SimPype Documentation

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Contents

Overview

SimPype is a simulation framework based on SimPy that relies on the concepts of resource and pipe. SimPype decouples the resource from its queue (pipe) in such a way multiple queueing techniques can be used with the same resource. SimPype also allows to create both custom resource and pipe models that can be reused in multiple simulations.

SimPype supports only Python >= 3.6. Previous versions of Python are not supported. The quickest way to install SimPype is through *pip3*:

```
>>> pip3 install simpype
```

SimPype automatically installs SimPy as dependency.

SimPype documentation can be found on ReadTheDocs while the source code repository is available on GitHub.

1.1 Scope

SimPype is tailored to scenarios where the queueing disciplines and the resources occupation are key parts of the system under simulation. People queueing at a post office, supermarket, car wash, cafeteria, etc. are examples of such scenarios.

1.2 Concept

A SimPype simulation environment comprises at least one *generator* and one *resource* which are connected via a *pipeline*. The generator generates *messages* with a given *arrival time*. Those messages are firs enqueue in the resource *pipe* and next processed by the resources according with a *service time*.

A simple scenario with one generator and one resource can be defined as follows in a python3 console:

```
>>> import simpype
>>> import random
>>> sim = simpype.Simulation(id = 'overview')
```

(continues on next page)

```
>>> gen0 = sim.add_generator(id = 'gen0')
>>> gen0.random['arrival'] = {0: lambda: random.expovariate(1.0)}
>>> res0 = sim.add_resource(id = 'res0')
>>> res0.random['service'] = {0: lambda: random.expovariate(2.0)}
>>> p0 = sim.add_pipeline(gen0, res0)
>>> sim.run(until = 10)
```

The simulation steps can be summarized as follows:

1. The generator waits a `random arrival time` and generates a message;

2. The generator `sends the message` to the resource;

3. The `message is enqueued` in the resource's pipe;

4. When the resource becomes available, the `message is dequeued` from the pipe;

5. The `message is served` by the resource;

6. The message leaves the resource after a `random service time` and is sent to the next resource (if any) - Go to step 3.

Any simulation steps can be customized as desired. Follows the tutorial to learn how to customize your simulation environment.

SimPype also provides a built-in logging system for your simulation that automatically logs the simulation steps 3, 4, and 5. The built-in system produces the logs in a tidy format where each variable is saved in its own column and each observation is saved in its own row:

```
>>> timestamp,message,seq_num,resource,event
... 0.000000000,gen0,0,res0,pipe.in
... 0.000000000,gen0,0,res0,pipe.out
... 0.030509067,gen0,0,res0,resource.serve
... 4.283987797,gen0,1,res0,pipe.in
... 4.283987797,gen0,1,res0,pipe.out
... 4.296562508,gen0,1,res0,resource.serve
... 4.944812881,gen0,2,res0,pipe.in
... 4.944812881,gen0,2,res0,pipe.out
... 5.128244999,gen0,2,res0,resource.serve
... 6.402898951,gen0,3,res0,pipe.in
... 6.402898951,gen0,3,res0,pipe.out
... 7.044417615,gen0,3,res0,resource.serve
... 7.561061272,gen0,4,res0,pipe.in
... 7.561061272,gen0,4,res0,pipe.out
... 7.729431178,gen0,5,res0,pipe.in
... 8.129979622,gen0,4,res0,resource.serve
... 8.129979622,gen0,5,res0,pipe.out
... 8.171601538,gen0,6,res0,pipe.in
... 8.886733703,gen0,5,res0,resource.serve
... 8.886733703,gen0,6,res0,pipe.out
... 8.949540209,gen0,6,res0,resource.serve
```

This data format is well-suited for being directly processed by data manipulation tools like pandas or tidyverse. SimPype does not provide any tools for parsing the data.

Tutorial

This tutorial explains how to build and configure a SimPype simulation.

2.1 Installation

SimPype is a simulation framework based on SimPy (>=4.0.1) and runs on Python 3 (>=3.6) only. So make sure you have a recent version of Python installed on your system. SimPype also supports PyPy for an easy distribution and installation. If you have pip3 installed, just type:

```
$ pip3 install simpype
```

Please note that the command is called pip3 and not simply pip. SimPy is automatically installed as dependency, so you do not need to install it manually.

If you don't have pip3 installed on your system, you might install it with the following commands:

On Centos:

```
$ yum install python34-pip
```

On Fedora:

```
$ dnf install python3-pip
```

On Debian:

```
$ apt-get install python3-pip
```

On Ubuntu:

```
$ apt-get install python3-pip
```

For any other systems, please refer to their documentation.

2.1.1 Installing from source

If you prefer installing SimPype from source, you have two options:

From PyPi

You can download SimPype and install it manually. Extract the archive, open a terminal window where you extracted SimPype and type:

```
$ python3 setup.py install
```

From GitHub

Alternatively, you can clone SimPype repository from GitHub by typing in a terminal windows:

```
$ git clone https://github.com/Mallets/SimPype.git
```

Now change your working directory in the freshly cloned repository and type:

```
$ python3 setup.py install
```

2.2 Simple simulation

To build your first SimPype simulation, you simply need a console environment and a text editor. Write the following block of code into a text file, e.g. `simple.py`.

```python
# [Mandatory] Import SimPype module
import simpype
import random

# [Mandatory] Create a SimPype simulation object
sim = simpype.Simulation(id = 'simple')

# [Mandatory] Add at least one generator to the simulation
gen0 = sim.add_generator(id = 'gen0')
gen0.random['arrival'] = {
        0: lambda: random.expovariate(2.0)
}

# [Mandatory] Add at least one resource to the simulation
res0 = sim.add_resource(id = 'res0')
# [Mandatory] Assign a service time
res0.random['service'] = {
        0: lambda: random.expovariate(3.0)
}

# [Mandatory] Add a pipeline connecting the generator to the resource
p0 = sim.add_pipeline(gen0, res0)

# [Mandatory] Run the simulation e.g. until t=5
#             sim.run calls Simpy's env.run
#             Any args passed to sim.run is then passed to env.run
sim.run(until = 5)
```

Now run the simulation by typing the following command in the console:

```
$ python3 simple.py
```

If your simulation name has a different name than `simple.py`, just replace `simple.py` with `your filename`. SimPype automatically logs the simulation results, see *Log system* for a detailed explaination on how to read the log files.

2.3 Log system

SimPype automatically logs the simulation results in a log directory having the following structure in case of our simple simulation (see *Simple simulation*):

```
<working directory>
|-- simple.py
|-- log
    |-- simple
        |-- <simulation date i.e. '2017-06-05 10:31:30.512772'>
            |-- sim.cfg
            `-- sim.log
```

`sim.cfg` contains information about the simulation environment and has the following format:

```
Simulation Seed: 13690689176067105280
Simulation Time: 5.000000000
Execution Time: 0.003524998
```

`sim.log` contains the log of the simulation events and looks like:

```
timestamp,message,seq_num,resource,event
0.000000000,gen0,0,res0,pipe.in
0.000000000,gen0,0,res0,pipe.out
0.252555552,gen0,0,res0,resource.serve
0.722431377,gen0,1,res0,pipe.in
0.722431377,gen0,1,res0,pipe.out
0.869881996,gen0,1,res0,resource.serve
1.413266674,gen0,2,res0,pipe.in
1.413266674,gen0,2,res0,pipe.out
1.478382544,gen0,2,res0,resource.serve
2.833221707,gen0,3,res0,pipe.in
2.833221707,gen0,3,res0,pipe.out
3.117096444,gen0,3,res0,resource.serve
3.455033536,gen0,4,res0,pipe.in
3.455033536,gen0,4,res0,pipe.out
4.174690658,gen0,5,res0,pipe.in
4.301555284,gen0,6,res0,pipe.in
4.587560103,gen0,4,res0,resource.serve
4.587560103,gen0,5,res0,pipe.out
4.898210753,gen0,5,res0,resource.serve
4.898210753,gen0,6,res0,pipe.out
4.975600594,gen0,6,res0,resource.serve
```

Let's analyze the first three log entries:

```
timestamp,message,seq_num,resource,event
0.000000000,gen0,0,res0,pipe.in
```

1. A message with id `gen0` and sequence number `0` has been enqueued to the pipe of resource `res0` in the queue `default` at simulation time `0.000000000`.

```
timestamp,message,seq_num,resource,event
0.000000000,gen0,0,res0,pipe.out
```

2. The message with id `gen0` and sequence number `0` has been dequeued from the pipe of resource `res0` and queue `default` at simulation time `0.000000000`. This means that the resource was available as soon as the message reached the resource. Therefore, the time spent waiting in the pipe was `0`.

```
timestamp,message,seq_num,resource,event
0.252555552,gen0,0,res0,resource.serve
```

3. The resource `res0` served the message with id `gen0` and sequence number `0` at simulation time `0.252555552`.

2.3.1 Change log directory

You can change the default log directory by setting the following variable in the simulation environment:

```python
import simpype

sim = simpype.Simulation(id = 'simple')
sim.log.dir = '<your preferred dir>'
```

Please make sure you have writing permissions to `<your preferred dir>`.

2.3.2 Log custom message properties

You can configure SimPype's logger to log any additional message properties as you wish by calling the following function in the simulation environment:

```python
import simpype

sim = simpype.Simulation(id = 'simple')
sim.log.property('test')

gen0.message.property['test'] = {
    0: lambda: 1
}
```

`sim.log` file now will containt a column containing the value of `test` message property:

```
timestamp,message,seq_num,resource,event,test
0.000000000,gen0,0,res0,pipe.in,1
```

If a message does not have the custom property, SimPype logs `NA` instead.

2.3.3 Print the logs

If you prefer to print the logs instead of storing them in a file, you can do it by setting the following variables in the simulation environment:

```python
import simpype

sim = simpype.Simulation(id = 'simple')
sim.log.file = False
sim.log.print = True
```

2.4 Pipeline

Pipelines allow to arbitrarly interconnect generators and resources by chaining them. Messages belonging to a pipeline automatically flow from a resource to another without the needs of explicitly defining the *hops*. Please note that a generator (and their messages) belong only to a single pipeline. If multiple pipelines are needed simultaneously, they need to be merged fisrt. See *Branching pipeline* for more details.

2.4.1 Single pipeline

Let's start with a simulation where messages are generated by `Generator #0` and are served by `Resource #0` and `Resource #1`.

```
|Generator #0| -> |Resource #0| -> |Resource #1|
```

The SimPype code would hence be:

```python
import simpype
import random

sim = simpype.Simulation(id = 'single')
gen0 = sim.add_generator(id = 'gen0')
gen0.random['arrival'] = {0: lambda: random.expovariate(1.0)}
res0 = sim.add_resource(id = 'res0')
res0.random['service'] = {0: lambda: random.expovariate(2.0)}
res1 = sim.add_resource(id = 'res1')
res1.random['service'] = {0: lambda: random.expovariate(2.0)}

p0 = sim.add_pipeline(gen0, res0, res1)

sim.run(until = 5)
```

As it can be noticed in `sim.log` file, messages generated by `Generator #0` automatically flow through `Resource #0` and `Resource #1` without the needs of explicitly defining the next hop:

```
timestamp,message,seq_num,resource,event
0.000000000,gen0,0,res0,pipe.in
0.000000000,gen0,0,res0,pipe.out
0.044474460,gen0,0,res0,resource.serve
0.044474460,gen0,0,res1,pipe.in
0.044474460,gen0,0,res1,pipe.out
0.867233916,gen0,1,res0,pipe.in
0.867233916,gen0,1,res0,pipe.out
1.099185483,gen0,0,res1,resource.serve
1.876512438,gen0,1,res0,resource.serve
1.876512438,gen0,1,res1,pipe.in
1.876512438,gen0,1,res1,pipe.out
2.873364054,gen0,1,res1,resource.serve
```

2.4.2 Overlapping pipelines

Noe let's continue with a simulation scenarios like the following:

```
|Generator #0| -\                      /-> |Resource #1|
                )-> |Resource #0| -(
|Generator #1| -/                      \-> |Resource #2|
```

In this scenario we want to reproduce the following interconnection:

```
|Generator #0| -> |Resource #0| -> |Resource #1|

|Generator #1| -> |Resource #0| -> |Resource #2|
```

As it can be noticed, there are two dinstinct *paths/pipelines* that overlap at `Resource #0`. However, any messages generated by `Generator #0` should end to `Resource #1`. Similarly, any messages generated by `Generator #1` should end to `Resource #2`.

In this scenario, `Resource #0` is hence shared between the two *pipelines*. The SimPype code would hence be:

```python
import simpype
import random

sim = simpype.Simulation(id = 'overlap')
gen0 = sim.add_generator(id = 'gen0')
gen0.random['arrival'] = {0: lambda: random.expovariate(1.0)}
gen1 = sim.add_generator(id = 'gen1')
gen1.random['arrival'] = {0: lambda: random.expovariate(1.0)}
res0 = sim.add_resource(id = 'res0')
res0.random['service'] = {0: lambda: random.expovariate(4.0)}
res1 = sim.add_resource(id = 'res1')
res1.random['service'] = {0: lambda: random.expovariate(2.0)}
res2 = sim.add_resource(id = 'res2')
res2.random['service'] = {0: lambda: random.expovariate(2.0)}

p0 = sim.add_pipeline(gen0, res0, res1)
p1 = sim.add_pipeline(gen1, res0, res2)

sim.run(until = 2.5)
```

As it can be noticed in `sim.log` file, messages generated by `Generator #0` automatically flow through `Resource #0` and `Resource #1` and messages generated by `Generator #1` automatically flow through `Resource #0` and `Resource #2`. Moreover, `Resource #0` is shared between the two *pipelines*:

```
timestamp,message,seq_num,resource,event
0.000000000,gen0,0,res0,pipe.in
0.000000000,gen1,0,res0,pipe.in
0.000000000,gen0,0,res0,pipe.out
0.372608250,gen0,0,res0,resource.serve
0.372608250,gen0,0,res1,pipe.in
0.372608250,gen0,0,res1,pipe.out
0.372608250,gen1,0,res0,pipe.out
0.515112655,gen0,1,res0,pipe.in
0.636849329,gen1,0,res0,resource.serve
0.636849329,gen1,0,res2,pipe.in
0.636849329,gen1,0,res2,pipe.out
0.636849329,gen0,1,res0,pipe.out
0.653319564,gen0,1,res0,resource.serve
```

```
0.653319564,gen0,1,res1,pipe.in
0.684766776,gen1,1,res0,pipe.in
0.684766776,gen1,1,res0,pipe.out
0.851617505,gen0,0,res1,resource.serve
0.851617505,gen0,1,res1,pipe.out
0.921614468,gen1,2,res0,pipe.in
0.949578262,gen1,1,res0,resource.serve
0.949578262,gen1,1,res2,pipe.in
0.949578262,gen1,2,res0,pipe.out
1.052881475,gen1,2,res0,resource.serve
1.052881475,gen1,2,res2,pipe.in
1.079748898,gen0,1,res1,resource.serve
1.245866822,gen1,3,res0,pipe.in
1.245866822,gen1,3,res0,pipe.out
1.352498249,gen1,0,res2,resource.serve
1.352498249,gen1,1,res2,pipe.out
1.369990105,gen1,4,res0,pipe.in
1.384336838,gen1,1,res2,resource.serve
1.384336838,gen1,2,res2,pipe.out
1.385217621,gen1,5,res0,pipe.in
1.418331444,gen1,2,res2,resource.serve
1.582122574,gen1,3,res0,resource.serve
1.582122574,gen1,3,res2,pipe.in
1.582122574,gen1,3,res2,pipe.out
1.582122574,gen1,4,res0,pipe.out
2.028251841,gen1,4,res0,resource.serve
2.028251841,gen1,4,res2,pipe.in
2.028251841,gen1,5,res0,pipe.out
2.148959938,gen1,6,res0,pipe.in
```

2.4.3 Branching pipeline

Now let's continue with a pipeline having a branching point with one generator and three resources:

```
                              /-> |Resource #1|
|Generator #0| -> |Resource #0| -(
                              \-> |Resource #2|
```

There are two possible options at this stage:

- Serve a copy of the same message to both `Resource #1` and `Resource #2`;

- Either serve a message to `Resource #1` or to `Resource #2`.

Automatic copy

In case of serving a copy of the same message to both `Resource #1` and `Resource #2`, the SimPype code would hence be:

```python
import simpype
import random

sim = simpype.Simulation(id = 'single')
gen0 = sim.add_generator(id = 'gen0')
```

```python
gen0.random['arrival'] = {0: lambda: random.expovariate(1.0)}
res0 = sim.add_resource(id = 'res0')
res0.random['service'] = {0: lambda: random.expovariate(2.0)}
res1 = sim.add_resource(id = 'res1')
res1.random['service'] = {0: lambda: random.expovariate(2.0)}
res2 = sim.add_resource(id = 'res2')
res2.random['service'] = {0: lambda: random.expovariate(2.0)}

p0 = sim.add_pipeline(gen0, res0, res1)
p1 = sim.add_pipeline(gen0, res0, res2)
pM = sim.merge_pipeline(p0, p1)

sim.run(until = 5)
```

Please note the use of *merge_pipeline()*. This function merges multiple *pipelines* into a single one, thus creating the branching point. Withouth calling the *merge_pipeline()* function, the only active *pipeline* would have been p1.

As it can be noticed in sim.log file, messages are automatically copied and served to both Resource #1 and Resource #2 after being served by Resource #0:

```
timestamp,message,seq_num,resource,event
0.000000000,gen0,0,res0,pipe.in
0.000000000,gen0,0,res0,pipe.out
0.412762064,gen0,0,res0,resource.serve
0.412762064,gen0,0,res2,pipe.in
0.412762064,gen0,0,res1,pipe.in
0.412762064,gen0,0,res2,pipe.out
0.412762064,gen0,0,res1,pipe.out
0.631472230,gen0,0,res1,resource.serve
0.989221320,gen0,0,res2,resource.serve
2.545794865,gen0,1,res0,pipe.in
2.545794865,gen0,1,res0,pipe.out
2.572402316,gen0,1,res0,resource.serve
2.572402316,gen0,1,res2,pipe.in
2.572402316,gen0,1,res1,pipe.in
2.572402316,gen0,1,res2,pipe.out
2.572402316,gen0,1,res1,pipe.out
2.602942195,gen0,1,res1,resource.serve
4.163453623,gen0,2,res0,pipe.in
4.163453623,gen0,2,res0,pipe.out
4.222865258,gen0,2,res0,resource.serve
4.222865258,gen0,2,res2,pipe.in
4.222865258,gen0,2,res1,pipe.in
4.222865258,gen0,2,res1,pipe.out
4.270038314,gen0,1,res2,resource.serve
4.270038314,gen0,2,res2,pipe.out
4.360461106,gen0,2,res2,resource.serve
4.551208266,gen0,2,res1,resource.serve
```

Next hop selection

Please refer to *Next* in *Message* section to understand how the next hop of the messages can be dynamically changed.

2.4.4 Miscellaneous

add_pipeline() admits both *Resource* and *Pipeline* objects as arguments as shown in this examples:

```python
import simpype

sim = simpype.Simulation(id = 'single')
gen0 = sim.add_generator(id = 'gen0')
gen1 = sim.add_generator(id = 'gen1')
res0 = sim.add_resource(id = 'res0')
res1 = sim.add_resource(id = 'res1')
res2 = sim.add_resource(id = 'res2')
res3 = sim.add_resource(id = 'res3')
res4 = sim.add_resource(id = 'res4')
res5 = sim.add_resource(id = 'res5')
res6 = sim.add_resource(id = 'res6')

# Only resources
p0 = sim.add_pipeline(res0, res1, res2)
p1 = sim.add_pipeline(res3, res4, res5)
# Mixed pipeline and resources
p2 = sim.add_pipeline(gen0, p0)
p3 = sim.add_pipeline(gen1, p1)
p4 = sim.add_pipeline(p3, res6)
# Only pipelines
# Equivalent to sim.add_pipeline(res0, res1, res2, res3, res4, res5)
p4 = sim.add_pipeline(p0, p1)
```

Instead, *merge_pipeline()* only admits *Pipeline* objects as arguments.

2.5 Random variables

SimPype comes with a custom random variable generation system that allows you to generate random values according to different random distributions depending on the current simulation time. See *Random* for a detailed API reference.

```python
import simpype

sim = simpype.Simulation(id = 'test')
myrand = simpype.Random(sim, {
    initial_time : lambda_function
    ...
})
```

Where each dictionary element is so defined:

- `initial_time` is the element key and must be of *int* or *float* type. It represents the initial simulation time at which the `lambda_function` is invoked;

- `lambda_function` is the element value. It is mandatory that for the value to be a *lambda* function. Such function must return a value, usually a *int* or a *float*;

An example of random variable initialization is the following:

```python
import simpype
import random
```

(continues on next page)

```python
sim = simpype.Simulation(id = 'test')
myrand = simpype.Random(sim, {
    # From t=0 to t=10, the random variable returns
    # the constant value of 3.0
    0    : lambda: 3.0,
    # From t=10 to t=20, the random variable returns
    # value uniformly distributed between 2.5 and 3.5
    10    : lambda: random.uniform(2.5, 3.5),
    # From t=20 to t=inf, the random variable returns
    # a value exponentially distributed with lambda 0.20
    20    : lambda: random.expovariate(0.20)
})
```

To generate a random value:

```python
# Simulation time = 5.0
random_value = myrand.value    # random_value = 3.0
...
# Simulation time = 15.0
random_value = myrand.value    # random_value = 3.2476115513945767
...
# Simulation time = 25.0
random_value = myrand.value    # random_value = 7.374759019459148
```

As you can see, depending on the current simulation `myrand.value` returns a random value according to a different random distribution.

2.5.1 Generator arrival time

The arrival time of a generator is described with a *Random* variable.

```python
import simpype
import random

sim = simpype.Simulation(id = 'simple')
gen0 = sim.add_generator(id = 'gen0')
# Start generating events at a random simulation time
gen0.random['arrival'] = {
        # From t=0 to t=10, the arrival time is constant to 3.0
        0       : lambda: 3.0,
        # From t=10 to t=20, the arrival time is uniformly distributed between 2.
→5 and 3.5
        10      : lambda: random.uniform(2.5, 3.5),
        # From t=20 to t=inf, the arrival time is exponentially distributed with␣
→lambda 0.20
        20      : lambda: random.expovariate(0.20)
}
```

Please note that in this case there is no need of calling the `simpype.Random` constructor. The generator object automatically converts the dictionary into a *Random* object.

2.5.2 Generation of more than one message at once

The number of messages to be generated at any arrival time is described with a *Random* variable.

```
import simpype
import random

sim = simpype.Simulation(id = 'simple')
gen0 = sim.add_generator(id = 'gen0')
# Arrival time of 1 second
gen0.random['arrival'] = {0: lambda: 1}
# Start generating events at a random simulation time
gen0.random['quantity'] = {
        # From t=0 to t=10, 3 messages are generated at once
        0       : lambda: 3,
        # From t=10 to t=20, a random number of messages (between 1 and 10) is
→generated at once
        10      : lambda: random.randint(1, 10),
        # From t=20 to t=inf, 1 message is generated everytime
        20      : lambda: 1
}
```

Please note that in this case there is no need of calling the `simpype.Random` constructor. The generator object automatically converts the dictionary into a *Random* object.

