HOPEX Simulation BPMN Edition

User Guide

HOPEX V2

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INTRODUCTION

Simulation is a tool that aids decision-making, enabling analysis of company business process operation and performance. By identifying relevant indicators, it enables indication of organization improvements.

Complementing **HOPEX Business Process Analysis**, **HOPEX Simulation BPMN Edition** software is edited by **MEGA International** to assist organizers and decision-makers in:

- Analyzing enterprise process performances.
- Improving existing processes or processes being redesigned.

HOPEX Simulation BPMN Edition is used to:

- Description of the detailed organization of operations during execution of organizational processes, and the participation of each of the enterprise org-units in these processes.
- Association of quantitative information with operations executed and resources used.
- Creation of several optimization scenarios to build a comparative performance analysis of the different configurations.
- Production of dashboards comparing indicators of performances obtained with objectives expected

☛ *Simulation of processes described using BPMN formalism is only available with **HOPEX Simulation BPMN Edition** and **Windows Front-End** module.*

Why Simulate a Process?

Simulation offers:

- An alternative viewpoint on the system, seen as a set of resources that must be shared by the different elements.
- Additional credibility supplementing traditional measures.
- Obtaining performance measurements on configurations impossible in reality, or on indicators that cannot be measured.

There are therefore multiple reasons for simulating a process described with **HOPEX Business Process Analysis**:

- Improving enterprise operation.
- Considering organizational changes from valuated data.
- Defining IT requirements.

Improving enterprise operation

The fact of describing organization operation with a view to its simulation can reveal:

- Possible reasons for performance deterioration.
- Simple improvement solutions that have not been envisaged.

Considering organizational changes from valuated data.

Solutions envisaged to improve enterprise process performance can, by increasing system productivity, highlight weaknesses that extend production deadlines. Simulation enables anticipation of this type of problem: proposed scenarios are tested and valuated results can be compared.

Defining IT requirements

You can add to the process descriptions by describing the information technology means required:

- Equipment resources.
- applications
- Application services.

An estimate of quantities required can be obtained using simulation.

Using HOPEX Simulation BPMN Edition

The powerful graphics tools of **HOPEX Business Process Analysis** allow you to easily provide a detailed description of your organization. This organization can then be simulated and performance criteria can be compared to identify the configuration that best meets enterprise objectives.

You will use the following concepts:

- process,
- operations,
- resources,
- gateways,
- scenarios,
- indicators and objectives.

This User Guide is designed to help you quickly discover the power of **HOPEX Simulation BPMN Edition**.

CONNECTING TO HOPEX SIMULATION BPMN EDITION

To connect to **HOPEX Simulation BPMN Edition**, see in **HOPEX Common Features** guide, chapter "The HOPEX Windows Front-End Desktop".

Conventions Used in the Guide

☛ *Remark on the preceding points.*

📖 *Definition of terms used.*

☺ *A tip that may simplify things.*

Compatibility with previous versions.

Things you must not do.

Very important remark to avoid errors during an operation.

Commands are presented as seen here: **File > Open**.

Names of products and technical modules are presented in bold as seen here: **HOPEX**.

About This Guide

The **HOPEX Business Process Analysis** guide presented how to create your process diagram with **HOPEX**.

The **HOPEX Simulation BPMN Edition** guide presents how to make best use of modeling to simulate operation of your organization and improve its performance.

Chapter "Simulating a BPMN process", page 5 covers the following points:

- Simulation overview.
- Introduction to the scenario concept proposed by **HOPEX Simulation BPMN Edition** to identify a process architecture configuration.
- Introduction of basic concepts to simply obtain initial performance indicators.
- Description of advanced mechanisms enabling more detailed description of behavior of the modeled system, obtaining more precise results.

Supplements to this guide

This guide is supplemented by:

- The **HOPEX Business Process Analysis** guide, which will help you create your first organizational diagrams with **HOPEX** ..
- The **HOPEX Common Features** guide presents functions common to all **HOPEX** Suite products.

SIMULATING A BPMN PROCESS

The simulation engine is available in Beginner and Standard modes. It is in Beginner mode by default.

☛ *To access advanced functions, open **Tools Options** of the **HOPEX** navigator, click "Simulation" and select the "Standard Level" filter.*

The points covered in this chapter are:

- ✓ "Simulation Objects", page 6
- ✓ "Simulation Steps", page 7
- ✓ "Scenarios", page 10
- ✓ "Simulation: Beginner mode", page 14
- ✓ "Simulation: Standard mode", page 19
- ✓ "Indicators", page 31
- ✓ "Schedules", page 36

SIMULATION OBJECTS

Before being able to simulate a process, it must be represented graphically. Simulation is based on the diagram that describes the business process. The goal is to obtain a stream representing the various business process steps.

Simulating a business process consists of moving tokens through the various steps in the process. A token represents a request for work that must be executed by the process. It is introduced in the model from a process start event and stops at an end event.

For example: in a purchasing processing business process, the tokens that circulate are purchasing requests. A purchasing request is triggered at sending the request and ends at delivery of the order. In the meantime, it traverses the various steps (request recording, request processing, etc.).

In this way, the circulating tokens enable representation of the business process material or IS flows jetons circulant permettent ainsi de représenter le flux de matière ou d'information d'un processus.

From their respective BPMN diagrams, you can simulate the following concepts:

- Organizational process
- System process

SIMULATION STEPS

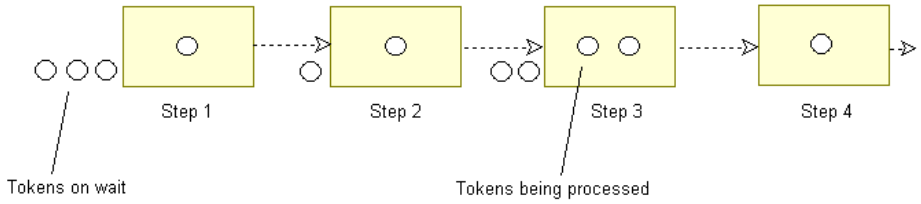
The BPMN model of a process represents an organized series of steps. At simulation, tokens traverse a sequence flow, respecting specified time constraints. They therefore simulate the time required for execution of a step before passing to the next step.

For an organizational process, the steps correspond to operations, events and gateways encountered during progress.

When a process is itself described by a diagram, or if an elementary tasks calls a process, the simulation editor hierarchically integrates the diagram associated with the process called. In this way the tokens move into the most detailed description levels of all the steps encountered.

It is also possible to consider a process described by a diagram as a simple processing step.

Participants and resources are objects that have an impact on process performance. Execution of a step can be delayed by unavailability of a required resource.



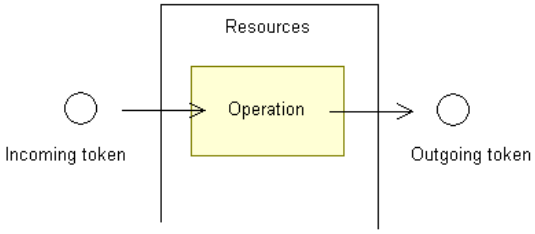
Process Steps Sequence Flow

Tasks

In a BPMN process, tasks are associated with processing steps requiring the intervention of an enterprise participant (for example an organization org-unit or an IT service).

```
A task can be industrial (machining a component),
logistical (receiving a delivery), or it can involve
information processing (entering an order).
```

At simulation, the participants execute the process tasks. These tasks may also require use of application services or other resources.



Execution of a task is generally triggered by the fact that a token takes the **sequence flow** that connects the task to other objects describing process organization.

However, a task can also be triggered by merging several tokens from either a **gateway**, or from several **sequence flows**.

Events

BPMN events enable representation of:

- The simulated process start point: this is the point from which tokens are generated. Nature of these events must be **Start** or **Catching**,
- The point marking the end of the simulated process: the tokens then exit the system. Nature of these events must be **End** or **Throwing**,
- Occurrence of a particular fact that modifies behavior of the current process or another process. Events used in this case are of intermediate nature **Catching** or **Throwing**.

