which is then propagated through its own context and then through parent contexts and "up" to higher contexts until caught by an Escalation Start Event or Catch Escalation Intermediate Event or until no higher context exists. Once caught by an Escalation Start Event or Catch Escalation Intermediate Event, the Escalation object is not propagated further. If there are multiple Escalation Catch elements in the same context, only one of the elements consumes the Escalation signal and only the catch event that consumes the escalation object produces a token.

The object must define its escalation code, a string that serves as its identifier: the code can be then used by filters of the Escalation Catch Events to filter the objects.

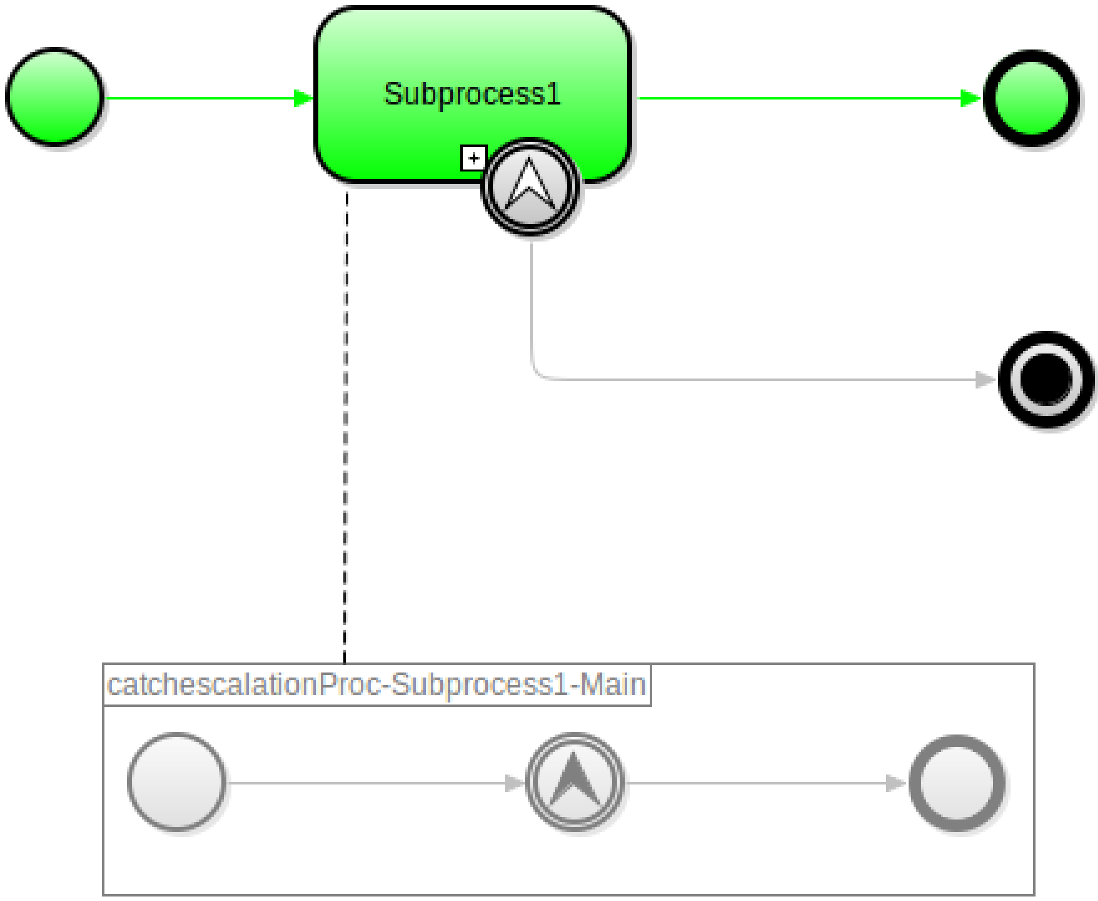


Figure 4.1 Demonstration of escalation with an Escalation produced in a subprocess and caught be a Catch Escalation Event

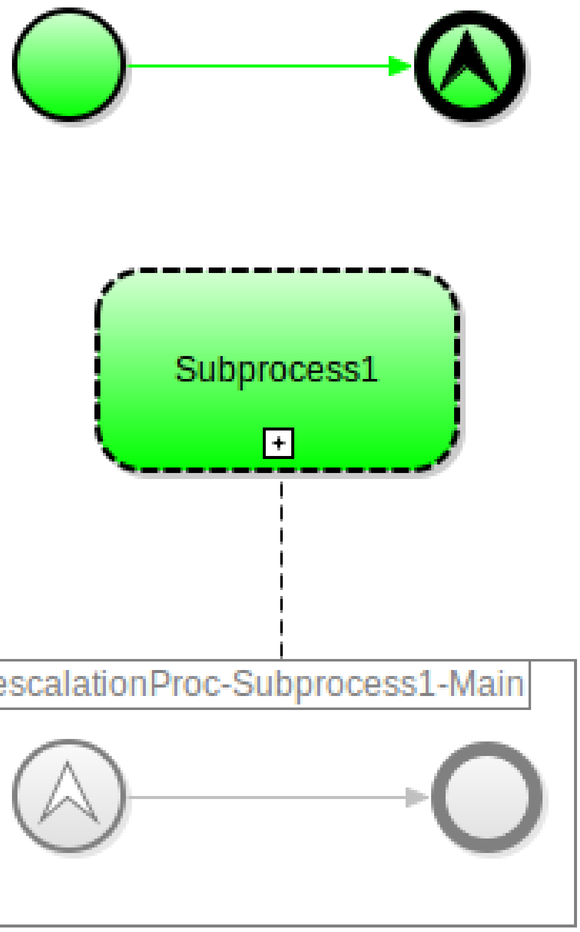


Figure 4.2 Process that terminates in an Escalation End Event which triggers the Escalation Start Event of its Inline Event Subprocess

Plan and BPMN Modeling Elements Goal Model

4.4.6 Plan and BPMN Modeling Elements

The Plan and BPMN-based processes use a similar set of modeling element in their workflows with some additional modeling element available for the BPMN-based process workflows so that you can model logic that is accommodated by Goal hierarchies:

- In a Plan, the workflow is triggered by the Plan.
- In a BPMN-Process, the workflow is triggered by the Process.

4.4.6.1 Plan Model

A *Plan Model* is a sum of all elements with execution semantics encapsulated in a Plan.

Every Plan Model:

- must contain one None Start Event, which is triggered, when the parent Plan becomes Running;

- must contain at least one End Event or an Activity with no outgoing flow;

Apart form that, it can contain an arbitrary number of activities, events, flows, and gateways connected with Sequence Flows (Connectors). The elements in the flows must meet their modeling rules and must create an uninterrupted workflow.

A Plan Model is triggered when the parent Plan becomes *Running* and its None Start Event produces a token and the respective namespace context is initiated.

4.4.6.2 BPMN Model

A *BPMN Process Model* is a sum of all elements with execution semantics encapsulated within a BPMN-based Process.

A BPMN-based Process:

- must contain at least one Start Event (it may contain several Start Events);
- must contain at least one End Events or an Activity with no outgoing flow;

Apart form that, it can contain an arbitrary number of activities, events, and gateways connected with sequence flows. The elements in the flows must create an uninterrupted workflow and meet any other modeling rules that apply.

4.4.6.2.1 Instantiation of Plans and BPMN Processes

When a Process with a None Start Event is instantiated:

1. A Process namespace is created.
2. A local process context is initialized.
3. The Process instance becomes *Running* and one Start Event produces token).
4. If there are no activity in the workflow (no more tokens in workflows), the Process instance is terminated and becomes *Finished*.

When a Process with another type of Start Event is instantiated:

1. A Process namespace is created.
2. The respective Start Event condition is checked.
3. If the Start Event conditions are fulfilled, the local process contexts are initialized.
4. The Start Event triggers execution (releases the token) and the process instances becomes *Running*.
5. If there is no more activity in the workflow (no more tokens in workflows), the Process instance is terminated and becomes *Finished*.

> **Note:** If a BPMN-based Process instance ends with an uncaught Error End Event, the last transaction is rolled back.

Events Flows Activities Gateway Swimlanes

4.4.6.3 Events

An *Event* is any element in a BPMN-based Process or Plan model that triggers or terminates the workflow, thus modifying the execution pace or causing a flow change.

Based on the position and function in the workflow, the following types events are available:

- Start Events trigger workflow execution by creating contexts and producing tokens.
- Intermediate Events delay processes based on events or handle an event produced in an activity if used as a boundary element.
- End Events consume the incoming token.

4.4.6.3.1 Start Events

A Start Event indicates where a particular workflow starts. When triggered, it creates the context for the element, that is, a process, plan, or subprocess, and produces a token, which leaves through its outgoing flow, in the context.

A Start Event has no incoming flow and only one outgoing Normal Flow.

In *Plans of Goal-based Processes and Sub-Processes*, its None Start Event is triggered when the Plan becomes *running.* A Plan can contain only a None Start Event.

While a model instance is running, any Start Events in its *BPMN-based Process* can create their process instance when their trigger occurs: if there is a Condition Start Event and its condition is true, the event is triggered when the model instance starts and whenever the condition becomes *false* and *true* again as long as the model instance is *running*.

Start Events with triggers can start BPMN-based processes and inline event sub-processes:

- In a BPMN-based process: Start Events whose triggers occurred, are triggered when the model instance is created. Each Start Event creates its process instance. If the trigger occurs again while the process instance is *running*, the start event creates a new process instance.
- In an [inline event sub-process], if the trigger occurs at any time while the parent process instance or sub-process instance is running, the events creates an instance of their sub-process and produces a token. Note that the inline event subprocess can also be a reusable sub-process so the start events can be in the referenced process.

4.4.6.3.1.1 None Start Event

A *None Start Event* is triggered when its parent context is created. It does the following depending on its location:

- When in a BPMN-based Process, it creates the context of the process instance and produces a token when the model instance becomes running;
- When in a Sub-Process: it creates the context of the subprocess and produces a token when the sub-Process is triggered, that is, it receives a token via its incoming flow or, if the sub-process does not have an incoming flow, at the moment it is triggered.
- Plan, once the Plan becomes *running*, the None Start Event of the Plan Model is triggered.

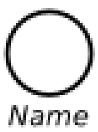


Figure 4.3 None Start Event

4.4.6.3.1.2 Conditional Start Event

A *Conditional Start Event* defines a boolean condition expression as its trigger and starts a BPMN-based Process or an inline-event subprocess:

- When in a BPMN-based Process, the event creates and triggers an instance of the process:
  - when its condition is *true* at model instantiation
  - when the condition, previously evaluated to *false*, becomes *true* while process instance is running.
- When in an inline-event subprocess, the event creates and triggers an instance of the sub-process
  - when its condition is *true* at process instantiation
  - when the condition, previously evaluated to *false*, becomes *true* while process instance is running.

Note that the condition cannot reference local context since the context does not exist at the moment when it is evaluated.

Figure 4.4 Conditional Start Event

Conditional Start Event Attributes

- **Condition** evaluated when the event is triggered. If true, the event produces a token.

4.4.6.3.1.3 Signal Start Event

A *Signal Start Event* creates the context of a BPMN-based Process or an inline-event subprocess and produces a token when it receives a Signal that passes through the *Filter*.

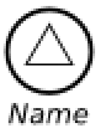


Figure 4.5 Signal Start Event

- **Filter**: filter for the expected Signal object
- **Signal**: reference where to store the received signal value

4.4.6.3.1.4 Timer Start Event

A *Timer Start Event* instantiates a BPMN-based process or an inline event subprocess at a particular point in time. The point in time is defined by its date and period attributes:

- If *only the date* is defined, the event occurs at the moment when the date occurs.
- If both *date and period* are defined, the event occurs after the period since the date has elapsed.
- If only the period is defined (the date is `null` or not set at all), the event is never triggered.

If the date occurred in the past, the event is triggered immediately.

Timer Start Event Notation

Figure 4.6 Timer Start Event

4.4.6.3.1.5 Escalation Start Event

An *Escalation Start Event* starts only an inline event subprocess and produces a token when an Escalation object which it can consume appears in its parent process or subprocess instance: when designing, you can insert it either into a process which is used by a Reusable Subprocess activity or a Subprocess: both must be inline event subprocesses. In other than the Inline Event Sub-Process, the event is ignored.

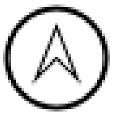


Figure 4.7 Escalation Start Event

Escalation Start Event Attributes

- **Filter** defines the escalation codes of accepted Escalation objects. If no codes are defined, any Escalation object triggers the event. The filter is evaluated at the moment when the escalation event is received.
- **Escalation** is the reference to a local or global context (for example, a variable or a variable field) that will store the received Escalation object.
- **Escalation code reference**: Event consumes only escalations with the defined escalation code (if the escalation code is not specified then the Event accepts all escalations).

4.4.6.3.1.6 Error Start Event

An Error Start Event triggers its flow when it receives an Error object. You can use it only as a start event of an Inline Event Sub-Process: When the parent of the sub-process throws an error and the error code matches a code in the Error Code Filter of the Error Start Event, the event creates the context of the inline event sub-process and produces a token. The Error Code Filter is evaluated at the moment when the error event is received (An Error is thrown either by the system automatically when something goes wrong, or you can throw an Error with the `error()` call).

The parent can be either a process instance or a sub-process instance if that the sub-process is nested in another sub-process.

In other than an Inline Event Sub-Process, the event is ignored.

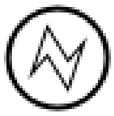
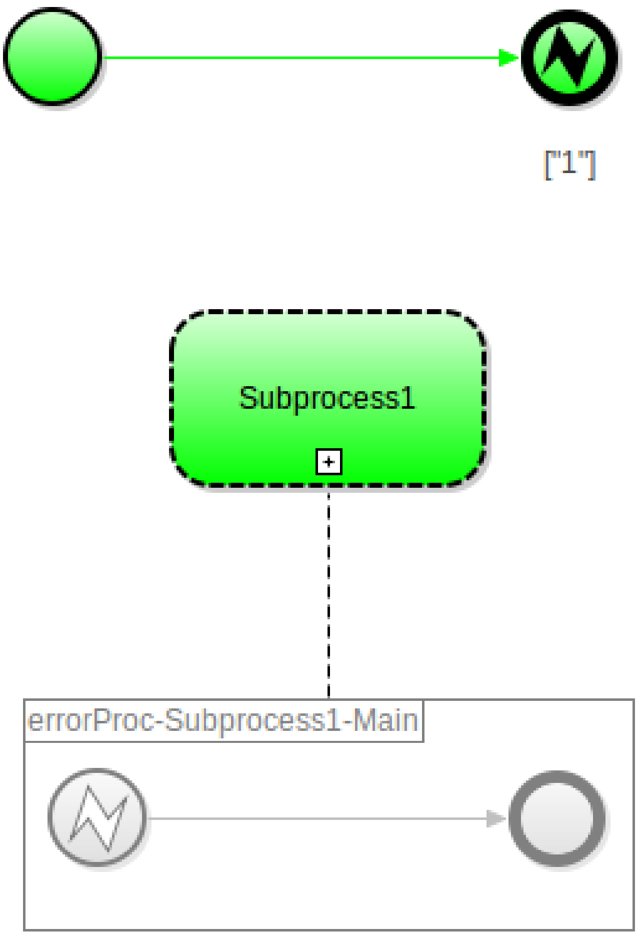


Figure 4.8 Error Start Event



Error Start Event Attributes

- **Error Code Filter** defines the filter that returns the expected errors (only error events from the Error reference that meet the filter criterion trigger the start event).
- **Error Code** is the reference to a local or global context (variable or a variable field) that will store the received error.