2.5.3 Resource service time

The service time of a resource is described with a *Random* variable.

```
import simpype
import random

sim = simpype.Simulation(id = 'simple')
res0 = sim.add_resource(id = 'res0')
res0.random['arrival'] = {
        # From t=0 to t=10, the service time is constant to 3.0
        0       : lambda: 3.0,
        # From t=10 to t=20, the service time is uniformly distributed between 2.
→5 and 3.5
        10      : lambda: random.uniform(2.5, 3.5),
        # From t=20 to t=inf, the service time is exponentially distributed with
→lambda 0.20
        20      : lambda: random.expovariate(0.20)
}
```

Please note that in this case there is no need of calling the `simpype.Random` constructor. The resource object automatically converts the dictionary into a *Random* object.

2.5.4 Message property

A message property can be described with a a *Random* variable.

```
import simpype
import random

sim = simpype.Simulation(id = 'simple')
gen0 = sim.add_generator(id = 'gen0')
gen0.message.property['test'] = {
```

```
        # Every message generated between t=0 and t=10 will have the 'test'␣
→property value equal to 3.0
        0       : lambda: 3.0,
        # Every message generated between t=10 and t=20 will have the 'test'␣
→property uniformly distributed between 2.5 and 3.5
        10      : lambda: random.uniform(2.5, 3.5),
        # Every message generated between t=20 and t=inf will have the 'test'␣
→property exponentially distributed with lambda 0.20
        20      : lambda: random.expovariate(0.20)
}
```

Please note that in this case there is no need of calling the `simpype.Random` constructor. The message object automatically converts the dictionary into a *Random* object. Please also note that property values can be randomly generated, nevertheless once they are generated they will always return the same value unless an explicit refresh is called

```
message.property['test'].refresh()
```

2.6 Message

Messages are the units processed by the resources and can store arbitrary information, called *properties* in SimPype. Message properties can be of any values, including *Random* objects (see *Random variables*). See *Message* for a detailed API reference.

```python
import simpype
import random

sim = simpype.Simulation(id = 'simple')
gen0 = sim.add_generator(id = 'gen0')
gen0.message.property['rand_prop'] = {
    # Every message generated between t=0 and t=10 will have
    # the 'test' property value equal to 3.0
    0 : lambda: 3.0,
    # Every message generated between t=10 and t=20 will have
    # the 'test' property uniformly distributed between 2.5 and 3.5
    10: lambda: random.uniform(2.5, 3.5),
    # Every message generated between t=20 and t=inf will have
    # the 'test' property exponentially distributed with lambda 0.20
    20: lambda: random.expovariate(0.20)
}
# Store the property as normal dictionary if no lambda functions is present
gen0.message.property['dict_prop'] = {
    'a': 'avalue',
    'b': 'bvalue',
}
gen0.message.property['str_prop'] = 'mystr'
gen0.message.property['int_prop'] = 3
gen0.message.property['float_prop'] = 3.0
# You can also store objects
e = sim.env.event()
gen0.message.property['event_prop'] = e
```

Please note that in this case there is no need of calling the `simpype.Random` constructor. The message object automatically converts the dictionary into a *Random* object. Please also note that property values can be randomly

generated, nevertheless once they are generated they will always return the same value unless an explicit refresh is called

```
message.property['test'].refresh()
```

2.6.1 Drop

A message can be suddenly dropped by calling the function *drop()*:

```
message.drop(id = 'bad luck')
```

In addition, a message can be dropped upon the occurence of a given event:

```
# Create a SimPy event
e = sim.env.event()
# Subscribe the dropping of the message to the event e
message.drop(id = 'event bad luck', event = e)
# Trigger the event
e.succeed()
# The message has now been dropped
```

The message is dropped only when the event e is triggered, that is *succeed* in SimPy notation.

2.6.2 Lifetime

A *lifetime* can be assigned to generated messages in the following way:

```
import simpype
import random

sim = simpype.Simulation(id = 'simple')
gen0 = sim.add_generator(id = 'gen0')
gen0.message.property['lifetime'] = {
    0: lambda: random.expovariate(0.20)
}
```

The message is dropped when the *lifetime* expires. To remove any *lifetime* from the message, use the following function:

```
message.unsubscribe(id = 'lifetime')
```

2.6.3 Event subscription

A message can be susbscribed to a given event and a custom function can be executed upong event triggering, e.g.:

```
import simpype
import random

sim = simpype.Simulation(id = 'simple')
gen0 = sim.add_generator(id = 'gen0')
res0 = sim.add_resource(id = 'res0')
res1 = sim.add_resource(id = 'res1')
```

```
e = sim.env.event()
def c(message, value):
    # Value of the event, e.g. 'OK'
    message.property['myevent'] = value

@simpype.resource.service(res0)
def service(self, message):
    global e
    # Trigger the event
    e.succeed(value = 'OK')
    e = sim.env.event()

@simpype.resource.service(res1)
def service(self, message):
    # Unsubscribe from the event
    message.unsubscribe(id = 'mysub')

gen0.message.subscribe(event = e, callback = c, id = 'mysub')
```
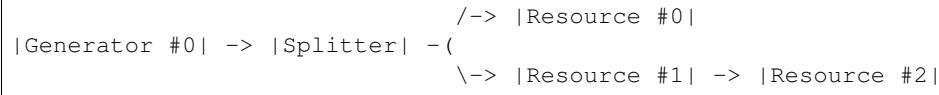
The callback function must be defined according to the following format:

```
def callback(message, value):
    ... your code here ...
```

2.6.4 Next

Let's assume we have a simulation scenario like the following:

```
                           /-> |Resource #0|
|Generator #0| -> |Splitter| -(
                           \-> |Resource #1| -> |Resource #2|
```

Messages can be either go to Resource #0 or to Resource #1 depending on Splitter decision. In this example, messages with even sequence number are sent to Resource #0 while messages with odd sequence number are sent to Resource #1 and next to Resource #2. To achive this, the next hop of a message can be dynamically changed by setting the message next variable. next admits both *Resource* and *Pipeline* objects as values.

```
import simpype
import random

sim = simpype.Simulation(id = 'next')
gen0 = sim.add_generator(id = 'gen')
gen0.random['arrival'] = {0: lambda: 1.0}
res0 = sim.add_resource(id = 'res0')
res1 = sim.add_resource(id = 'res1')
res2 = sim.add_resource(id = 'res2')
splitter = sim.add_resource(id = 'splitter')

p0 = sim.add_pipeline(gen0, splitter)
p1a = sim.add_pipeline(splitter, res0)
p1b = sim.add_pipeline(res1, res2)
p2 = sim.add_pipeline(splitter, p1b)
pM = sim.merge_pipeline(p0, p1a, p1b, p2)

# Change next
```

```
@simpype.resource.service(splitter)
def service(self, message):
    yield self.env.timeout(1.0)
    if message.seq_num % 2 == 0:
        message.next = res0
    else:
        message.next = p1b


sim.run(until = 10)
```

As it can be noticed in `sim.log` file, messages are either sent to `Resource #0` or to `Resource #1` based on their sequence number:

Moreover, `next` variable could also be set to a *pipeline* instead of a *resource*.

```
timestamp,message,seq_num,resource,event
0.000000000,gen,0,splitter,pipe.in
0.000000000,gen,0,splitter,pipe.out
1.000000000,gen,1,splitter,pipe.in
1.000000000,gen,0,splitter,resource.serve
1.000000000,gen,0,res0,pipe.in
1.000000000,gen,0,res0,pipe.out
1.000000000,gen,1,splitter,pipe.out
1.000000000,gen,0,res0,resource.serve
2.000000000,gen,2,splitter,pipe.in
2.000000000,gen,1,splitter,resource.serve
2.000000000,gen,1,res1,pipe.in
2.000000000,gen,1,res1,pipe.out
2.000000000,gen,2,splitter,pipe.out
2.000000000,gen,1,res1,resource.serve
2.000000000,gen,1,res2,pipe.in
2.000000000,gen,1,res2,pipe.out
2.000000000,gen,1,res2,resource.serve
3.000000000,gen,3,splitter,pipe.in
3.000000000,gen,2,splitter,resource.serve
3.000000000,gen,2,res0,pipe.in
3.000000000,gen,2,res0,pipe.out
3.000000000,gen,3,splitter,pipe.out
3.000000000,gen,2,res0,resource.serve
4.000000000,gen,4,splitter,pipe.in
4.000000000,gen,3,splitter,resource.serve
4.000000000,gen,3,res1,pipe.in
4.000000000,gen,3,res1,pipe.out
4.000000000,gen,4,splitter,pipe.out
4.000000000,gen,3,res1,resource.serve
4.000000000,gen,3,res2,pipe.in
4.000000000,gen,3,res2,pipe.out
4.000000000,gen,3,res2,resource.serve
```

2.7 Resource

The resource behavior can be customized in case of more complex operations are needed in addition to the simple random generated service time. With this purpose, the decorator `@simpype.resource.service` can be used (see *service()* for more details). There are two ways of customizing the behavior of your resource:

- Work directly on the simulation scenario and perform an *inline customization*;

- Create a *resource model* to be included in the simulation scenario.

Either approaches are valid, however *inline customization* is more suited for small customizations while *resource model* is more suited for larger customizations and code re-usability (you can include the smae model multiple times in different simulations).

2.7.1 Inline customization

In this example, the service time of the resource also depends on the message property value `wait`.

```python
import simpype
import random

sim = simpype.Simulation(id = 'simple')
gen0 = sim.add_generator(id = 'gen0')
gen0.message.property['wait'] = {
    0: lambda: random.uniform(0,1)
}
res0 = sim.add_resource(id = 'res0')
res0.random['service'] = {
    0: lambda: 2.0
}

@simpype.resource.service(res0)
def service(self, message):
    # Wait for a random time
    yield self.env.timeout(self.random['service'])
    # Wait for a time as reported in the message property
    yield self.env.timeout(message.property['wait'].value)

sim.run(until = 10)
```

2.7.2 Custom model

Alternatively, a separate *resource model* can be created to implement the same resource behavior:

1. Edit `myresource.py` with a text editor and create a resource model in the following way:

```python
import simpype

class MyResource(simpype.Resource):
    def __init__(self, sim, id, capacity = 1, pipe = None):
        super().__init__(sim, id, capacity, pipe)

    @simpype.resource.service
    def service(self, message):
        # Wait for a random time
        yield self.env.timeout(self.random['service'])
        # Wait for a time as reported in the message property
        yield self.env.timeout(message.property['wait'].value)


# Do NOT remove. This is required for SimPype to build your model.
resource = lambda *args: MyResource(*args)
```

2. Create your simulation scenario including the new model:

```python
import simpype
import random

sim = simpype.Simulation(id = 'simple')
gen0 = sim.add_generator(id = 'gen0')
gen0.message.property['wait'] = {
    0: lambda: random.uniform(0,1)
}
res0 = sim.add_resource(id = 'res0', model = 'myresource')
res0.random['service'] = {
    0: lambda: 2.0
}

sim.run(until = 10)
```

3. Make sure that the file and directory structure is the following:

```
<working directory>
|-- simple.py
|-- myresource.py
```

4. If you want to change the directory where SimPype looks for custom models, set the following variable in the simulation environment:

```python
import simpype

sim = simpype.Simulation(id = 'simple')
sim.model.dir = '<your model dir>'
```

Please make sure you have reading permissions for `<your model dir>`. In this case, the file and directory structure would look like:

```
<working directory>
|-- simple.py

<your model dir>
|-- myresource.py
```

2.8 Pipe

The pipe behavior of a given resource can be customized in case of more complex queueing operations are needed in addition to the simple FIFO discipline. With this purpose, multiple queueus can be added to the pipe and two decorators can be used to determine the *enqueueing* and *dequeueing* behavior of the pipe. The two decorators are `@simpype.pipe.enqueue` and `@simpype.pipe.dequeue` (see *enqueue()* and *dequeue()* for more details). There are two ways of customizing the behavior of a pipe:

- Work directly on the simulation scenario and perform an *inline customization*;

- Create a *pipe model* to be included in the simulation scenario.

Either approaches are valid, however *inline customization* is more suited for small customizations while *pipe model* is more suited for larger customizations and code re-usability (you can include the smae model multiple times in different simulations).

2.8.1 Inline customization

In this example, a priority queue with two service classes is implemented.

```python
import simpype
import random

sim = simpype.Simulation(id = 'simple')
gen0 = sim.add_generator(id = 'gen0')
gen0.message.property['priority'] = {
    0: lambda: random.randint(0,1)
}
res0 = sim.add_resource(id = 'res0')
res0.pipe.add_queue('slow')
res0.pipe.add_queue('fast')
res0.random['service'] = {
    0: lambda: 2.0
}

@simpype.pipe.enqueue(res0.pipe)
def enqueue(self, message):
    if message.property['priority'] == 0:
        return self.queue['slow'].push(message)
    elif message.property['priority'] == 1:
        return self.queue['fast'].push(message)
    else:
        return message.drop('unsupported priority')

@simpype.pipe.dequeue(res0.pipe)
def dequeue(self):
    if len(self.queue['fast']) > 0:
        return self.queue['fast'].pop()
    elif len(self.queue['slow']) > 0:
        return self.queue['slow'].pop()
    else
        return None

sim.run(until = 10)
```

2.8.2 Custom model

Alternatively, a separate *pipe model* can be created to implement the same pipe behavior:

1. Edit `mypipe.py` with a text editor and create a pipe model in the following way:

```python
import simpype

class MyPipe(simpype.Pipe):
    def __init__(self, sim, resource, id):
        super().__init__(sim, resource, id)
        self.add_queue(id = 'slow')
        self.add_queue(id = 'fast')

    @simpype.pipe.enqueue
    def enqueue(self, message):
        if message.property['priority'] == 0:
```

(continues on next page)

```python
            return self.queue['slow'].push(message)
        elif message.property['priority'] == 1:
            return self.queue['fast'].push(message)
        else:
            return message.drop('unsupported priority')

    @simpype.pipe.dequeue
    def dequeue(self):
        if len(self.queue['fast']) > 0:
            return self.queue['fast'].pop()
        elif len(self.queue['slow']) > 0:
            return self.queue['slow'].pop()
        else
            return None

# Do NOT remove. This is required for SimPype to build your model.
pipe = lambda *args: MyPipe(*args)
```

2. Create your simulation scenario including the new model:

```python
import simpype
import random

sim = simpype.Simulation(id = 'simple')
gen0 = sim.add_generator(id = 'gen0')
gen0.message.property['priority'] = {
    0: lambda: random.randint(0,1)
}
res0 = sim.add_resource(id = 'res0', pipe = 'mypipe')
res0.random['service'] = {
    0: lambda: 2.0
}

sim.run(until = 10)
```

3. Make sure that the file and directory structure is the following:

```
<working directory>
|-- simple.py
|-- mypipe.py
```

4. If you want to change the directory where SimPype looks for custom models, set the following variable in the simulation environment:

```python
import simpype

sim = simpype.Simulation(id = 'simple')
sim.model.dir = '<your model dir>'
```

Please make sure you have reading permissions for `<your model dir>`. In this case, the file and directory structure would look like:

```
<working directory>
|-- simple.py

<your model dir>
|-- mypipe.py
```

2.9 Queue

The queue behavior of a given pipe can be customized in case of more complex queueing operations are needed in addition to the simple FIFO buffer. With this purpose, two decorators can be used to determine the *push* and *pop* behavior of the queue. The two decorators are `@simpype.queue.push` and `@simpype.queue.pop` (see *push()* and *pop()* for more details). There are two ways of customizing the behavior of a queue:

- Work directly on the simulation scenario and perform an *inline customization*;

- Create a *queue model* to be included in the simulation scenario through a custom *pipe model*.

Either approaches are valid, however *inline customization* is more suited for small customizations while *queue model* is more suited for larger customizations and code re-usability (you can include the smae model multiple times in different simulations).

2.9.1 Inline customization

In this example, a LIFO discipline is implemented.

```python
import simpype
import random

sim = simpype.Simulation(id = 'simple')
gen0 = sim.add_generator(id = 'gen0')
gen0.message.property['priority'] = {
    0: lambda: random.randint(0,1)
}
res0 = sim.add_resource(id = 'res0')
res0.pipe.add_queue(id = 'lifo')
res0.random['service'] = {
    0: lambda: 2.0
}

@simpype.pipe.enqueue(res0.pipe)
def enqueue(self, message):
    return self.queue['lifo'].push(message)

@simpype.pipe.dequeue(res0.pipe)
def dequeue(self):
    return self.queue['lifo'].pop()

@simpype.queue.push(res0.pipe.queue['lifo'])
def push(self, message):
    return self.buffer.append(message)

@simpype.queue.pop(res0.pipe.queue['lifo'])
def pop(self):
    return self.buffer.pop(-1)

sim.run(until = 10)
```

2.9.2 Custom model

Alternatively, a separate *pipe model* and *queue model* can be created to implement the same discipline:

1. Edit `mylifo.py` with a text editor and create a pipe model in the following way:

```python
import simpype


class MyQueue(simpype.Queue):
    def __init__(self, sim, pipe, id):
        super().__init__(sim, pipe, id)

    @simpype.queue.push
    def push(self, message):
        return self.buffer.append(message)

    @simpype.queue.pop
    def pop(self):
        return self.buffer.pop(-1)


class MyPipe(simpype.Pipe):
    def __init__(self, sim, resource, id):
        super().__init__(sim, resource, id)
        self.add_queue(id = 'lifo', model = 'mylifo')

    @simpype.pipe.enqueue
    def enqueue(self, message):
        return self.queue['lifo'].push(message)

    @simpype.pipe.dequeue
    def dequeue(self):
        return self.queue['lifo'].pop()

# Do NOT remove. This is required for SimPype to build your model.
queue = lambda *args: MyQueue(*args)
pipe = lambda *args: MyPipe(*args)
```

2. Create your simulation scenario including the new model:

```python
import simpype
import random

sim = simpype.Simulation(id = 'simple')
gen0 = sim.add_generator(id = 'gen0')
gen0.message.property['priority'] = {
    0: lambda: random.randint(0,1)
}
res0 = sim.add_resource(id = 'res0', pipe = 'mylifo')
res0.random['service'] = {
    0: lambda: 2.0
}

sim.run(until = 10)
```

3. Make sure that the file and directory structure is the following:

```
<working directory>
|-- simple.py
|-- mylifo.py
```

4. If you want to change the directory where SimPype looks for custom models, set the following variable in the simulation environment:

```python
import simpype

sim = simpype.Simulation(id = 'simple')
sim.model.dir = '<your model dir>'
```

Please make sure you have reading permissions for `<your model dir>`. In this case, the file and directory structure would look like:

```
<working directory>
|-- simple.py

<your model dir>
|-- mylifo.py
```

Examples

This section contains examples of SimPype simulations. The source code of the examples is also available on GitHub.

3.1 Bank renege

SimPype features used in this example: Message lifetime.

The scenario of the simulation is the classical bank renege:

```
|Customer| -> |Counter|
```

This is example is taken from SimPy. This example models a bank counter and customers arriving t random times. Each customer has a certain patience. It waits to get to the counter until she's at the end of her tether. If she gets to the counter, she uses it for a while before releasing it.

The scenario is so implemented with SimPype:

```python
# Import SimPype module
import simpype
# Import python random module
import random

NEW_CUSTOMERS = 5  # Total number of customers
INTERVAL_CUSTOMERS = 10.0  # Generate new customers roughly every x seconds
MIN_PATIENCE = 1  # Min. customer patience
MAX_PATIENCE = 3  # Max. customer patience
TIME_IN_BANK = 12.0 # Time spent in the bank by the customers

# [Mandatory] Create a SimPype simulation object
sim = simpype.Simulation(id = 'bank')
# [Optional] Fix the seed for the pseudo-random generator
sim.seed = 42
# [Optional] Configure the log directory.
# [Default] Log are store by default in the 'current working directory/log'
```

```python
sim.log.dir = 'log'
# [Optional] Disable the logging to file and print to console instead
#sim.log.file = False
#sim.log.print = True

# [Mandatory] Add at least one generator to the simulation
customer = sim.add_generator(id = 'customer')
# Generate 5 customer arrivals
customer.to_send = NEW_CUSTOMERS
# [Mandatory] Assign an arrival time
customer.random['arrival'] = {
        0: lambda: random.expovariate(1.0 / INTERVAL_CUSTOMERS)
}
# Assign a patience to the customer
customer.message.property['lifetime'] = {
        0: lambda: random.uniform(MIN_PATIENCE, MAX_PATIENCE)
}

# [Mandatory] Add at least one resource to the simulation
counter = sim.add_resource(id = 'counter')
# [Mandatory] Assign a service time
counter.random['service'] = {
        0: lambda: random.expovariate(1.0 / TIME_IN_BANK)
}

# Define the resource service behavior when receiving a message
@simpype.resource.service(counter)
def service(self, message):
        # Unsubscribe the customer from the lifetime event so to not leave
        # while being served.
        message.unsubscribe('lifetime')
        # Wait a random time according to random.expovariate(0.10) distribution
        yield self.env.timeout(self.random['service'].value)

# [Mandatory] Add a pipeline connecting the generator and the resource
p0 = sim.add_pipeline(customer, counter)

# [Mandatory] Run the simulation
# The simulations stops if no events are available
# (e.g., 5 customers have been served)
sim.run()
```

sim.cfg stored under the log folder contains:

```
Simulation Seed: 42
Simulation Time: 29.943697835
Execution Time: 0.003769120
```

sim.log stored under the log folder contains:

```
timestamp,message,seq_num,resource,event
0.000000000,customer,0,counter,pipe.in
0.000000000,customer,0,counter,pipe.out
3.031034228,customer,0,counter,resource.serve
3.216240641,customer,1,counter,pipe.in
3.216240641,customer,1,counter,pipe.out
14.507970729,customer,2,counter,pipe.in
```

```
15.681848394,customer,2,counter,pipe.default.expired
19.988432323,customer,3,counter,pipe.in
21.048026762,customer,3,counter,pipe.default.expired
22.455599282,customer,4,counter,pipe.in
24.466309859,customer,4,counter,pipe.default.expired
29.943697835,customer,1,counter,resource.serve
```

3.2 Supermarket

SimPype features used in this example: Random variables, Resource inline customization, Log custom message properties.

The scenario of the simulation is a supermaket:

```
    |Mom| -\
          ) -> |Cashier|
|Single| -/
```

This example models the last 4 hours of a normal working day of a supermarket. There are two types of customer (`mom` and `single`) arriving at different times and purchasing a variable number of `items` each. The customers pay the goods at a cashier who takes a random service time for `scanning the items` and `finalize the payment`. The arrival time and the number of time vary depending on the hour for both types of customer. Both customers cease to arrive at hour 4 because of the supermarket doors have been closed and no one is allowed to enter. Nevertheless, customers already in the supermarket will do their grocery as usual. Moreover, there are no single customers arriving between the 2nd and 3rd hour.