Managing task inputs

Several sequence flows can lead to the same task. In this case, we must define token processing policy at task input.

By default, each token arriving in a task is taken into account as soon as the resources required for its processing are available. Input policy is then exclusive type, or **Junction**.

If input policy is parallel type, or **Synchronization**, a token must arrive via each of the different sequence flows to be grouped into a single token which will execute the task.

```
For example, in an order delivery process, the various items
that make up the order are processed separately. These items
are then assembled to form a single order.
```

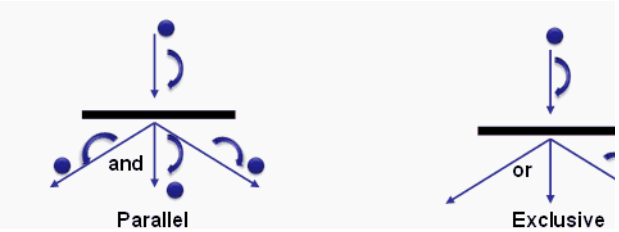
Managing task outputs

A task can produce different processings executed in parallel. There are basically two output policies:

- A policy of exclusive type, or **Condition**: the incoming token is directed onto one and only one sequence flow of the different possible outputs.

  ☛ *By default, the output policy of a task is **Parallel** type, except if an output link is explicitly specified as **Condition** type.*

- A policy of **Parallel** type, the token is duplicated and directed onto each of the output sequence flows.



☛ *Although the BPMN standard covers other input and output management policies, only the Parallel and Exclusive policies are taken into account by the simulator.*

SCENARIOS

Scenarios enable definition of what we wish to simulate. They memorize definition of the object to be taken into account, as well as the simulation parameters specific to each scenario.

Creating several scenarios for a process enables comparisons between them and identification of the one that is best adapted.

For example, by changing the number of org-units from one scenario to another, you can analyze the impact of additional personnel on production.

Creating a Scenario

To create a scenario:

1. Right-click the object to be simulated and select **Simulate New scenario**.
2. Indicate the name of the scenario and click **OK**.
   The scenario update dialog box appears. It enables definition of objects to be taken into account in the scenario when unknowns exist.

   ☛ *If several start events exist (nature **Start** or **Catching**) or several diagrams, you must specify which you wish to take into account in the scenario.*
3. Click **Next**.
4. When scenario objects have been defined, click **Finish**.
   The scenario name appears in the editor navigator.

   ☛ *You can create as many scenarios as you wish. However, a scenario is valid for one process only.*

Open scenario

To open a scenario:

1. Right-click the object to be simulated and select **Simulate Existing scenarios**.
   The names of the various scenarios assigned to the current object appear.
2. Select the one you wish to open and click **OK**.

The simulation editor appears. A navigator displays the org-units and the steps of the process. When you select one of these objects, its characteristics appear in the right pane of the editor.

Not all of the diagram objects appear in the editor.

In the toolbar, the following buttons allow you to display:

all events

gateways

Scenario Parameters

Main parameters that can be defined in a scenario are:

- Simulation duration,
- Conditions of arrival of requests for work sent to the simulated process
- Characteristics of the resources used.

Simulation duration

You can indicate the time the simulation will last.

In standard mode, you can define a start date and a warmup period. This latter parameter corresponds to the period required by the system to reach a point from which performance is optimum, no result being collected until this period has elapsed.

You can also restrict result collection to a given period. For example, based on a simulation over the entire year, you can display only those results for a particular month.

Input flow

The **Input Flow** tab enables definition of the characteristics of tokens generated by the simulator to represent the work requests.

☛ *When a process can be triggered by several events, you must specify which of these should be taken into account in the scenario.*

By default, tokens are introduced continuously and at regular intervals. You can specify the average time interval between two arrivals.

In standard mode, you can create a **Schedule** to define the period of activity of the generator. For more details, see "Generator Schedules", page 36.

Through the use of objects of **Input Schedule** type, you can also define arrival of a variable number of tokens on fixed days at fixed times. In this case, you must indicate the number of tokens introduced at each due date by using a statistical law and its parameters.

Resource availability

Human resources

To access the org-units available in a scenario:

1. In the simulation editor, select the scenario.

2. In the right pane, select the **Resources** tab.
3. For each org-unit, indicate the quantity available in the **Quantity** column.

You can arrange that org-units are automatically created according to requirements. This lets you know the maximum number of org-units required in parallel for execution of the process.

- To do this, select **Automatic Creation**.

In this case, the quantity that you may have defined for the org-unit is not taken into account. On completion of simulation, the **Quantity** box is then automatically entered as a function of the units created.

Other resource

To access a resource from a scenario:

1. Select the scenario.
2. In the right pane, select the **Resources** tab.

For each resource you can indicate:

- If it is a consumable or not (for resources other than human resources).
- Its available quantity.
- Automatic creation of this resource.

> ☛ *If you select this check box, the quantity is then calculated automatically at the time of simulation as a function of the units created.*

Viewing a Scenario

Viewing the scenario lets you see the path followed by a token as a function of the step sequence. Different paths can be possible, for example when two tasks are separated by a gateway. By default, the editor displays the path for which you indicated the highest likelihood.

To view the path of a scenario:

- Click button

A dialog box opens. It allows you to follow the scenario step-by step.

Excluding an Object from the Scenario

You can exclude from the scenario objects that you do not wish to take into account in the simulation. In this way you can mask:

- The process description. This can be the process called by a task or the diagram describing the process. The object is then considered as a simple step.
- An event. In this case, what follows the event is ignored and the event is considered as being **Terminate** type.

To exclude an object description:

- In the simulation editor, right-click the object in question and select **Exclude description.**
  An exclusion sign appears on the object.

To exclude a sequence flow and what follows:

- Right-click the sequence flow and select **Mark as excluded from stream**.

  ☛ *You can display sequence flows using the command **Display** > **Show Sequence Flows**.*

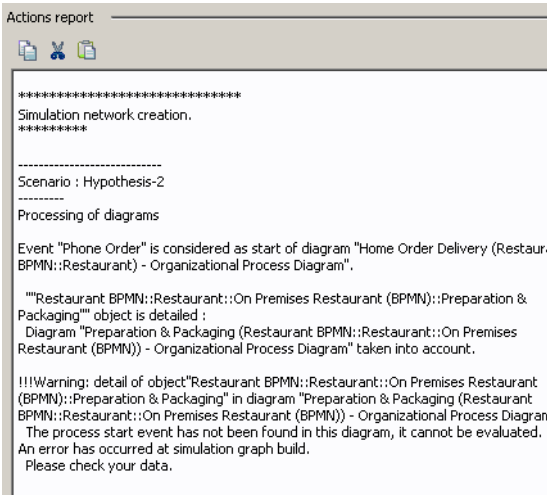
Updating a Scenario

Clicking the editor Update Scenario button takes into account scenario object modifications.

It could be that the editor displays an error message on certain modified objects. This indicates that the object is not taken into account in the scenario.

If this error message persists after updating the scenario, this means that an error has been detected in the object description. In this case, display the scenario report to localize the source of the error.

```
There is no start event in the organizational process
diagram. If you do not specify the event to be taken into
account to activate a described process, the following
error message appears in the scenario report:
```



SIMULATION: BEGINNER MODE

By default, the simulation editor is in **Beginner** mode.

When the token arrives at a task, the simulator checks that resources expected for task execution are available. If this is not the case, the token is placed in a queue until the resource is free.

Token Processing by a Task

When you run the simulation, tasks behave according to the parameters you have defined for each. By default, these parameters are valid for all scenarios.

To define the operating mode for a task:

- In the editor, select the task in question.
  Its characteristics appear in the right pane of the editor.