4.4.6.3.2 Intermediate Events

An *intermediate event* process element handles a predictable event that can occur during workflow execution, such as, an error, timeout, breached condition, etc. When such event occurs, the event produces a token, which takes the outgoing flow of the event.

The scope the events listen to is defined by where they are placed:

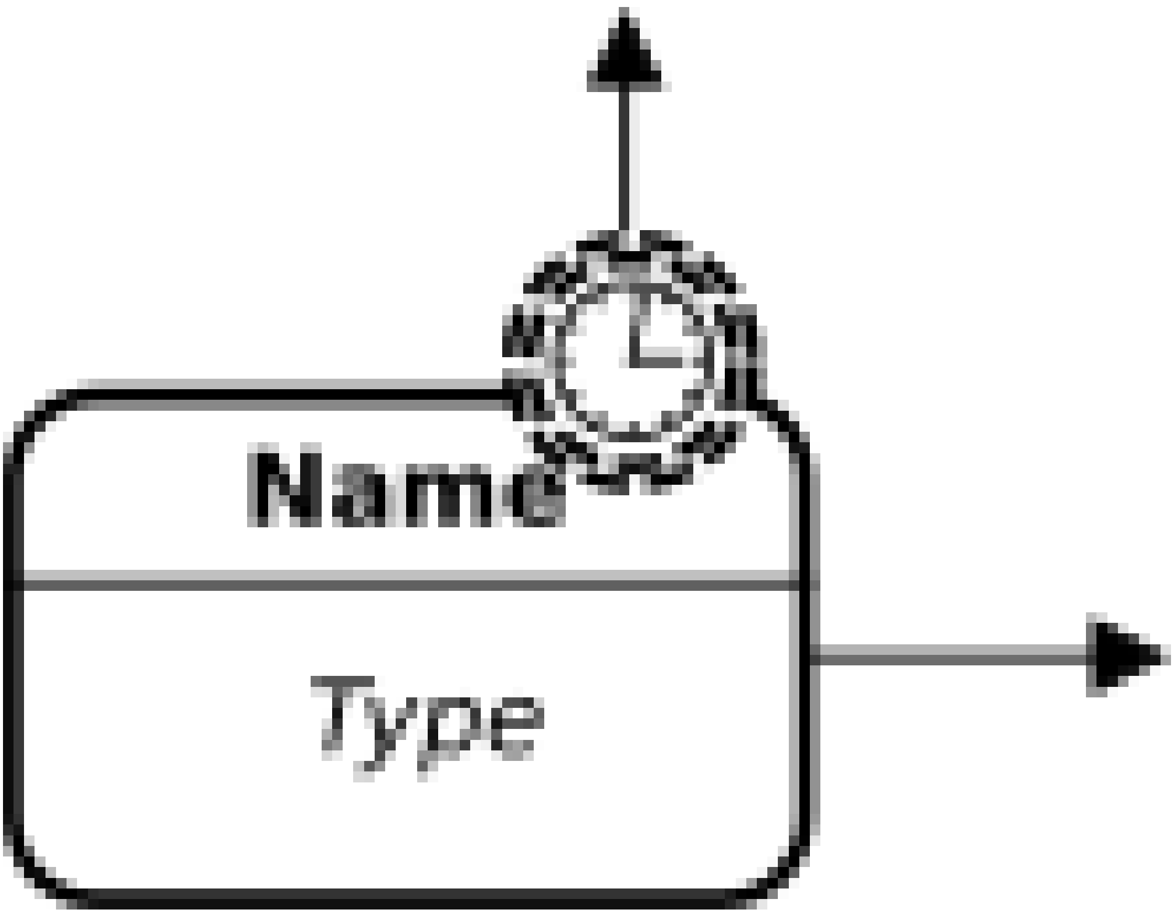
- **on the boundary of an Activity**: If the activity is *Alive* and the event occurs, the outgoing flow of the Intermediate Event is taken.

  Note: If a boundary event is attached to a multi-instance Activity, all the instances of the Activity are interrupted when the Event is triggered.

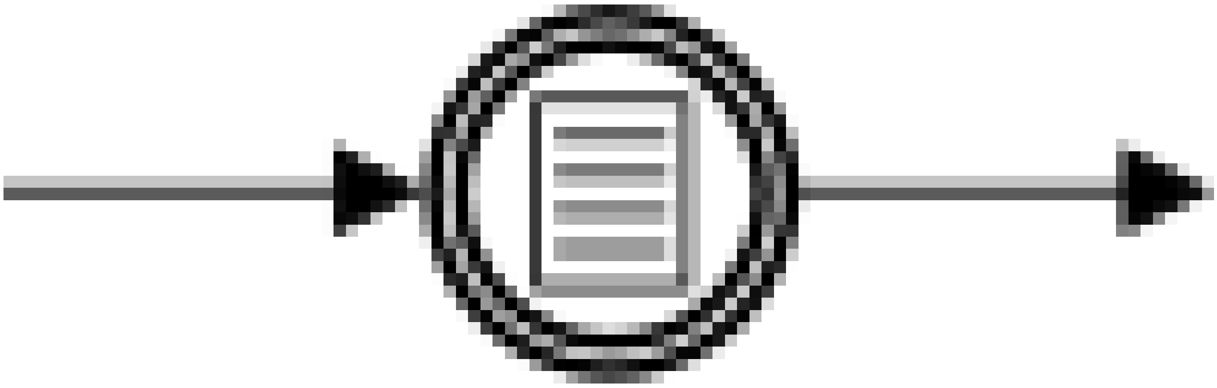
  When the Intermediate Event on an activity is triggered, the activity can either continue or terminate. This depends on the interruptibility property of the Intermediate Event:

  – If the event is *interrupting*, the activity is deactivated when the event is triggered.

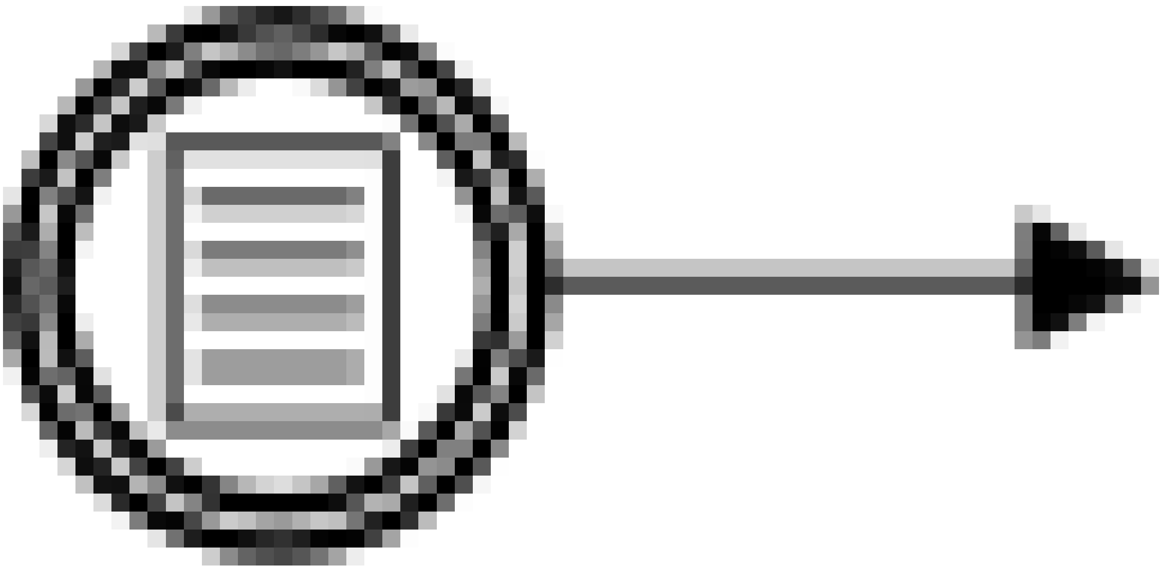
  – If the event is *non-interrupting*, the activity continues its execution: note that if the event occurs again while the Activity is alive, the boundary event is triggered again.



- **flow object with one incoming and one outgoing flow**: the event is triggered when the flow reaches the event. Once the event occurs, the execution continues via the outgoing flow of the Intermediate Event.



- **flow object with no incoming and one outgoing flow**: the event is triggered whenever the event condition occurs while its context is *running*.



4.4.6.3.2.1 Timer Intermediate Events

A *Timer Intermediate Event* delays a workflow. The delay is defined by its date and period attributes. The interpretation of the attributes depends on where the event is placed:

- When placed in a workflow *as a flow object with one incoming and one outgoing flow*, the event holds the incoming token. When the token is released depends on the date and period attributes:

- If only the date is defined, the token is released when the date occurs (immediately if the date has already occurred when the activity becomes running).
- If only the period is defined, the token is released immediately.
- If both are defined, the period is ignored.

  Note: A Timer Intermediate Event in a workflow cannot be the target element of a Sequence Flow leaving a Gateway.

• When placed *on an Activity border*, the event can be triggered only while its Activity is running and that as follows:

- If only the date is defined, the event produces a token when the date occurs (immediately if the date has already occurred when the activity becomes running).
- If both are defined, the event fires first on the date and then always when the period elapses. If the event is *interrupting*, the period attribute is never applied since the activity is interrupted once the first token is produced by the event.
- If only the period is defined, the event is never triggered.

• When placed into a process or subprocess *with no incoming flow*, the event can be triggered only while its process or subprocess context is running and that as follows:

- If the date is defined, a token is produced when the date occurs.
- If both are defined, the event fires first on the date and then always when the period elapses.
- If only the period is defined, the event is never triggered.

Figure 4.9 Non-Interrupting Timer Intermediate Event

Figure 4.10 Interrupting Timer Intermediate Event

4.4.6.3.2.2 Error Intermediate Events

An *Error Intermediate Event* serves to define a workflow that is taken after an Activity produces an error: it explicitly produces an error or it ends with an Error End Event.

The element is placed on boundaries of Activities, that is, Tasks or Sub-Process. An Activity can have multiple Error Intermediate Events attached to its boundary.

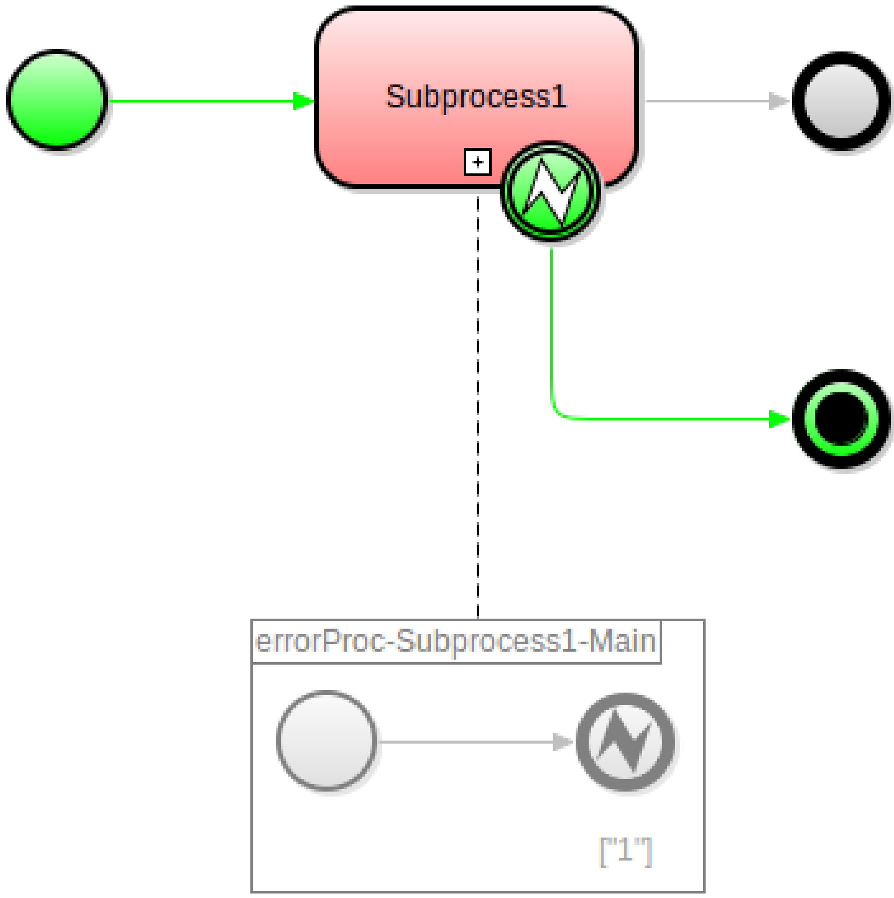
An Error Intermediate Event can define a set of errors it may consume. The errors are identified by their error code. Once the event catches one of the error codes, its outgoing Flow is taken. If no error code is specified (`null`), the Error Intermediate Event catches any Error produced in its child contexts unless it is processed by other Error Intermediate Event, which explicitly specifies the error code.

If there are several Error Intermediate Events attached to an Activity, the Error is caught and processed by the Error Intermediate Event with the priority depending on the way its error codes are defined:

1. only the error code of the particular error;
2. set of error codes including the particular error code;
3. no particular error code.

Figure 4.11 Non-Interrupting Error Intermediate Event

Figure 4.12 Interrupting Error Intermediate Event



Error Intermediate Event Attributes

- **Error Code Filter** defines the filter that returns the expected errors (only error events from the Error reference that meet the filter criterion trigger the event).

  If no filter is defined of returns `null`, the event catches all errors.

- **Error Code** is the reference to a local or global context (variable or a variable field) that will store the received error.

4.4.6.3.2.3 Cancel Intermediate Events

A *Cancel Intermediate Event* is an event that handles a Cancel End Event with the aim to cancel the actions of a Transaction Sub-Process.

Hence, it can be attached only to a boundary of a Transaction Sub-Process that contains a Cancel End Event. When the Sub-Process finishes with the Cancel End Event, the outgoing flow of the Cancel Intermediate Event attached to its boundary is taken.

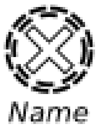


Figure 4.13 Non-Interrupting Cancel Intermediate Event

Figure 4.14 Interrupting Cancel Intermediate Event

4.4.6.3.2.4 Conditional Intermediate Event

A *Conditional Intermediate Event* is an intermediate event which checks a particular condition and is triggered when the condition becomes *true*:

- If placed on an Activity boundary, the condition is checked continuously while the Activity is *active* or *running*. At the moment the condition becomes true, the execution of the Activity becomes *interrupted* and the Flow leaving the Conditional Intermediate Event is taken.

  Note: There can be one or multiple Conditional Intermediate Events attached to one Activity.

- If used in a workflow as a flow element with an incoming and outgoing flow, when the token reaches the Event, it is held until the condition becomes `true`.

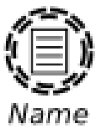


Figure 4.15 Non-Interrupting Conditional Intermediate Event

Figure 4.16 Interrupting Conditional Intermediate Event

4.4.6.3.2.5 Throw Signal Intermediate Event

A *Throw Signal Intermediate Event* produces a Signal that can be caught by Start Signal Events and Signal Intermediate Events.

It can be used only as a workflow element with one incoming and one outgoing Flow.

When reached during execution, it sends the defined signal to the target model instances:

- If the target model instance is the same model instance, it is synchronous, that is, it is produced and processed in the same transaction.
- If the target model instance is another model instance, the signal is asynchronous, that is, it is processed by the target model instance only in the next transaction.