The scenario is so implemented with SimPype:

```python
# Import SimPype module
import simpype
# Import python random module
import random

# [Mandatory] Create a SimPype simulation object
sim = simpype.Simulation(id = 'supermarket')
# [Optional] Fix the seed for the pseudo-random generator
sim.seed = 42
# [Optional] Configure the log directory.
# [Default] Log are store by default in the 'current working directory/log'
sim.log.dir = 'log'
# [Optional] Disable the logging to file and print to console instead
#sim.log.file = False
#sim.log.print = True
# [Optional] Log custom message properties
sim.log.property('items')

# [Mandatory] Add at least one generator to the simulation
mom = sim.add_generator(id = 'mom')
# [Mandatory] Assign an arrival time
mom.random['arrival'] = {
        # 0h
        0: lambda: random.expovariate(1.0 / 60.0),
        # 1h
        3600: lambda: random.expovariate(1.0 / 300.0),
```

```python
        # 2h
        7200: lambda: random.expovariate(1.0 / 180.0),
        # 3h
        10800: lambda: random.expovariate(1.0 / 600.0),
        # 4h
        # The supermarket closes and new customer are not allowed to enter
        14400: lambda: None
}
mom.message.property['items'] = {
        # 0h
        0: lambda: random.randint(10, 50),
        # 1h
        3600: lambda: random.randint(5, 25),
        # 2h
        7200: lambda: random.randint(15, 45),
        # 3h
        10800: lambda: random.randint(5, 50),
}

# [Mandatory] Add at least one generator to the simulation
single = sim.add_generator(id = 'single')
# [Mandatory] Assign an arrival time
single.random['arrival'] = {
        # 1h
        3600: lambda: random.expovariate(1.0 / 3600.0),
        # 2h
        # No single comes to the supermarket
        7200: lambda: None,
        # 3h
        10800: lambda: random.expovariate(1.0 / 30.0),
        # 4h
        # The supermarket closes and new customer are not allowed to enter
        14400: lambda: None
}
single.message.property['items'] = {
        # 1h
        3600: lambda: random.randint(5, 25),
        # 3h
        10800: lambda: random.randint(1, 5),
}

# [Mandatory] Add at least one resource to the simulation
cashier = sim.add_resource(id = 'cashier')
# Define the cashier service behavior when receiving a message
@simpype.resource.service(cashier)
def service(self, message):
        for i in range(0, message.property['items'].value):
                yield self.env.timeout(random.expovariate(1.0 / 2.0))
        yield self.env.timeout(random.expovariate(1.0 / 30.0))

# [Mandatory] Add a pipeline connecting the generator and the resource
p0 = sim.add_pipeline(mom, cashier)
p1 = sim.add_pipeline(single, cashier)

# [Mandatory] Run the simulation
sim.run()
```

`sim.cfg` stored under the `log` folder contains:

```
Simulation Seed: 42
Simulation Time: 14899.608748515
Execution Time: 0.158448884
```

`sim.log` stored under the `log` folder contains:

```
timestamp,message,seq_num,resource,event,items
53.388522378,mom,0,cashier,pipe.in,10
53.388522378,mom,0,cashier,pipe.out,10
63.705582990,mom,0,cashier,resource.serve,10
138.718083873,mom,1,cashier,pipe.in,39
138.718083873,mom,1,cashier,pipe.out,39
184.819829315,mom,2,cashier,pipe.in,50
221.256144325,mom,1,cashier,resource.serve,39
221.256144325,mom,2,cashier,pipe.out,50
254.736108725,mom,3,cashier,pipe.in,17
264.688144177,mom,4,cashier,pipe.in,26
385.844345447,mom,2,cashier,resource.serve,50
385.844345447,mom,3,cashier,pipe.out,17
440.480361404,mom,3,cashier,resource.serve,17
440.480361404,mom,4,cashier,pipe.out,26
477.278091226,mom,5,cashier,pipe.in,23
504.341904366,mom,4,cashier,resource.serve,26
504.341904366,mom,5,cashier,pipe.out,23
523.769979715,mom,6,cashier,pipe.in,18
556.648579069,mom,7,cashier,pipe.in,25
567.562277900,mom,8,cashier,pipe.in,41
606.954811567,mom,9,cashier,pipe.in,35
660.563541416,mom,5,cashier,resource.serve,23
660.563541416,mom,6,cashier,pipe.out,18
706.564013156,mom,6,cashier,resource.serve,18
706.564013156,mom,7,cashier,pipe.out,25
746.593836237,mom,10,cashier,pipe.in,14
747.155383264,mom,11,cashier,pipe.in,49
917.090782723,mom,7,cashier,resource.serve,25
917.090782723,mom,8,cashier,pipe.out,41
997.674205259,mom,8,cashier,resource.serve,41
997.674205259,mom,9,cashier,pipe.out,35
1094.237239136,mom,9,cashier,resource.serve,35
1094.237239136,mom,10,cashier,pipe.out,14
1135.497554920,mom,12,cashier,pipe.in,35
1155.321703927,mom,10,cashier,resource.serve,14
1155.321703927,mom,11,cashier,pipe.out,49
1203.773327065,mom,13,cashier,pipe.in,22
1230.947627207,mom,14,cashier,pipe.in,21
1288.298644241,mom,15,cashier,pipe.in,20
1297.292748821,mom,11,cashier,resource.serve,49
1297.292748821,mom,12,cashier,pipe.out,35
1352.824756211,mom,16,cashier,pipe.in,37
1367.643360603,mom,17,cashier,pipe.in,43
1409.579860824,mom,12,cashier,resource.serve,35
1409.579860824,mom,13,cashier,pipe.out,22
1481.165000235,mom,13,cashier,resource.serve,22
1481.165000235,mom,14,cashier,pipe.out,21
1531.515701299,mom,14,cashier,resource.serve,21
1531.515701299,mom,15,cashier,pipe.out,20
```

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1560.952553042,mom,15,cashier,resource.serve,20
1560.952553042,mom,16,cashier,pipe.out,37
1632.478939040,mom,18,cashier,pipe.in,16
1684.341371340,mom,19,cashier,pipe.in,25
1690.789890052,mom,20,cashier,pipe.in,29
1708.948405492,mom,16,cashier,resource.serve,37
1708.948405492,mom,17,cashier,pipe.out,43
1804.006200358,mom,17,cashier,resource.serve,43
1804.006200358,mom,18,cashier,pipe.out,16
1804.734499582,mom,21,cashier,pipe.in,15
1821.307862556,mom,22,cashier,pipe.in,33
1859.770810879,mom,23,cashier,pipe.in,27
1865.184076185,mom,18,cashier,resource.serve,16
1865.184076185,mom,19,cashier,pipe.out,25
1881.741695100,mom,24,cashier,pipe.in,27
1943.361829976,mom,19,cashier,resource.serve,25
1943.361829976,mom,20,cashier,pipe.out,29
1959.110269015,mom,25,cashier,pipe.in,13
1968.983435168,mom,26,cashier,pipe.in,15
2041.302187370,mom,20,cashier,resource.serve,29
2041.302187370,mom,21,cashier,pipe.out,15
2097.503696012,mom,21,cashier,resource.serve,15
2097.503696012,mom,22,cashier,pipe.out,33
2196.998303435,mom,22,cashier,resource.serve,33
2196.998303435,mom,23,cashier,pipe.out,27
2264.306918367,mom,23,cashier,resource.serve,27
2264.306918367,mom,24,cashier,pipe.out,27
2275.129947122,mom,27,cashier,pipe.in,38
2334.268055485,mom,24,cashier,resource.serve,27
2334.268055485,mom,25,cashier,pipe.out,13
2402.770568286,mom,28,cashier,pipe.in,47
2408.485728182,mom,25,cashier,resource.serve,13
2408.485728182,mom,26,cashier,pipe.out,15
2465.204046373,mom,26,cashier,resource.serve,15
2465.204046373,mom,27,cashier,pipe.out,38
2568.345896853,mom,27,cashier,resource.serve,38
2568.345896853,mom,28,cashier,pipe.out,47
2694.757919705,mom,28,cashier,resource.serve,47
2811.644676457,mom,29,cashier,pipe.in,13
2811.644676457,mom,29,cashier,pipe.out,13
2842.245771344,mom,29,cashier,resource.serve,13
2956.534131679,mom,30,cashier,pipe.in,50
2956.534131679,mom,30,cashier,pipe.out,50
3018.899391741,mom,31,cashier,pipe.in,45
3046.220486290,mom,32,cashier,pipe.in,16
3084.080166937,mom,30,cashier,resource.serve,50
3084.080166937,mom,31,cashier,pipe.out,45
3113.626125282,mom,33,cashier,pipe.in,27
3115.621931164,mom,34,cashier,pipe.in,25
3174.310206816,mom,31,cashier,resource.serve,45
3174.310206816,mom,32,cashier,pipe.out,16
3215.816734770,mom,32,cashier,resource.serve,16
3215.816734770,mom,33,cashier,pipe.out,27
3231.669800033,mom,35,cashier,pipe.in,13
3333.665828154,mom,33,cashier,resource.serve,27
3333.665828154,mom,34,cashier,pipe.out,25
3443.653811732,mom,34,cashier,resource.serve,25
```

```
3443.653811732,mom,35,cashier,pipe.out,13
3470.095347275,mom,35,cashier,resource.serve,13
3624.714427551,single,0,cashier,pipe.in,13
3624.714427551,single,0,cashier,pipe.out,13
3625.381811847,mom,36,cashier,pipe.in,22
3710.465613459,single,0,cashier,resource.serve,13
3710.465613459,mom,36,cashier,pipe.out,22
3748.507941095,mom,36,cashier,resource.serve,22
4726.653621788,mom,37,cashier,pipe.in,21
4726.653621788,mom,37,cashier,pipe.out,21
4762.903334828,mom,38,cashier,pipe.in,7
4800.801917304,mom,37,cashier,resource.serve,21
4800.801917304,mom,38,cashier,pipe.out,7
4839.622135344,mom,38,cashier,resource.serve,7
4914.690171668,mom,39,cashier,pipe.in,14
4914.690171668,mom,39,cashier,pipe.out,14
4951.399238012,mom,40,cashier,pipe.in,10
4951.747273721,mom,39,cashier,resource.serve,14
4951.747273721,mom,40,cashier,pipe.out,10
4974.825368308,mom,40,cashier,resource.serve,10
4975.235400012,mom,41,cashier,pipe.in,9
4975.235400012,mom,41,cashier,pipe.out,9
5026.018139866,mom,41,cashier,resource.serve,9
5403.639546918,mom,42,cashier,pipe.in,24
5403.639546918,mom,42,cashier,pipe.out,24
5460.836646269,mom,42,cashier,resource.serve,24
5520.757041358,mom,43,cashier,pipe.in,24
5520.757041358,mom,43,cashier,pipe.out,24
5588.212113514,mom,43,cashier,resource.serve,24
5714.423806321,mom,44,cashier,pipe.in,24
5714.423806321,mom,44,cashier,pipe.out,24
5850.558660535,mom,44,cashier,resource.serve,24
6334.155611550,mom,45,cashier,pipe.in,20
6334.155611550,mom,45,cashier,pipe.out,20
6398.115520887,mom,46,cashier,pipe.in,19
6428.275478037,mom,45,cashier,resource.serve,20
6428.275478037,mom,46,cashier,pipe.out,19
6472.074069124,mom,46,cashier,resource.serve,19
6681.056449853,mom,47,cashier,pipe.in,20
6681.056449853,mom,47,cashier,pipe.out,20
6697.496991554,single,1,cashier,pipe.in,9
6725.978312572,mom,47,cashier,resource.serve,20
6725.978312572,single,1,cashier,pipe.out,9
6772.294425569,single,1,cashier,resource.serve,9
7302.777031359,mom,48,cashier,pipe.in,43
7302.777031359,mom,48,cashier,pipe.out,43
7317.634305137,mom,49,cashier,pipe.in,29
7329.310221598,mom,50,cashier,pipe.in,24
7430.251437643,mom,51,cashier,pipe.in,20
7438.117543205,mom,48,cashier,resource.serve,43
7438.117543205,mom,49,cashier,pipe.out,29
7503.277090954,mom,49,cashier,resource.serve,29
7503.277090954,mom,50,cashier,pipe.out,24
7550.085461078,mom,50,cashier,resource.serve,24
7550.085461078,mom,51,cashier,pipe.out,20
7583.221811223,mom,51,cashier,resource.serve,20
7749.610353076,mom,52,cashier,pipe.in,26
```

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7749.610353076,mom,52,cashier,pipe.out,26
7840.970143277,mom,53,cashier,pipe.in,42
7866.978728331,mom,52,cashier,resource.serve,26
7866.978728331,mom,53,cashier,pipe.out,42
7871.819955813,mom,54,cashier,pipe.in,20
8021.307033541,mom,53,cashier,resource.serve,42
8021.307033541,mom,54,cashier,pipe.out,20
8086.713238957,mom,54,cashier,resource.serve,20
8155.933095292,mom,55,cashier,pipe.in,39
8155.933095292,mom,55,cashier,pipe.out,39
8308.744581518,mom,56,cashier,pipe.in,29
8400.944873280,mom,55,cashier,resource.serve,39
8400.944873280,mom,56,cashier,pipe.out,29
8433.065121924,mom,57,cashier,pipe.in,38
8455.844627545,mom,56,cashier,resource.serve,29
8455.844627545,mom,57,cashier,pipe.out,38
8515.029140747,mom,58,cashier,pipe.in,35
8519.890693484,mom,59,cashier,pipe.in,40
8546.994281535,mom,57,cashier,resource.serve,38
8546.994281535,mom,58,cashier,pipe.out,35
8639.080922386,mom,58,cashier,resource.serve,35
8639.080922386,mom,59,cashier,pipe.out,40
8756.522523552,mom,59,cashier,resource.serve,40
9163.855758010,mom,60,cashier,pipe.in,19
9163.855758010,mom,60,cashier,pipe.out,19
9164.790843007,mom,61,cashier,pipe.in,44
9195.733794567,mom,62,cashier,pipe.in,28
9229.064878175,mom,60,cashier,resource.serve,19
9229.064878175,mom,61,cashier,pipe.out,44
9362.266384547,mom,61,cashier,resource.serve,44
9362.266384547,mom,62,cashier,pipe.out,28
9423.001910450,mom,62,cashier,resource.serve,28
9580.780588692,mom,63,cashier,pipe.in,37
9580.780588692,mom,63,cashier,pipe.out,37
9661.614962737,mom,64,cashier,pipe.in,45
9684.635313470,mom,63,cashier,resource.serve,37
9684.635313470,mom,64,cashier,pipe.out,45
9759.778215239,mom,65,cashier,pipe.in,27
9785.926426820,mom,64,cashier,resource.serve,45
9785.926426820,mom,65,cashier,pipe.out,27
9847.272798995,mom,65,cashier,resource.serve,27
9863.812470714,mom,66,cashier,pipe.in,22
9863.812470714,mom,66,cashier,pipe.out,22
9928.203425134,mom,67,cashier,pipe.in,30
9939.328726127,mom,66,cashier,resource.serve,22
9939.328726127,mom,67,cashier,pipe.out,30
9970.380503908,mom,68,cashier,pipe.in,24
10056.619170012,mom,69,cashier,pipe.in,33
10081.623508021,mom,67,cashier,resource.serve,30
10081.623508021,mom,68,cashier,pipe.out,24
10186.609937203,mom,68,cashier,resource.serve,24
10186.609937203,mom,69,cashier,pipe.out,33
10285.760666089,mom,70,cashier,pipe.in,29
10333.963957210,mom,69,cashier,resource.serve,33
10333.963957210,mom,70,cashier,pipe.out,29
10420.001126747,mom,70,cashier,resource.serve,29
10435.595233794,mom,71,cashier,pipe.in,16
```

```
10435.595233794,mom,71,cashier,pipe.out,16
10471.174764090,mom,72,cashier,pipe.in,17
10505.868282321,mom,71,cashier,resource.serve,16
10505.868282321,mom,72,cashier,pipe.out,17
10586.274229677,mom,72,cashier,resource.serve,17
10596.226909721,mom,73,cashier,pipe.in,17
10596.226909721,mom,73,cashier,pipe.out,17
10639.173597500,mom,73,cashier,resource.serve,17
10862.472856427,mom,74,cashier,pipe.in,11
10862.472856427,mom,74,cashier,pipe.out,11
10878.440600501,mom,75,cashier,pipe.in,41
10920.645682552,mom,74,cashier,resource.serve,11
10920.645682552,mom,75,cashier,pipe.out,41
11001.175008454,mom,75,cashier,resource.serve,41
11320.204359971,mom,76,cashier,pipe.in,39
11320.204359971,mom,76,cashier,pipe.out,39
11418.040334834,mom,76,cashier,resource.serve,39
11439.221666502,mom,77,cashier,pipe.in,32
11439.221666502,mom,77,cashier,pipe.out,32
11506.414156254,mom,78,cashier,pipe.in,20
11543.046066255,mom,77,cashier,resource.serve,32
11543.046066255,mom,78,cashier,pipe.out,20
11600.623405791,mom,78,cashier,resource.serve,20
11941.808820029,mom,79,cashier,pipe.in,28
11941.808820029,mom,79,cashier,pipe.out,28
12015.436273202,mom,79,cashier,resource.serve,28
12178.510489210,mom,80,cashier,pipe.in,16
12178.510489210,mom,80,cashier,pipe.out,16
12207.193040343,mom,80,cashier,resource.serve,16
12664.201223595,mom,81,cashier,pipe.in,6
12664.201223595,mom,81,cashier,pipe.out,6
12715.083847551,mom,81,cashier,resource.serve,6
13098.775949674,single,2,cashier,pipe.in,4
13098.775949674,single,2,cashier,pipe.out,4
13119.421508520,single,2,cashier,resource.serve,4
13122.712931748,single,3,cashier,pipe.in,1
13122.712931748,single,3,cashier,pipe.out,1
13131.275269051,single,3,cashier,resource.serve,1
13165.526938783,single,4,cashier,pipe.in,4
13165.526938783,single,4,cashier,pipe.out,4
13168.768410542,single,5,cashier,pipe.in,2
13179.370630698,single,6,cashier,pipe.in,4
13188.518131864,single,7,cashier,pipe.in,1
13233.352116590,single,8,cashier,pipe.in,2
13240.419160405,single,9,cashier,pipe.in,5
13247.922008072,single,4,cashier,resource.serve,4
13247.922008072,single,5,cashier,pipe.out,2
13270.521083522,single,5,cashier,resource.serve,2
13270.521083522,single,6,cashier,pipe.out,4
13275.470920394,single,10,cashier,pipe.in,2
13305.970959407,single,6,cashier,resource.serve,4
13305.970959407,single,7,cashier,pipe.out,1
13324.581436875,single,11,cashier,pipe.in,3
13334.827986552,single,12,cashier,pipe.in,3
13422.236921087,single,7,cashier,resource.serve,1
13422.236921087,single,8,cashier,pipe.out,2
13426.173989088,single,13,cashier,pipe.in,1
```

```
13430.545193706,single,14,cashier,pipe.in,4
13469.890130609,single,8,cashier,resource.serve,2
13469.890130609,single,9,cashier,pipe.out,5
13505.858837218,single,15,cashier,pipe.in,2
13525.855461182,single,9,cashier,resource.serve,5
13525.855461182,single,10,cashier,pipe.out,2
13548.857094132,single,16,cashier,pipe.in,3
13555.297188255,single,10,cashier,resource.serve,2
13555.297188255,single,11,cashier,pipe.out,3
13578.507845571,single,17,cashier,pipe.in,4
13600.254007959,single,18,cashier,pipe.in,3
13603.505461711,single,11,cashier,resource.serve,3
13603.505461711,single,12,cashier,pipe.out,3
13617.632172212,mom,82,cashier,pipe.in,10
13635.848174634,single,19,cashier,pipe.in,4
13636.418652953,single,12,cashier,resource.serve,3
13636.418652953,single,13,cashier,pipe.out,1
13666.070809412,single,20,cashier,pipe.in,5
13681.281588370,single,21,cashier,pipe.in,4
13695.743461287,single,13,cashier,resource.serve,1
13695.743461287,single,14,cashier,pipe.out,4
13704.338968154,single,14,cashier,resource.serve,4
13704.338968154,single,15,cashier,pipe.out,2
13733.544561336,single,22,cashier,pipe.in,1
13734.955514825,single,23,cashier,pipe.in,4
13735.447975326,single,24,cashier,pipe.in,2
13752.911499520,single,25,cashier,pipe.in,1
13778.644266192,single,15,cashier,resource.serve,2
13778.644266192,single,16,cashier,pipe.out,3
13859.608792531,single,16,cashier,resource.serve,3
13859.608792531,single,17,cashier,pipe.out,4
13882.266729765,single,17,cashier,resource.serve,4
13882.266729765,single,18,cashier,pipe.out,3
13888.311805612,single,18,cashier,resource.serve,3
13888.311805612,mom,82,cashier,pipe.out,10
13897.160358595,single,26,cashier,pipe.in,2
13916.594487611,single,27,cashier,pipe.in,1
13935.970711662,mom,82,cashier,resource.serve,10
13935.970711662,single,19,cashier,pipe.out,4
13977.829554394,single,19,cashier,resource.serve,4
13977.829554394,single,20,cashier,pipe.out,5
14028.289453620,single,20,cashier,resource.serve,5
14028.289453620,single,21,cashier,pipe.out,4
14040.557714784,single,21,cashier,resource.serve,4
14040.557714784,single,22,cashier,pipe.out,1
14049.669741552,single,28,cashier,pipe.in,2
14060.057355983,single,22,cashier,resource.serve,1
14060.057355983,single,23,cashier,pipe.out,4
14070.419057185,single,23,cashier,resource.serve,4
14070.419057185,single,24,cashier,pipe.out,2
14079.342039692,single,29,cashier,pipe.in,4
14092.336486740,single,30,cashier,pipe.in,4
14100.139845307,single,24,cashier,resource.serve,2
14100.139845307,single,25,cashier,pipe.out,1
14103.664850673,single,31,cashier,pipe.in,1
14110.170135915,single,25,cashier,resource.serve,1
14110.170135915,single,26,cashier,pipe.out,2
```

```
14112.222083383,single,32,cashier,pipe.in,3
14149.743690713,single,26,cashier,resource.serve,2
14149.743690713,single,27,cashier,pipe.out,1
14157.505741421,single,33,cashier,pipe.in,3
14164.404960620,single,34,cashier,pipe.in,5
14185.733937182,single,27,cashier,resource.serve,1
14185.733937182,single,28,cashier,pipe.out,2
14185.776240842,single,35,cashier,pipe.in,3
14216.944382950,single,36,cashier,pipe.in,2
14237.433619080,single,37,cashier,pipe.in,1
14238.916531782,single,28,cashier,resource.serve,2
14238.916531782,single,29,cashier,pipe.out,4
14245.709455749,single,38,cashier,pipe.in,3
14249.955771005,single,39,cashier,pipe.in,5
14258.952437165,single,29,cashier,resource.serve,4
14258.952437165,single,30,cashier,pipe.out,4
14266.342285116,single,40,cashier,pipe.in,1
14266.847192287,single,41,cashier,pipe.in,1
14267.263875455,single,42,cashier,pipe.in,2
14268.483125214,single,43,cashier,pipe.in,1
14286.152717641,single,30,cashier,resource.serve,4
14286.152717641,single,31,cashier,pipe.out,1
14324.237273525,single,31,cashier,resource.serve,1
14324.237273525,single,32,cashier,pipe.out,3
14357.573365606,single,44,cashier,pipe.in,5
14359.977074470,single,32,cashier,resource.serve,3
14359.977074470,single,33,cashier,pipe.out,3
14369.615403367,single,33,cashier,resource.serve,3
14369.615403367,single,34,cashier,pipe.out,5
14386.290423847,single,45,cashier,pipe.in,1
14397.429704473,single,46,cashier,pipe.in,4
14405.306718746,mom,83,cashier,pipe.in,20
14415.336868575,single,34,cashier,resource.serve,5
14415.336868575,single,35,cashier,pipe.out,3
14434.896110713,single,35,cashier,resource.serve,3
14434.896110713,single,36,cashier,pipe.out,2
14436.705079699,single,47,cashier,pipe.in,3
14471.159983859,single,36,cashier,resource.serve,2
14471.159983859,single,37,cashier,pipe.out,1
14471.928669764,single,37,cashier,resource.serve,1
14471.928669764,single,38,cashier,pipe.out,3
14486.390470761,single,38,cashier,resource.serve,3
14486.390470761,single,39,cashier,pipe.out,5
14557.621426597,single,39,cashier,resource.serve,5
14557.621426597,single,40,cashier,pipe.out,1
14564.030785291,single,40,cashier,resource.serve,1
14564.030785291,single,41,cashier,pipe.out,1
14580.873449642,single,41,cashier,resource.serve,1
14580.873449642,single,42,cashier,pipe.out,2
14592.632353518,single,42,cashier,resource.serve,2
14592.632353518,single,43,cashier,pipe.out,1
14629.642355160,single,43,cashier,resource.serve,1
14629.642355160,single,44,cashier,pipe.out,5
14641.980204918,single,44,cashier,resource.serve,5
14641.980204918,single,45,cashier,pipe.out,1
14712.354265669,single,45,cashier,resource.serve,1
14712.354265669,single,46,cashier,pipe.out,4
```

```
14776.250875656,single,46,cashier,resource.serve,4
14776.250875656,mom,83,cashier,pipe.out,20
14833.994298247,mom,83,cashier,resource.serve,20
14833.994298247,single,47,cashier,pipe.out,3
14899.608748515,single,47,cashier,resource.serve,3
```
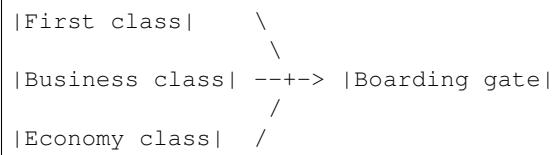
3.3 Boarding gate

SimPype features used in this example: Random variables, Pipe custom model.