  ☛ *The simulator does not take into account behaviors of tasks as defined specifically by the BPMN standard. For more details on these behaviors, see "Specifying Process Behavior", page 79. Behaviors **Loop** and **Multiple** must be described explicitly in the model.*

You can indicate:

- The task execution time.
- Task default cost.

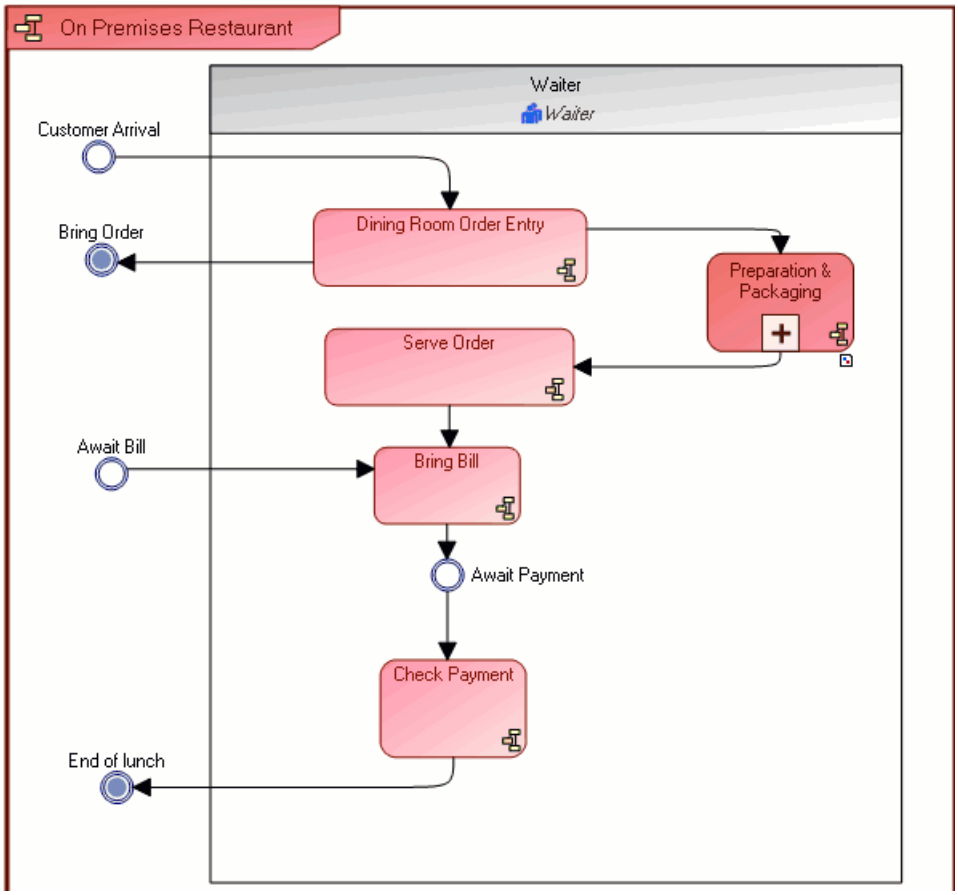
  ☛ *For costs, the editor takes no particular currency into account .*

- The participants and resources participating in its execution:
  - for a consumable resource, you can specify the quantity consumed by the task. See "Other resources", page 16.
  - For an IT service, you can indicate the number of points used. See "Software resources", page 16.

    ☺ *Characteristics of consumer resources and IT services only appear if an object of this type is connected to the task.*

Token Routing

Take for example the "On Premises Restaurant" organizational process.



Simulation start event

When a process has several entry points, the simulation editor asks you to choose between the different possible start events.

In the above example, the editor asks you to choose between the entry points "Customer Arrival" and "Await Bill".

Creating an event between two sequence flows

To indicate that there is a delay between two tasks, for example "Await Payment" you can use a timer event type between two sequence flows.

You can indicate an execution time for the event. For more details, see "Event Advanced Characteristics", page 26.

Sequence flows

A task could contain several input or output flows.

In the **Routing** tab, available from the selected task, you can modify the gateway type for input and output objects.

With BPMN, sequence flows can also carry information on their type: "Conditioned" or "Default". In this case, routing of the task that generates these flows is **Condition**.

Resource characteristics

Execution of certain tasks can require use of human, software or hardware resources, depending on the described process type.

The characteristics you define on resources are valid for all scenarios.

You can then customize their quantity on each particular scenario.

Human resources

Human resources correspond to org-units. You can define the cost of each.

To define the hourly rate of an org-unit:

1. Select the org-unit concerned in the scenario editor.
2. In the **Cost & Availability** tab, enter the hourly rate.

Software resources

A task can use a service.

To define the cost of use of a service:

1. In the scenario editor navigator, select the service.
2. In the right pane, enter a value in the **Transaction Point Cost** box.

Other resources

A resource can be consumable or not. A consumable resource, for example a postage stamp, can be used once only.

A non-consumable resource, for example a printer, can be used several times.

The cost of resources varies as a function of their type.

- If a resource is consumable, you can specify its unit cost.
- If it is non-consumable, you can specify the hourly rate and fixed cost of its use.

See also "Resource availability", page 11 and "Systems Used By a Task", page 25.

Simulation Results

When the parameters of the various process objects have been entered, you can then run simulation.

To run simulation:

- Click the **Simulate** button in the simulation editor.

The simulation results are displayed. These results are saved in the scenario.

Scenario report

In Results mode you can view the scenario report in the **Scenario report** tab. It includes the name of the diagram concerned, the start event and any problems encountered.

> *The scenario report is also accessible by selecting **Tools Open Report**.*

Another tab allows you to view the workload of scenario org-units in graphical form.

Parameters mode and results mode

You can at any time switch from results to parameters via the **View** menu of the editor, or by using the following buttons:

Display Configurations

Display Results

Results for the entire process

To view results relating to the process:

- In the simulation editor navigator, select the simulated process.

In its right pane, the editor displays the various processing times and costs.

The **Time** tab displays:

- The average processing time is the average time spent by each token in the process, queuing included.
- Average effective work time is the average task execution time for each token.
- The average queuing time corresponds to time spent in queues.
- The average transfer time is the average time tokens output from this process have spent in the system.
- The number of tokens at input, at output and in the course of processing.

The **Costs** tab displays:

- Total cost of the object over the entire simulation.
- Total cost of the different resources used by the process in scenario configuration.
- The total transfer cost is the average cost of tokens output from the system by this process.
- The total default cost is the cost of the process excluding resource costs.
- The number of tokens at input, at output and in the course of processing.

Results for org-units

On an org-unit, the **Results** tab displays:

- The number of tokens processed by the org-unit.
- Total cost of the org-unit over the entire simulation (this cost covers only the time during which the org-unit was occupied).
- Its available quantity. See "Resource availability", page 11.
- Its availability and workload.
- The percentage of its time spent processing tokens.
- Result details of tasks that it executes.

Graphical representations can be seen in other subtabs.

Results for software resources

For each service are indicated:

- The number of participations in token processing.
- The total cost.
- The total quantity of points required.
- Result details of tasks that it executes.

Results for other resources

For each resource are indicated:

- The number of participations in token processing.
- The total cost.
- The quantity consumed over the entire process in the case of a consumable resource.
- The work load and the activity rate in the case of a usable resource.
- Result details of tasks that it executes.

SIMULATION: STANDARD MODE

Whether you are in Beginner or Standard mode, parameters to be specified for simulation are:

- Execution time for the various steps
- Execution probabilities on possible conditions through which the tokens pass.
- Token arrival frequency.

Changing to standard mode allows you to further detail token processing, in particular by defining the way in which tokens are managed at task input and output.

To display standard mode:

1. From the **HOPEX** desktop menu, select **Tools** > **Options**.
2. In the user options window, click **Simulation** and select "Standard Level".

Scenario Advanced Parameters

Influence of random numbers

Random numbers allow a simulation model to take account of the variability that exists in a real situation. So, when you use a statistic (other than the fixed law) or when percentages are involved (at output of a condition for example), the random number generator emulates the chance concept.