If no model instance is defined, the Signal is sent to its own model instance.

The Throw Signal Intermediate Event has to define the signal and the target model instances:

- **Model instances** defines the IDs of model instances to which you want to send the Signal.
- **Signal value** defines the Signal value.

Figure 4.17 Non-Interrupting Throw Signal Intermediate Event

Figure 4.18 Interrupting Throw Signal Intermediate Event

> **Note:** You can throw a signal also with the `sendSignal` function from the Standard Library.

4.4.6.3.2.6 Catch Signal Intermediate Event

A *Catch Signal Intermediate Event* is triggered when it catches a Signal. Subsequently it produces a token which takes its outgoing Flow.

It can be either attached to a boundary of an Activity or used as a workflow element with one incoming and one outgoing Normal Flow. When active it waits until it has receives a Signal.

It can define a filter for the signals it accepts; if the received signal does not meet the defined filter criteria, it does not send a token.

The Catch Signal Intermediate Event cannot handle Signals of type Reference, Goal, Plan, or ModelInstance. Catching such signals causes a runtime exception.

Catch Signal Intermediate Event defines:

- **Filter**: filter of the accepted Signal
- **Signal**: reference to a storage, where the caught signal is stored

Figure 4.19 Non-Interrupting Catch Signal Intermediate Event

Figure 4.20 Interrupting Catch Signal Intermediate Event

4.4.6.3.2.7 Throw Escalation Intermediate Event

A *Throw Escalation Intermediate Event* is an Event which sends an Escalation object when triggered.

It can be used only as a workflow object with one incoming and one outgoing flow. When reached during execution, it sends the defined Escalation object, which is propagated throughout its context and up to higher contexts either until consumed by a Start Escalation Event or a Catch Escalation Intermediate Event or until no higher context is available.

Throw Escalation Intermediate Event Attributes

- **Escalation code** defines the escalation code sent with the escalation object.
- **Escalation** defines the payload of the Escalation object.

  Important: It is not possible to filter according to information in payload. You can use only the escalation code.

4.4.6.3.2.8 Catch Escalation Intermediate Event

A *Catch Escalation Intermediate Event* is a boundary intermediate event that catches and consumes an Escalation object that was thrown in its Activity and meets the filter criterion, and produces a token. It can be used only as a boundary element on an Activity and with an outgoing Normal Flow.

The event is active while the Activity is active. When the Escalation object is thrown in the Activity or its child contexts, the boundary Catch Escalation Intermediate Event consumes the Escalation object and produces a token which takes its outgoing Flow. Note that just like other boundary Intermediate Events, it can be non-interrupting or interrupting.

Catch Escalation Intermediate Event must define a reference object, where the object is stored. It can optionally define a filter definition: if the received Escalation object does not meet the filter criteria, it is ignored.

Catch Escalation Intermediate Event Notation

Figure 4.21 Non-Interrupting Catch Escalation Intermediate Event

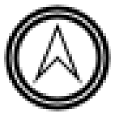


Figure 4.22 Interrupting Catch Escalation Intermediate Event

Catch Escalation Intermediate Event Attributes

- **Filter** contains the escalation codes of accepted Escalation objects.
- **Escalation** defines a reference to a storage, where the caught escalation signal is to be stored.
- **Escalation code reference**: Event consumes just escalations with the defined escalation code (if the escalation code is not specified then the Event accepts all escalations).

4.4.6.3.3 End Events

An *End Event* ends a workflow (consumes a token).

A workflow has one or multiple End Events and one or multiple Sequence Flows can enter an End Event. No outgoing Flow is allowed.

There are multiple types of End Events, which differ by the actions they perform when an execution flow enters the end events, that is, how they behave when they consume a token.

4.4.6.3.3.1 Simple End Events

A *Simple End Event* is the basic end Event type which consumes the incoming token; other tokens in the workflow remain uninfluenced. The particular workflow is finished successfully if it does not contain any other tokens.

Simple End Event Notation

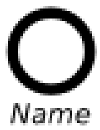


Figure 4.23 Simple End Event

4.4.6.3.3.2 Terminate End Event

When a workflow reaches a *Terminate End Event*, all tokens in the given context and its subcontexts and the execution ends successfully: when a token reaches a Terminate End Event, any tokens in the given workflow and any sub-workflows are discarded.

For example, let's assume process A with subprocess B and subprocess C. Subprocess B finishes with a terminate end event has a subprocess BB. On runtime, subprocess B finishes with a terminate end event: As a result, any tokens in subprocess B and subprocess BB are discarded. Tokens in subprocess C and process A continue their flow unaltered.

Terminate End Event Notation

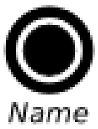


Figure 4.24 Terminate End Event

4.4.6.3.3.3 Error End Events

A *Error End Event* is an end event that implement error handling on a workflow end. The actions when triggered depend on the type of the parent namespace of the End Event. When a token enter an Error End Event, enters an Error End Event the following happens:

- if in a Sub-Process:

The End Event generates an error with the respective Error Code (see Error) and the workflow is finished. The error is distributed gradually to higher namespaces and can be caught by an Error Intermediate Event contained in any parent namespace as to trigger a compensation process (see Error Intermediate Event).

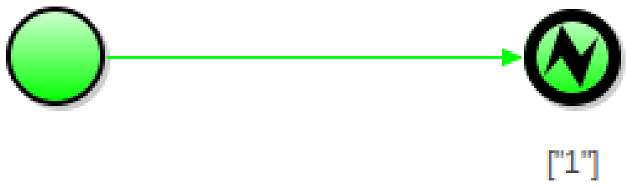
- Plan Models

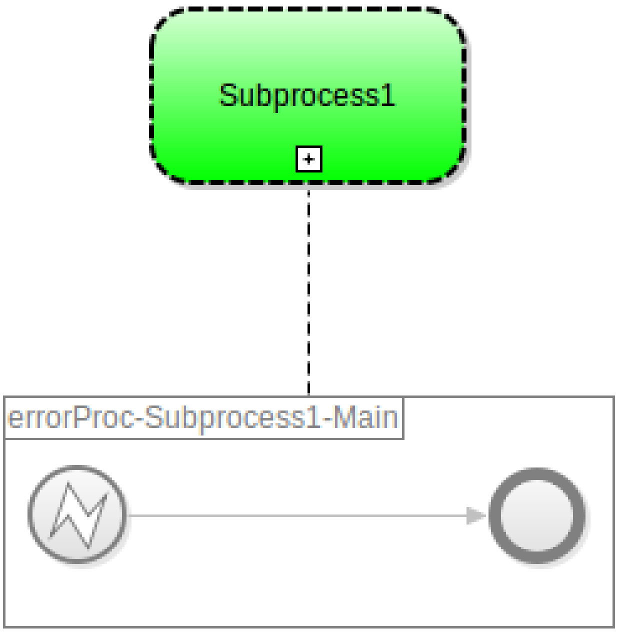
  If a Plan Model ends with an Error End Event, the Plan fails (becomes `Failed`).

- BPMN-based Processes

  If a BPMN-based Process instance finishes with an Error End Event, the last transaction is rolled back and an exception is created.

Figure 4.25 Error End Event





Error End Event Attributes

- **Error code** defines the error code to be sent.

4.4.6.3.3.4 Cancel End Events

A *Cancel End Event* is a special End Event which ends a Transaction Sub-Processes.

When a token enters a Cancel End Event and the parent Transaction Sub-Process has no Cancel Intermediate Event attached, the last transaction is rolled back.

If there is a Cancel Intermediate Event attached to the parent Sub-Process, the Sub-Process execution fails (the Sub-Process becomes Interrupted) and the outgoing Flow of the attached Event is taken.

Cancel End Event Notation

Figure 4.26 Cancel End Event

4.4.6.3.3.5 Throw Escalation End Events

When a workflow ends with a Throw Escalation End Event, the event generates an Escalation object with the respective code and the workflow finishes. The escalation is distributed gradually to higher context and can be caught by a Catch Escalation Intermediate Event or Escalation Start Event in any parent context.

Escalation End Event Notation

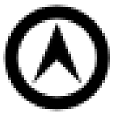


Figure 4.27 Escalation End Event

Escalation End Event Attributes

- **Escalation code** defines a code sent with the escalation object that serves as the escalation identifier.
- **Escalation** defines the payload of the Escalation object.

Note: It is not possible to filter according to information in payload. You can use only the escalation code.

4.4.6.3.3.6 No Exit End Events

A *No Exit End Event* is an end event that consumes a token in the workflow of an Inline Event Sub-Process without triggering the Sub-Process' outgoing Flow: no token for any outgoing Flow if present is produced but the Sub-↩ Process execution finishes with success.

If a Process with such an event is used by a Reusable Inline Event Sub-Process which is not used as part of the workflow, that is, it does not have an outgoing Flow, the No Exit End Event behaves as a Simple End Event.

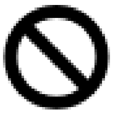


Figure 4.28 No Exit End Event

4.4.6.4 Flows

A *Sequence Flow* is a connector which establishes an oriented relationship between two elements of a workflow (Activities, Events, and Gateways). The purpose of a sequence flow is to defines the execution order of workflow elements. In GO-BPMN, only the Normal Flow is supported with the Default Flow being considered a special case of Normal Flow.

4.4.6.4.1 Normal Flow

A *Normal Flow* is a Flow type designating the execution order of the workflow elements. It connects a source and a target element in an oriented way: On execution, the flow pass from the source to the target element.

A source or target element of a Normal Flow can be Events, Activities, or Gateways.

If the source of a Normal Flow is an Exclusive Gateway, a Normal Flow can define a guard. A guard defines a Boolean condition, which has to be true for the Flow to be taken. If false, the execution is held by the Flow and the Flow guard is evaluated continuously.

Figure 4.29 Normal Flow with a guard

4.4.6.4.2 Default Flows

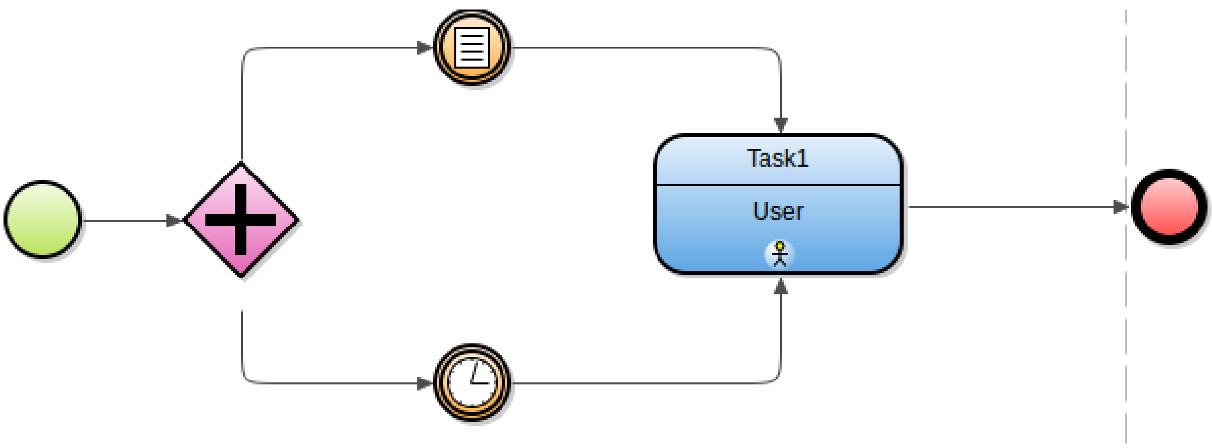
A *Default Flow* is a special case of the Normal Flow which has an Exclusive Gateway as its source element. It is the last-resort Flow which is taken if not other Flows leaving an Exclusive Gateway can be taken: If conditions on guards of all other Flows prevent them from being taken, the Default Flow is used.

Figure 4.30 Default Flow

4.4.6.5 Activities

An *Activity* represents a piece of work that need to be done and that either by a human or a system (machine). The term covers Tasks, which are considered atomic, and the Sub-Process, which encapsulate other elements.

An Activity is executed whenever it receives a token: the token is typically passed by the incoming flow of the Activity: each token results in a single Activity execution.



In the example above, the parallel gateway "splits" the incoming tokens into two tokens: further down your execution flow, the tokens enter an Activity: each token will result in its own Activity execution, in this case, the activity is executed twice: once for the token from the Condition Intermediate Event and once for the token from the Timer End Event.

The logic of the execution depends on the activity type and additional mechanisms, such as, looping. Mind that looping does not influence the number of Activity executions.

An activity has an arbitrary number of incoming and one or none outgoing sequence flow. The flows influence the execution in the following ways:

- Incoming flows:
  - If an activity does not have an incoming Flow, it is instantiated when the process is instantiated. If there are multiple Activities with no incoming flows in one Process, all such Activities are instantiated (multiple tokens are produced).
  - If it has one or multiple incoming flow, it is instantiated always when the any of the flows send a token to the activity.
- Outgoing flows:
  - If an activity has no outgoing flow, the execution finishes along with the Activity execution (its token ceases to exist after the activity is accomplished).

Activities can have intermediate events attached to their boundary. These events react to specific events or conditions that can occur during the activity execution; for example, they can be used if the execution of an activity should time out after a certain amount of time.

4.4.6.5.1 Tasks

A *Task* is an atomic Activity in a workflow: it represents the smallest logical piece of work, which cannot be broken down any further (for example, sending a file, filling in a questionnaire, displaying a text, etc.).

A Task can have none or multiple incoming, and none or one outgoing Normal Flow.

When the workflow hits a task, the task becomes alive and its logic is executed: if the execution is successful, the task becomes accomplished. If the parent model instance is suspended, an alive task also becomes Suspended.

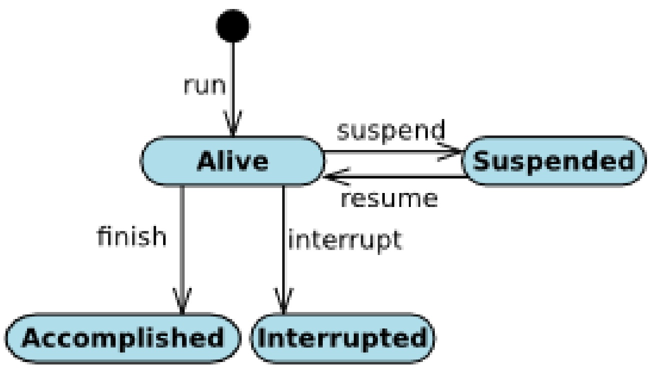


Figure 4.31 Task Lifecycle

Activities of task types can be reflected as Records: this allows you to create instances of tasks by instantiating them as Record instances. Typically you will send the Record as a parameter to the `Execute Task` which makes sure its gets executed as a task in your workflow. In the LSPS implementation, a task type is reflected after you set the `Create activity reflection type` flag.

> **Note:** To-dos generated by human tasks can be saved. The human task remains alive while the to-do is saved.

Every task is of a particular task type: the task type determines what kind of action the task performs. Depending on the type, every task has a set of parameters, which define the input and output data for the task execution.

You can execute a task multiple times in one execution using the looping mechanism.