The scenario of the simulation is a boarding gate:

```
|First class|    \
                   \
|Business class| --+-> |Boarding gate|
                  /
|Economy class|  /
```

This simulation models a boarding gate for a flight with three separate classes: `first`, `business`, and `economy`. Boarding priority is given to the different classes according to the following order:

1. first class

2. business class

3. economy class

With `first class` having the highest priority and `economy class` having the lowest.

```python
import simpype
import random


# [Mandatory] Create a SimPype simulation object
sim = simpype.Simulation(id = 'boarding')
# [Optional] Fix the seed used by the pseudo-random generator
sim.seed = 42
# [Optional] Configure the log directory.
# [Default] Log are store by default in the 'current working directory/log'
sim.log.dir = 'log'
# [Optional] Disable the logging to file and print to console instead
#sim.log.file = False
#sim.log.print = True
# [Optional] Configure the path containting the models for the simulation.
# [Default] Current working directory
sim.model.dir = 'examples/model'

# Create a generator
first = sim.add_generator(id = 'first')
first.to_send = 12
# Assign an arrival time
first.random['arrival'] = {
        0   : lambda: random.expovariate(1.0 / 900),
        1800: lambda: random.expovariate(1.0 / 30)
}
# Create a generator
```

```python
business = sim.add_generator(id = 'business')
business.to_send = 24
# Assign an arrival time
business.random['arrival'] = {
        0   : lambda: random.expovariate(1.0 / 450),
        900 : lambda: random.expovariate(1.0 / 60),
        1800: lambda: random.expovariate(1.0 / 30),
}
# Create a generator
economy = sim.add_generator(id = 'economy')
economy.to_send = 160
# Assign an arrival time
economy.random['arrival'] = {
        0   : lambda: random.expovariate(1.0 / 60),
        600 : lambda: random.expovariate(1.0 / 30),
        1200: lambda: random.expovariate(1.0 / 10),
}


# Add a resource
gate = sim.add_resource(id = 'gate', pipe = 'p_priority')
gate.random['service'] = {
        # The gate opens 30 mins from the simulation start
        # Check boarding pass and passport takes ~10s
        1800: lambda: random.expovariate(1.0 / 10)
}


# Add a pipiline connecting the generator to the resource
p0 = sim.add_pipeline(first, gate)
p1 = sim.add_pipeline(business, gate)
p2 = sim.add_pipeline(economy, gate)

# Run the simulation
sim.run()
```

Where pipe model `p_priority` is so implemented:

```python
import simpype


class Priority(simpype.pipe.Pipe):
        def __init__(self, sim, resource, id):
                super().__init__(sim, resource, id)
                self.add_queue(id = 'express')
                self.add_queue(id = 'fast')
                self.add_queue(id = 'slow')

        @simpype.pipe.dequeue
        def dequeue(self):
                if len(self.queue['express']) > 0:
                        m = self.queue['express'].pop()
                elif len(self.queue['fast']) > 0:
                        m = self.queue['fast'].pop()
                else:
                        m = self.queue['slow'].pop()
                return m

        @simpype.pipe.enqueue
```

```python
        def enqueue(self, message):
                if message.id == 'first':
                        m = self.queue['express'].push(message)
                elif message.id == 'business':
                        m = self.queue['fast'].push(message)
                elif message.id == 'economy':
                        m = self.queue['slow'].push(message)
                else:
                        m = self.queue['slow'].push(message)
                return m


# Do NOT remove
pipe = lambda *args: Priority(*args)
```

`sim.cfg` stored under the `log` folder contains:

```
Simulation Seed: 42
Simulation Time: 3902.496932801
Execution Time: 0.122058369
```

`sim.log` stored under the `log` folder contains:

```
timestamp,message,seq_num,resource,event
12.102481656,business,0,gate,pipe.in
12.102481656,business,0,gate,pipe.out
13.301500150,economy,0,gate,pipe.in
60.541255404,economy,1,gate,pipe.in
75.482840542,economy,2,gate,pipe.in
128.871362920,economy,3,gate,pipe.in
228.335648574,economy,4,gate,pipe.in
228.726846687,economy,5,gate,pipe.in
327.064798413,economy,6,gate,pipe.in
398.932194871,economy,7,gate,pipe.in
423.885900061,economy,8,gate,pipe.in
434.025076146,economy,9,gate,pipe.in
484.373882206,business,1,gate,pipe.in
623.116435052,economy,10,gate,pipe.in
626.036414593,economy,11,gate,pipe.in
629.087975142,economy,12,gate,pipe.in
633.523975080,first,0,gate,pipe.in
669.039900653,business,2,gate,pipe.in
685.504587391,economy,13,gate,pipe.in
724.754800305,economy,14,gate,pipe.in
747.805673026,economy,15,gate,pipe.in
856.292128596,economy,16,gate,pipe.in
870.562369082,economy,17,gate,pipe.in
894.653951447,economy,18,gate,pipe.in
947.707780984,economy,19,gate,pipe.in
976.618667138,economy,20,gate,pipe.in
1035.970065198,economy,21,gate,pipe.in
1061.806543439,economy,22,gate,pipe.in
1098.386430606,economy,23,gate,pipe.in
1099.793656814,economy,24,gate,pipe.in
1107.552825924,economy,25,gate,pipe.in
1117.801685640,economy,26,gate,pipe.in
1120.296351313,economy,27,gate,pipe.in
```

```
1128.246227605,economy,28,gate,pipe.in
1131.440442640,economy,29,gate,pipe.in
1141.211250040,economy,30,gate,pipe.in
1171.503296306,economy,31,gate,pipe.in
1185.119277203,economy,32,gate,pipe.in
1198.988959711,economy,33,gate,pipe.in
1206.041915204,economy,34,gate,pipe.in
1209.147708416,economy,35,gate,pipe.in
1236.739236349,economy,36,gate,pipe.in
1247.181482696,economy,37,gate,pipe.in
1256.575310976,economy,38,gate,pipe.in
1258.452334830,economy,39,gate,pipe.in
1271.513379397,economy,40,gate,pipe.in
1273.297501405,economy,41,gate,pipe.in
1278.069080072,economy,42,gate,pipe.in
1323.655143756,economy,43,gate,pipe.in
1333.871649561,economy,44,gate,pipe.in
1342.012370263,economy,45,gate,pipe.in
1353.551958156,economy,46,gate,pipe.in
1372.057625503,economy,47,gate,pipe.in
1387.018713825,economy,48,gate,pipe.in
1389.620006400,economy,49,gate,pipe.in
1389.946273948,economy,50,gate,pipe.in
1393.736254384,economy,51,gate,pipe.in
1396.852462715,economy,52,gate,pipe.in
1399.222134853,economy,53,gate,pipe.in
1409.618373385,business,3,gate,pipe.in
1427.853347906,economy,54,gate,pipe.in
1431.632010948,economy,55,gate,pipe.in
1442.286842594,economy,56,gate,pipe.in
1447.322560908,economy,57,gate,pipe.in
1466.608495340,first,1,gate,pipe.in
1471.920517539,economy,58,gate,pipe.in
1474.997735082,economy,59,gate,pipe.in
1477.829690040,economy,60,gate,pipe.in
1486.070637961,economy,61,gate,pipe.in
1489.118806453,economy,62,gate,pipe.in
1497.903602875,economy,63,gate,pipe.in
1520.714078238,economy,64,gate,pipe.in
1525.812347882,economy,65,gate,pipe.in
1528.288257049,economy,66,gate,pipe.in
1535.044944176,business,4,gate,pipe.in
1577.787960613,business,5,gate,pipe.in
1583.506592604,business,6,gate,pipe.in
1586.402342461,business,7,gate,pipe.in
1588.354471375,economy,67,gate,pipe.in
1593.370721964,business,8,gate,pipe.in
1598.228205347,economy,68,gate,pipe.in
1603.712787424,economy,69,gate,pipe.in
1604.369140848,economy,70,gate,pipe.in
1609.175650547,economy,71,gate,pipe.in
1664.698409753,economy,72,gate,pipe.in
1672.229809607,economy,73,gate,pipe.in
1687.606651856,business,9,gate,pipe.in
1707.661467448,economy,74,gate,pipe.in
1707.776941825,economy,75,gate,pipe.in
1720.532411132,economy,76,gate,pipe.in
```

```
1731.980346347,economy,77,gate,pipe.in
1739.679987805,economy,78,gate,pipe.in
1742.783699003,economy,79,gate,pipe.in
1753.026963858,economy,80,gate,pipe.in
1754.209757399,economy,81,gate,pipe.in
1759.914898885,economy,82,gate,pipe.in
1765.961202873,economy,83,gate,pipe.in
1796.712405792,economy,84,gate,pipe.in
1805.908515321,business,10,gate,pipe.in
1812.404983428,business,0,gate,resource.serve
1812.404983428,first,0,gate,pipe.out
1815.079377637,business,11,gate,pipe.in
1817.575290306,economy,85,gate,pipe.in
1819.348184371,first,0,gate,resource.serve
1819.348184371,first,1,gate,pipe.out
1820.983624853,business,12,gate,pipe.in
1831.617295308,business,13,gate,pipe.in
1839.790362416,first,1,gate,resource.serve
1839.790362416,business,1,gate,pipe.out
1841.951076056,economy,86,gate,pipe.in
1843.609724424,economy,87,gate,pipe.in
1849.180077779,business,1,gate,resource.serve
1849.180077779,business,2,gate,pipe.out
1856.931875433,business,2,gate,resource.serve
1856.931875433,business,3,gate,pipe.out
1857.986055729,economy,88,gate,pipe.in
1862.179418118,business,14,gate,pipe.in
1862.196579910,business,15,gate,pipe.in
1865.543809345,economy,89,gate,pipe.in
1865.740498479,economy,90,gate,pipe.in
1872.010914055,business,3,gate,resource.serve
1872.010914055,business,4,gate,pipe.out
1873.950372405,business,16,gate,pipe.in
1892.205151769,economy,91,gate,pipe.in
1893.107602460,business,4,gate,resource.serve
1893.107602460,business,5,gate,pipe.out
1893.704308125,business,5,gate,resource.serve
1893.704308125,business,6,gate,pipe.out
1895.879826157,economy,92,gate,pipe.in
1914.742437319,business,6,gate,resource.serve
1914.742437319,business,7,gate,pipe.out
1915.637893560,business,7,gate,resource.serve
1915.637893560,business,8,gate,pipe.out
1922.293028158,business,8,gate,resource.serve
1922.293028158,business,9,gate,pipe.out
1923.010271126,business,9,gate,resource.serve
1923.010271126,business,10,gate,pipe.out
1925.244925735,economy,93,gate,pipe.in
1927.404443868,business,17,gate,pipe.in
1931.526890360,business,18,gate,pipe.in
1937.306556430,business,10,gate,resource.serve
1937.306556430,business,11,gate,pipe.out
1939.762194202,economy,94,gate,pipe.in
1942.841812491,economy,95,gate,pipe.in
1945.287269756,business,11,gate,resource.serve
1945.287269756,business,12,gate,pipe.out
1950.788790811,business,12,gate,resource.serve
```

```
1950.788790811,business,13,gate,pipe.out
1950.873741084,business,19,gate,pipe.in
1953.168802185,business,13,gate,resource.serve
1953.168802185,business,14,gate,pipe.out
1963.432951334,economy,96,gate,pipe.in
1965.678785501,economy,97,gate,pipe.in
1966.259582714,business,14,gate,resource.serve
1966.259582714,business,15,gate,pipe.out
1969.414327088,economy,98,gate,pipe.in
1974.123732604,business,20,gate,pipe.in
1979.909064873,economy,99,gate,pipe.in
1987.198380413,economy,100,gate,pipe.in
1988.488131961,economy,101,gate,pipe.in
1991.033149891,economy,102,gate,pipe.in
1991.416678510,business,21,gate,pipe.in
1995.159339684,economy,103,gate,pipe.in
1997.774477470,economy,104,gate,pipe.in
2000.261878432,economy,105,gate,pipe.in
2000.998269410,economy,106,gate,pipe.in
2010.970646319,economy,107,gate,pipe.in
2013.570560328,economy,108,gate,pipe.in
2018.041124325,business,22,gate,pipe.in
2019.264473246,first,2,gate,pipe.in
2019.546022070,business,15,gate,resource.serve
2019.546022070,first,2,gate,pipe.out
2021.469263235,first,3,gate,pipe.in
2022.264170122,first,2,gate,resource.serve
2022.264170122,first,3,gate,pipe.out
2024.675168258,first,3,gate,resource.serve
2024.675168258,business,16,gate,pipe.out
2026.094397274,business,16,gate,resource.serve
2026.094397274,business,17,gate,pipe.out
2037.153654120,economy,109,gate,pipe.in
2045.617642278,economy,110,gate,pipe.in
2052.016949145,economy,111,gate,pipe.in
2053.507505911,business,17,gate,resource.serve
2053.507505911,business,18,gate,pipe.out
2054.636356359,first,4,gate,pipe.in
2060.973173155,first,5,gate,pipe.in
2064.031856479,first,6,gate,pipe.in
2067.370436106,economy,112,gate,pipe.in
2069.983941205,business,18,gate,resource.serve
2069.983941205,first,4,gate,pipe.out
2072.879599391,economy,113,gate,pipe.in
2076.276742579,first,4,gate,resource.serve
2076.276742579,first,5,gate,pipe.out
2076.946483057,business,23,gate,pipe.in
2080.950800491,first,7,gate,pipe.in
2085.938763236,economy,114,gate,pipe.in
2086.974804617,economy,115,gate,pipe.in
2087.465848114,first,5,gate,resource.serve
2087.465848114,first,6,gate,pipe.out
2091.610441547,first,6,gate,resource.serve
2091.610441547,first,7,gate,pipe.out
2092.126844601,economy,116,gate,pipe.in
2094.985765807,economy,117,gate,pipe.in
2097.095555569,economy,118,gate,pipe.in
```

```
2103.048749075,economy,119,gate,pipe.in
2108.528515634,economy,120,gate,pipe.in
2111.391756345,first,7,gate,resource.serve
2111.391756345,business,19,gate,pipe.out
2111.793370367,economy,121,gate,pipe.in
2114.265996707,business,19,gate,resource.serve
2114.265996707,business,20,gate,pipe.out
2120.120244681,business,20,gate,resource.serve
2120.120244681,business,21,gate,pipe.out
2137.467421977,economy,122,gate,pipe.in
2139.878205183,business,21,gate,resource.serve
2139.878205183,business,22,gate,pipe.out
2140.397332987,business,22,gate,resource.serve
2140.397332987,business,23,gate,pipe.out
2145.459730719,economy,123,gate,pipe.in
2163.540301390,economy,124,gate,pipe.in
2198.276774880,economy,125,gate,pipe.in
2205.317178905,first,8,gate,pipe.in
2212.794268859,business,23,gate,resource.serve
2212.794268859,first,8,gate,pipe.out
2214.613218665,first,8,gate,resource.serve
2214.613218665,economy,0,gate,pipe.out
2221.261559241,economy,0,gate,resource.serve
2221.261559241,economy,1,gate,pipe.out
2223.666329600,economy,1,gate,resource.serve
2223.666329600,economy,2,gate,pipe.out
2224.363392414,economy,126,gate,pipe.in
2224.967639957,economy,127,gate,pipe.in
2228.791939095,economy,2,gate,resource.serve
2228.791939095,economy,3,gate,pipe.out
2229.731449070,economy,128,gate,pipe.in
2232.813059945,economy,129,gate,pipe.in
2248.141097801,economy,130,gate,pipe.in
2254.210946175,economy,131,gate,pipe.in
2259.710206040,economy,132,gate,pipe.in
2261.971052875,first,9,gate,pipe.in
2270.997034934,economy,3,gate,resource.serve
2270.997034934,first,9,gate,pipe.out
2279.111125519,first,9,gate,resource.serve
2279.111125519,economy,4,gate,pipe.out
2291.249901830,economy,133,gate,pipe.in
2291.784095938,economy,4,gate,resource.serve
2291.784095938,economy,5,gate,pipe.out
2292.931684201,economy,134,gate,pipe.in
2295.303924563,economy,5,gate,resource.serve
2295.303924563,economy,6,gate,pipe.out
2303.959432376,economy,6,gate,resource.serve
2303.959432376,economy,7,gate,pipe.out
2311.772556272,economy,7,gate,resource.serve
2311.772556272,economy,8,gate,pipe.out
2325.554848407,economy,8,gate,resource.serve
2325.554848407,economy,9,gate,pipe.out
2326.143491153,economy,9,gate,resource.serve
2326.143491153,economy,10,gate,pipe.out
2327.576048466,economy,135,gate,pipe.in
2334.564691044,economy,136,gate,pipe.in
2334.918461349,economy,10,gate,resource.serve
```

```
2334.918461349,economy,11,gate,pipe.out
2336.631479067,economy,11,gate,resource.serve
2336.631479067,economy,12,gate,pipe.out
2353.718881135,economy,137,gate,pipe.in
2354.553908876,economy,138,gate,pipe.in
2356.609707881,economy,139,gate,pipe.in
2365.649256863,economy,140,gate,pipe.in
2369.016884019,economy,12,gate,resource.serve
2369.016884019,economy,13,gate,pipe.out
2371.698344120,economy,13,gate,resource.serve
2371.698344120,economy,14,gate,pipe.out
2372.975389440,economy,14,gate,resource.serve
2372.975389440,economy,15,gate,pipe.out
2376.895100080,economy,141,gate,pipe.in
2379.721585669,economy,142,gate,pipe.in
2388.748402078,economy,143,gate,pipe.in
2395.074292209,economy,15,gate,resource.serve
2395.074292209,economy,16,gate,pipe.out
2398.407979528,economy,144,gate,pipe.in
2400.508209356,economy,16,gate,resource.serve
2400.508209356,economy,17,gate,pipe.out
2407.170805155,economy,145,gate,pipe.in
2407.906043045,economy,17,gate,resource.serve
2407.906043045,economy,18,gate,pipe.out
2410.190860780,economy,18,gate,resource.serve
2410.190860780,economy,19,gate,pipe.out
2422.785427019,economy,19,gate,resource.serve
2422.785427019,economy,20,gate,pipe.out
2423.570363240,first,10,gate,pipe.in
2425.512520309,economy,20,gate,resource.serve
2425.512520309,first,10,gate,pipe.out
2434.459395934,economy,146,gate,pipe.in
2436.650497050,first,10,gate,resource.serve
2436.650497050,economy,21,gate,pipe.out
2438.026103656,economy,147,gate,pipe.in
2438.685160808,first,11,gate,pipe.in
2440.451061588,economy,21,gate,resource.serve
2440.451061588,first,11,gate,pipe.out
2441.204151290,first,11,gate,resource.serve
2441.204151290,economy,22,gate,pipe.out
2447.334313399,economy,22,gate,resource.serve
2447.334313399,economy,23,gate,pipe.out
2451.963906461,economy,148,gate,pipe.in
2507.422589801,economy,149,gate,pipe.in
2508.183419856,economy,150,gate,pipe.in
2510.580651120,economy,151,gate,pipe.in
2512.058008675,economy,23,gate,resource.serve
2512.058008675,economy,24,gate,pipe.out
2513.662226020,economy,152,gate,pipe.in
2534.937136412,economy,153,gate,pipe.in
2539.127423533,economy,24,gate,resource.serve
2539.127423533,economy,25,gate,pipe.out
2543.740274417,economy,25,gate,resource.serve
2543.740274417,economy,26,gate,pipe.out
2545.457020775,economy,26,gate,resource.serve
2545.457020775,economy,27,gate,pipe.out
2556.079142813,economy,154,gate,pipe.in
```

```
2563.399343294,economy,27,gate,resource.serve
2563.399343294,economy,28,gate,pipe.out
2568.237570056,economy,155,gate,pipe.in
2572.858541127,economy,28,gate,resource.serve
2572.858541127,economy,29,gate,pipe.out
2583.471021731,economy,29,gate,resource.serve
2583.471021731,economy,30,gate,pipe.out
2583.549560412,economy,30,gate,resource.serve
2583.549560412,economy,31,gate,pipe.out
2600.537943737,economy,31,gate,resource.serve
2600.537943737,economy,32,gate,pipe.out
2604.095822144,economy,32,gate,resource.serve
2604.095822144,economy,33,gate,pipe.out
2611.846535518,economy,156,gate,pipe.in
2614.984086856,economy,33,gate,resource.serve
2614.984086856,economy,34,gate,pipe.out
2616.426152724,economy,34,gate,resource.serve
2616.426152724,economy,35,gate,pipe.out
2617.652673970,economy,35,gate,resource.serve
2617.652673970,economy,36,gate,pipe.out
2618.784763845,economy,36,gate,resource.serve
2618.784763845,economy,37,gate,pipe.out
2626.841735093,economy,37,gate,resource.serve
2626.841735093,economy,38,gate,pipe.out
2630.021061681,economy,38,gate,resource.serve
2630.021061681,economy,39,gate,pipe.out
2639.305449573,economy,39,gate,resource.serve
2639.305449573,economy,40,gate,pipe.out
2639.803881478,economy,157,gate,pipe.in
2642.080384798,economy,158,gate,pipe.in
2651.950188872,economy,40,gate,resource.serve
2651.950188872,economy,41,gate,pipe.out
2652.138107978,economy,159,gate,pipe.in
2655.015221749,economy,41,gate,resource.serve
2655.015221749,economy,42,gate,pipe.out
2661.719921425,economy,42,gate,resource.serve
2661.719921425,economy,43,gate,pipe.out
2685.294188290,economy,43,gate,resource.serve
2685.294188290,economy,44,gate,pipe.out
2704.008951954,economy,44,gate,resource.serve
2704.008951954,economy,45,gate,pipe.out
2704.977348588,economy,45,gate,resource.serve
2704.977348588,economy,46,gate,pipe.out
2710.486462422,economy,46,gate,resource.serve
2710.486462422,economy,47,gate,pipe.out
2713.725501063,economy,47,gate,resource.serve
2713.725501063,economy,48,gate,pipe.out
2713.761020962,economy,48,gate,resource.serve
2713.761020962,economy,49,gate,pipe.out
2728.506561318,economy,49,gate,resource.serve
2728.506561318,economy,50,gate,pipe.out
2738.643209594,economy,50,gate,resource.serve
2738.643209594,economy,51,gate,pipe.out
2741.680717956,economy,51,gate,resource.serve
2741.680717956,economy,52,gate,pipe.out
2755.198909486,economy,52,gate,resource.serve
2755.198909486,economy,53,gate,pipe.out
```

```
2763.221399038,economy,53,gate,resource.serve
2763.221399038,economy,54,gate,pipe.out
2768.802089967,economy,54,gate,resource.serve
2768.802089967,economy,55,gate,pipe.out
2768.899257514,economy,55,gate,resource.serve
2768.899257514,economy,56,gate,pipe.out
2769.681509602,economy,56,gate,resource.serve
2769.681509602,economy,57,gate,pipe.out
2791.146420625,economy,57,gate,resource.serve
2791.146420625,economy,58,gate,pipe.out
2814.573053804,economy,58,gate,resource.serve
2814.573053804,economy,59,gate,pipe.out
2822.460614216,economy,59,gate,resource.serve
2822.460614216,economy,60,gate,pipe.out
2840.454198090,economy,60,gate,resource.serve
2840.454198090,economy,61,gate,pipe.out
2849.189134577,economy,61,gate,resource.serve
2849.189134577,economy,62,gate,pipe.out
2850.791922928,economy,62,gate,resource.serve
2850.791922928,economy,63,gate,pipe.out
2852.155224776,economy,63,gate,resource.serve
2852.155224776,economy,64,gate,pipe.out
2855.840652087,economy,64,gate,resource.serve
2855.840652087,economy,65,gate,pipe.out
2878.765167079,economy,65,gate,resource.serve
2878.765167079,economy,66,gate,pipe.out
2894.667517066,economy,66,gate,resource.serve
2894.667517066,economy,67,gate,pipe.out
2914.378956405,economy,67,gate,resource.serve
2914.378956405,economy,68,gate,pipe.out
2937.297845079,economy,68,gate,resource.serve
2937.297845079,economy,69,gate,pipe.out
2939.656037301,economy,69,gate,resource.serve
2939.656037301,economy,70,gate,pipe.out
2942.526589846,economy,70,gate,resource.serve
2942.526589846,economy,71,gate,pipe.out
2943.611283519,economy,71,gate,resource.serve
2943.611283519,economy,72,gate,pipe.out
2958.757845963,economy,72,gate,resource.serve
2958.757845963,economy,73,gate,pipe.out
2980.311115783,economy,73,gate,resource.serve
2980.311115783,economy,74,gate,pipe.out
2985.526230762,economy,74,gate,resource.serve
2985.526230762,economy,75,gate,pipe.out
2995.219494357,economy,75,gate,resource.serve
2995.219494357,economy,76,gate,pipe.out
2996.898396333,economy,76,gate,resource.serve
2996.898396333,economy,77,gate,pipe.out
3023.474013374,economy,77,gate,resource.serve
3023.474013374,economy,78,gate,pipe.out
3043.469653263,economy,78,gate,resource.serve
3043.469653263,economy,79,gate,pipe.out
3080.852885413,economy,79,gate,resource.serve
3080.852885413,economy,80,gate,pipe.out
3097.500897030,economy,80,gate,resource.serve
3097.500897030,economy,81,gate,pipe.out
3118.822251377,economy,81,gate,resource.serve
```

```
3118.822251377,economy,82,gate,pipe.out
3119.073238537,economy,82,gate,resource.serve
3119.073238537,economy,83,gate,pipe.out
3132.412704692,economy,83,gate,resource.serve
3132.412704692,economy,84,gate,pipe.out
3136.450152598,economy,84,gate,resource.serve
3136.450152598,economy,85,gate,pipe.out
3163.159992697,economy,85,gate,resource.serve
3163.159992697,economy,86,gate,pipe.out
3179.366757941,economy,86,gate,resource.serve
3179.366757941,economy,87,gate,pipe.out
3199.322470951,economy,87,gate,resource.serve
3199.322470951,economy,88,gate,pipe.out
3215.969298705,economy,88,gate,resource.serve
3215.969298705,economy,89,gate,pipe.out
3219.072744208,economy,89,gate,resource.serve
3219.072744208,economy,90,gate,pipe.out
3234.554973405,economy,90,gate,resource.serve
3234.554973405,economy,91,gate,pipe.out
3235.698936971,economy,91,gate,resource.serve
3235.698936971,economy,92,gate,pipe.out
3256.269225533,economy,92,gate,resource.serve
3256.269225533,economy,93,gate,pipe.out
3275.830373525,economy,93,gate,resource.serve
3275.830373525,economy,94,gate,pipe.out
3278.346237403,economy,94,gate,resource.serve
3278.346237403,economy,95,gate,pipe.out
3295.306364283,economy,95,gate,resource.serve
3295.306364283,economy,96,gate,pipe.out
3301.473842711,economy,96,gate,resource.serve
3301.473842711,economy,97,gate,pipe.out
3305.115023715,economy,97,gate,resource.serve
3305.115023715,economy,98,gate,pipe.out
3320.979344549,economy,98,gate,resource.serve
3320.979344549,economy,99,gate,pipe.out
3323.561813411,economy,99,gate,resource.serve
3323.561813411,economy,100,gate,pipe.out
3323.801302758,economy,100,gate,resource.serve
3323.801302758,economy,101,gate,pipe.out
3325.947227276,economy,101,gate,resource.serve
3325.947227276,economy,102,gate,pipe.out
3329.926095504,economy,102,gate,resource.serve
3329.926095504,economy,103,gate,pipe.out
3349.903084789,economy,103,gate,resource.serve
3349.903084789,economy,104,gate,pipe.out
3383.982013469,economy,104,gate,resource.serve
3383.982013469,economy,105,gate,pipe.out
3387.254908638,economy,105,gate,resource.serve
3387.254908638,economy,106,gate,pipe.out
3397.512665457,economy,106,gate,resource.serve
3397.512665457,economy,107,gate,pipe.out
3402.615562870,economy,107,gate,resource.serve
3402.615562870,economy,108,gate,pipe.out
3442.327820580,economy,108,gate,resource.serve
3442.327820580,economy,109,gate,pipe.out
3450.011178336,economy,109,gate,resource.serve
3450.011178336,economy,110,gate,pipe.out
```

```
3478.018943708,economy,110,gate,resource.serve
3478.018943708,economy,111,gate,pipe.out
3479.244482397,economy,111,gate,resource.serve
3479.244482397,economy,112,gate,pipe.out
3514.444498002,economy,112,gate,resource.serve
3514.444498002,economy,113,gate,pipe.out
3516.411556967,economy,113,gate,resource.serve
3516.411556967,economy,114,gate,pipe.out
3549.254855487,economy,114,gate,resource.serve
3549.254855487,economy,115,gate,pipe.out
3552.340050366,economy,115,gate,resource.serve
3552.340050366,economy,116,gate,pipe.out
3553.487455710,economy,116,gate,resource.serve
3553.487455710,economy,117,gate,pipe.out
3559.189033080,economy,117,gate,resource.serve
3559.189033080,economy,118,gate,pipe.out
3572.228624307,economy,118,gate,resource.serve
3572.228624307,economy,119,gate,pipe.out
3575.992698051,economy,119,gate,resource.serve
3575.992698051,economy,120,gate,pipe.out
3585.312043998,economy,120,gate,resource.serve
3585.312043998,economy,121,gate,pipe.out
3592.474627165,economy,121,gate,resource.serve
3592.474627165,economy,122,gate,pipe.out
3597.339135560,economy,122,gate,resource.serve
3597.339135560,economy,123,gate,pipe.out
3605.933232374,economy,123,gate,resource.serve
3605.933232374,economy,124,gate,pipe.out
3608.873218924,economy,124,gate,resource.serve
3608.873218924,economy,125,gate,pipe.out
3621.210163200,economy,125,gate,resource.serve
3621.210163200,economy,126,gate,pipe.out
3621.227090301,economy,126,gate,resource.serve
3621.227090301,economy,127,gate,pipe.out
3647.206746258,economy,127,gate,resource.serve
3647.206746258,economy,128,gate,pipe.out
3654.938438413,economy,128,gate,resource.serve
3654.938438413,economy,129,gate,pipe.out
3667.647758691,economy,129,gate,resource.serve
3667.647758691,economy,130,gate,pipe.out
3681.193780851,economy,130,gate,resource.serve
3681.193780851,economy,131,gate,pipe.out
3692.299470845,economy,131,gate,resource.serve
3692.299470845,economy,132,gate,pipe.out
3696.828520868,economy,132,gate,resource.serve
3696.828520868,economy,133,gate,pipe.out
3697.553946200,economy,133,gate,resource.serve
3697.553946200,economy,134,gate,pipe.out
3708.467463849,economy,134,gate,resource.serve
3708.467463849,economy,135,gate,pipe.out
3712.475225573,economy,135,gate,resource.serve
3712.475225573,economy,136,gate,pipe.out
3716.242772498,economy,136,gate,resource.serve
3716.242772498,economy,137,gate,pipe.out
3735.082525360,economy,137,gate,resource.serve
3735.082525360,economy,138,gate,pipe.out
3747.803409646,economy,138,gate,resource.serve
```

```
3747.803409646,economy,139,gate,pipe.out
3751.374763977,economy,139,gate,resource.serve
3751.374763977,economy,140,gate,pipe.out
3755.075038947,economy,140,gate,resource.serve
3755.075038947,economy,141,gate,pipe.out
3760.324164561,economy,141,gate,resource.serve
3760.324164561,economy,142,gate,pipe.out
3765.472507490,economy,142,gate,resource.serve
3765.472507490,economy,143,gate,pipe.out
3768.977380226,economy,143,gate,resource.serve
3768.977380226,economy,144,gate,pipe.out
3770.338874668,economy,144,gate,resource.serve
3770.338874668,economy,145,gate,pipe.out
3775.793844795,economy,145,gate,resource.serve
3775.793844795,economy,146,gate,pipe.out
3803.988748186,economy,146,gate,resource.serve
3803.988748186,economy,147,gate,pipe.out
3815.299626098,economy,147,gate,resource.serve
3815.299626098,economy,148,gate,pipe.out
3838.610042338,economy,148,gate,resource.serve
3838.610042338,economy,149,gate,pipe.out
3848.168545177,economy,149,gate,resource.serve
3848.168545177,economy,150,gate,pipe.out
3851.748873469,economy,150,gate,resource.serve
3851.748873469,economy,151,gate,pipe.out
3859.688215467,economy,151,gate,resource.serve
3859.688215467,economy,152,gate,pipe.out
3859.692275688,economy,152,gate,resource.serve
3859.692275688,economy,153,gate,pipe.out
3863.073804205,economy,153,gate,resource.serve
3863.073804205,economy,154,gate,pipe.out
3868.693031298,economy,154,gate,resource.serve
3868.693031298,economy,155,gate,pipe.out
3877.367674629,economy,155,gate,resource.serve
3877.367674629,economy,156,gate,pipe.out
3888.001254240,economy,156,gate,resource.serve
3888.001254240,economy,157,gate,pipe.out
3894.255918821,economy,157,gate,resource.serve
3894.255918821,economy,158,gate,pipe.out
3900.092746183,economy,158,gate,resource.serve
3900.092746183,economy,159,gate,pipe.out
3902.496932801,economy,159,gate,resource.serve
```