By default, when you restart simulation on the same scenario, the random number generator produces the same results. Therefore two consecutive simulations of the same model without parameter changes will produce the same results. Changing the chain of generated random numbers improves reliability of results of a model.

To take account of random numbers in the simulation:

- Click button in the simulation editor.

  ☛ *Take care, this button is also available in beginner mode, but the value of the random generator seed is only visible in standard mode. To access the value of this number: click the scenario and select the **Definition** tab to display the **Random Generator Seed** box.*

Schedule

In standard mode, you can create schedules to specify that tokens will be generated continuously over a given period.

See "Generator Schedules", page 36.

Token data

You can declare the data for generated tokens. This data can take different values.

Example:

In a scenario, you want to specify that there are two delivery types, normal delivery and urgent delivery. To do this:

1. Click the scenario and select the **Token Data** tab.
2. Right-click the **Token Data** folder and select **New**.
3. Call it "Delivery type".

This data is connected to the scenario input flow.

Token data values

You can then customize data values at the level of each scenario.

To define data values:

- In the **Selected Data Value** box, create values using the **New** button.

For our example, create the two values "Normal" and "Urgent".

Internal values

You can allocate non-translatable values to a token data and thus avoid the simulation being affected by language changes.

To create the internal value of a data value:

1. Open the properties dialog box of the data.
2. Select the **Characteristics** tab.
3. In the **Possible values** box, enter an internal value for each value. Each internal value must be different.

The data created will be carried by all tokens generated on simulation.

In the scenario, you can specify token data distribution.

Example: in 80% of cases the "Delivery type" is "Normal", in 20% of cases it is "Urgent".

This percentage is defined in the **Probability** field of the value.

☛ *For data declared in the scenario, if no value is specified, the first data value is assigned to the token.*

You can modify the data value at the level of tasks traversed by the token. See "Queue order", page 21.

You can also use values to identify the valid output branch from a gateway or task . See "Token condition and data", page 26.

Scenario objectives

In standard mode, you can associate objectives with scenarios. These objectives are connected to indicators calculated from standard results of the simulation. On completion of simulation, if the value of each indicator is within the expected interval, then the required objective is considered as achieved.

☛ *To show objectives and indicators, confirm that the **Architecture Process Modeling Objectives and Requirements Modeling** option is selected.*

See "Indicators", page 31.

See "Objectives and Requirements" in the **HOPEX Common Features** documentation.

Before the task: token queue

When a token arrives at a task that has reached its maximum simultaneous processing capacity, or for which a resource is not available, it is placed in a queue.

The simulation editor allows you to indicate how tokens in the queue will be managed.

Queue order

To specify the order in which tokens are processed by the task:

1. In the left pane of the editor, select the task.
2. In the right pane, select the **Input** subtab.
3. In the **Order** list box, you can specify the selection order of tokens:
   - Random
   - Earliest, the first to arrive is the first served

     `Example: in a fast food service, orders will be processed in their order of arrival, in other words from the earliest to the latest.`
     `Latest, the last to arrive is the first served`
   - Token data, we must specify on which token data type the choice will depend.

     `Example:`

     `In your scenario you have created a "Delivery type" token data that differentiates between "Normal" and "Urgent" deliveries.`

To indicate that the "Serve Order" task processes urgent orders first:

1. In the **Selection** box, select "Token Data".
2. In the **Criterion Token Data** box, specify that it is the"Delivery type" token data.
   Data values are taken according to their order. So that the "Urgent" value is handled first by the task, it must be placed first in the data.

To modify the order of values in a token data:

1. Open the properties dialog box of the token data.
2. Select the **Characteristics** tab.
3. In the **Possible Values** box, click the **Reorganize** button
4. Modify the position of values by dragging with the mouse, then click **OK**.

See also "Token data", page 19.

Queue capacity

To specify a maximum capacity for the queue:

- Select the **Limit Queue Capacity** check box and indicate the maximum number of tokens to be held in the queue.

When this quantity has been reached, tokens are discarded or in other words lost. The number of discarded tokens is displayed in simulation results.

Queuing time

To limit the time tokens wait in the queue:

- Select the **Limit Queuing Time** and specify the maximum queuing time.

When this time has been reached, tokens are discarded. The number of discarded tokens is displayed in simulation results.

During: advanced processing of tasks

To display the following parameters:

1. Open the simulation editor in Standard mode.
2. Select a task, then its **Performing** tab.

Performing time

In standard mode, you can refine the execution time for a task by specifying a **DistributionLaw** and as a function of this law, a **Standard Deviation**.

You can also define a **Startup time**. This corresponds to the time taken to start a step, independently of token processing time. This time is counted when an org-unit starts processing a new task or restarts an interrupted task.

Priority level

When tasks requiring the same org-unit are to be executed simultaneously, you can specify priority.

If no priority is specified on tasks, the priority of the object containing the task(for example an organizational process) takes priority.

Processing capacity

Outside the resources or org-units, you can define a **Processing Maximum Capacity**, that is the number of tokens that can be simultaneously processed in the task.

Task Interrupt

In standard mode, you can authorize interrupt of the task due to schedule reasons, for example at the end of an org-unit working day.

This authorizes start of the task despite time being insufficient for its completion.

After: Output Object Processing

You can apply an automatic discard percentage at task output, in other words a percentage of tokens rejected.

To apply automatic discard:

1. Select the task in question and then the **Exiting** tab.
2. Select the **Throughput analysis** check box.

3. Indicate the **Discard rate**.

Adding a data collector

A data collector records the parameters and results of a simulation object.

You can add a data collector on a task. The collector created is attached to the scenario in progress. You can then modify task parameters only for the scenario. Data relating to this task is then calculated and displayed in the simulation. When you remove a data collector, the task reverts to its initial values.

To add a data collector to a task:

- Select the task in the simulation editor and click the **Add data collector** button

See also "Data collector", page 30.

Task Participants

Participants used in BPMN notation enable specification of the list of org-units involved in execution of a task.

You can specify the **Involvement** of the participant in execution of the task, in other words the percentage of time during which org-units participate in execution of the task. This participation is 100% by default. However, an org-unit can be connected to a task without participating in its execution, for example the cook is only involved 5% of the time required for preparation of a dish. In this case, you define an involvement of 5%.

When a token must traverse different steps executed by the same org-unit, you can remember this org-unit so that the same org-unit occurrence, in other words the same person, will process this token throughout its path.

To memorize a participant:

1. Select the first token processing task.
2. Select the **Participants** tab.
3. Select the org-unit in question.
4. In the **Follow-up Policy** column:
   - If you select **Remember**, the token will be processed by the same person if a task requires this org-unit again over its path.
   - If you select **Acquire**, as well as being memorized, the person will not be available for another token until processing of the acquirer token has been completed, or until it is discarded.
5. To make the org-unit available again when the token has been processed, select **Forget** on the final processing task.

You can also define replacement org-units for tasks. If the **Regular Performer** is not available, it can be replaced by the **Alternative Performer** org-unit.