Figure 4.32 Task notation

In addition to the common modeling element attributes and apart from attributes specific for a task type, tasks define the following attributes:

- **Public**: task type visibility

  If not Public, the task type cannot be used by any importing modules.
- **Deprecated**: flag which signalizes that the task will be removed in the next version of the model or application If the flag is selected, on validation, a warning notification is logged about that the user is using a deprecated task.
- **Parameters**: task specific parameters Parameters define the following properties:
  - **Name**: parameter name
  - **Type**: data type of the parameter
  - **Required**: if true the parameter is obligatory
  - **Dynamic**: if true the parameter value is wrapped in a non-parameteric closure automatically (the parameter is then processed as `{ -> <parameter_value> }`.) This is the case of the `uiDefinition` parameter in the `User` task. Hence the user does not need to define the uiDefinition parameter as `{ -> <form()> }` but only provides directly the call to the form (`form()`).
- **Class name**: name of the task class

4.4.6.5.2 Sub-Process

A Sub-Process is a compound Activity encapsulating a workflow: it is a “process within a process” that serves to organize the workflow content.

It exists in its own context with its variables and parameters and its workflow is triggered as part of its process. It can be triggered by token passed by its incoming flow or by an event: if you want to trigger a Sub-Process with events, use an Inline Event Sub-Process.

A Sub-Process can be of the following types:

- Embedded Sub-Process defines its workflow in-place inside the parent Process or Sub-Process
- Reusable Sub-Process defines a reference to a process and uses this process as its content

4.4.6.5.2.1 Embedded Sub-Process

An *Embedded Sub-Process* is a Sub-Process that is defined as part of its parent Process or Sub-Process. Its workflow must contain one None Start Event or one or multiple Activities with no incoming Flows.

On runtime, a sub-process instance is created when the token passes to the Sub-Process through its incoming flow: then the None Start Event produces a token and Activities with no incoming Flow are triggered. The execution finishes when there are no tokens in the sub-process instance.

Also, an embedded Sub-Process can be marked as a *transaction* embedded Sub-Process to mark it as comprising a business transaction that is "atomic". Its workflow can finish with a Cancel End Event: the subprocess must have a Cancel Intermediate Event on its border with an outgoing flow: When the flow finishes with the Cancel End Event, the outgoing flow of the border Cancel Intermediate Event is taken.

Figure 4.33 Embedded Sub-Process notation

4.4.6.5.2.2 Reusable Sub-Process

A *Reusable Sub-Process* references a Process: when triggered, it instantiates the Process as a subprocess.

Figure 4.34 Reusable Sub-Process notation

Reusable Sub-Process Attributes

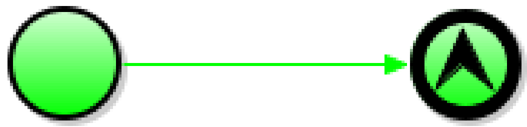
- **Referenced Process Name** defines the assigned Reusable Process.
- **Parameters** are key-value pairs used as parameters when the Sub-Process is instantiated (similar to process parameters)

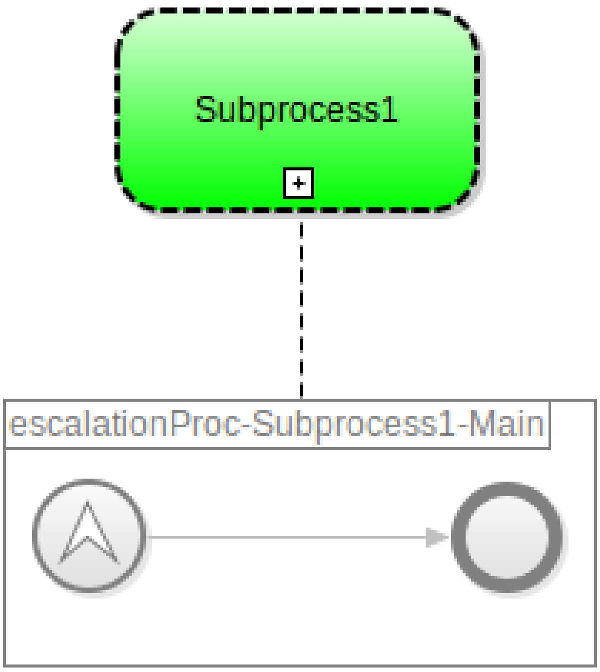
4.4.6.5.2.3 Inline Event Sub-Process

When you mark a Sub-Process as an inline sub-process, its Start Events are considered part of the parent context, which is either a process or another sub-process. Such start events can be of different types so they are triggered when a particular event occurs in their parent Process or sub-process: When they start with a None Start Event they are triggered when the parent is triggered and in the case of other Start Events whenever the trigger event occurs in the parent.

> **Note:** Also a BPMN-based process can contain any type of Start Events: this allows you to trigger it when it is used in a Reusable Subprocesses.

For example, if a process instance finishes with an Escalation End Event, all Escalation Start Events in its inline event subprocesses receive the escalation and one creates its sub-process instance. This allows you to consume a token and at the same time, produce a token somewhere else while keeping the process instance running.





An Inline Event Sub-Process can be placed into the workflow *with an incoming and outgoing Flow* or *with no incoming or outgoing Flow*.

- When used as part of a Process or Sub-Process workflow with at least one incoming Flows and one outgoing Flow, the workflow inside the Sub-Process must contain a None Start Event or one or multiple Activities without an incoming Flow and it can contain an arbitrary number of Start Events other than the None Start Event. The subprocess is then triggered as follows:
  - None Start Event is triggered when a token passes through the incoming Flow into the Sub-Process: a new Sub-Process instance is created and the None Start Event produces a token.
  - Start Events of other types are triggered whenever their event occurs during the life of the parent instance, that is, either a Process or Sub-Process instance.
  - Activities with no incoming Flow are triggered whenever a Sub-Process instance is created and that as part of the Sub-Process instance.
- When part of a Process or Sub-Process with no incoming or outgoing Flows:
  - None Start Event is triggered when the parent Process or Sub-Process is triggered.
  - Start Events of other types are triggered whenever their event occurs during the entire life of the parent Process or Sub-Process.
  - Activities with no incoming flow are triggered whenever a Sub-Process instance is created and that as part of the Sub-Process instance.

Note: Inline Sub-Processes cannot use the looping mechanism.

4.4.6.5.3 Looping

Looping allows you to execute the logic of an Activity multiple times: individual loop runs are considered part of the Activity execution: looping *does not* change the amount of tokens.

Loops can be executed in the following ways:

- standard (for): Activity is repeated successively (serially) the defined number of times unless the loop condition becomes false.
- multi-instance (foreach): Activity is repeated in parallel or in sequential manner over a list of items.

> **Note:** Alternatively, loops can be also created by cycling the workflow using flow elements: In such loops, a Gateway has an outgoing flow “returning” to a preceding Gateway.

Looping defines its iterator, which stores the number of the loop starting from 0 and is incremented by 1 after each loop.

4.4.6.5.3.1 Multi-Instance Looping

Multi-instance looping enables you to execute the logic of one Activity on each object of a list of objects. The looping can be either parallel or sequential.

Multi-instance looping defines the following:

- list of elements the looping is performed for (For each attribute);
- how the multi-instance loop is to be executed:
  - sequential: when one instance of the Activity finishes, a new instance is created
  - parallel: activity instances for all list objects are started at once; the Activity finishes after all its instances finished.
- looping iterator: name used to refer to the currently iterated object.

Multi-Instance Looping Notation

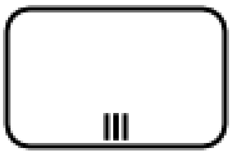


Figure 4.35 Activity with multi-instance loop

Multi-Instance Looping Attributes

- **Iterator**: name of the iterator (you can use it in the For each expression and anywhere within the activity to get the current loop object)
- **For each**: list of objects to be used in the loops
- **Ordering**: loop ordering strategy (sequential or parallel)

4.4.6.5.3.2 Standard Looping

Activity with a Standard looping definition is repeated serially for a set number of times.

On each loop of standard looping, the server checks either before or after each loop whether the loop condition is true. If it is false, the looping finishes.

When the looping finishes, the Activity releases one token to its outgoing flow.

> **Note:** If the loop condition is evaluated always before the execution of the loop and the condition is at the first evaluation `false`, the Activity is never performed.

The looping iterator is initialized to 0 and incremented by 1 after each loop.

Standard Looping Notation

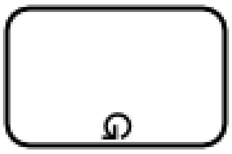


Figure 4.36 Activity with standard loop

Standard Looping Attributes

- **Iterator**: name of the iterator (you can use it in the loop condition or anywhere within the Activity to gets the number of loop that is currently executed (The iterator is initialized to 0 and bumped after or before each loop.)
- **Loop condition**: condition that finishes the loop; it defines also its time time, the moment when the loop condition is checked (before or after a loop)
- **Loop maximum**: maximum number of loops (Once the maximum number of loops has been reached, the looping finishes regardless of the value of the loop condition.)

4.4.6.6 Gateway

A Gateway is a workflow modeling element used to direct, or fork or merge workflows.

GO-BPMN defines the following Gateway types:

- Parallel Gateway creates or merges multiple flows
- Exclusive Gateway selects one flow out of multiple flows

> **Important:** The target element of a Sequence Flow leaving a Gateway must not be a Timer Intermediate Event.

4.4.6.6.1 Parallel Gateways

Parallel Gateway changes the number of parallel flows in the process.

It can have multiple incoming and outgoing flows:

- The gateway waits until it has received workflows from all incoming flows (tokens from all incoming flows must enter the gateway).
- Once all incoming flows have reached the gateway, all outgoing flows are taken (possibly multiple tokens are produced).

Figure 4.37 Parallel Gateway notation

4.4.6.6.2 Exclusive Gateways

An *Exclusive Gateway* directs the flow so that exactly one outgoing flow is taken depending on the circumstances, rendering it a decision-making mechanism similar to the *switch* language construct.

An exclusive gateway has one or several incoming normal flows and one or several outgoing flows. If there are multiple outgoing flows, each flow, apart from the default flow, must define a guard with a Boolean condition.

When a workflow enters an Exclusive Gateway, one of the following happens:

1. The first outgoing flow with the guard condition which is `true` is taken.
2. If no such flow is available, the default flow is taken.
3. If no default flow is available, the execution fails with a *NoValidBranchError*.

Figure 4.38 Exclusive Gateway notation

4.4.6.7 Swimlanes

Swimlanes serve to denote and set common performers for multiple elements of a process workflow: if a human task has no performer, the performer set the closest ancestor swimlane is used. This applies to elements in Reusable Sub-Processes.

Swimlanes can contain any element allowed by their parent entity, be it a Plan, BPMN-based Process, or Sub-↩ Process: if you are using Swimlanes in a Plan, you can use the same elements, which you would use in a Plan normally.

Pool

A Pool groups a workflow executed fully or partially by a common set of performers, typically one organization or department. It sets the common performer set: The performers property set on the Pool is adopted by process elements that require the performers parameter but do not define it themselves.

Each BPMN-based process, plan body, or sub-process may have an arbitrary number of Pools with one Pool marked as the Main Pool: Only the flow in the Main pool is executed. Non-main Pools serve for informational purposes only and are excluded from validation.

Pools may contain an arbitrary number of Lanes. Once a Pool contains at least one Lane, the Pool cannot contain any other BPMN elements: all flow elements must be in a Lane.

Sequence Flows cannot cross Pool boundaries.

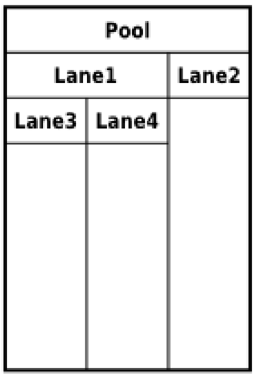


Figure 4.39 Vertical expanded Pool with Lanes

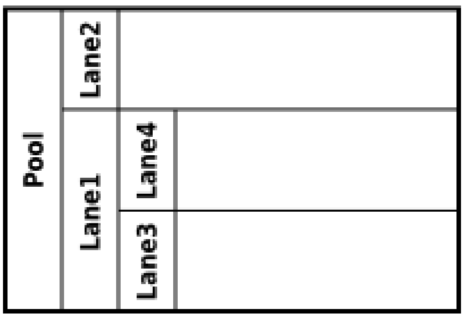


Figure 4.40 Horizontal expanded Pool with Lanes

Figure 4.41 Vertical collapsed Pool with Lanes

Figure 4.42 Horizontal collapsed Pool with Lanes

Pool Attributes

- **Main** is a Boolean attribute; if true the workflow in the Pool is executed.
- **Performers** defines the performers of the Tasks in the Pool if the Tasks do not define their performers or the setting is overriden by a child Lane.

Lane

A Lane holds a part of a workflow of its parent, either a Pool or another Lane, and defines the performers of the activities in the Lane.

A Lane can contain other Lanes: if a Lane contains a Lane, it cannot contain any other BPMN elements. All workflow elements in a Lane take over the Performers parameter value of the Lane. If a parent Lane does not define the parameter, the parameter of the "closest" parent Lane is used. If no such Lane exists, the performers set on the Pool are used.

Sequence Flows of Lane workflows can cross Lane boundaries.

4.4.7 Goal Model

A *Goal Model* is a hierarchy of Achieve and Maintain Goals, and Plans and their connections. A Goal specifies what needs to be achieved while the Plans of the Goal specify how the Goal can be achieved.

When a model instances starts its process instances, the GO-BPMN process instances are executed as follows:

1. All top Goals become *ready*.
2. All top Goals with the pre-condition evaluated to *true* become *running*.

3. For Goals which become *running*, all sub-Goals become *ready*: the Goal triggers all its sub-Goals;
4. All *ready* sub-Goals can become *running* and commit further to their child modeling elements, that is, either to Achieve Goals or to Plans.
5. If a running Goal has several Plans as its child elements, the Goal triggers one Plan: this is either the first Plan with its pre-condition evaluated to *true* or if no Plan pre-conditions are defined, a randomly chosen Plan.

   Important: Since pre-conditions are evaluated continuously, they must not perform any assignments. Such assignments can cause performance issues.

If a Plan fails, another Plan is triggered. If all Plans fail, the parent Goal fails.

Goals and Plans are considered special variables and as such can be accessed by their name directly.

4.4.7.1 Achieve Goal

Achieve Goals represent explicit objectives or states, such as, placing an order, producing a car, sending a message, etc. that need to be achieved either by the process or a goal: If the goal is a top goal, it is the goal of the process; if it is a subgoal of another goal, it is a partial goal required by the parent goal.

An Achieve Goal exist in a goal hierarchy: it may have no parent modeling element or it can have another Achieve Goal as its super-Goal. It can have one or multiple child elements; the child elements can be either Achieve Goals or Plans and are connected with the *Decomposition* flow. It is not possible to decompose an Achieve Goal into both Goals and Plans.

When executed, Achieve Goals go through a set of statuses as part of their life cycle).

An Achieve Goal can define the following:

- **Pre-condition** is a Boolean expression checked continuously while the *Achieve Goal* is *Ready*. When a pre-condition becomes `true`, the Goal becomes Running.

  Important: Since pre-conditions are evaluated continuously, they must not perform any assignments since this can cause performance issues.

- **Deactivate condition** is a Boolean expression checked continuously while an Achieve Goal is *Not finished*, that is, it is *Inactive*, *Ready*, or *Running*. When evaluated to `true`, the Achieve Goal, its sub-Goals and Plans become *Deactivated* immediately.
- **Visibility** defines Goal access rules: a *public* Goal is accessible from the entire model; if you unselect the option, the Goal is private and accessible only from within its module.