3.4 Pallet preparation - Preemption no restart

SimPype features used in this example: Random variables, Resource custom model, Pipe custom model, Log custom message properties.

The scenario of the simulation is the following:

```
|Urgent order| -\
                 ) -> |Worker|
|Normal order| -/
```

This example models a working day (8 hours) of a `worker` in a warehouse. The worker's job is to prepare a pallet

upon receiving an order. There are two types of orders:

- Urgent

- Normal

Each order comprises a number of items to be packed on the same pallet. Urgent orders `preempt` normal orders. This means that if an urgent order is received while the worker is preparing the pallet for a normal order, the worker will stop what is doing and will immdietaly start preparing the pallet for the urgent order. Once the urgent pallet is prepare, the worker will resume the preparation of the pallet of the normal order.

This kind of interaction is usually called **preemption with no restart**.

The scenario is so implemented with SimPype:

```python
import simpype
import random


# [Mandatory] Create a SimPype simulation object
sim = simpype.Simulation(id = 'pallet_norestart')
# [Optional] Fix the seed used by the pseudo-random generator
sim.seed = 42
# [Optional] Configure the log directory.
# [Default] Log are store by default in the 'current working directory/log'
sim.log.dir = 'log'
# [Optional] Disable the logging to file and print to console instead
#sim.log.file = False
#sim.log.print = True
# [Optional] Log custom message properties
sim.log.property('items')
# [Optional] Configure the path containting the models for the simulation.
# [Default] Current working directory
sim.model.dir = 'examples/model'

# Create a generator
urgent = sim.add_generator(id = 'urgent')
# Assign an arrival time
urgent.random['arrival'] = {
        0: lambda: random.expovariate(1.0 / 3600)
}
urgent.message.property['priority'] = 'urgent'
urgent.message.property['items'] = {
        0: lambda: random.randint(1, 5)
}
# Create a generator
normal = sim.add_generator(id = 'normal')
# Assign an arrival time
normal.random['arrival'] = {
        0: lambda: random.expovariate(1.0 / 300)
}
normal.message.property['priority'] = 'normal'
normal.message.property['items'] = {
        0: lambda: random.randint(10, 30)
}

# Add a resource
worker = sim.add_resource(id = 'worker', model = 'r_preemption', pipe = 'p_preemption
↪')
worker.random['service'] = {
```

(continues on next page)

3.4. Pallet preparation - Preemption no restart   51

```
        0: lambda: random.expovariate(1.0 / 10)
}

# Add a pipeline connecting the generator to the resource
p0 = sim.add_pipeline(urgent, worker)
p1 = sim.add_pipeline(normal, worker)

# Run until t=28800 (8 hours)
sim.run(until = 28800)
```

Where pipe model `p_preemption` is so implemented:

```python
import simpype


class PriorityPreemption(simpype.Pipe):
        def __init__(self, sim, resource, id):
                super().__init__(sim, resource, id)
                self.add_queue(id = 'preempted')
                self.add_queue(id = 'urgent')
                self.add_queue(id = 'normal')

        @simpype.pipe.dequeue
        def dequeue(self):
                if len(self.queue['urgent']) > 0:
                        return self.queue['urgent'].pop()
                elif len(self.queue['preempted']) > 0:
                        return self.queue['preempted'].pop()
                else:
                        return self.queue['normal'].pop()

        @simpype.pipe.enqueue
        def enqueue(self, message):
                if message.property['priority'].value == 'urgent':
                        m = self.queue['urgent'].push(message)

                        tlist = [t for t in self.resource.task.values() if t.process.
→is_alive and t.message.property['priority'].value != 'urgent']
                        # If the resource is busy, preempt the current task
                        if len(tlist) > 0:
                                #task = max(tlist, key = lambda task: task.message.
→property['priority'].value)
                                task = tlist[0]
                                task.interrupt(cause = 'preempted')
                                # This if is useful only in case of preemption with␣
→no restart
                                if 'wait' in task.message.property:
                                        task.message.property['wait'] = task.message.
→property['wait'].value - (task.interrupted - task.started)
                                self.queue['preempted'].push(task.message)
                else:
                        m = self.queue['normal'].push(message)

                return m


# Do NOT remove
```

```
pipe = lambda *args: PriorityPreemption(*args)
```

And resource model r_preemption is so implemented:

```python
import simpype


class ResourcePreemption(simpype.Resource):
        def __init__(self, sim, id, capacity = 1, pipe = None):
                super().__init__(sim, id, capacity, pipe)
                # This is overwritten later in the simulaiton file
                self.random['service'] = {
                        0: lambda: 1.0
                }

        @simpype.resource.service
        def service(self, message):
                if 'wait' not in message.property:
                        message.property['wait'] = message.property['items'].value *␣
→self.random['service'].value
                yield self.env.timeout(message.property['wait'].value)


# Do NOT remove
resource = lambda *args: ResourcePreemption(*args)
```

sim.cfg stored under the log folder contains:

```
Simulation Seed: 42
Simulation Time: 28800.000000000
Execution Time: 0.060198644
```

sim.log stored under the log folder contains:

```
timestamp,message,seq_num,resource,event,items
27.285721382,normal,0,worker,pipe.in,23
27.285721382,normal,0,worker,pipe.out,23
36.975335053,normal,1,worker,pipe.in,17
49.913040803,normal,0,worker,resource.serve,23
49.913040803,normal,1,worker,pipe.out,17
54.485089429,normal,1,worker,resource.serve,17
248.149993412,normal,2,worker,pipe.in,16
248.149993412,normal,2,worker,pipe.out,16
441.493859789,normal,2,worker,resource.serve,16
625.805024250,normal,3,worker,pipe.in,23
625.805024250,normal,3,worker,pipe.out,23
700.512949940,normal,4,worker,pipe.in,10
830.461026699,normal,3,worker,resource.serve,23
830.461026699,normal,4,worker,pipe.out,10
847.855816062,normal,4,worker,resource.serve,10
1127.160757415,normal,5,worker,pipe.in,23
1127.160757415,normal,5,worker,pipe.out,23
1166.027599075,normal,5,worker,resource.serve,23
1251.929283365,normal,6,worker,pipe.in,20
1251.929283365,normal,6,worker,pipe.out,20
1284.275103075,normal,7,worker,pipe.in,21
1347.512993521,normal,6,worker,resource.serve,20
```

```
1347.512993521,normal,7,worker,pipe.out,21
1541.899381582,normal,7,worker,resource.serve,21
1848.441225565,normal,8,worker,pipe.in,11
1848.441225565,normal,8,worker,pipe.out,11
1932.961092209,normal,8,worker,resource.serve,11
2240.943354699,normal,9,worker,pipe.in,22
2240.943354699,normal,9,worker,pipe.out,22
2265.566852517,normal,10,worker,pipe.in,30
2317.278253108,normal,9,worker,resource.serve,22
2317.278253108,normal,10,worker,pipe.out,30
2554.675714055,normal,11,worker,pipe.in,28
2618.740849180,normal,12,worker,pipe.in,12
2632.813111258,normal,13,worker,pipe.in,17
2910.792233711,normal,10,worker,resource.serve,30
2910.792233711,normal,11,worker,pipe.out,28
3077.745021529,normal,14,worker,pipe.in,17
3681.804460196,normal,15,worker,pipe.in,22
3779.512534186,normal,16,worker,pipe.in,30
4090.875545150,normal,11,worker,resource.serve,28
4090.875545150,normal,12,worker,pipe.out,12
4112.177708608,normal,12,worker,resource.serve,12
4112.177708608,normal,13,worker,pipe.out,17
4186.794914503,normal,13,worker,resource.serve,17
4186.794914503,normal,14,worker,pipe.out,17
4318.442414000,normal,17,worker,pipe.in,30
4340.666385782,normal,18,worker,pipe.in,30
4375.357825977,normal,14,worker,resource.serve,17
4375.357825977,normal,15,worker,pipe.out,22
4396.977101389,normal,19,worker,pipe.in,15
4583.091251682,normal,20,worker,pipe.in,18
4662.700806454,normal,15,worker,resource.serve,22
4662.700806454,normal,16,worker,pipe.out,30
4969.195980592,normal,16,worker,resource.serve,30
4969.195980592,normal,17,worker,pipe.out,30
5213.417601642,normal,17,worker,resource.serve,30
5213.417601642,normal,18,worker,pipe.out,30
5559.605238443,normal,18,worker,resource.serve,30
5559.605238443,normal,19,worker,pipe.out,15
5837.190248640,normal,19,worker,resource.serve,15
5837.190248640,normal,20,worker,pipe.out,18
5950.673162214,normal,21,worker,pipe.in,17
6106.489838444,normal,20,worker,resource.serve,18
6106.489838444,normal,21,worker,pipe.out,17
6384.438244483,normal,21,worker,resource.serve,17
6468.132158445,normal,22,worker,pipe.in,22
6468.132158445,normal,22,worker,pipe.out,22
6520.264945496,normal,22,worker,resource.serve,22
6561.618408373,normal,23,worker,pipe.in,28
6561.618408373,normal,23,worker,pipe.out,28
6667.420973560,normal,23,worker,resource.serve,28
7188.751262326,normal,24,worker,pipe.in,30
7188.751262326,normal,24,worker,pipe.out,30
7396.234526404,normal,25,worker,pipe.in,30
7580.453185706,normal,26,worker,pipe.in,18
7625.571122030,normal,27,worker,pipe.in,27
7836.772789002,normal,24,worker,resource.serve,30
7836.772789002,normal,25,worker,pipe.out,30
```

```
7857.863514232,normal,28,worker,pipe.in,23
8018.237158385,urgent,0,worker,pipe.in,4
8018.237158385,normal,25,worker,pipe.in,30
8018.237158385,normal,25,worker,resource.preempted,30
8018.237158385,urgent,0,worker,pipe.out,4
8255.201029505,urgent,0,worker,resource.serve,4
8255.201029505,normal,25,worker,pipe.out,30
8486.062775099,normal,25,worker,resource.serve,30
8486.062775099,normal,26,worker,pipe.out,18
8512.862063805,normal,26,worker,resource.serve,18
8512.862063805,normal,27,worker,pipe.out,27
8542.177775118,normal,29,worker,pipe.in,11
8696.532862972,normal,27,worker,resource.serve,27
8696.532862972,normal,28,worker,pipe.out,23
8734.682332207,normal,28,worker,resource.serve,23
8734.682332207,normal,29,worker,pipe.out,11
8753.858847901,normal,29,worker,resource.serve,11
9134.384368328,normal,30,worker,pipe.in,23
9134.384368328,normal,30,worker,pipe.out,23
9246.107955706,normal,30,worker,resource.serve,23
9406.590378189,normal,31,worker,pipe.in,29
9406.590378189,normal,31,worker,pipe.out,29
9625.000973941,normal,31,worker,resource.serve,29
9636.118275916,urgent,1,worker,pipe.in,5
9636.118275916,urgent,1,worker,pipe.out,5
9636.695647801,urgent,1,worker,resource.serve,5
11072.273154374,normal,32,worker,pipe.in,13
11072.273154374,normal,32,worker,pipe.out,13
11172.368493323,normal,32,worker,resource.serve,13
11415.711210823,normal,33,worker,pipe.in,18
11415.711210823,normal,33,worker,pipe.out,18
11490.551853380,normal,33,worker,resource.serve,18
11854.791807040,normal,34,worker,pipe.in,19
11854.791807040,normal,34,worker,pipe.out,19
11969.671582824,normal,34,worker,resource.serve,19
12025.946051615,normal,35,worker,pipe.in,18
12025.946051615,normal,35,worker,pipe.out,18
12284.304693889,normal,35,worker,resource.serve,18
13097.414730980,normal,36,worker,pipe.in,26
13097.414730980,normal,36,worker,pipe.out,26
13628.911360163,normal,36,worker,resource.serve,26
13828.688303491,normal,37,worker,pipe.in,19
13828.688303491,normal,37,worker,pipe.out,19
13963.320707091,normal,37,worker,resource.serve,19
14381.609213366,normal,38,worker,pipe.in,16
14381.609213366,normal,38,worker,pipe.out,16
14431.368664391,normal,39,worker,pipe.in,27
14611.630514253,normal,38,worker,resource.serve,16
14611.630514253,normal,39,worker,pipe.out,27
15301.919839754,normal,39,worker,resource.serve,27
15351.857926270,normal,40,worker,pipe.in,10
15351.857926270,normal,40,worker,pipe.out,10
15418.919364046,normal,40,worker,resource.serve,10
15625.954626627,normal,41,worker,pipe.in,13
15625.954626627,normal,41,worker,pipe.out,13
15900.211575902,normal,41,worker,resource.serve,13
16419.894225302,normal,42,worker,pipe.in,19
```