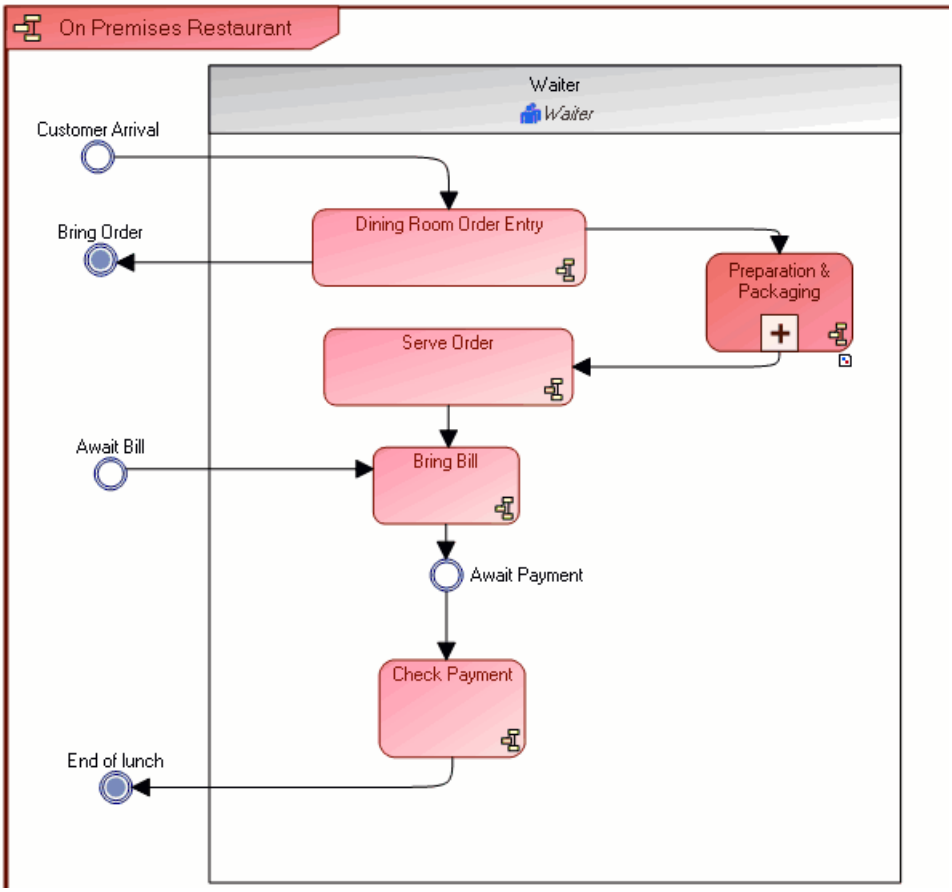
Example:

In the following example, the waiter executes several operations when processing the order.

If no follow-up rule is specified, the waiter serving the order can be different from the waiter entering the order.

If you "remember" the waiter on the first processing operation (Enter order), the same waiter will intervene until completion of processing or until the waiter is forgotten.

If you select "Acquire", as well as being remembered, it cannot process anything else until order processing has been completed or until it is forgotten.



In Standard mode, you can also define the period of activity of an org-unit. You can use a default schedules or create new schedules. For more details, see "Org-Unit Schedules", page 37.

In addition, the percentage of org-units present in a given schedule can be modified.

Systems Used By a Task

In standard simulation, when you are on a task, the **System Used** tab allows you to define the systems used for execution of a task.

Software resources

When a task uses a service, you can indicate the number of transaction points it represents. The number of points gives an indication of use of a service by tasks.

A cost can be associated with a point so as to obtain the IS resource use cost.

Other Resources

You can specify the way in which resources are used for a task.

This can be a **Consumable** resource such as a postage stamp. In this case, you can specify the number consumed by the task.

Or the resource can be **Consumable**, for example a printer. You can then indicate the time for which the resource is used by the task.

Asynchronous allocation

It could be that a task requires several resources.

By default, these resources must all be available simultaneously so that the task can be executed. If one is not available, the others do not wait for it and the token remains in the queue.

To arrange that the resources will wait:

1. Select the task that requires availability of several resources.
2. Select the **Resources** tab.
3. Select the **Allow asynchronous allocations** check box.

The first available resource then takes a token from the queue and waits for the missing resources.

Resources on wait are not available for any other operation.

You can limit the time spent waiting for other resources.

Example of resource configuration:

```
A fast food service has one phone operator, three delivery
drivers and two delivery vehicles.

We assume that a delivery driver can take orders when the
phone operator is absent: in this case we indicate that the
delivery driver is "Alternative executor" for the order
taking operation.

The delivery operation requires a delivery driver and a
delivery vehicle as resources.

When no delivery vehicle is available for the delivery
operation, the delivery driver must wait: we must therefore
"Allow asynchronous allocations" for the delivery
operation.
```

```
We can specify that after 10 minutes wait for a vehicle, the
delivery driver returns the order to be delivered to the
queue.

We can also indicate the maximum time in the queue and
specify that the order to be delivered is deleted after 15
minutes wait.
```

Advance Characteristics on Gateways

Limiting gateway queuing time

When several sequence flows arrive at a parallel type gateway input, tokens of each of the different input branches queue before being merged in a single token on the output branch. You can limit this queuing time.

When this limit time has been reached, tokens are discarded or in other words lost. The number of discarded tokens is displayed in simulation results. See "Results for gateways with parallel inputs", page 30.

To limit the time tokens wait in the queue:

1. In the simulation editor, select the synchronization.
2. In the right pane of the editor, select the **Limit synchronization time**.
3. Then enter a value in the **Synchronization limit time** box.

Token condition and data

At a gateway, the input token is directed onto a branch from among the different possible outputs.

You can use token data to define the valid output branch.

To define a token data as condition mode:

1. In the simulation editor, select the condition.
2. In the right pane **Condition mode** box, select "Token Data".
3. In the **Tested token data** field, select the token data in question.
4. Enter the data value on the valid output branch.

See also "Token data", page 19.

Event Advanced Characteristics

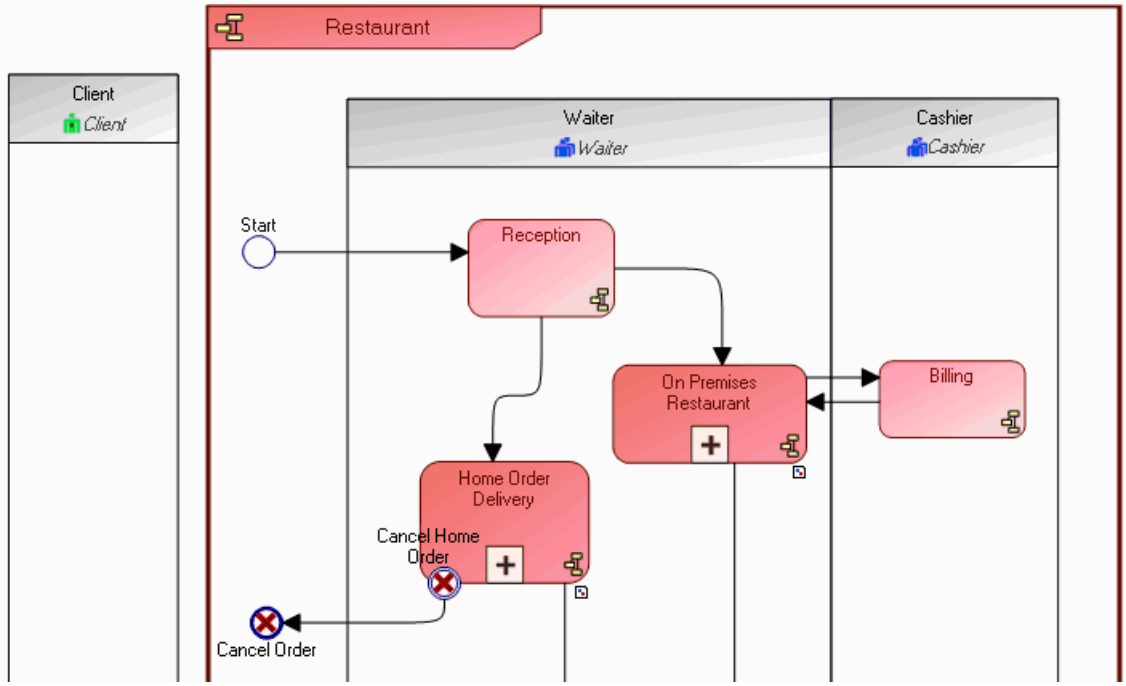
HOPEXproposes all events introduced in the BPMN standard. For more details on how to use these in a process diagram, see "", page 52.