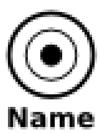


Figure 4.43 Achieve Goal in the iconic notation

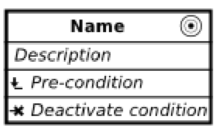


Figure 4.44 Achieve Goal in the decorative notation

4.4.7.1.1 Achieve Goal Life Cycle

When a GO-BPMN process is instantiated, all top Achieve Goals of the process instance become *ready*. If their pre-conditions evaluate to `true`, achieve goals becomes *running*:

- The *running* achieve goals that are decomposed in achieve goals activate all their child achieve goals.
- The *running* achieve goals that are decomposed in *plans*, activate one plan that becomes *ready*.

A *running* Achieve Goal can become either *achieved* or *failed*:

- It becomes *achieved* when one of its Plans is achieved or all of its sub-Goals are *achieved* or *deactivated*;
- It becomes *failed* when at least one of its sub-goals failed or none of its Plans was achieved.

The status of an Achieve Goal can be in addition influence by the deactivation and activation mechanism.

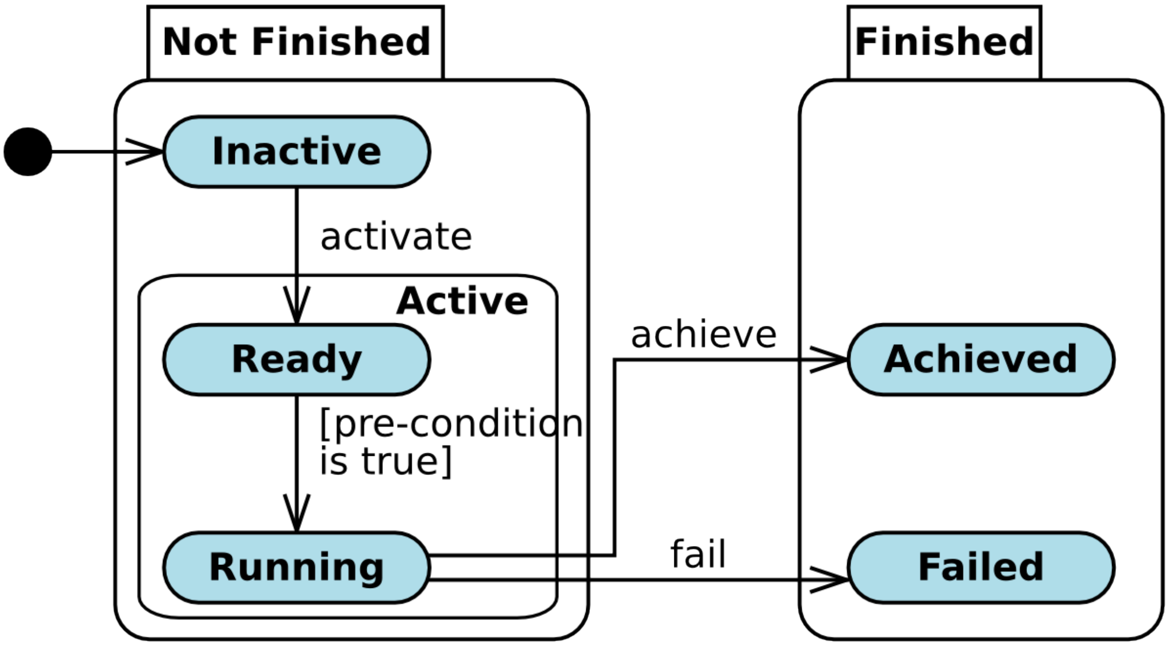


Figure 4.45 Lifecycle of Achieve Goals

4.4.7.2 Decomposition

In a goal model, *Decomposition* represents a relationship used either for detailing a Goal to its sub-Goals, or specifying how a Goal can be achieved by its Plans. It establishes acyclic oriented relationships between:

- two Achieve Goals,
- a Maintain Goal and an Achieve Goal, or
- a Goal and a Plan.

During execution the following rules apply:

- If a Goal is decomposed in sub-Goals, all the sub-Goals are committed to and executed. The super Goal is accomplished only if all its sub-Goals have been *achieved* or *deactivated*.
  - If one of the sub-Goal fails, the super Goal fails and any other sub-Goals become *deactivated*. The failure is distributed also to other parent Goals of the failed Goal: if a Goal, which fails, has any parent Goals, these parent Goals fail as well.
  - A super Goal can succeed even if one or multiple Goals were deactivated. If a Goal is decomposed in several Plans, only one of the Plans is triggered (either the one with the pre-condition evaluated to `true` or the first randomly-chosen Plan). When a Plan is Achieved, its parent Achieve Goal becomes *achieved* or its parent Maintain Goal becomes *ready*.
  - If a Plan fails, an alternative Plan is selected.
  - If all Plans of a Goal fail, the Goal fails.

Figure 4.46 Decomposition notation

4.4.7.3 Maintain Goal

A *Maintain Goal* serves to ensure that a condition is met while the GO-BPMN process or an Achieve Goal is *running*. Should the condition become *false*, the objective of the Maintain Goal is to remedy the situation and make the condition *true* again.

The process and the Achieve Goal, which the Maintain Goal depends on, are referred to as the *scope*. The scope is defined:

- either by the Maintain Scope connector, which connects the Maintain Goal and its scope Achieve Goal,
- or implicitly as the Process.

A Maintain Goal is always a top Goal and can be decomposed in Plans or Achieve Goals.

> **Example:** The maintain condition defines the minimum amount of material that must be on stock at all times. If the amount on stock is lower than the defined amount, the condition becomes false, and the Maintain Goal is activated: Plans or sub-Goals attached to the Maintain Goal provide for restocking.

4.4.7.3.1 Maintain Goal Life Cycle

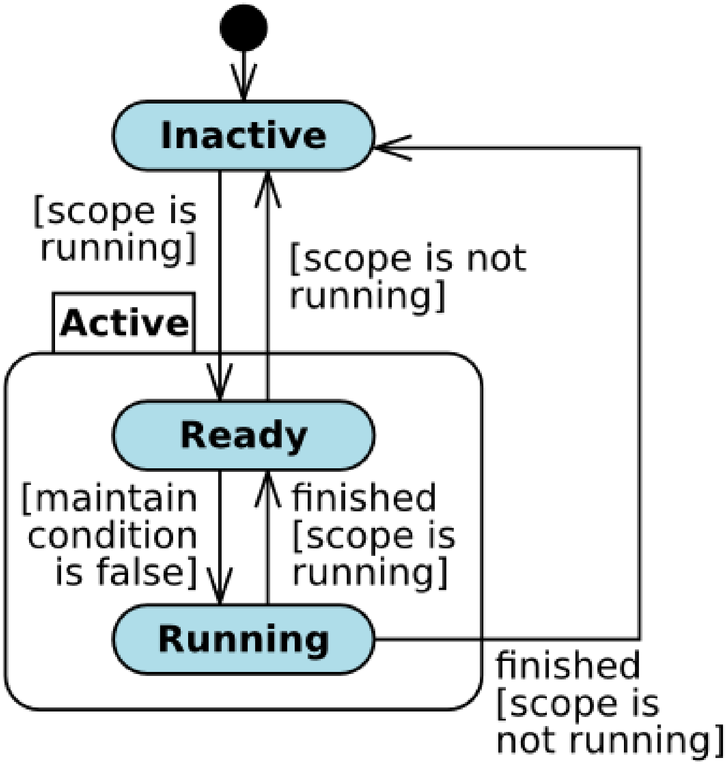


Figure 4.47 Maintain Goal life cycle without the Activation mechanism

A Maintain Goal is *inactive* only when the scope is an Achieve Goal which is *Inactive* or *Ready*. When the Achieve Goal becomes *Running*, the Maintain Goal becomes *Ready* and the maintain condition is from now on checked continuously.

If the scope is the parent process, the maintain goal becomes *Ready* immediately on process start: It does not enter the *inactive* state.

When the maintain condition becomes *false*, the Maintain Goal becomes *Running*: its sub-goals become *Ready* or one of its Plans becomes *Running*. The maintain condition is not checked while the Maintain Goal is *Running*.

When the sub-tree execution of a Maintain Goal is finished, the following can occur:

- If the scope is still Running, the Maintain Goal becomes Ready and the maintain condition is being checked again.
- If the scope is no longer *Running*, the Maintain Goal becomes *Inactive*.

If the scope is a Process which is *Finished*, the Inactive state is only transient and the Maintain Goal becomes *Deactivated*.

4.4.7.3.2 Maintain Scope

A *Maintain Scope* connects a Maintain Goal with its Achieve Goal. The connected Achieve Goal is the *scope* of a Maintain Goal.

A Maintain Goal can have only one Maintain Scope. If you require a more diverse Maintain Scope, consider using maintain conditions.

Figure 4.48 Maintain Scope

If the Achieve Goal targeted by the Maintain Scope is:

- reactivated, the Maintain Goal becomes *ready*.
- not active and the Maintain Goal is transferring from *running*, the Maintain Goal becomes *inactive* (for example, if the scoped Achieve Goal becames deactivated, its Maintain Goal remains *ready* or *running*: if it is *ready* it will become *inactive*).

4.4.7.3.3 Maintain Goal Attributes

- **Maintain condition** is a Boolean expression which is checked continuously while the Maintain Goal is Ready. When the condition becomes *false*, the Maintain Goal becomes *Running*. While the goal is Running the condition is not checked.

  Important: Since conditions are evaluated continuously, do not perform any assignments in maintain conditions. Any such logic can cause performance issues.

- **Public**: visibility of the Maintain Goal; if public, the goal is accessible from outside of the process

A Maintain Goal can be shown either in the decorative or iconic notation.

Figure 4.49 Maintain Goal in the iconic notation

Figure 4.50 Maintain Goal shown in the decorative notation

4.4.7.4 Plan

A Plan is an encapsulation element of a Goal hierarchy which specifies what to do to achieve its parent Achieve or Maintain Goal. It contains a Plan Model, an uninterrupted work flow of Events and Activities connected with Flows.

A Plan must have exactly one incoming decomposition originating from a Goal: one Plan can have only one parent Goal. It is the leaf element of a Goal hierarchy with no outgoing flow elements.

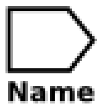


Figure 4.51 Plan in iconic notation

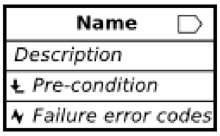


Figure 4.52 Plan in decorative notation

A Plan can define the following:

- **Pre-condition** is a Boolean condition, which is continuously checked while a Plan is Inactive.
- **Failure Error Codes** is a set of error codes (every error code being a string), which cause the Plan to fail after it has received any of the error codes: the error can be produced either by an error code end event in its body). If `null`, any error code causes the Plan to fail.

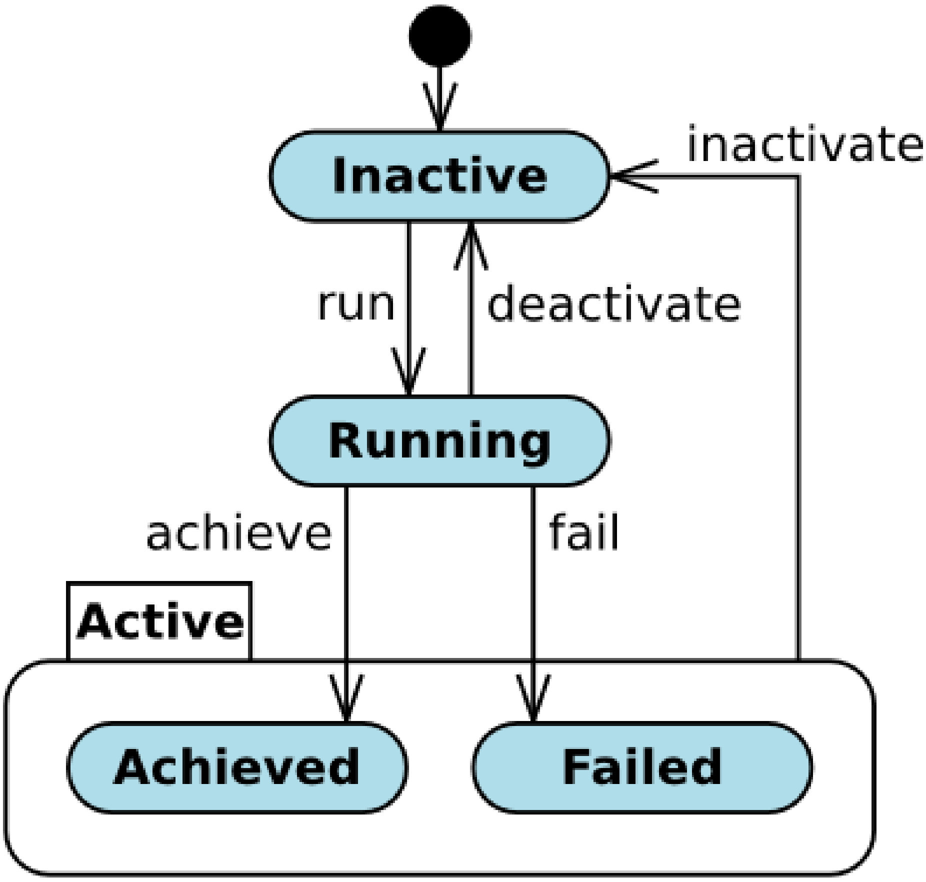


Figure 4.53 Plan life cycle

When a Process is instantiated, all the Plans are created and becomes *Inactive*. When a Goal, which is decomposed in Plans is triggered, a random Plan has its pre-condition checked. If the pre-condition is `true`, the Plan starts execution of its Plan Model: Its namespace context is initiated and its None Start Event produces a token. If the pre-condition is `false` another Plan is selected. To make the Goal check Plans in a particular order, use the pre-condition expression.

While Running, a Plan can be deactivated by its parent goal. A deactivated Plan becomes *Inactive*. A *Running* Plan becomes *Failed* if its Plan Model ends with an Error End Event, or an error code is caught Errors. A Plan becomes Achieved, if the execution of its Plan Model finishes with any other End Event.

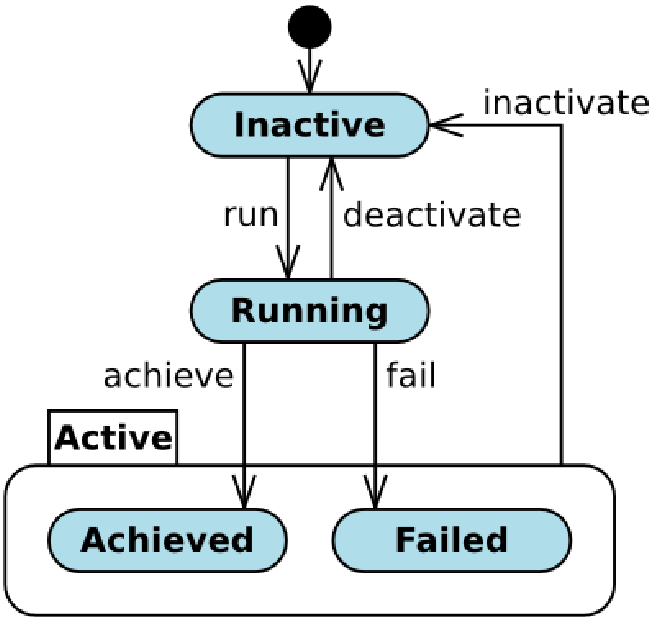


Figure 4.54 Plan life cycle

4.4.7.5 Goal Activation and Deactivation

Goal activation and deactivation is a mechanism that enables an instant change of a Goal status to either make the entire Goal sub-tree to come to a halt or to continue its execution.