3.4. Pallet preparation - Preemption no restart

```
16419.894225302,normal,42,worker,pipe.out,19
16472.255249139,normal,42,worker,resource.serve,19
16502.009163586,normal,43,worker,pipe.in,28
16502.009163586,normal,43,worker,pipe.out,28
16527.081938335,normal,43,worker,resource.serve,28
16734.230083868,urgent,2,worker,pipe.in,4
16734.230083868,urgent,2,worker,pipe.out,4
16886.870413510,urgent,2,worker,resource.serve,4
17382.962150916,normal,44,worker,pipe.in,27
17382.962150916,normal,44,worker,pipe.out,27
17420.064169340,normal,44,worker,resource.serve,27
17818.480204946,normal,45,worker,pipe.in,25
17818.480204946,normal,45,worker,pipe.out,25
17863.599108038,normal,45,worker,resource.serve,25
18698.863905021,normal,46,worker,pipe.in,26
18698.863905021,normal,46,worker,pipe.out,26
18841.903452458,normal,46,worker,resource.serve,26
19316.598070304,normal,47,worker,pipe.in,16
19316.598070304,normal,47,worker,pipe.out,16
19541.810884695,normal,47,worker,resource.serve,16
20109.755390857,normal,48,worker,pipe.in,16
20109.755390857,normal,48,worker,pipe.out,16
20191.218996064,normal,48,worker,resource.serve,16
20484.183976048,normal,49,worker,pipe.in,30
20484.183976048,normal,49,worker,pipe.out,30
20624.427862433,normal,50,worker,pipe.in,24
20663.120408863,normal,51,worker,pipe.in,17
20682.970649833,normal,52,worker,pipe.in,10
20949.215107980,normal,53,worker,pipe.in,17
21173.803986105,normal,49,worker,resource.serve,30
21173.803986105,normal,50,worker,pipe.out,24
21175.536022348,normal,50,worker,resource.serve,24
21175.536022348,normal,51,worker,pipe.out,17
21215.555329820,normal,54,worker,pipe.in,11
21293.552750087,normal,55,worker,pipe.in,11
21384.713698988,normal,51,worker,resource.serve,17
21384.713698988,normal,52,worker,pipe.out,10
21392.062998951,normal,52,worker,resource.serve,10
21392.062998951,normal,53,worker,pipe.out,17
21438.271515829,normal,53,worker,resource.serve,17
21438.271515829,normal,54,worker,pipe.out,11
21559.884190617,normal,54,worker,resource.serve,11
21559.884190617,normal,55,worker,pipe.out,11
21586.405170112,normal,55,worker,resource.serve,11
21882.606337410,normal,56,worker,pipe.in,14
21882.606337410,normal,56,worker,pipe.out,14
22182.251464310,normal,56,worker,resource.serve,14
22268.109752762,normal,57,worker,pipe.in,28
22268.109752762,normal,57,worker,pipe.out,28
22460.088958772,normal,58,worker,pipe.in,23
22523.457126729,normal,59,worker,pipe.in,13
22698.007387668,normal,57,worker,resource.serve,28
22698.007387668,normal,58,worker,pipe.out,23
22798.613185133,normal,58,worker,resource.serve,23
22798.613185133,normal,59,worker,pipe.out,13
22828.835347781,urgent,3,worker,pipe.in,1
22828.835347781,normal,59,worker,pipe.in,13
```

```
22828.835347781,normal,59,worker,resource.preempted,13
22828.835347781,urgent,3,worker,pipe.out,1
22846.203791242,normal,60,worker,pipe.in,13
22864.962010388,normal,61,worker,pipe.in,20
22870.290807252,urgent,3,worker,resource.serve,1
22870.290807252,normal,59,worker,pipe.out,13
22908.904002618,normal,59,worker,resource.serve,13
22908.904002618,normal,60,worker,pipe.out,13
22923.946671982,normal,60,worker,resource.serve,13
22923.946671982,normal,61,worker,pipe.out,20
22966.483874513,normal,61,worker,resource.serve,20
23348.683469526,normal,62,worker,pipe.in,27
23348.683469526,normal,62,worker,pipe.out,27
23496.637166619,normal,62,worker,resource.serve,27
23527.279274699,normal,63,worker,pipe.in,18
23527.279274699,normal,63,worker,pipe.out,18
23713.598718948,normal,64,worker,pipe.in,12
23889.226158169,normal,65,worker,pipe.in,27
23900.840043944,normal,63,worker,resource.serve,18
23900.840043944,normal,64,worker,pipe.out,12
23920.138030907,normal,66,worker,pipe.in,27
24027.556353701,normal,64,worker,resource.serve,12
24027.556353701,normal,65,worker,pipe.out,27
24462.555151011,normal,67,worker,pipe.in,17
24517.123645165,normal,68,worker,pipe.in,25
24714.086313499,normal,69,worker,pipe.in,22
24965.441137940,normal,65,worker,resource.serve,27
24965.441137940,normal,66,worker,pipe.out,27
25014.011185055,normal,66,worker,resource.serve,27
25014.011185055,normal,67,worker,pipe.out,17
25014.377994824,normal,67,worker,resource.serve,17
25014.377994824,normal,68,worker,pipe.out,25
25138.124986531,normal,68,worker,resource.serve,25
25138.124986531,normal,69,worker,pipe.out,22
25412.281436852,normal,70,worker,pipe.in,24
25513.027847554,normal,71,worker,pipe.in,27
25712.482462920,normal,69,worker,resource.serve,22
25712.482462920,normal,70,worker,pipe.out,24
25838.326464180,normal,72,worker,pipe.in,16
25872.523850704,normal,70,worker,resource.serve,24
25872.523850704,normal,71,worker,pipe.out,27
25943.921322946,normal,73,worker,pipe.in,28
26343.164663794,normal,74,worker,pipe.in,11
26756.633427859,normal,75,worker,pipe.in,11
26772.066368153,normal,76,worker,pipe.in,25
26807.921685859,normal,71,worker,resource.serve,27
26807.921685859,normal,72,worker,pipe.out,16
26856.913340344,urgent,4,worker,pipe.in,2
26856.913340344,normal,72,worker,pipe.in,16
26856.913340344,normal,72,worker,resource.preempted,16
26856.913340344,urgent,4,worker,pipe.out,2
26871.091901142,urgent,4,worker,resource.serve,2
26871.091901142,normal,72,worker,pipe.out,16
26981.725645489,normal,77,worker,pipe.in,15
27003.020242686,normal,78,worker,pipe.in,12
27067.734039713,urgent,5,worker,pipe.in,2
27067.734039713,normal,72,worker,pipe.in,16
```

```
27067.734039713,normal,72,worker,resource.preempted,16
27067.734039713,urgent,5,worker,pipe.out,2
27124.541501249,urgent,5,worker,resource.serve,2
27124.541501249,normal,72,worker,pipe.out,16
27185.374749646,normal,72,worker,resource.serve,16
27185.374749646,normal,73,worker,pipe.out,28
27340.395539196,normal,79,worker,pipe.in,28
27421.475088222,normal,73,worker,resource.serve,28
27421.475088222,normal,74,worker,pipe.out,11
27527.730440170,normal,74,worker,resource.serve,11
27527.730440170,normal,75,worker,pipe.out,11
27587.503528787,normal,75,worker,resource.serve,11
27587.503528787,normal,76,worker,pipe.out,25
27611.200031467,normal,80,worker,pipe.in,26
27725.301496893,normal,81,worker,pipe.in,18
27793.846028968,normal,82,worker,pipe.in,20
27806.574169467,normal,76,worker,resource.serve,25
27806.574169467,normal,77,worker,pipe.out,15
27875.658827669,normal,83,worker,pipe.in,30
27882.148157306,normal,77,worker,resource.serve,15
27882.148157306,normal,78,worker,pipe.out,12
27927.754931762,normal,78,worker,resource.serve,12
27927.754931762,normal,79,worker,pipe.out,28
27982.660059338,normal,84,worker,pipe.in,12
27985.467794470,normal,85,worker,pipe.in,29
28318.013410298,normal,79,worker,resource.serve,28
28318.013410298,normal,80,worker,pipe.out,26
```

3.5 Pallet preparation - Preemption with restart

SimPype features used in this example: Random variables, Resource inline customization, Pipe custom model, Log custom message properties.

The scenario of the simulation is the following:

```
|Urgent order| -\
                 ) -> |Worker|
|Normal order| -/
```

The scenario description is the same as the one in Pallet preparation - Preemption no restart. The difference resides in the fact that the worker will restart the pallet preparation from scratch if preempted. This means that the worker will not resume the pallet preparation but rather will start again the preparation from the beginning. The worker pipe model is the same while the resource model is sligthly different (it does not consider the `wait` message property). The difference in the code is highlighted below.

This kind of interaction is usually called **preemption with restart**.

The scenario is so implemented with SimPype:

```python
import simpype
import random


# [Mandatory] Create a SimPype simulation object
sim = simpype.Simulation(id = 'pallet_restart')
```

```python
# [Optional] Fix the seed used by the pseudo-random generator
sim.seed = 42
# [Optional] Configure the log directory.
# [Default] Log are store by default in the 'current working directory/log'
sim.log.dir = 'log'
# [Optional] Disable the logging to file and print to console instead
#sim.log.file = False
#sim.log.print = True
# [Optional] Log custom message properties
sim.log.property('items')
# [Optional] Configure the path containting the models for the simulation.
# [Default] Current working directory
sim.model.dir = 'examples/model'

# Create a generator
urgent = sim.add_generator(id = 'urgent')
# Assign an arrival time
urgent.random['arrival'] = {
        0: lambda: random.expovariate(1.0 / 3600)
}
urgent.message.property['priority'] = 'urgent'
urgent.message.property['items'] = {
        0: lambda: random.randint(1, 5)
}
# Create a generator
normal = sim.add_generator(id = 'normal')
# Assign an arrival time
normal.random['arrival'] = {
        0: lambda: random.expovariate(1.0 / 300)
}
normal.message.property['priority'] = 'normal'
normal.message.property['items'] = {
        0: lambda: random.randint(10, 30)
}

# Add a resource
worker = sim.add_resource(id = 'worker', pipe = 'p_preemption')
worker.random['service'] = {
        0: lambda: random.expovariate(1.0 / 10)
}
# Service time depends on the number of items
@simpype.resource.service(worker)
def service(self, message):
        yield self.env.timeout(message.property['items'].value * self.random['service
→'].value)

# Add a pipeline connecting the generator to the resource
p0 = sim.add_pipeline(urgent, worker)
p1 = sim.add_pipeline(normal, worker)

# Run until t=28800 (8 hours)
sim.run(until = 28800)
```

Where pipe model `p_preemption` is so implemented:

```python
import simpype
```

```python
class PriorityPreemption(simpype.Pipe):
        def __init__(self, sim, resource, id):
                super().__init__(sim, resource, id)
                self.add_queue(id = 'preempted')
                self.add_queue(id = 'urgent')
                self.add_queue(id = 'normal')

        @simpype.pipe.dequeue
        def dequeue(self):
                if len(self.queue['urgent']) > 0:
                        return self.queue['urgent'].pop()
                elif len(self.queue['preempted']) > 0:
                        return self.queue['preempted'].pop()
                else:
                        return self.queue['normal'].pop()

        @simpype.pipe.enqueue
        def enqueue(self, message):
                if message.property['priority'].value == 'urgent':
                        m = self.queue['urgent'].push(message)

                        tlist = [t for t in self.resource.task.values() if t.process.
→is_alive and t.message.property['priority'].value != 'urgent']
                        # If the resource is busy, preempt the current task
                        if len(tlist) > 0:
                                #task = max(tlist, key = lambda task: task.message.
→property['priority'].value)
                                task = tlist[0]
                                task.interrupt(cause = 'preempted')
                                # This if is useful only in case of preemption with␣
→no restart
                                if 'wait' in task.message.property:
                                        task.message.property['wait'] = task.message.
→property['wait'].value - (task.interrupted - task.started)
                                self.queue['preempted'].push(task.message)
                else:
                        m = self.queue['normal'].push(message)

                return m


# Do NOT remove
pipe = lambda *args: PriorityPreemption(*args)
```

`sim.cfg` stored under the `log` folder contains:

```
Simulation Seed: 42
Simulation Time: 28800.000000000
Execution Time: 0.058570670
```

`sim.log` stored under the `log` folder contains:

```
timestamp,message,seq_num,resource,event,items
27.285721382,normal,0,worker,pipe.in,23
27.285721382,normal,0,worker,pipe.out,23
36.975335053,normal,1,worker,pipe.in,17
```

```
49.913040803,normal,0,worker,resource.serve,23
49.913040803,normal,1,worker,pipe.out,17
54.485089429,normal,1,worker,resource.serve,17
248.149993412,normal,2,worker,pipe.in,16
248.149993412,normal,2,worker,pipe.out,16
441.493859789,normal,2,worker,resource.serve,16
625.805024250,normal,3,worker,pipe.in,23
625.805024250,normal,3,worker,pipe.out,23
700.512949940,normal,4,worker,pipe.in,10
830.461026699,normal,3,worker,resource.serve,23
830.461026699,normal,4,worker,pipe.out,10
847.855816062,normal,4,worker,resource.serve,10
1127.160757415,normal,5,worker,pipe.in,23
1127.160757415,normal,5,worker,pipe.out,23
1166.027599075,normal,5,worker,resource.serve,23
1251.929283365,normal,6,worker,pipe.in,20
1251.929283365,normal,6,worker,pipe.out,20
1284.275103075,normal,7,worker,pipe.in,21
1347.512993521,normal,6,worker,resource.serve,20
1347.512993521,normal,7,worker,pipe.out,21
1541.899381582,normal,7,worker,resource.serve,21
1848.441225565,normal,8,worker,pipe.in,11
1848.441225565,normal,8,worker,pipe.out,11
1932.961092209,normal,8,worker,resource.serve,11
2240.943354699,normal,9,worker,pipe.in,22
2240.943354699,normal,9,worker,pipe.out,22
2265.566852517,normal,10,worker,pipe.in,30
2317.278253108,normal,9,worker,resource.serve,22
2317.278253108,normal,10,worker,pipe.out,30
2554.675714055,normal,11,worker,pipe.in,28
2618.740849180,normal,12,worker,pipe.in,12
2632.813111258,normal,13,worker,pipe.in,17
2910.792233711,normal,10,worker,resource.serve,30
2910.792233711,normal,11,worker,pipe.out,28
3077.745021529,normal,14,worker,pipe.in,17
3681.804460196,normal,15,worker,pipe.in,22
3779.512534186,normal,16,worker,pipe.in,30
4090.875545150,normal,11,worker,resource.serve,28
4090.875545150,normal,12,worker,pipe.out,12
4112.177708608,normal,12,worker,resource.serve,12
4112.177708608,normal,13,worker,pipe.out,17
4186.794914503,normal,13,worker,resource.serve,17
4186.794914503,normal,14,worker,pipe.out,17
4318.442414000,normal,17,worker,pipe.in,30
4340.666385782,normal,18,worker,pipe.in,30
4375.357825977,normal,14,worker,resource.serve,17
4375.357825977,normal,15,worker,pipe.out,22
4396.977101389,normal,19,worker,pipe.in,15
4583.091251682,normal,20,worker,pipe.in,18
4662.700806454,normal,15,worker,resource.serve,22
4662.700806454,normal,16,worker,pipe.out,30
4969.195980592,normal,16,worker,resource.serve,30
4969.195980592,normal,17,worker,pipe.out,30
5213.417601642,normal,17,worker,resource.serve,30
5213.417601642,normal,18,worker,pipe.out,30
5559.605238443,normal,18,worker,resource.serve,30
5559.605238443,normal,19,worker,pipe.out,15
```

```
5837.190248640,normal,19,worker,resource.serve,15
5837.190248640,normal,20,worker,pipe.out,18
5950.673162214,normal,21,worker,pipe.in,17
6106.489838444,normal,20,worker,resource.serve,18
6106.489838444,normal,21,worker,pipe.out,17
6384.438244483,normal,21,worker,resource.serve,17
6468.132158445,normal,22,worker,pipe.in,22
6468.132158445,normal,22,worker,pipe.out,22
6520.264945496,normal,22,worker,resource.serve,22
6561.618408373,normal,23,worker,pipe.in,28
6561.618408373,normal,23,worker,pipe.out,28
6667.420973560,normal,23,worker,resource.serve,28
7188.751262326,normal,24,worker,pipe.in,30
7188.751262326,normal,24,worker,pipe.out,30
7396.234526404,normal,25,worker,pipe.in,30
7580.453185706,normal,26,worker,pipe.in,18
7625.571122030,normal,27,worker,pipe.in,27
7836.772789002,normal,24,worker,resource.serve,30
7836.772789002,normal,25,worker,pipe.out,30
7857.863514232,normal,28,worker,pipe.in,23
8018.237158385,urgent,0,worker,pipe.in,4
8018.237158385,normal,25,worker,pipe.in,30
8018.237158385,normal,25,worker,resource.preempted,30
8018.237158385,urgent,0,worker,pipe.out,4
8255.201029505,urgent,0,worker,resource.serve,4
8255.201029505,normal,25,worker,pipe.out,30
8299.866510682,normal,25,worker,resource.serve,30
8299.866510682,normal,26,worker,pipe.out,18
8422.313710127,normal,26,worker,resource.serve,18
8422.313710127,normal,27,worker,pipe.out,27
8542.177775118,normal,29,worker,pipe.in,13
8591.937952381,normal,30,worker,pipe.in,15
8802.931266977,normal,27,worker,resource.serve,27
8802.931266977,normal,28,worker,pipe.out,23
8929.076654768,normal,28,worker,resource.serve,23
8929.076654768,normal,29,worker,pipe.out,13
8937.609249269,normal,29,worker,resource.serve,13
8937.609249269,normal,30,worker,pipe.out,15
9009.706894762,normal,30,worker,resource.serve,15
9063.117601840,normal,31,worker,pipe.in,24
9063.117601840,normal,31,worker,pipe.out,24
9289.059597445,normal,32,worker,pipe.in,10
9631.155697245,normal,33,worker,pipe.in,13
9636.118275916,urgent,1,worker,pipe.in,5
9636.118275916,normal,31,worker,pipe.in,24
9636.118275916,normal,31,worker,resource.preempted,24
9636.118275916,urgent,1,worker,pipe.out,5
9709.298375285,urgent,1,worker,resource.serve,5
9709.298375285,normal,31,worker,pipe.out,24
9809.085898695,normal,31,worker,resource.serve,24
9809.085898695,normal,32,worker,pipe.out,10
9843.829124590,normal,32,worker,resource.serve,10
9843.829124590,normal,33,worker,pipe.out,13
9866.210267659,normal,33,worker,resource.serve,13
9974.593753693,normal,34,worker,pipe.in,10
9974.593753693,normal,34,worker,pipe.out,10
10183.222598832,normal,34,worker,resource.serve,10
```

```
10897.129841255,normal,35,worker,pipe.in,18
10897.129841255,normal,35,worker,pipe.out,18
11155.488483529,normal,35,worker,resource.serve,18
11968.598520620,normal,36,worker,pipe.in,26
11968.598520620,normal,36,worker,pipe.out,26
12500.095149803,normal,36,worker,resource.serve,26
12699.872093131,normal,37,worker,pipe.in,19
12699.872093131,normal,37,worker,pipe.out,19
12834.504496732,normal,37,worker,resource.serve,19
13252.793003006,normal,38,worker,pipe.in,16
13252.793003006,normal,38,worker,pipe.out,16
13302.552454031,normal,39,worker,pipe.in,27
13482.814303893,normal,38,worker,resource.serve,16
13482.814303893,normal,39,worker,pipe.out,27
14173.103629395,normal,39,worker,resource.serve,27
14223.041715910,normal,40,worker,pipe.in,10
14223.041715910,normal,40,worker,pipe.out,10
14290.103153686,normal,40,worker,resource.serve,10
14497.138416267,normal,41,worker,pipe.in,13
14497.138416267,normal,41,worker,pipe.out,13
14639.440533474,urgent,2,worker,pipe.in,3
14639.440533474,normal,41,worker,pipe.in,13
14639.440533474,normal,41,worker,resource.preempted,13
14639.440533474,urgent,2,worker,pipe.out,3
14647.708063554,urgent,2,worker,resource.serve,3
14647.708063554,normal,41,worker,pipe.out,13
14756.627554918,normal,41,worker,resource.serve,13
15291.078014942,normal,42,worker,pipe.in,12
15291.078014942,normal,42,worker,pipe.out,12
15317.941702172,normal,43,worker,pipe.in,12
15370.939630123,normal,42,worker,resource.serve,12
15370.939630123,normal,43,worker,pipe.out,12
15462.235273946,normal,43,worker,resource.serve,12
15624.819792891,urgent,3,worker,pipe.in,2
15624.819792891,urgent,3,worker,pipe.out,2
15637.717693374,urgent,3,worker,resource.serve,2
16119.513371870,urgent,4,worker,pipe.in,5
16119.513371870,urgent,4,worker,pipe.out,5
16157.017642058,urgent,4,worker,resource.serve,5
16462.744174488,normal,44,worker,pipe.in,29
16462.744174488,normal,44,worker,pipe.out,29
16531.764504347,normal,44,worker,resource.serve,29
16627.789806147,normal,45,worker,pipe.in,27
16627.789806147,normal,45,worker,pipe.out,27
16769.225576392,urgent,5,worker,pipe.in,3
16769.225576392,normal,45,worker,pipe.in,27
16769.225576392,normal,45,worker,resource.preempted,27
16769.225576392,urgent,5,worker,pipe.out,3
16802.639208424,urgent,5,worker,resource.serve,3
16802.639208424,normal,45,worker,pipe.out,27
16928.858706170,normal,45,worker,resource.serve,27
17050.063833129,normal,46,worker,pipe.in,26
17050.063833129,normal,46,worker,pipe.out,26
17124.136129913,normal,46,worker,resource.serve,26
17230.226653091,normal,47,worker,pipe.in,12
17230.226653091,normal,47,worker,pipe.out,12
17336.724436350,normal,47,worker,resource.serve,12
```

```
17354.012346898,normal,48,worker,pipe.in,17
17354.012346898,normal,48,worker,pipe.out,17
17355.239205904,normal,48,worker,resource.serve,17
17620.352568738,normal,49,worker,pipe.in,30
17620.352568738,normal,49,worker,pipe.out,30
17638.555968902,normal,50,worker,pipe.in,11
17641.286342667,normal,49,worker,resource.serve,30
17641.286342667,normal,50,worker,pipe.out,11
17649.370572626,normal,50,worker,resource.serve,11
18227.609556225,normal,51,worker,pipe.in,17
18227.609556225,normal,51,worker,pipe.out,17
18325.526972951,normal,52,worker,pipe.in,27
18340.556460593,normal,51,worker,resource.serve,17
18340.556460593,normal,52,worker,pipe.out,27
18368.103843431,normal,53,worker,pipe.in,28
18602.156693553,urgent,6,worker,pipe.in,2
18602.156693553,normal,52,worker,pipe.in,27
18602.156693553,normal,52,worker,resource.preempted,27
18602.156693553,urgent,6,worker,pipe.out,2
18625.660180106,normal,54,worker,pipe.in,16
18635.109564140,urgent,6,worker,resource.serve,2
18635.109564140,normal,52,worker,pipe.out,27
18655.382871022,normal,55,worker,pipe.in,21
18820.657769568,normal,56,worker,pipe.in,24
18925.581562202,normal,52,worker,resource.serve,27
18925.581562202,normal,53,worker,pipe.out,28
18941.175794093,normal,53,worker,resource.serve,28
18941.175794093,normal,54,worker,pipe.out,16
19110.734835310,normal,54,worker,resource.serve,16
19110.734835310,normal,55,worker,pipe.out,21
19328.917751344,normal,55,worker,resource.serve,21
19328.917751344,normal,56,worker,pipe.out,24
19343.924326661,normal,56,worker,resource.serve,24
19418.827989615,normal,57,worker,pipe.in,20
19418.827989615,normal,57,worker,pipe.out,20
19441.970557868,normal,57,worker,resource.serve,20
19902.549448753,normal,58,worker,pipe.in,16
19902.549448753,normal,58,worker,pipe.out,16
19965.843141624,normal,59,worker,pipe.in,23
19997.800544845,normal,58,worker,resource.serve,16
19997.800544845,normal,59,worker,pipe.out,23
20026.657255714,normal,60,worker,pipe.in,12
20140.645452103,normal,59,worker,resource.serve,23
20140.645452103,normal,60,worker,pipe.out,12
20202.284694935,normal,61,worker,pipe.in,27
20233.196567673,normal,62,worker,pipe.in,30
20377.740978117,normal,60,worker,resource.serve,12
20377.740978117,normal,61,worker,pipe.out,27
20865.916386211,normal,61,worker,resource.serve,27
20865.916386211,normal,62,worker,pipe.out,30
21908.010590921,normal,62,worker,resource.serve,30
22405.104643840,normal,63,worker,pipe.in,17
22405.104643840,normal,63,worker,pipe.out,17
22459.673137995,normal,64,worker,pipe.in,16
22518.126433639,normal,63,worker,resource.serve,17
22518.126433639,normal,64,worker,pipe.out,16
22890.497166094,normal,64,worker,resource.serve,16
```

```
23059.641390231,normal,65,worker,pipe.in,15
23059.641390231,normal,65,worker,pipe.out,15
23202.555663625,normal,66,worker,pipe.in,18
23692.717827817,normal,65,worker,resource.serve,15
23692.717827817,normal,66,worker,pipe.out,18
23969.507264275,normal,66,worker,resource.serve,18
23985.770404155,normal,67,worker,pipe.in,19
23985.770404155,normal,67,worker,pipe.out,19
24129.411999484,urgent,7,worker,pipe.in,5
24129.411999484,normal,67,worker,pipe.in,19
24129.411999484,normal,67,worker,resource.preempted,19
24129.411999484,urgent,7,worker,pipe.out,5
24150.748200119,normal,68,worker,pipe.in,16
24162.753955272,urgent,7,worker,resource.serve,5
24162.753955272,normal,67,worker,pipe.out,19
24256.343058885,normal,69,worker,pipe.in,28
24655.586399733,normal,70,worker,pipe.in,11
24820.996876307,normal,67,worker,resource.serve,19
24820.996876307,normal,68,worker,pipe.out,16
24830.415160243,normal,68,worker,resource.serve,16
24830.415160243,normal,69,worker,pipe.out,28
25069.055163798,normal,71,worker,pipe.in,26
25076.114325739,normal,69,worker,resource.serve,28
25076.114325739,normal,70,worker,pipe.out,11
25159.430689843,normal,70,worker,resource.serve,11
25159.430689843,normal,71,worker,pipe.out,26
25174.656629241,normal,71,worker,resource.serve,26
25824.484256334,normal,72,worker,pipe.in,26
25824.484256334,normal,72,worker,pipe.out,26
25849.535088579,normal,73,worker,pipe.in,29
25870.649230507,normal,74,worker,pipe.in,17
25877.935030450,normal,72,worker,resource.serve,26
25877.935030450,normal,73,worker,pipe.out,29
26025.790657825,normal,75,worker,pipe.in,28
26110.585225500,normal,76,worker,pipe.in,29
26122.751104181,normal,77,worker,pipe.in,12
26285.768618591,normal,78,worker,pipe.in,28
26535.647932996,normal,79,worker,pipe.in,20
26701.643222715,normal,73,worker,resource.serve,29
26701.643222715,normal,74,worker,pipe.out,17
26740.485124224,normal,74,worker,resource.serve,17
26740.485124224,normal,75,worker,pipe.out,28
27093.132978907,normal,75,worker,resource.serve,28
27093.132978907,normal,76,worker,pipe.out,29
27172.218684318,normal,76,worker,resource.serve,29
27172.218684318,normal,77,worker,pipe.out,12
27232.677874590,normal,77,worker,resource.serve,12
27232.677874590,normal,78,worker,pipe.out,28
27354.305656355,normal,80,worker,pipe.in,19
27537.623542977,normal,81,worker,pipe.in,12
27540.431278109,normal,82,worker,pipe.in,29
27544.541223340,normal,78,worker,resource.serve,28
27544.541223340,normal,79,worker,pipe.out,20
28032.995398995,urgent,8,worker,pipe.in,1
28032.995398995,normal,79,worker,pipe.in,20
28032.995398995,normal,79,worker,resource.preempted,20
28032.995398995,urgent,8,worker,pipe.out,1
```

```
28040.045262756,urgent,8,worker,resource.serve,1
28040.045262756,normal,79,worker,pipe.out,20
28068.463203843,normal,79,worker,resource.serve,20
28068.463203843,normal,80,worker,pipe.out,19
28150.022453409,normal,80,worker,resource.serve,19
28150.022453409,normal,81,worker,pipe.out,12
28158.575078333,normal,81,worker,resource.serve,12
28158.575078333,normal,82,worker,pipe.out,29
28239.801232244,normal,82,worker,resource.serve,29
```