The **HOPEX** simulator allows you to associate a duration and a cost to an event, whatever its type or nature.

In standard mode, you can also attach a data collector so as to view results specific to the event. See "Data collector", page 30.

Connecting processes by events

To be able to execute simulation on several sequenced processes, it is important to correctly connect events to sequence flows. For more details on specification of these links, see "Connecting Events to Sequence Flows", page 40.



In the "On Premises Restaurant" example, we must distinguish between tokens arriving at the "Reception" operation representing the arrival of new clients, from the "Billing" operation that represents issue of a new bill. In addition, at output we must distinguish between tokens representing the end of the meal from tokens representing issue of the order to the cashier.

☛ *Events taken into account at simulation of a process as well as errors encountered are indicated in the service report. See "Updating a Scenario", page 13.*

Processing an event attached to a process

An event placed at the edge of a process is considered by the simulator as an output of the process handled in a specific way. For more details on how to attach an event to a process, see "Attaching an Event to a Process", page 42.

From the viewpoint of the simulator, an event placed at the edge of a process can be processed in various ways:

- If the process is not described, the probability of occurrence of the event placed at the edge of the process is defined on the event output sequence flow .

  ☛ *Implicitly, the simulator firstly considers an exclusive choice between the edge event and all other process outputs.*

  ☛ *An error is generated if no probability is specified on the edge event output sequence flow.*
- If the process is described and the edge event is connected to an internal event within the process, then each token arriving at the process internal event is sent to the edge event.
- If the process is described but no internal event is connected to the edge event, the description of the process is ignored, and the simulator takes into account the probability of occurrence of the event as specified on its output sequence flow.

  ☛ *It is also possible to exclude from the scenario the event attached to the edge of a process.*

Standard mode: Advanced results

In Standard mode, new results are added to those of Beginner mode.

Results for simple and complex tasks

The following are added to standard mode results:

- standard deviation
- Average startup time if you have specified startup times on tasks. See "Performing time", page 22.
- Average interrupt time if you are using schedules and have allowed interrupts on tasks.
- Allocation time if you have allowed asynchronous allocations. See "Asynchronous allocation", page 25.

  ☛ *These different times apply to tokens which, over the complete simulation, have reached one of the procedure outputs.*
- Number of tokens discarded for queue timeout if you have defined a maximum queuing time.
- Number of tokens discarded for queue saturation if you have defined a maximum queue capacity.
- Number of tokens discarded for throughput analysis if you have applied an automatic discard rate on tasks.

  ☛ *If the task is used in a process, results are transferred in the global process.*

Results for org-units and resources

The new results on org-units and other resources are:

- Percentage of allocation time if you have allowed asynchronous allocations.
- Percentage of start-up time.

Results for simulation end events

Simulation end events can be events of **End** type or **Throwing** type.

The simulation editor **Time** tab displays output token processing times. This includes:

- Quantity of tokens obtained at the end of simulation.
- Average processing time for all tokens, in other words the time spent in the simulation and the standard deviation.
- Average effective work time, in other words the time during which tasks are executed.
- Average transfer time.
- Average interrupt time
- Start-up time
- Average allocation time

The **Costs** tab displays the various processing costs:

- The number of tokens processed.
- Average total cost for all tokens.
- Average cost of various resources used.
- Average transfer cost
- Default average cost, if a default cost has been indicated on a task.

Sample

For each end event, the editor displays an average processing time and cost. In certain cases, this average is not truly representative. To obtain more accurate results, you can retain all the values used to calculate the average.

To retain all values enabling calculation of the time average:

1. Select the event in the editor.
2. In the **Time** tab, select **Sample**.

In the next simulation, all calculated values will be retained.

This sample can be viewed in the **Time Chart** tab. A Pareto graph shows the sample of values calculated for the event.

The vertical axis represents time, the horizontal axis the number of tokens in the interval. The higher the number of intervals, the more exactly are values represented.

You can keep the cost sample linked to the tokens output by this event.

The sample can also be reused in indicators. See "Indicator and Sample", page 33.

In addition to end events, you can also display results linked to intermediate events by adding a data collector to these.

Data collector

A data collector enables recording of simulation object results. By default, the simulated object, the end events and the scenario resources have a data collector.

You can create data collectors on:

- Described objects (for example a sub-process)
- Tasks
- Events
- Gateways

Example:

To create a data collector on an intermediate event of the diagram:

1. Display **Results mode** in the simulation editor
2. In the simulation editor toolbar, click the button. This displays all events in the diagram.
3. In the navigator, select the event in question.
4. Click the **Add data collector** button

   ☛ *This command is also accessible in the event pop-up menu.*

The collector created is attached to the scenario in progress.

Data relating to this event is then calculated in the simulation. This does not influence scenario results, but enables display of intermediate results linked to this event.

Addition of a data collector also enables modification of data of a task. See "During: advanced processing of tasks", page 22.

Results for gateways with parallel inputs

You can display data obtained on a parallel gateway assuring synchronization of several sequence flows with the aid of a data collector.

To add a data collector to a gateway:

1. Display **Results mode** in the simulation editor.
2. Select the gateway and click the **Add data collector** button.

You obtain:

- The average synchronization time.
- The number of input tokens.
- The number of output tokens.
- The number of tokens in progress.
- The number of tokens discarded for queuing time overrun. See "Limiting gateway queuing time", page 26.

INDICATORS

For a given scenario and following a simulation, the tool proposes multiple results.

Two disadvantages can result:

- Results of interest are buried in the mass of results proposed.
- Considered separately, the results are not representative of the quality of your scenario.

The answer to both of these problems is the use of indicators.

Interest of Indicators

Indicators are presented directly at scenario level and can be defined from unitary results of simulation objects. They allow you to highlight the significant results of your simulation and to use these to create magnitudes representative of the overall quality of the scenario.

Example

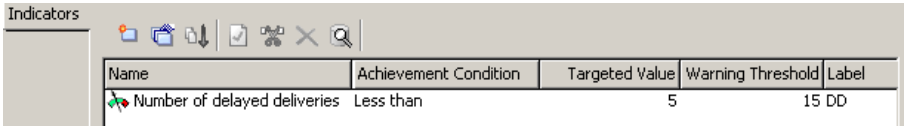
We shall consider the "Home Order Delivery" organizational process. You can define "Client satisfaction" as the primary objective. To achieve this objective, the number of delayed deliveries must be less than 5. You will use simulation results to calculate the value of this indicator.

To view the objectives in the simulation editor:

1. Right-click the scenario name and select **Connect Objective**.
2. Select the objective of the simulated object, in this case "Customer satisfaction", and click **OK**.

The objective appears in the editor.

When you select it, the indicators connected to it appear in the right pane of the editor.



The value of each indicator is calculated following simulation. This value is computed as a function of results for the object to which the indicators relate.

The simulated value is compared with the targeted value. When simulated values of all indicators correspond to those targeted, the simulation engine considers that the objective has been achieved.