You can activate and deactivate Goal with one of the `management tools` or with the `activate()` and `deactivate()` functions of the Standard Library.

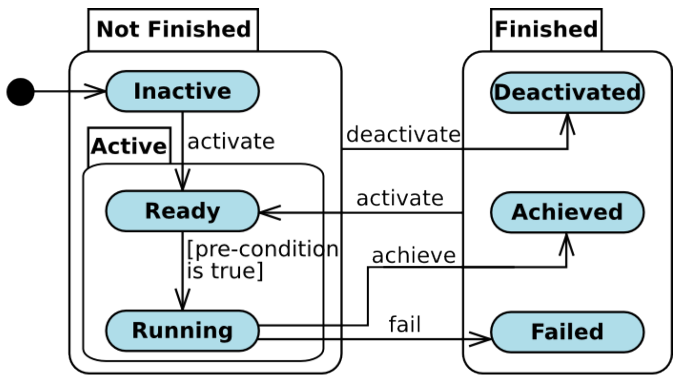


Figure 4.55 Life Cycle of Achieve Goals with Activation and Deactivation

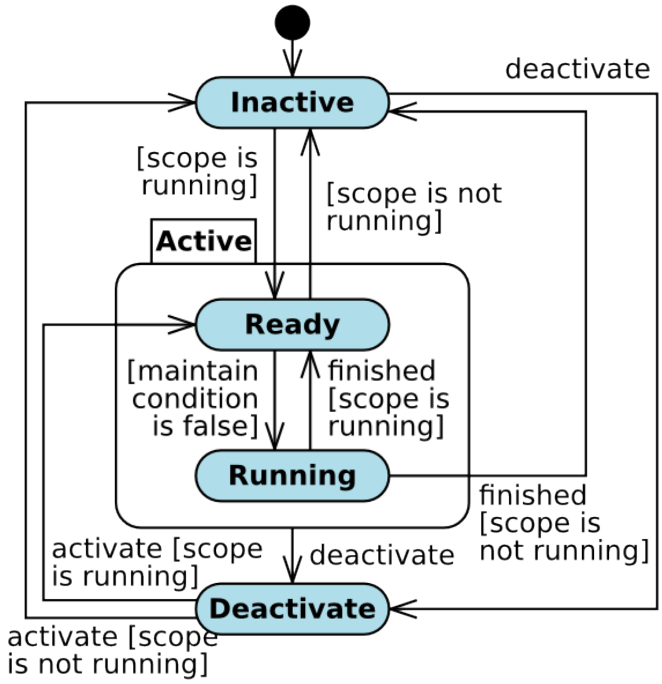


Figure 4.56 Life Cycle of Maintain Goals with Activation and Deactivation

4.4.7.5.1 Deactivation

Achieve and Maintain Goal can be `deactivated manually` or with the `deactivate` function.

Also Goals can define a deactivate condition, which causes the Goal to become *Deactivated* when the condition becomes `true`. The condition is checked as follows:

- When defined on Achieve Goals, while they are Not Finished (inactive, ready, or running).
- When defined on Maintain Goals, while they are Alive (parent process instance is running).

When a goal is deactivated, the following happens:

1. All its sub-Goals and Plans in a top-down manner become *Deactivated*.
2. Any Running child Plans stop their execution immediately and become `Inactive`.
3. When a scoped Achieve Goal is *Deactivated* and the Maintain Goal is running, the Maintain Goal finishes its current lifecycle, either achieves one of its Plans or all of its Plans fails, and only then becomes *Deactivated*.

An Achieve Goal or a Plan is deactivated also when their parent fails.

4.4.7.5.2 Activation

If an Achieve Goal is Achieved, Failed, or Deactivated, it is considered Finished. Only a finished Achieve Goal can be activated: on activation it becomes Ready. Note that the status of its parent Goals remains unchanged, only its sub-elements go through their life cycle.

Chapter 5

Data Type Model

A *data type model* is the hierarchy of all records–user-defined data types with an inner structure–with all their relationships in a model.

The purpose of records and their relationships is to define the data structure that accommodates the business data used in your model.

A data type model can contain the following:

- Records, shared records, enumerations and interfaces that represent the types of entities involved in your module logic.
- Inheritance and relationships between records that establish logical connections between the entities.

5.1 Record

A *record* represents a complex data type, such as, a person, product, service, etc. The structure of a record is defined by a set of record fields of a given data type, for example, a record *Persona* could have the fields *surname*, *firstName*, and *dob*. The data types of fields should be preferably simple data types.

In situation, where a record requires further structure data, create another record and use a Relationship to connect them.

Records can establish inheritance: a record can be a subtype of a record; the subtype record *inherits the fields of all its supertype records*.

On runtime, a record is used as a blueprint for its instances, which hold the business data: While an Invoice record defines the structure of an invoice, a particular invoice is represented by an instance of the Invoice record. Record instances are created with the `new` operator; for example, you can create a person record instance of the Person record as `new Person("Doe", "John", date(1982, 1, 14))`. For further information on the behavior of operators when a record is involved, refer to the `Expression Language guide`.

Each record can be marked as the following:

- *read-only*: prevents any changes to a record instance.Instances of such records can be initialized and deleted during runtime; however, they cannot be modified.
- *abstract*: prevents instantiation of a record.

- *system* record: System records *cannot be instantiated or modified from model instances.*

  Such operations can be performed only by `custom objects` implemented in Java in your LSPS Application code.

Figure 5.1 Record notation

Allowed record values can be restricted with constraints.

5.2 Shared Record

A *shared record* serves to persist the record instances: each instance of a shared record is persisted in the database and hence survives after their context is destroyed.

A shared record is mapped to a database table:

- Every shared record is stored in its own table.
- If there is a relationship between two records the mapping is realized as follows:
  - For 1:1 relationships, the foreign key of the source record is placed in the table of the target record. On the side without a foreign key, fetching is always eager.
  - For 1:N relationships, the foreign key of the source record is placed in the table of the target record.
  - For N:N relationships, a join table with the target-source-record primary keys is created.

Make sure your shared record is mapped to the correct table. By default, the name of the target table is based solely on the record name and does not reflect the module name. Therefore, if you define multiple shared records with the same named and you don't change the target table, or schema, they will be mapped to the same table even if they are defined in different modules.

Any readings, modifications, and deletions of shared record instances are immediately reflected in the mapped database entry.

Fetching of record instances is governed by Hibernate's principles and by the transactions of the model instances.

> **Important:** When a field of a shared record is of a different type than Boolean, Integer, Decimal, String, Date, or Enumeration the field must define the space that is reserved in the underlying database column as its BLOB size. The field data is then serialized when stored and must be deserialized when queried. This is considered bad practise: A field of a shared record must not be of type collection, map, record or any other complex type. Use record relationships instead. Neither can a field be of type Closure or Reference since these types are bound to their context on runtime.

For information on the implementation of shared records and the related mapping and fetching mechanisms refer to Designer User Guide.

Figure 5.2 Shared Record notation

5.3 Interface

An *Interface* serves to enforce implementation of a set of methods on its child Records. It does not have any Fields or Relationships.

Records that implement the Interface are connected to it with the Realization connector.

5.4 Enumeration

An *enumeration* is a special data type that holds literals which represent the possible values of the enumeration object. The values are called in the form `<enumeration_name>.<literal_name>`. Since the literals are arranged as a list of values, comparing enumeration literals is based on comparing their indexes: The order depends on the order of the literal as modeled in the enumeration. The comparison operators =, !=, <, >, <=, >= can be used on the literals of the same enumeration type.

Enumerations don't engage in relationships: they cannot be targets or sources of inheritance or data relations.

Figure 5.3 Enumeration notation

5.5 Record Import

The *record import* serves for importing records defined in another resource, such as an imported module or in another data type definition of the current module.

If the record import is an import of a shared record, the following restrictions apply:

- No data relationship can be established between shared record imports if their parent data type definition uses a different target database.

- If the record import is from a definition in an imported module:

  – It can be establish relationships only to shared records.

  – Any relationships of the record import can define only navigation directed toward the shared record import; Navigation *out* of the shared record import is not supported.

5.6 Inheritance

Inheritance is an oriented relationship between two records, shared or common, in which the source record is a more specific record of the target record, for example, the `Person` record as a supertype of the `Natural↩ Person` and `LegalPerson` records: a subtype is able to substitute its supertype in any operation valid for the supertype.

The subtype record adopts all fields as well as public and protected methods of the supertype Record and the supertype's supertype records, etc.

Inherited methods can be overridden: when overridden, their visibility can be changed only from *protected* to *public*.

A *inheritance relationship cannot be cyclic*, for example, if type T has subtype V, the subtype V cannot have T as its subtype: A record can be *final* to prevent it from being a supertype.

The read-only setting of field is preserved when inherited, that is, if record A contains a read-only field A and record B is the supertype of record A, then the inherited field remains read-only.

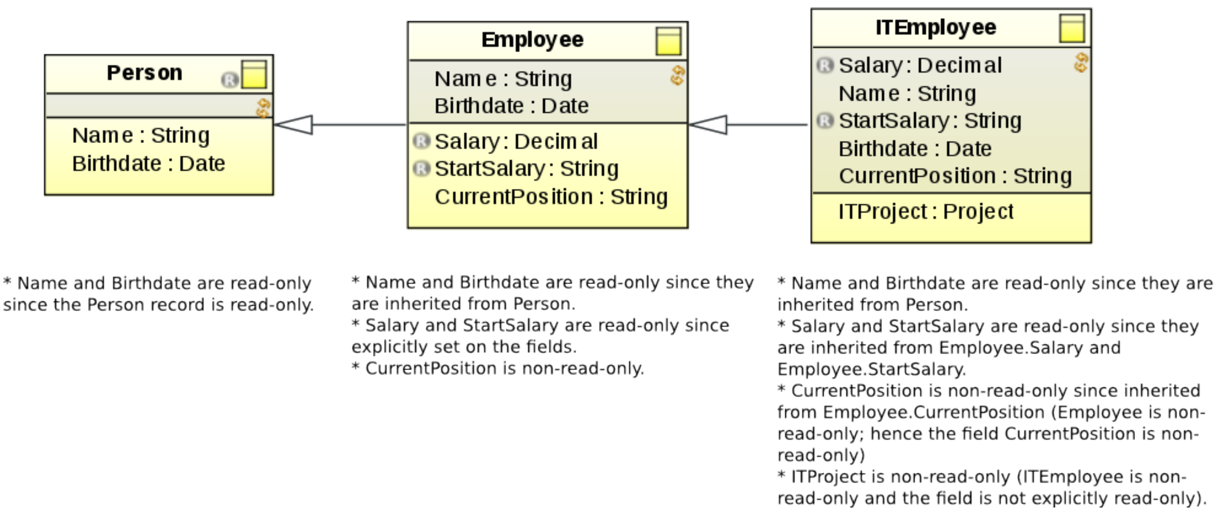


Figure 5.4 Person is the super type of the Employee and Employee is the super type of ITEmployee: All fields of Person are inherited by both subtypes and ITEmployee inherits all fields of Employee.

5.7 Data Relationships

A *data relationship* establishes a logical connections between two records, such as, employee and company. With a relationship, you can navigate between the records to query and work with such related data easily.

A relationship can be cyclic: the source and target can be the same record. For example, if a company can cooperate with a set of other companies, you can create a relationship with the company record as its source and target and 1:N multiplicity.

Note: Read-only records can only be targets of data relationships, but not their sources. This prevents a possible inconsistency of data.

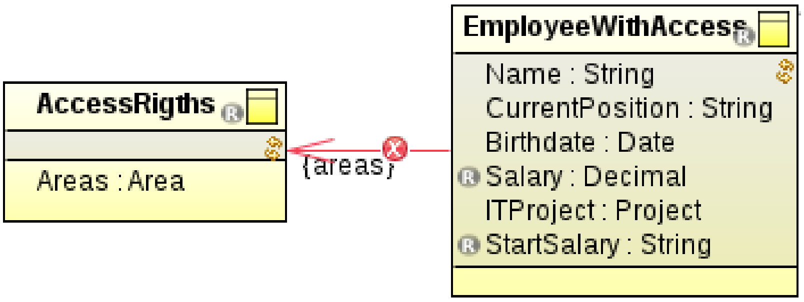


Figure 5.5 Invalid data relationship between read-only Records

Data relationships define the following:

Navigability *Navigability* of a data relationship end enables you to "move" to the related record. To establish navigability, the respective relationship end must be named: every data relationship must define at least one of its ends' name.

The relationship works both ways equally and properties of the navigations to either end are defined for both ends (they are symmetrical).

Example: The records Author and Book are connected with a relationship: The end pointing to the Book is named "books" so you can navigate from the Author record to the Book record: `heller.books`. The relationship end pointing to the Author does not have a name. Therefore, you cannot navigate from a book *to its Author*.

Visibility Visibility restricts the accessibility of the relationship:

- private: accessible only to the record and its methods
- protected: accessible only from within the data type hierarchy ** public: accessible from anywhere

Multiplicity Multiplicity of a relationship and defines how many record instances can be at the end of the relationship:

- **Single**: one record instance

  For example, let's assume *Sport Shoes* and *Production Batch* records: a pair of shoes is produced as part of *only one* batch; hence the relationship from the Sport Shoes to the Production Batch has Single multiplicity.
- **Set**: multiple *different* record instances

  In the example, this would be the multiplicity on the relationship end pointing to the Sport Shoes.

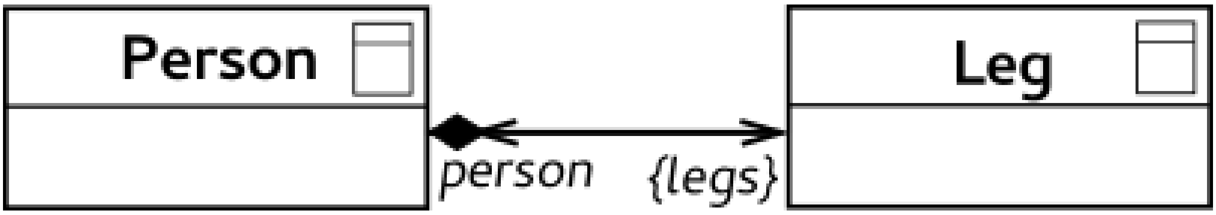
  For two *shared* records, the Set multiplicity can define the **Order By** property with the database column that is used to order the related record instances. If no value is specified, the instances are ordered according to their primary key. For example, if the shared record Person has a navigable Set relationship to the shared record Citizenship and defines the Order by property as `countryCode`, then the *Citizenship* record instances fetched as related record instances by the expression `Person.citizenship` will the ordered according to the countryCode.

- **List**: multiple record instances can be on this end of the relationship

  Note: If one end defines the *List* multiplicity and the other end a Single multiplicity, then for every item of the List exactly one item in the other end is available. Such a relationship does not handle situations where one entity is available multiple times in the list.

Composition A composition is a "target-is-part-of-source" relationship: the value at the target end cannot exist by itself, that is, without a source value. If the source value is removed, all its target values are removed.

The source end of a composition relationship must be of the *single* multiplicity: *when the value at the source end is deleted, the values at the target end are deleted as well*–cascade delete takes place.



Based on the example, when you delete a Person, all its Legs are deleted; when you create a Leg, it must have a relationship to a Person. If you delete a Person's leg, the Person is not deleted. Note that a leg can belong to one person only.