3.6 Fish factory

SimPype features used in this example: Random variables, Resource inline customization, Message next, Log custom message properties.

The scenario of the simulation is a food factory processing fish:

```
                    /-> |Dry|
                   /
|Fish| -> |Selector| -+---> |Can|
                   \
                    \-> |Grill|
```
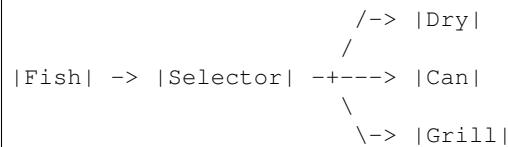
There are three species of fish arriving at the factory: cod, tuna, and calamari. These species need first to be sperated and process accordingly. Cod will be dried, tuna will be cut in chunks and put in a can, calamari will be grilled.

```python
import simpype
import random


# [Mandatory] Create a SimPype simulation object
sim = simpype.Simulation(id = 'fish')
# [Optional] Fix the seed used by the pseudo-random generator
sim.seed = 42
# [Optional] Configure the log directory.
# [Default] Log are store by default in the 'current working directory/log'
sim.log.dir = 'log'
# [Optional] Disable the logging to file and print to console instead
#sim.log.file = False
#sim.log.print = True
# [Optional] Log custom message properties
sim.log.property('species')
# [Mandatory] Add at least one generator to the simulation
fish = sim.add_generator(id = 'fish')
# [Mandatory] Assign an arrival time
fish.random['arrival'] = {
        0: lambda: random.expovariate(1.0 / 0.1)
}
fish.message.property['species'] = {
        0: lambda: random.choice(['cod', 'tuna', 'calamari'])
}
```

```python
# [Mandatory] Add at least one resource to the simulation
dry = sim.add_resource(id = 'dry')
dry.random['service'] = {
        0: lambda: 60
}

# Add an additional resource
can = sim.add_resource(id = 'can')
can.random['service'] = {
        0: lambda: random.expovariate(1.0 / 20)
}

# Add an additional resource
grill = sim.add_resource(id = 'grill')
grill.random['service'] = {
        0: lambda: random.expovariate(1.0 / 60)
}

# Add an additional resource
selector = sim.add_resource(id = 'selector')
@simpype.resource.service(selector)
def selector_service(self, message):
        if message.property['species'].value == 'cod':
                message.next = dry
        elif message.property['species'].value == 'tuna':
                message.next = can
        elif message.property['species'].value == 'calamari':
                message.next = grill


# [Mandatory] Add a pipeline connecting the generator and the resource
p0 = sim.add_pipeline(fish, selector)
p1 = sim.add_pipeline(selector, can)
p2 = sim.add_pipeline(selector, grill)
pM = sim.merge_pipeline(p0, p1, p2)

# [Mandatory] Run the simulation e.g. until t=2
sim.run(until = 2)
```

`sim.cfg` stored under the `log` folder contains:

```
Simulation Seed: 42
Simulation Time: 2.000000000
Execution Time: 0.014687043
```

`sim.log` stored under the `log` folder contains:

```
timestamp,message,seq_num,resource,event,species
0.133359267,fish,0,selector,pipe.in,calamari
0.133359267,fish,0,selector,pipe.out,calamari
0.133359267,fish,0,selector,resource.serve,calamari
0.133359267,fish,0,grill,pipe.in,calamari
0.133359267,fish,0,grill,pipe.out,calamari
0.268323787,fish,1,selector,pipe.in,calamari
0.268323787,fish,1,selector,pipe.out,calamari
0.268323787,fish,1,selector,resource.serve,calamari
0.268323787,fish,1,grill,pipe.in,calamari
```

```
0.323128403,fish,2,selector,pipe.in,cod
0.323128403,fish,2,selector,pipe.out,cod
0.323128403,fish,2,selector,resource.serve,cod
0.323128403,fish,2,dry,pipe.in,cod
0.323128403,fish,2,dry,pipe.out,cod
0.332966368,fish,3,selector,pipe.in,cod
0.332966368,fish,3,selector,pipe.out,cod
0.332966368,fish,3,selector,resource.serve,cod
0.332966368,fish,3,dry,pipe.in,cod
0.403357921,fish,4,selector,pipe.in,cod
0.403357921,fish,4,selector,pipe.out,cod
0.403357921,fish,4,selector,resource.serve,cod
0.403357921,fish,4,dry,pipe.in,cod
0.485739346,fish,5,selector,pipe.in,calamari
0.485739346,fish,5,selector,pipe.out,calamari
0.485739346,fish,5,selector,resource.serve,calamari
0.485739346,fish,5,grill,pipe.in,calamari
0.590688546,fish,6,selector,pipe.in,calamari
0.590688546,fish,6,selector,pipe.out,calamari
0.590688546,fish,6,selector,resource.serve,calamari
0.590688546,fish,6,grill,pipe.in,calamari
0.645078509,fish,7,selector,pipe.in,tuna
0.645078509,fish,7,selector,pipe.out,tuna
0.645078509,fish,7,selector,resource.serve,tuna
0.645078509,fish,7,can,pipe.in,tuna
0.645078509,fish,7,can,pipe.out,tuna
0.734059379,fish,8,selector,pipe.in,cod
0.734059379,fish,8,selector,pipe.out,cod
0.734059379,fish,8,selector,resource.serve,cod
0.734059379,fish,8,dry,pipe.in,cod
0.876275315,fish,9,selector,pipe.in,cod
0.876275315,fish,9,selector,pipe.out,cod
0.876275315,fish,9,selector,resource.serve,cod
0.876275315,fish,9,dry,pipe.in,cod
0.996054309,fish,10,selector,pipe.in,tuna
0.996054309,fish,10,selector,pipe.out,tuna
0.996054309,fish,10,selector,resource.serve,tuna
0.996054309,fish,10,can,pipe.in,tuna
1.028609505,fish,11,selector,pipe.in,cod
1.028609505,fish,11,selector,pipe.out,cod
1.028609505,fish,11,selector,resource.serve,cod
1.028609505,fish,11,dry,pipe.in,cod
1.343761770,fish,12,selector,pipe.in,tuna
1.343761770,fish,12,selector,pipe.out,tuna
1.343761770,fish,12,selector,resource.serve,tuna
1.343761770,fish,12,can,pipe.in,tuna
1.354543710,fish,13,selector,pipe.in,tuna
1.354543710,fish,13,selector,pipe.out,tuna
1.354543710,fish,13,selector,resource.serve,tuna
1.354543710,fish,13,can,pipe.in,tuna
1.364715578,fish,14,selector,pipe.in,tuna
1.364715578,fish,14,selector,pipe.out,tuna
1.364715578,fish,14,selector,resource.serve,tuna
1.364715578,fish,14,can,pipe.in,tuna
1.457280525,fish,15,selector,pipe.in,cod
1.457280525,fish,15,selector,pipe.out,cod
1.457280525,fish,15,selector,resource.serve,cod
```

```
1.457280525,fish,15,dry,pipe.in,cod
1.588114568,fish,16,selector,pipe.in,calamari
1.588114568,fish,16,selector,pipe.out,calamari
1.588114568,fish,16,selector,resource.serve,calamari
1.588114568,fish,16,grill,pipe.in,calamari
1.601447842,fish,17,selector,pipe.in,tuna
1.601447842,fish,17,selector,pipe.out,tuna
1.601447842,fish,17,selector,resource.serve,tuna
1.601447842,fish,17,can,pipe.in,tuna
1.609655675,fish,18,selector,pipe.in,tuna
1.609655675,fish,18,selector,pipe.out,tuna
1.609655675,fish,18,selector,resource.serve,tuna
1.609655675,fish,18,can,pipe.in,tuna
1.786501773,fish,19,selector,pipe.in,calamari
1.786501773,fish,19,selector,pipe.out,calamari
1.786501773,fish,19,selector,resource.serve,calamari
1.786501773,fish,19,grill,pipe.in,calamari
```

API Reference

The API reference provides detailed descriptions of SimPype's classes and functions. It should be helpful if you plan to extend SimPype with custom components.

4.1 `simpype.build`

SimPype's build library.

simpype.build.**generator**(*sim*, *id*, *model=None*)
    Create a [*Resource*](#) object implementing a generator.

   Dynamically build a generator object based on the model. If model is None the default generator model is built.

> **Parameters**
>
>   - **sim** (*Simulation*) – The SimPype simulation object
>
>   - **id** (*str*) – The resource id to build
>
>   - **model** (*str, optional*) – The model of the resource
>
> **Returns** *Resource*

simpype.build.**logger**(*name*, *path*)
    Create a logger object.

   This function creates a logger object for logging the simulation results. A logger accepts a (str) as input and writes it to the log file.

> **Parameters**
>
>   - **name** (*str*) – The name of the logger
>
>   - **path** (*str*) – The path of the log file managed by the logger
>
> **Returns** Python Logger from logging module `logging.Logger`

`simpype.build.`**`pipe`**(*sim*, *resource*, *id*, *model=None*)

> Create a [*Pipe*](#) object.
>
> Dynamically build a pipe object based on the model. If model is None the default pipe model is built.
>
>> **Parameters**
>>
>> - **sim** ([*Simulation*](#)) – The SimPype simulation object
>> - **resource** ([*Resource*](#)) – The resource object this pipe is associated to
>> - **id** (*str*) – The pipe id to build
>> - **model** (*str, optional*) – The model of the pipe
>>
>> **Returns** [*Pipe*](#)

`simpype.build.`**`queue`**(*sim*, *pipe*, *id*, *model=None*)

> Create a [*Queue*](#) object.
>
> Dynamically build a queue object based on the model. If model is None the default queue model is built.
>
>> **Parameters**
>>
>> - **sim** ([*Simulation*](#)) – The SimPype simulation object
>> - **pipe** ([*Pipe*](#)) – The pipe object this queue is associated to
>> - **id** (*str*) – The queue id to build
>> - **model** (*str, optional*) – The model of the queue
>>
>> **Returns** [*Queue*](#)

`simpype.build.`**`resource`**(*sim*, *id*, *model=None*, *capacity=1*, *pipe=None*)

> Create a [*Resource*](#) object.
>
> Dynamically build a resource object based on the model. If model is None the default resource model is built.
>
>> **Parameters**
>>
>> - **sim** ([*Simulation*](#)) – The SimPype simulation object
>> - **id** (*str*) – The resource id to build
>> - **model** (*str, optional*) – The model of the resource
>> - **capacity** (*int, optional*) – The capacity of the resource
>> - **pipe** (*str, optional*) – The model of the pipe associated to the resource
>>
>> **Returns** [*Resource*](#)

4.2 `simpype.message`

SimPype's message.

class `simpype.message.`**`Message`**(*sim*, *resource*, *id*)

> This class implements the simpype.Message object.
>
> simpype.Message object is the atomic unit processed by simpype.Resource objects.
>
>> **Parameters**
>>
>> - **sim** ([*Simulation*](#)) – The SimPype simulation object
>> - **resource** ([*Resource*](#)) – The simpype.Resource object generating this message

- **id** (*str*) – The SimPype message id

sim
> The SimPype simulation object.
>
> > **Type** *Simulation*

env
> The SimPy environment object.
>
> > **Type** simpy.Environment

id
> The simpype.Message id
>
> > **Type** str

generated
> The simulation time when this object was generated.
>
> > **Type** float

generator
> The simpype.Resource that created the message.
>
> > **Type** *Resource*

is_alive
> The boolean value marking if the message is alive or not. A message is not alive when no further steps are available or if it is used as a template by a generator.
>
> > **Type** bool

location
> The location of the simpype.Message inside the simulation pipeline.
>
> > **Type** *ResourcePipeQueue*

property
> The PropertyDict dictionary storing the *Property* objects
>
> > **Type** *PropertyDict*

seq_num
> The sequence number of the message
>
> > **Type** int

subscription
> The dictionary storing the Subscription objects
>
> > **Type** dict

visited
> The list of the visited simpype.Resource objects
>
> > **Type** list

copy()
> Create a dopy of this simpype.Message object.
>
> > **Returns** *Message*

done()
> Deactivate the message, empty the next adjency list, and defuse all the active subscriptions

drop(*id='dropped'*, *event=None*)
> Drop the simpype.Message object from the simulation.

> If event is not None, subscribe the message to the event and the default drop callback

> > **Parameters**
> > > • **id** (`str, optional`) – The id identifying in the log this drop action
> > >
> > > • **event** (`simpy.Event, optional`) – The event that will trigger the message dropping

next
> The next resources available to the message in the form of adjency list

> Next property admits only simpype.Resource, simpype.Pipeline, and next-compatible values

pipeline
> The pipeline associated to the message in the form of adjency.

> A pipeline represents all the possible paths to the message. Pipeline property admits only simpype.Pipeline objects as a value

resource
> The resource currently managing the message.

> Resource property admits only simpype.Resource objects as a value

subscribe(*event*, *callback*, *id*)
> Subscribe the message to a given event which will execute a callback function.

> > **Parameters**
> > > • **event** (`simpy.Event`) – The simpy.Event to subscribe to
> > >
> > > • **callback** (`user-defined python function`) – The function to call upon event triggering
> > >
> > > • **id** (`str`) – The id identifying this subscription

> > **Returns** *Subscription*

timestamp(*description*)
> Create and write a timestamp to the log file

> > **Parameters** **description** (`str`) – The timestamp description

unsubscribe(*id*)
> Unsubscribe the message from the subscription id

> > **Parameters** **id** (`any`) – The subscription id to unsubscribe

class simpype.message.**Property**(*sim*, *name*, *value*)
> This class implements the properties used by simpype.Message objects.

> A property value can be either static or dynamic. In the latter case the `value` must follow the simpype.Random value dictionary format.

> > **Parameters**
> > > • **sim** (*Simulation*) – The SimPype simulation object
> > >
> > > • **name** (`str`) – The property name
> > >
> > > • **value** (`any`) – The property value

sim
> The SimPype simulation object
>
> > **Type** *Simulation*

env
> The SimPy environment object
>
> > **Type** simpy.Environment

name
> The property name
>
> > **Type** str

value
> The property value
>
> > **Type** any

copy()
> Create a copy of the object.
>
> > **Returns** *Property*

refresh()
> Generate a new random value for the simpype.Property object.
>
> This function does not produce any effects if the simpype.Property value is static.

value
> The value of the simpype.Property.

class simpype.message.**PropertyDict**(*sim*)
> A custom dictionary storing simpype.Property objects.
>
> > **Parameters** **sim** (*Simulation*) – The SimPype simulation object

sim
> The SimPype simulation object
>
> > **Type** *Simulation*

env
> The SimPy environment object
>
> > **Type** simpy.Environment

class simpype.message.**Subscription**(*sim*, *message*, *event*, *callback*, *id*)
> This class implements the subscriptions used by simpype.Message objects.
>
> Subscription used to execute a given function upong some events triggering.
>
> > **Parameters**
> >
> > - **sim** (*Simulation*) – The SimPype simulation object
> >
> > - **message** (*Message*) – The SimPype message object this timestamp is associated to
> >
> > - **event** (*simpy.Event*) – The Simpy event the simpype.Message object is subscribed to
> >
> > - **callback** (*user-defined python function*) – The python function to call upon event triggering
> >
> > - **id** (*str*) – The simpype.Subscription id

sim
> The SimPype simulation object
>
> > **Type** *Simulation*

env
> The SimPy environment object
>
> > **Type** simpy.Environment

message
> The SimPype message object this timestamp is associated to
>
> > **Type** *Message*

event
> The Simpy event the simpype.Message object is subscribed to
>
> > **Type** simpy.Event

callback
> The python function to call upon event triggering
>
> > **Type** user-defined python function

id
> The simpype.Subscription id
>
> > **Type** str

disable
> The Simpy event used to remove the subscription
>
> > **Type** simpy.Event

class simpype.message.**Timestamp**(*message*, *timestamp*, *resource*, *description*)
> This class implements the timestamps used by simpype.Message objects.