Indicator Calculation Rule

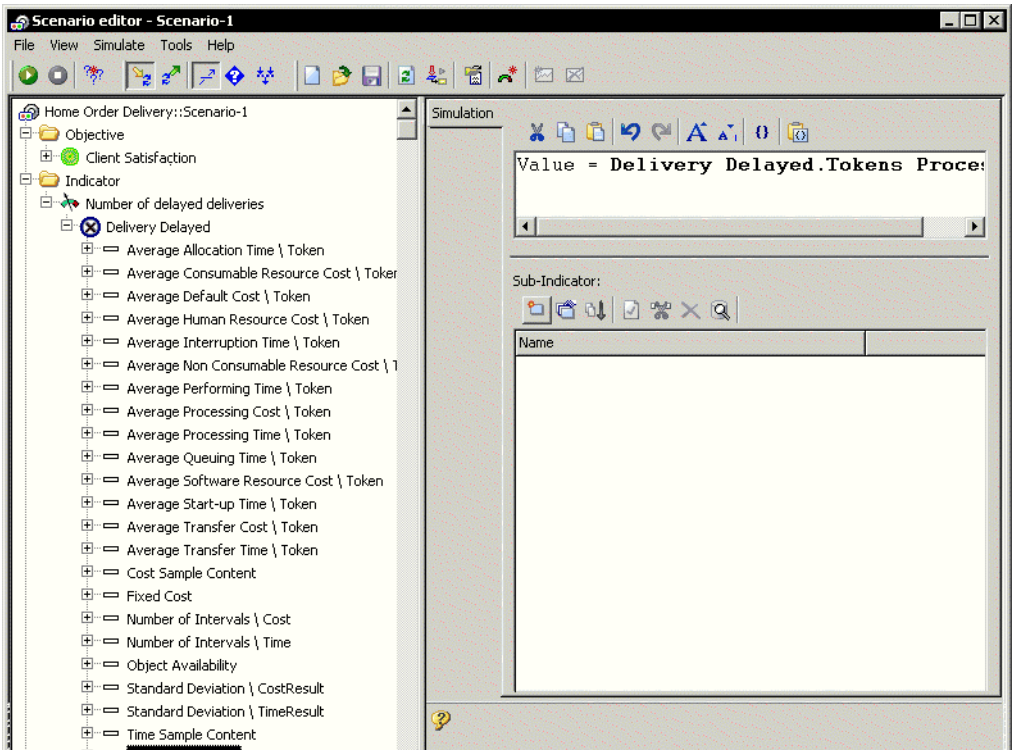
The value of an indicator is calculated from results for objects linked to this indicator.

These results are visible under the object in question.

To define the indicator calculation rule:

1. Connect to the indicator the objects whose results will enable you to calculate the value of the indicator. To do this, select the objects and drag them onto the indicator.
2. Click the indicator to display its calculation rule.
3. Select the results that interest you and drag them onto the calculation rule.

In the following example, the number of delayed deliveries is calculated from the number of tokens processed by the "Delayed delivery" event.



An indicator can be defined from several unitary results from several simulation objects:

Value = "Result 1" + "Result 2"

An indicator can also be defined from other indicators. To do this, they must be defined as sub-indicators of the indicator to be defined:

Value = "Result1" + Indicator 2

The indicator value appears in the scenario results tree.

Time

The simulated value of an indicator has no unit. Functions **dayOf**, **hourOf** and **minuteOf** allow you to return a value in days, hours or minutes.

For example, the calculation rule returning the "Order for delivery" procedure processing time in minutes is:

```
value=minuteOf(Order for delivery. Average processing time /
Result)
```

Rerunning indicator calculation

The value of indicators is recalculated at each simulation. In the case of modification of an indicator computation rule, the **Calculate indicators** button enables computation of the new results for this indicator without the need to rerun the entire simulation.

Indicator and Sample

For a simulation event with a data collector, you can request memorization of the complete sample used to calculate the average results. See "Sample", page 29.

This sample can be used in the calculation of an indicator.

Example

Consider the "Served order" event, end of the "Preparation and Packaging" organizational process.

The representative magnitude of scenario quality is the number of orders served in less than 30 minutes.

The "Served order" message processing time average value is not sufficiently precise information to assure process quality. In fact, for one pizza served in 10 minutes and 3 pizzas served in 35 minutes, you obtain an average value of 28 minutes 45 seconds, yet only one pizza was in fact served in less than 30 minutes.

Use of the sample allows you to count the number of orders served within 30 minutes and to compare this with the total number of pizzas served.

The indicator calculation rule will be:

```
Value = ScountIf("Time sample", "value(Processing)  30*60"
)
```

ScountIf is a function of sample calculation. **Processing** is the result variable to which this function relates.

All the sampling functions are described in the comment available under the **Calculation rule**.

A calculation function can be defined from any result variable of a message.

For a time sample, the available variables are:

- **Processing**: processing time
- **Performing**: effective working time
- **Queuing**: Limiting queuing time
- **Transfer**: Transfer time.
- **StartUp**: Start-up time
- **Allocation**: Allocation time
- **Interruption**: interrupt time

For a cost sample, the available variables are:

- **Processing**: total cost
- **Fixed**: Total default cost
- **Human** Resource: human resources cost
- **Software Resource**: services cost
- **Non Consumable Resource**: non-consumable resources cost
- **Consumable Resource**: consumable resources cost
- **Transfer**: Transfer cost
- **Default**: Default cost

Exporting to Excel

You can export sample data in an XML file. For improved readability, you can open it in an Excel file on condition that you have a version of Excel later than Excel 2002.

To export sample data in an XML file:

1. Execute macro "Create the time and cost sample xml files in C:\tmp".
2. Select the scenario for which you wish to export data and click **OK**.
3. Select the appropriate start message if several exist.
4. Click **OK**.
   The corresponding XML file is created under C:\tmp.

Token Sample and Data

If you have defined token data, this is restored in the sample and can be used as a classical variable of the sample.

Example:

Assume that you have created an "Order type" token data with two data values"Urgent" and "Non-urgent" of which internal values are respectively "1" and "2".

In the result sample, in addition to variables available as default, you will find an "Order type" variable. For a token of the sample, the value of this variable will be 1 or 2.

This variable can therefore be used in filter conditions of the sample.

Example

Assume that you want to obtain the average token processing time of "Urgent" tokens.

The indicator calculation rule will be:

```
Value = SAverageIf(Time sample , "value(Order type) = 1","
Processing")
```

SCHEDULES

Schedules enable definition of generator and org-unit periods of activity. They are available in Standard mode.

Generator Schedules

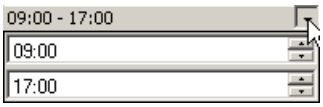
Continuous mode

The generator, which corresponds to the process entry point, introduces tokens into the simulation continuously by default.

In standard mode, you can create a **Schedule** to define the period of activity of the generator. Indicate for example that customer calls to a bank are generated during opening hours, in other words Monday through Friday, between 09h00 and 17h00.

To create this new schedule:

1. In the simulation editor, select the scenario name then the **Input Flows** tab.
2. Clear the **Use default schedules** option.
3. Create a new schedule using the **New** button
4. Right-click the schedule name and select **Properties**.
   The calendar properties dialog box opens.
5. In **Schedule type**, select "Activity".
6. Select "Enabled" from Monday through Friday, and "Disabled" Saturday and Sunday.
7. In the **Number of time slots** field, select"1". This field corresponds to the number of time windows. If you wish to divide the day by a one hour break at noon, you must create two time slots, one for morning and another for afternoon.
8. Then indicate the daily hours.



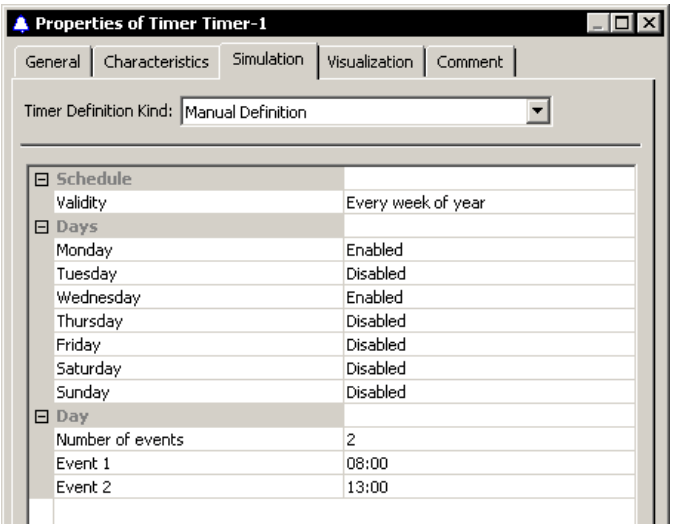
9. When the schedule has been defined, click **OK**.

Event mode

In standard mode, you can also define input of tokens as a function of **Events** triggered by a timer. In this case, the generator does not operate according to time slots but to precise moments.