5.7.1 Deleting Record Instances in a Data Relationship

The record instances in a relationship are deleted depending on the relationship multiplicity as follows:

- On a relationship with **single multiplicity**:
  - if the source instance is deleted, the entire instance takes the value `null`.

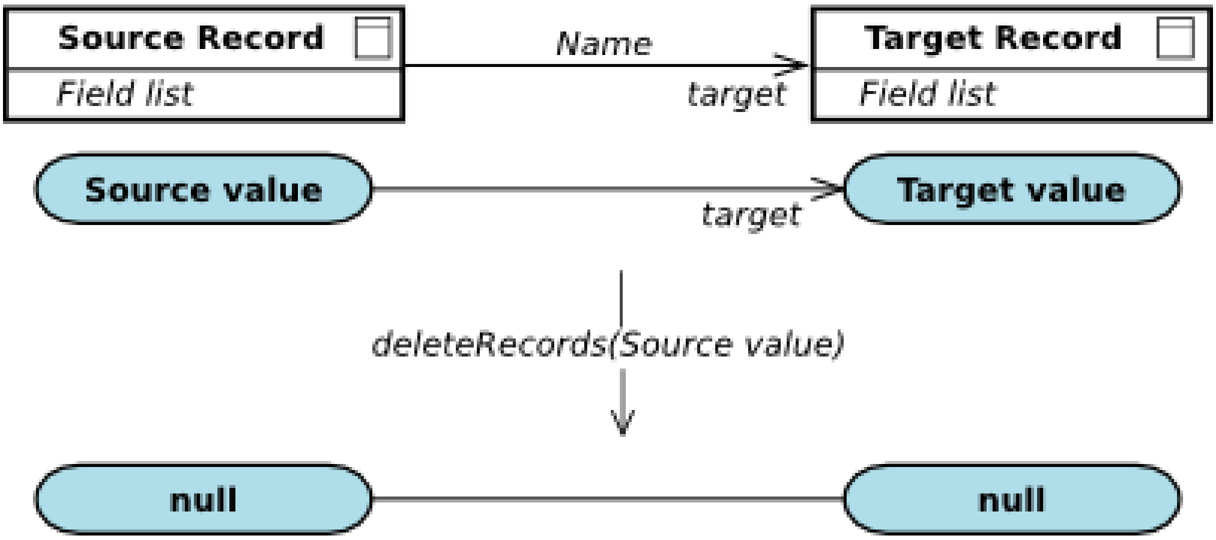


Figure 5.6 Deleting a Source Record instance

– if the target instance is deleted, the target instance takes the value `null`.

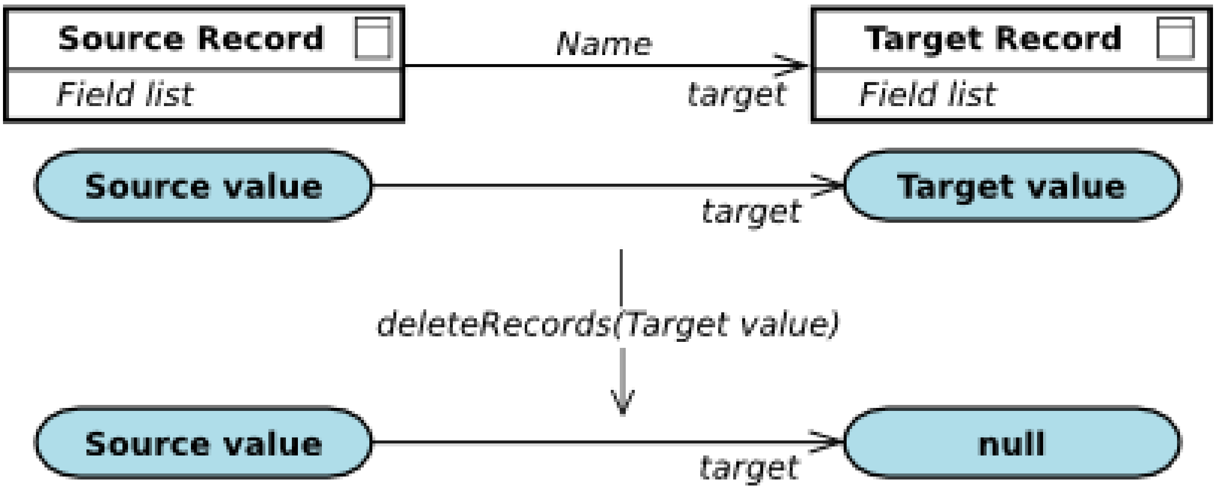


Figure 5.7 Deleting Target Record instance

If you want to delete the source instance as well, set the relationship end pointing to the source record as composition.

- On a relationship with **set or list multiplicity**, the deleted record instance of the set or list is removed from the relationship (the list or set record Instance with the null value is removed).

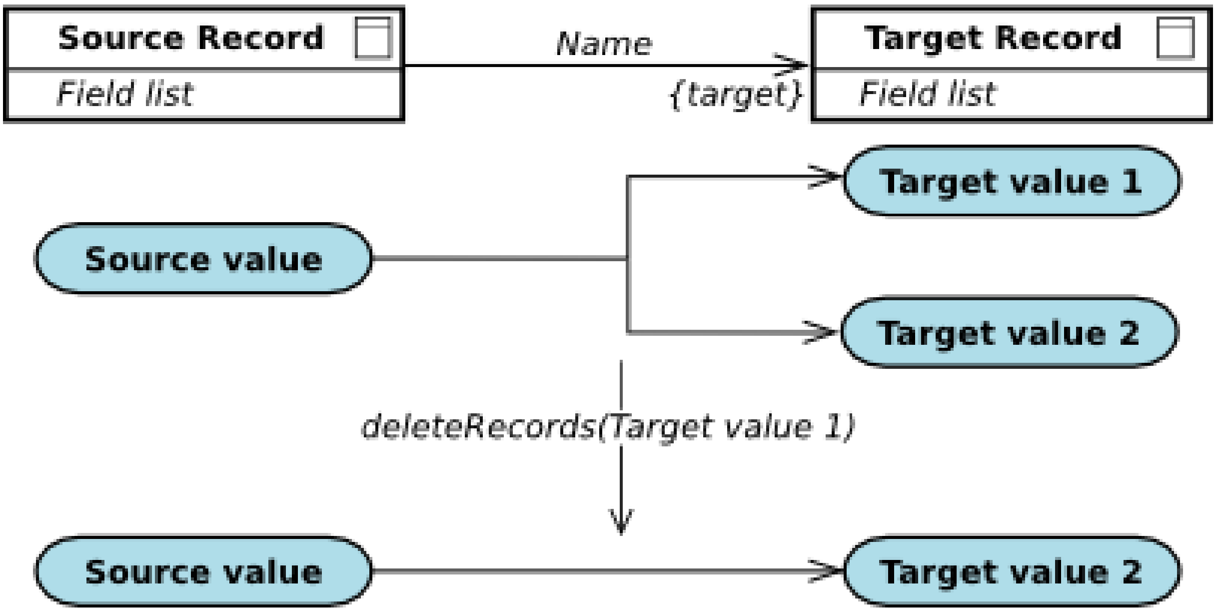


Figure 5.8 Deleting a target record instance in a set relationship

5.8 Constraint

A *constraint* defines a criterion which a value of a record field or property should meet.

Each constraint defines its *constraint type* and the Record or Property it applies to. It is the constraint type that defines the semantics of the validation—for the constraint to be met, the value of the Record or property must meet the condition defined in the constraint type. Constraint type can define parameters and it defines an expression with the validation logic which returns validation messages, when the validate value is not allowed. You can define custom constraint types if necessary.

For example, a *Persona.name* constraint could bind the *doesNotContainDigits* constraint type to the record field `givenName`. You could define a constraint type *isISBN* with a constraint expression that checks if a value is in the ISBN format and then use it in a constraint to bind it to the record field `Book.ISBN`.

When a record or its property is validated, the validation returns a list of constraint violations with messages from the violated constraints.

A *constraint* defines the following properties:

- **ID**: unique identifier of the constraint

  It is recommended to use IDs in the format `<RecordName>.<FieldName>.<ConstraintTypeName>`, such as, `Book.ISBN.Format`, `Book.ISBN.NotNull`, `ISIN.IsNumber`, `ISIN.HasMinLength`, etc.

- **Record (property)**: record or property to which the constraint applies

- **Tags**: expression that results in a list of tags

  When validating with tags, a constraint is invoked and checked only if its *tags* list defined by the *tag expression* contains at least one of the validation tags. The tag expression can contain tags, `and`, `or`, `not` keywords and parenthesis, for example, `MY_TAG1 or (MY_TAG2 and MY_TAG3).`

  In addition, tags can contain subtags so you can create hierarchical tags: if a tag contains a collection of subtags, the tag is considered the union of its subtags.

  Example Tag expression

  ```
  adminEditTag() and (onUpdateTag() or onDeletionTag()) and not archivingTag()
  ```

- **Constraint type**: constraint type that defines the constraint expression, type, parameters

While a constraint defines which record or property should be validated and whether it should be validated (using tags), it must define also the constraint type with the validation logic that is to be applied, such as, whether it value is not null or is in a format.

Constraint types have the following properties:

- **Name**: name that refers to what is being validated, for example, IsEmail, IsNumber, HasMinLength, etc.

- **Applied to**: data type to which the constraint type can apply

- **Type parameters**: type parameters to operate over a parameter that can be of different data types in different calls

  The concept is based on generics as used in Java. You can also make a generic data type extend another data type with the extends keyword. The syntax is then `<type_param_1> extends <type1>`, `<type_param_2> extends <type2>`.

- **Parameters**: input parameters

  The following parameters are provided by default and cannot be deleted:

  - value: input object value based on the Applied To property
  - `context`: additional data that can be passed as parameters from the *validate* call
  - constraintId: ID of the constraint definition that calls the constraint

- **Type**: return type of the constraint expression:
  - **simple**: String with the error message
  - **complex**: list of ConstraintViolation objects or their subtype

    Complex types allow cascading validation when related records and records fields are validated as part of the record validation. For an example, see the `RecordValidity` constraint. Example usage is available in `Validating a Related Record`.
- **Expression**: constraint check expression

  If validation is successful, the expression must return null; if it fails, it must return
- a String when Type is set to simple
- a List of ConstraintViolation objects when Type is complex.

Chapter 6

Organization Model

An *organization model* serves to acquire a group of persons (users) that meet some requirements.

The model defines a hierarchy of organization elements, which group persons, the users of the application. The model can contain the following:

- A Role represents a group of persons with common expertise.
- A Unit is an umbrella element for one or multiple roles.
- Decompositions establish relationships between roles and units.

On runtime, a runtime version of the role can be assigned to a person: the person then belongs to the role and any ancestor role or organization unit. A runtime role can define parameters with values. Parameters of any ancestor can be used. If an ancestor has a parameter with the same name as its descendant, the parameter on the descendant is considered the same parameters as the parameter on the ancestor.

To acquire persons in a role or organization unit, call the unit or role as `<ROLE_UNIT>(<MAP_OF_PARAMETERS>)`. You can use the functions in the `human module of the Standard Library` for additional features.

6.1 Organization Roles

An *organization role* groups persons with common behavior, rights, expertise, etc.

One role is usually assigned to multiple persons and one person can have multiple roles. It can be decomposed to other roles and be a target of a decomposition, descendant of a role or organization unit: a person with a role belongs to all ancestor roles and organization units.

Roles can define parameters, which allow you to exclude persons who are in the role or its descendant role but do not have the specified parameter with the specified value.

Figure 6.1 Iconic role notation

Figure 6.2 Decoration Role notation

6.2 Organization Unit

An *organization unit* is an umbrella element for roles: A person is part of an organization unit if they belong to a role that is a descendant of the organization unit.

Note that users are added only to roles, not organization units.

It can be decomposed to roles or other organization units and be a target of a decomposition originating from an organization unit: a person with a role belongs to all ancestor roles and organization units.

Organization units can define parameters which allow you to exclude persons who are in a descendant role of the unit but do not have the specified parameter with the specified value.

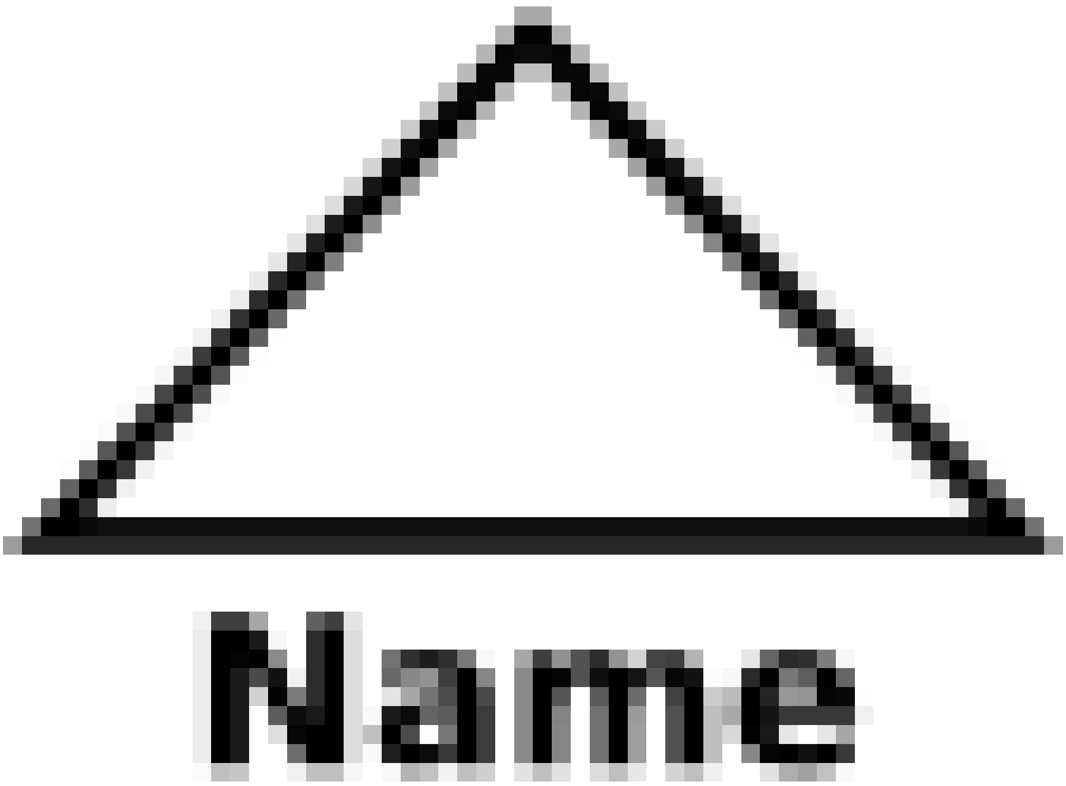


Figure 6.3 Iconic Unit notation

Figure 6.4 Decoration Unit notation

6.3 Decomposition in Organization Models

Note: GO-BPMN uses two decompositions: decompositions in goal structure and decomposition in organization models. The latter is documented below.

Organization units and roles can be decomposed with the decomposition relationship in one or several other organization elements: This enables you to create organization hierarchies and group organization elements; a person who belongs to a role belongs also to all its ancestor roles or role units.

One organization element can be the target or origin of multiple decompositions. However, decompositions cannot create cyclic relationships.