> Timestamp objects are used for logging purposes.

> > **Parameters**
> >
> > - **message** (*Message*) – The SimPype message object this timestamp is associated to
> > - **timestamp** (*int, float*) – The simulation time of the timestmap
> > - **resource** (*Resource*) – The SimPype resource object creating the timestamp
> > - **description** (*str*) – The description of the event generating the timestamp

message
> The SimPype message object this timestamp is associated to
>
> > **Type** *Message*

timestamp
> The simulation time of the timestmap
>
> > **Type** int,float

resource
> The SimPype resource object creating the timestamp
>
> > **Type** *Resource*

description
> The description of the event generating the timestamp

> **Type** str

4.3 `simpype.pipe`

SimPype's pipe.

class simpype.pipe.**Pipe**(*sim*, *resource*, *id*)

> The pipe implements the queueing disciplines.
>
> > **Parameters**
> >
> > - **sim** (Simulation) – The SimPype simulation object.
> >
> > - **resource** ([*Resource*](#)) – The resource the pipe is associated to.
> >
> > - **id** (*str*) – The pipe id.
>
> **sim**
>
> > The SimPype simulation object.
> >
> > > **Type** Simulation
>
> **env**
>
> > The SimPy environment object.
> >
> > > **Type** simpy.Environment
>
> **id**
>
> > The pipe id.
> >
> > > **Type** str
>
> **resource**
>
> > The resource the pipe is associated to.
> >
> > > **Type** [*Resource*](#)
>
> **available**
>
> > Event signaling the presence of a [*Message*](#) in the pipe.
> >
> > > **Type** simpy.events.Event
>
> **queue**
>
> > The dictionary storing the [*Queue*](#) instances associated to this pipe.
> >
> > > **Type** dict
>
> **add_queue**(*id*, *model=None*)
>
> > Add a new queue to the pipe.
> >
> > > **Parameters**
> > >
> > > - **id** (*str*) – The id of the new queue.
> > >
> > > - **model** (*str*) – The model of the new queue. If model is None, the default queue model is created.
> > >
> > > **Returns** [*Queue*](#)
>
> **full**()
>
> > Check if there is at least a [*Message*](#) in the pipe.
> >
> > > **Returns** bool

`simpype.pipe.`**`dequeue`**(*arg*)

> Decorator for overloading the default `Pipe` dequeue behavior.

>> **Parameters** **arg** (`Pipe`)(`self`) – The `Pipe` instance.

> If the overloading is done in scripts, the `Pipe` instance must be provided as decorator argument.

```
myresource = sim.add_resource(id = 'myresource')
myresource.add_queue(id = 'myqueue')

@simpype.pipe.dequeue(myresource.pipe)
def dequeue(self):
        return self.queue['myqueue'].pop()
```

> If the overloading is done inside a Pipe subclass, the decorator must be called without any arguments. `Pipe` instance is automatically provided through `self`.

```
class MyPipe(simpype.Pipe):
        def __init__(self, sim, resource, id):
                super().__init__(sim, resource, id)
                self.add_queue(id = 'myqueue')

        @simpype.pipe.dequeue
        def dequeue(self):
                return self.queue['myqueue'].pop()
```

`simpype.pipe.`**`enqueue`**(*arg*)

> Decorator for overloading the default `Pipe` enqueue behavior.

>> **Parameters** **arg** (`Pipe`)(`self`) – The `Pipe` instance.

> If the overloading is done in scripts, the `Pipe` instance must be provided as decorator argument.

```
myresource = sim.add_resource(id = 'myresource')
myresource.add_queue(id = 'myqueue')

@simpype.pipe.enqueue(myresource.pipe)
def enqueue(self, message):
        return self.queue['myqueue'].push(message)
```

> If the overloading is done inside a Pipe subclass, the decorator must be called without any arguments. `Pipe` instance is automatically provided through `self`.

```
class MyPipe(simpype.Pipe):
        def __init__(self, sim, resource, id):
                super().__init__(sim, resource, id)
                self.add_queue(id = 'myqueue')

        @simpype.pipe.enqueue
        def enqueue(self, message):
                return self.queue['myqueue'].push(message)
```

4.4 `simpype.pipeline`

SimPype's pipeline.

class `simpype.pipeline.`**`Pipeline`**(*sim*, *id*)

> The pipeline connecting the various `Resource` instances.

> **Parameters**
>
> - **sim** (Simulation) – The SimPype simulation object.
>
> - **id** (`str`) – The pipeline id.

sim
> The SimPype simulation object.
>
> > **Type** `Simulation`

env
> The SimPy environment object.
>
> > **Type** simpy.Environment

id
> The pipeline id.
>
> > **Type** str

resource
> The dictionary storing the connected resources in the form of adjency list.
>
> > **Type** dict

first
> The first resource of the pipeline.
>
> > **Type** *[Resource](#)*

last
> The last resource of the pipeline.
>
> > **Type** *[Resource](#)*

add_pipe(*src*, *dst*)
> Add a pipe to the pipeline.
>
> Connect resource `src` to resource `dst`.
>
> > **Parameters**
> >
> > - **src** (*[Resource](#)*) – The source resource of the pipe.
> >
> > - **dst** (*[Resource](#)*) – The destination resource of the pipe.

merge_pipe(*pipeline*)
> Merge `pipeline` with this pipeline.
>
> > **Parameters** **pipeline** (*[Pipeline](#)*) – The pipeline to be merged with this pipeline.

4.5 `simpype.queue`

SimPype's queue.

class simpype.queue.**Queue**(*sim*, *pipe*, *id*)
> Queue is used by *[Pipe](#)* to store *[Message](#)* objects.
>
> > **Parameters**
> >
> > - **sim** (Simulation) – The SimPype simulation object.
> >
> > - **pipe** (*[Pipe](#)*) – The pipe this queue is associated to.

- **id** (*str*) – The queue id.

sim
>   The SimPype simulation object.

>>   **Type** Simulation

env
>   The SimPy environment object.

>>   **Type** simpy.Environment

id
>   The queue id.

>>   **Type** str

pipe
>   The pipe this queue is associated to.

>>   **Type** *Pipe*

buffer
>   The data structure physically storing the *Message* objects.

>>   **Type** list

capacity
>   The capacity of the buffer. `Infinite` by default.

>>   **Type** int

active
>   Event signaling when the queue is active.

>>   **Type** simpy.events.Event

disable()
>   Disable this queue by resetting the `active` attribute.

enable()
>   Enable this queue by triggering the `active` attribute.

simpype.queue.**pop**(*arg*)
>   Decorator for overloading the default *Queue* pop behavior.

>>   **Parameters** **arg** (*Queue*)(self) – The *Queue* instance.

If the overloading is done in scripts, the *Queue* instance must be provided as decorator argument.

```python
myresource = sim.add_resource(id = 'myresource')
myresource.add_queue(id = 'myqueue')

@simpype.queue.pop(myresource.pipe['myqueue'])
def pop(self):
        return self.buffer.pop(0)
```

If the overloading is done inside a Queue subclass, the decorator must be called without any arguments. *Queue* instance is automatically provided through `self`.

```python
class MyQueue(simpype.Queue):
        def __init__(self, sim, pipe, id):
                super().__init__(sim, pipe, id)
```

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```
        @simpype.queue.pop
        def pop(self):
                return self.buffer.pop(0)
```

simpype.queue.**push**(*arg*)

>   Decorator for overloading the default *Queue* push behavior.

>>   **Parameters arg** (*Queue*)(self) – The *Queue* instance.

>   If the overloading is done in scripts, the *Queue* instance must be provided as decorator argument.

```
myresource = sim.add_resource(id = 'myresource')
myresource.add_queue(id = 'myqueue')

@simpype.queue.push(myresource.pipe['myqueue'])
def push(self, message):
        self.buffer.append(message)
        return message
```

>   If the overloading is done inside a Queue subclass, the decorator must be called without any arguments. *Queue* instance is automatically provided through self.

```
class MyQueue(simpype.Queue):
        def __init__(self, sim, pipe, id):
                super().__init__(sim, pipe, id)

        @simpype.queue.push
        def push(self, message):
                self.buffer.append(message)
                return message
```

4.6 `simpype.random`

Random is a custom dictionary accepting the following format as value:

```
sim = simpype.Simulation(id = 'test')
myrand = simpype.Random(sim, {
        initial_time : lambda_function
        ...
})
```

Where each dictionary element is so defined:

- `initial_time` is the element key and must be of *int* or *float* type. It represents the initial simulation time at which the `lambda_function` is invoked;

- `lambda_function` is the element value. It is mandatory that for the value to be a *lambda* function. Such function must return a value, usually a *int* or a *float*;

An example of random dictionary initialization is the following:

```
sim = simpype.Simulation(id = 'test')
myrand = simpype.Random(sim, {
        # From t=0 to t=10, the random variable returns
        # the constant value of 3.0
```

```
        0          : lambda: 3.0,
        # From t=10 to t=20, the random variable returns
        # value uniformly distributed between 2.5 and 3.5
        10         : lambda: random.uniform(2.5, 3.5),
        # From t=20 to t=inf, the random variable returns
        # a value exponentially distributed with lambda 0.20
        20         : lambda: random.expovariate(0.20)
})
```

A second example of random dictionary with generation interrupts is the following:

```
sim = simpype.Simulation(id = 'test')
myrand = simpype.Random(sim, {
        # From t=0 to t=10, the random variable returns
        # the constant value of 3.0 after time 10.
        # From time 0 to 10, no random variable is generated
        10         : lambda: 3.0,
        # From t=10 to t=20, no random variable is generated
        10         : lambda: None,
        # From t=20 to t=30, the random variable returns
        # a value exponentially distributed with lambda 0.20
        20         : lambda: random.expovariate(0.20)
        # From t=30 to t=inf, no random variable is generated
        30         : lambda: None
})
```

Produce a random value:

```
# Simulation time = 5.0
random_value = myrand.value      # random_value = 3.0
...
# Simulation time = 15.0
random_value = myrand.value      # random_value = 3.2476115513945767
...
# Simulation time = 25.0
random_value = myrand.value      # random_value = 7.374759019459148
```

class simpype.random.**Random**(*sim*, *step_dict*)

SimPype's random class that may return different values depending on the simulation time.

> **Parameters**
>
> - **sim** (Simulation) – The SimPype simulation object.
>
> - **step_dict** (*dict*) – The dictionary storing the random steps.

sim

The SimPype simulation object.

> **Type** Simulation

env

The SimPy environment object.

> **Type** simpy.Environment

step_dict

The dictionary storing the random steps.

> **Type** dict

step_list
>   The list storing the sorted random steps.
>
>>   **Type** list

value
>   Returns a random value given the current simulation time.
>
>>   **Returns** Value as returned by the the `lambda` function.

class simpype.random.**RandomDict**(*sim*)
>   A custom dictionary storing *Random* objects.
>
>>   **Parameters** **sim** (`Simulation`) – The SimPype simulation object.

sim
>   The SimPype simulation object.
>
>>   **Type** `Simulation`

4.7 `simpype.resource`

SimPype's resources process *Message* objects. The behavior of each resource can be customized by overloading the custom `service` function through the decorator `@simpype.resource.service`. See *Resource service()* for more details on how to customize a *Resource* behavior.

```python
import simpype
import random

sim = simpype.Simulation(id = 'simple')
gen0 = sim.add_generator(id = 'gen0')
gen0.message.property['wait'] = {
    0: lambda: random.uniform(0,1)
}
res0 = sim.add_resource(id = 'res0')
res0.random['service'] = {
    0: lambda: 2.0
}

@simpype.resource.service(res0)
def service(self, message):
    # Wait for a random time
    yield self.env.timeout(self.random['service'])
    # Wait for a time as reported in the message property
    yield self.env.timeout(message.property['wait'].value)

sim.run(until = 10)
```

class simpype.resource.**Resource**(*sim*, *id*, *capacity=1*, *pipe=None*)
>   This class implements the *Resource* object.
>
>>   **Parameters**
>>
>>> • **sim** (`Simulation`) – The SimPype simulation object.
>>>
>>> • **id** (`str`) – The resource id.
>>>
>>> • **capacity** (`int`) – The simpy.Resource capacity.
>>>
>>> • **pipe** (`Pipe`) – The SimPype pipe model associated to this resource.

sim
> The SimPype simulation object.
>
> > **Type** `Simulation`

env
> The SimPy environment object.
>
> > **Type** simpy.Environment

id
> The simpype.Resource id.
>
> > **Type** str

use
> The SimPy resource object.
>
> > **Type** simpy.Resource

pipe
> The SimPype pipe object.
>
> > **Type** `Pipe`

random
> The SimPype RandomDict object.
>
> > **Type** `RandomDict`

task
> The dictionary storing the task currenty being executed by the resource.
>
> > **Type** dict

send(*message*)
> Send a [*Message*](#).
>
> > **Parameters** **message** ([*Message*](#)) – The message to send.

class `simpype.resource.`**Task**(*sim*, *message*, *process*)
> This class implements the [*Task*](#) managed by the [*Resource*](#).
>
> > **Parameters**
> >
> > - **sim** (`Simulation`) – The SimPype simulation object.
> >
> > - **message** ([*Message*](#)) – The message being processed in this class
> >
> > - **process** (`simpy.events.Process`) – The SimPy process to execute

sim
> The SimPype simulation object.
>
> > **Type** `Simulation`

env
> The SimPy environment object.
>
> > **Type** simpy.Environment

message
> The message being processed in this class
>
> > **Type** [*Message*](#)

started
> The simulation time this task was started
>
> > **Type** float

interrupted
> The simulation time this task was interrupted. `None` if active.
>
> > **Type** float

process
> The SimPy process being executed
>
> > **Type** simpy.events.Process

`simpype.resource.`**`service`**`(arg)`
> Decorator for overloading the default `Resource` service behavior.
>
> > **Parameters** **arg** (`Resource`)(`self`) – The `Resource` instance.
>
> If the overloading is done in scripts, the `Resource` instance must be provided as decorator argument.

```python
myresource = sim.add_resource(id = 'myresource1')


@simpype.resource.service(myresource)
def service(self, message):
        yield self.env.timeout(1.0)
```

> If the overloading is done inside a Resource subclass, the decorator must be called without any arguments. `Resource` instance is automatically provided through `self`.

```python
class MyResource(simpype.Resource):
        def __init__(self, sim, id, capacity = 1, pipe = None):
                super().__init__(sim, id, capacity, pipe)

        @simpype.resource.service
        def service(self, message):
                yield self.env.timeout(1.0)
```

4.8 `simpype.simulation`

SimPype's simulation.

```python
# Import SimPype module
import simpype
# Import python random module
import random

# [Mandatory] Create a SimPype simulation object
sim = simpype.Simulation(id = 'simple')
# [Optional] Fix the seed for the pseudo-random generator
sim.seed = 42
# [Optional] Configure the log directory.
# [Default] Log are stored by default in the 'current working directory/log'
sim.log.dir = 'mylog'

# [Mandatory] Add at least one generator to the simulation
gen0 = sim.add_generator(id = 'gen0')
```

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```python
# [Mandatory] Assign an arrival time
# Generator.random is a custom dictionary accepting the following format as values:
# generator.random[<some_id>] = {
#       <initial_time> : lambda: <value>/<random_function>
#       ...
# }
# Random values can be generated in the following way:
#       generator.random[<some_id>].value
# The random value is:
#       <value>/<random_function> the simulation time is equal or
# greater than (>=) <initial_time>, 0 otherwise
gen0.random['arrival'] = {
        # From t=0 to t=10, arrival is constant every 3s
        0        : lambda: 3.0,
        # From t=10 to t=20, arrival is uniform between 2.5 and 3.5
        10       : lambda: random.uniform(2.5, 3.5),
        # From t=20 to t=inf, arrival is expovariate with lambda 0.20
        20       : lambda: random.expovariate(0.20)
}

# [Mandatory] Add at least one resource to the simulation
res0 = sim.add_resource(id = 'res0')
# [Mandatory] Assign a service time
# Resource.random is a dictionary accepting the same Generator.random format
res0.random['service'] = {
        # From t=0 to t=10, service is constant at 1.5s
        0        : lambda: 1.5,
        # From t=10 to t=20, service is uniform between 1.5 and 2.5
        10       : lambda: random.uniform(1.5, 2.5),
        # From t=20 to t=inf, arrival is expovariate with lambda 2.0
        20       : lambda: random.expovariate(2.0)
}

# [Mandatory] Add a pipeline connecting the generator and the resource
p0 = sim.add_pipeline(gen0, res0)

# [Mandatory] Run the simulation e.g. until t=30
#             sim.run calls Simpy's env.run
#             Any arg passed to sim.run is then passed to env.run
sim.run(until = 30)
```

The log directory structure is the following:

```
log.dir
|-- <simulation #1>
|    |-- <run #1>
|    |    |-- sim.cfg
|    |    `-- sim.log
|    |-- <run #2>
|    |    |-- sim.cfg
|    |    `-- sim.log
|-- <simulation #2>
|    |-- <run #1>
|    |    |-- sim.cfg
|    |    `-- sim.log
|    |-- <run #2>
|    |    |-- sim.cfg
```

```
|   |   `-- sim.log
|   ...
...
```

`sim.cfg` contains information about the simulation environment and has the following format:

```
Simulation Seed: 42
Simulation Time: 30.000000000
Execution Time: 0.003298451
```

`sim.log` contains the actual log of the simulation events and has the following format:

```
timestamp,message,seq_num,resource,event
0.000000000,gen0,0,res0,pipe.in
0.000000000,gen0,0,res0,pipe.out
1.500000000,gen0,0,res0,resource.serve
3.000000000,gen0,1,res0,pipe.in
3.000000000,gen0,1,res0,pipe.out
4.500000000,gen0,1,res0,resource.serve
6.000000000,gen0,2,res0,pipe.in
6.000000000,gen0,2,res0,pipe.out
7.500000000,gen0,2,res0,resource.serve
9.000000000,gen0,3,res0,pipe.in
9.000000000,gen0,3,res0,pipe.out
10.500000000,gen0,3,res0,resource.serve
12.000000000,gen0,4,res0,pipe.in
12.000000000,gen0,4,res0,pipe.out
13.525010755,gen0,4,res0,resource.serve
15.139426798,gen0,5,res0,pipe.in
15.139426798,gen0,5,res0,pipe.out
16.862637537,gen0,5,res0,resource.serve
17.914456117,gen0,6,res0,pipe.in
17.914456117,gen0,6,res0,pipe.out
20.091155604,gen0,6,res0,resource.serve
21.150927331,gen0,7,res0,pipe.in
21.150927331,gen0,7,res0,pipe.out
21.196403533,gen0,7,res0,resource.serve
```

class `simpype.simulation.`**`Log`**(*sim*)
   Class storing the simulation parameters regarding the dynamic models.

>   **Parameters** **sim** ([*Simulation*](#)) – The SimPype simulation object.

   sim
      The SimPype simulation object.

>   **Type** [*Simulation*](#)

   env
      The SimPy environment object.

>   **Type** simpy.Environment

   date
      The real world creation time of the simulation environment.

>   **Type** datetime.now()

   file
      Write the logs to a file if `True`. Default value is `True`.

> **Type** bool

print
> Print the logs to the console if `True`. Default value is `False`.
>
> > **Type** bool

dir
> The folder where the simulation logs are written.

init()
> Initialize the log folder and the simulation loggers.

property(*property*)
> Enable the logging of a message property.
>
> > **Parameters property** (*str*) – The property to log.

write(*entry*)
> Write a log entry.
>
> > **Parameters entry** (*Timestamp*)(str) – The entry to be logged. If the entry is *Timestamp*

class simpype.simulation.**Model**(*sim*)
> Class storing the simulation parameters regarding the dynamic models.
>
> > **Parameters sim** (*Simulation*) – The SimPype simulation object.

sim
> The SimPype simulation object.
>
> > **Type** *Simulation*

env
> The SimPy environment object.
>
> > **Type** simpy.Environment

dir
> The folder containing the customs models to be loaded by the SimPype simulation environment.

class simpype.simulation.**Simulation**(*id*)
> Class implementing the SimPype's simulation environment.
>
> > **Parameters id** (*str*) – The simulation environment id.

env
> The SimPy environment object.
>
> > **Type** simpy.Environment

id
> The simulation environment id.
>
> > **Type** str

resource
> The dictionary storing all the *Resource* objects of the simulation.
>
> > **Type** dict

generator
> The dictionary storing all the *Resource* objects implementing generator functionalities of the simulation.
>
> > **Type** dict

---

pipeline
>   The dictionary storing all the *Pipeline* objects of the simulation.

>   > **Type** dict

log
>   The log class storing the logging parameters.

>   > **Type** *Log*

model
>   The model class storing the custom model parameters.

>   > **Type** *Model*

add_generator(*id*, *model=None*)
>   Add a *Resource* implementing generator funcionalities to the simulation environment.

>   > **Parameters**

>   > > - **id** (*str*) – The generator id

>   > > - **model** (*str*) – The model of the generator. If model is None, the default model is used.

>   > **Returns** *Resource*

add_pipeline(**args*)
>   Chain multiples *Resource* or *Pipeline* objects into a pipeline..

>   > **Parameters** ***args** (*Resource*)(*Pipeline*) – Create a pipeline by chaining 2 or more *Resource* or *Pipeline* objects.

>   > **Returns** *Pipeline*

add_resource(*id*, *model=None*, *capacity=1*, *pipe=None*)
>   Add a *Resource* object to the simulation environment.

>   > **Parameters**

>   > > - **id** (*str*) – The resource id

>   > > - **model** (*str*) – The model of the resource. If model is None, the default model is used.

>   > > - **capacity** (*int*) – The capacity of the resource, that is the number of *Message* objects that the resource can simultaneously serve.

>   > > - **pipe** (*str*) – The model of the pipe associated to the resource. If model is None, the default model is used.

>   > **Returns** *Resource*

merge_pipeline(**args*)
>   Merge varioues *Pipeline* objects into a single pipeline.

>   > **Parameters** ***args** (*Pipeline*) – Create a pipeline by merging 2 or more *Pipeline* objects.

>   > **Returns** *Pipeline*

run(**args*, ***kwargs*)
>   Run the simulation environment using SimPy environment.

seed
>   The seed of the pseudo-random number generator used by this simulation.

CHAPTER 5

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