For example, to indicate that 4 tokens are generated every Monday and Friday at 08h00 and 13h00:

1. In the **Input flow structure** field, select "Several at once at scheduled dates" mode.
2. Create a timer and indicate "4" in the **Average quantity per arrival** column.
3. Open the timer properties dialog box and select the **Simulation** tab.
4. In the **Validity** field, select "Every week of year". This indicates that the timer will operate every week of the year.
5. Select "Enabled" on "Monday" and "Wednesday".
6. Select "Disabled" for the other days of the week.
7. In the **Number of events** field, indicate the number of triggered events: "2".
8. Then indicate the time at which they occur: "08h00" and "13h00".



Org-Unit Schedules

Schedules enable definition of an org-unit period of activity. These schedules are valid for all scenarios in which the org-unit participates.

To define a new schedule on an org-unit:

1. Select the org-unit in question.
2. Now select the **Cost & Duration** tab.
3. Clear the "Use default schedules" option.

   ☛ *This field will not appear if you are in Beginner mode.*

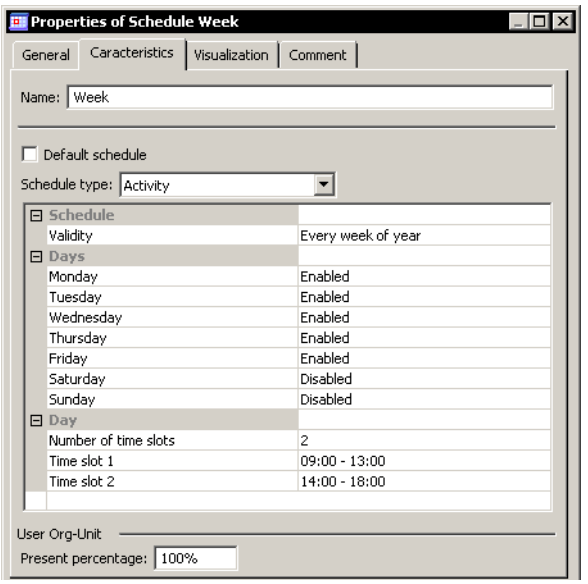
4. Click the **New** button. ⊕

5. Enter the name of the schedule.
   In the properties of this new schedule you can specify:
   - If this is a period of activity or inactivity.
   - For an activity period, the percentage presence of the org-unit.

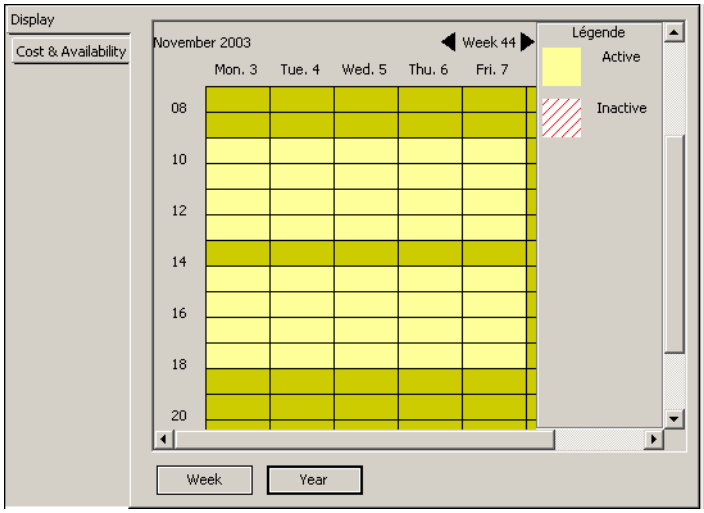
Activity schedule example

Create a schedule to indicate that an employee works every weekday, from 09h00 to 13h00, and from 14h00 to 18h00.

- To do this, create an "Activity" type schedule.
- In its properties dialog box, indicate that it is active Monday through Friday, from 09h00 to 13h00 and from 14h00 to 18h00.



By selecting the **Visualization** tab, you obtain the corresponding graph:

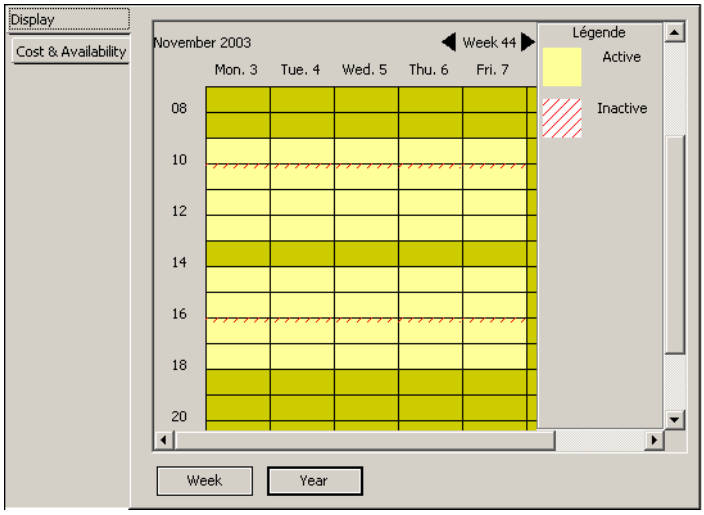


Inactivity schedule example

You can create a second schedule to specify break times, morning from 10h00 to 10h15 and afternoon from 16h00 to 16h15.

This is an "Inactivity" type schedule, also operating from Monday through Friday.

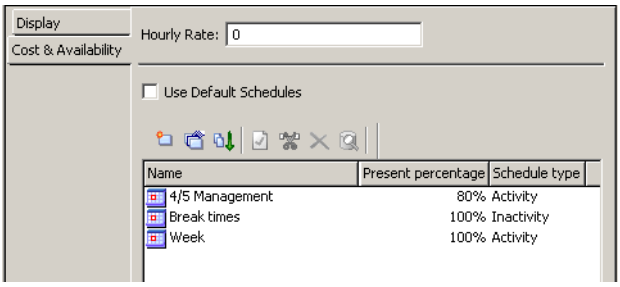
The org-unit graph is visualized as follows:



Partial time schedule example

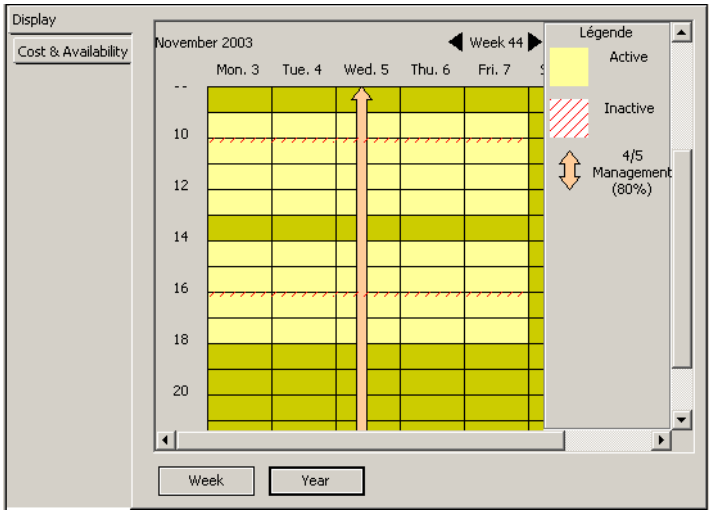
Imagine a third calendar for 4/5 management; according to which the percentage of org-units present drops to 80% on Wednesday.

- Create a third schedule on the org-unit.
- In **Present percentage**, indicate "80%".



- In the schedule properties dialog box, indicate that it is an activity type schedule, "Enabled" on Wednesday only.

You obtain the following:



The presence percentage of org-units on a schedule influences the number of org-units that you may have defined.

If for example you have defined a scenario in which by default 10 employees are available, according to the above schedules, the number of employees is 10 from Monday through Friday, dropping to 8 on Wednesday.