Decomposition can be used between the following organization elements:

- Unit-to-Unit decomposition: breakdown of an Organization Unit into a sub-Unit;
- Unit-to-Role decomposition: including a Role in the Unit;
- Role-to-Role decomposition: child Role representing a more specialized Role;

Note: The Role-to-Unit decomposition is not supported.

img{Decomposition.png, Decomposition notation, 90px}

6.4 Resolving Roles and Units to Persons

When you request persons with a role, it is resolved as follows:

- Without a parameter value or with a parameter value *null* or `"*"`, all persons with the role or its descendant roles are returned (role parameters are ignored).
- with a parameter value, it returns all persons with the role or its descendants which have the parameter with the specified parameter value or do not have the parameter (if the parameter has a different value, the person is excluded).

When you request persons of an organization unit:

- without a parameter value or with the parameter value *null* or `"*"`, it returns all persons with a descendants of the organization unit (parameters are ignored)
- with a parameter value, it returns all persons with a descendants of the organization unit which have the parameter with the specified value or do not have the parameter (if the parameter has a different value, the person is excluded).

Hence, parameters of the role units, organization units and roles provide a filtering mechanism over persons that belong to a role unit.

Note that if you define a parameter for a unit or role, it is recommended to add it to its child roles or units as well. Otherwise, the parameters will not be available on the children.

Example: Consider the following organization model:

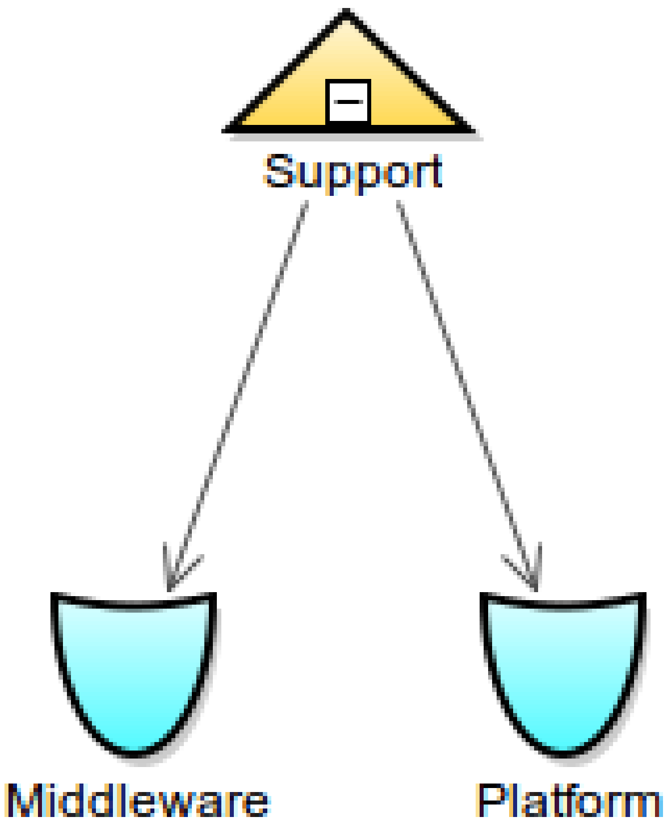


Figure 6.5 Unit decomposed in two Roles

- If a task is assigned to the Organization Unit Support (for example, `performers -> {Support([->])}`), it is assigned to all persons that have the *Middleware* or *Platform* Runtime Roles regardless of their parameter values.

- If a task is assigned to the Organization Unit Support with a parameter (for example, `performers -> {Support(["product"->"Wildfly"])}`), it is assigned to all persons that have the *Middleware* or *Platform* Runtime Roles with no parameter or with the parameter `product` set to `Wildfly`.

Example: The role `TechnicalExpert` defines the parameter `expertise`.

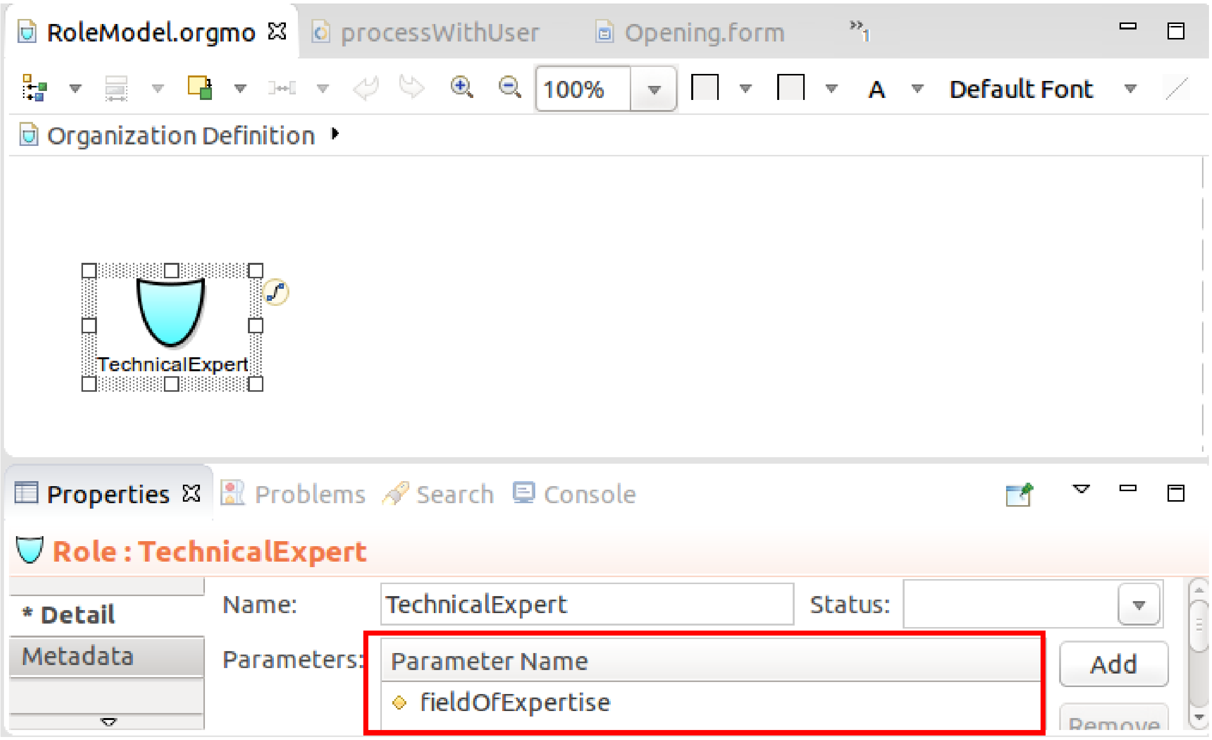


Figure 6.6 Parametric Role definition

The person *Eva* is a technical expert without a *field of expertise*: she is considered an expert in all fields and has the runtime role `TechnicalExpert` with no parameter.

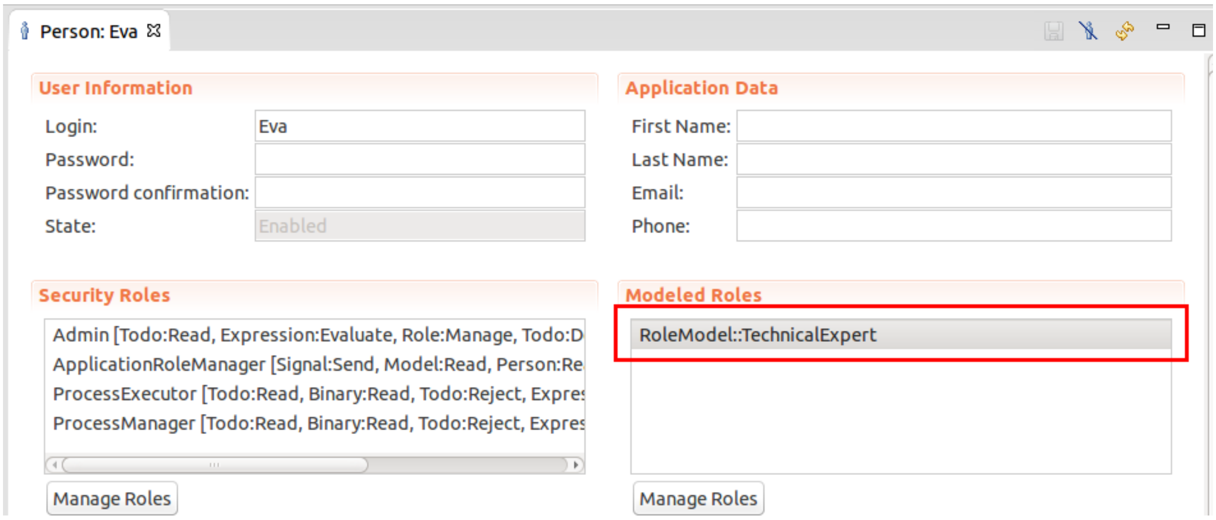


Figure 6.7 Person view of a person with the runtimee role TechnicalExpert with no parametric value

John and James are technical experts specialized in hydraulics and electrics: They have the runtime roles `TechnicalExpert` with the `expertise` parameter set to `hydraulics` and `electrics`.

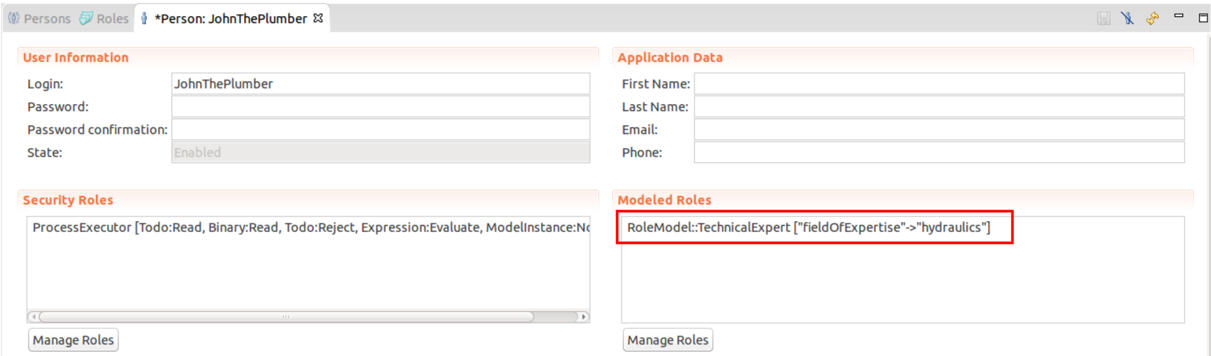


Figure 6.8 Person view of a person with the runtime role TechnicalExpert with the 'hydralics' expertise parameter

- If a task is assigned to *TechnicalExpert([->])*, the task is assigned to
  - all three persons regardless of the parameter values (any of 'TechnicalExpert' can perform the task);
- If a task is assigned to a `TechnicalExpert("expertise"->"hydraulics"`, the task is assigned to:
  - Eva, the technical expert with no parameter value,
  - John, the technical expert with the `hydraulics` parameter value James is left out.

6.5 Organization Element Import

For presentation purposes, you can add the views of the Roles and Unit from other organization definitions to the diagram in your definition as Role and Unit Imports. Note that such imported Role or Unit views cannot be decomposed, however, they can be a target of a Decomposition.

Note: Roles and Unit from other Modules become available for Diagram import only after their Module is imported.

Chapter 7

Diagrams

Diagrams provide space for a graphical representation of elements of a particular type in a Module: Visual representation (an element view) of one modeling element can appear several times in one or several Diagrams while still referencing the same single element. Note that a modeling element can be shown in one Diagram only once.

To add additional information for the reader of a Diagram, you can use diagram elements: these are the only elements that actually exist only within the Diagram.

A diagram can depict only elements from the same type of definition:

- Goal Diagrams depict Goals, Plans, and their Decompositions;
- Plan Diagrams depict modeling elements of a Plan (events, activities, flow objects, etc.);
- BPMN Diagrams depict modeling elements of a BPMN-based Process (events, activities, flow object, etc.);
- Data Type Diagrams depict Data Types and their subtype relations;
- Organization Diagrams depict views of Organization Units, Roles, and their Decompositions.

7.1 Goal Diagram

A Goal Diagram is a Diagram depicting an arbitrary number of modeling element of a goal model. It may contain Goals views, Plans views, and vies of their Decompositions, plus allowed diagram elements (Text Annotations, Associations).

Owned by Goal-based Process it depicts only views of Goals and Plans of the respective Process. A Goal-based Process may contain an arbitrary number of Goal Diagrams.

7.2 Plan Diagram

A Plan Diagram is a Diagram depicting element views of a plan body.

It may show views of one or several modeling elements of a plan body, and objects owned by the Diagram (Annotations and Associations).

Plan Diagrams are owned by Plans. One Plan may contain an arbitrary number of Plan Diagrams. Plan Diagrams can show view of any modeling element contained in the respective Plan Body, however, a modeling element can be shown in one Plan Diagram only once.

7.3 Process Diagram

A Process Diagram is a Diagram depicting element views of a body of a BPMN-based Process.

It may show views of one or several modeling elements of a body of a BPMN-based Process, and objects owned by the Diagram.

7.4 Organization Diagram

An Organization Diagram is a visual representation of a part or of an entire Organization Model.

Organization diagrams are owned by organization models. One model may contain one or several organization diagrams. Organization diagrams can show any organization element contained in an organization model, however, in one diagram, every element can be shown only once.

An organization diagram may contain diagram elements (Text Annotations, Associations).

7.5 Data Type Diagram

A *Data Type Diagram* is a diagram depicting element views of Record types.

Data Type Diagrams are owned by Modules and may contain views representing `Record types` and related entities: imported Record types, inheritance relationships of Records, and general diagram elements (Text Annotations, Associations).

A Module may own an arbitrary number of Data Type Diagrams. View of one data type element (record, record import, inheritance) may be shown in an arbitrary number of Data Diagrams.

7.6 Diagram Elements

Diagrams can *contain* diagram elements, which serve for documentation purposes, and have no execution semantics (they do not influence execution in any way). As such they are not considered elements of the definition but belong to the diagram only.

7.6.1 Diagram Frames

Diagram frames are diagram elements, which allow you to display the content of another diagram as read-only. The content of the diagram frame reflects the current state of the referenced diagram.

Diagram frame can display only a diagram of the same type as the diagram; for example, you cannot insert a goal diagram frame to an organization diagram. A diagram frame cannot reference itself.

Tip: Use directed associations and annotations to establish logical links between an element shown in a diagram frame or the entire diagram frame and other elements in the diagram.

7.6.2 Hyperlinks

Hyperlinks are diagram elements that provide direct links to a location, resource, or element: When you click a hyperlink, the linked entity is displayed.

There are four types of hyperlinks:

- Diagram hyperlink: link to another diagram;
- URL hyperlink: link to a URL;
- Element hyperlink: link to an element of the project;
- Resource hyperlink: link to a module resource of the project.

7.6.3 Text Annotations

A *Text Annotation* is a diagram element containing free-text information.

It does not influence execution: it is en element with no execution semantics. A Text Annotation provides additional information and has only an informative character. It belongs to the particular diagram.

It may be connected to one of several diagram elements using Associations. If left unconnected, a Text Annotation is intended to provide information about the entire Diagram.

Figure 7.1 Text Annotation notation

7.6.4 Associations

An association is an element without a semantic value used for informative linking of element views and diagram elements.

It may be assigned a particular direction to indicate a relationship orientation (Directed Association).

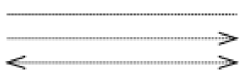


Figure 7.2 Association notation

Association attributes:

- **Direction** defines the arrow direction.