salabim Documentation

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CHAPTER

ONE

INTRODUCTION

Salabim is a package for discrete event simulation in Python. It follows the methodology of process description as originally demonstrated in *Simula* and later in *Prosim*, *Must* and *Tomas*. The process interaction methods are also quite similar to *SimPy 2*.

The package comprises discrete event simulation, queue handling, resources, statistical sampling and monitoring. On top of that real time animation is built in.

The package comes with a number of sample models.

1.1 Requirements

Salabim runs on

- CPython
- PyPy platform
- Pythonista (iOS)

The package runs only under Python 3.x.

The following packages are required:

Platform	Base functionality	Animation	Video (mp4, avi)	Animated GIF
CPython	•	Pillow, tkinter	opencv, numpy	Pillow
PyPy	•	Pillow, tkinter	N/A	Pillow
Pythonista	•	Pillow	N/A	Pillow

Several CPython packages, like *WinPython* support Pillow out of the box. If not, install with: `pip install Pillow`

Under Linux, Pillow can be installed with: `sudo apt-get purge python3-pil sudo apt-get install python3-pil python3-pil.imagetk`

For video production, installation of opencv and numpy may be required with `pip install opencv-python pip install numpy`

To add audio to a video (Windows only), installation of ffmpeg is required. Refer to *www.ffmpeg.org* for instructions and download.

Running models under PyPy is highly recommended for production runs, where run time is important. We have found 6 to 7 times faster execution compared to CPython. However, for development, nothing can beat CPython or Pythonista.

1.2 Installation

The preferred way to install salabim is from PyPI with: `pip install salabim`

or to upgrade to a new version: `pip install salabim --upgrade`

You can find the package along with some support files and sample models on www.github.com/salabim/salabim. From there you can directly download as a zip file and next extract all files. Alternatively the repository can be cloned.

For Pythonista, the easiest way to download salabim is:

- Tap 'Open in...'.
- Tap 'Run Pythonista Script'.
- Pick this script and tap the run button
- Import file
- Possibly after short delay, there will be a salabim-master.zip file in the root directory
- Tap this zip file and Extract files

- All files are now in a directory called salabim-master
- Optionally rename this directory to salabim

Salabim itself is provided as one Python script, called salabim.py. You may place that file in any directory where your models reside.

If you want salabim to be available from other directories, without copying the salabim.py script, either install from PyPI (see above) or run the supplied install.py file. In doing so, you will create (or update) a salabim directory in the site-package directory, which will then contain a copy of the salabim package.

1.3 Python

Python is a widely used high-level programming object oriented language for general-purpose programming, created by Guido van Rossum and first released in 1991. An interpreted language, Python has a design philosophy that emphasizes code readability (notably using whitespace indentation to delimit code blocks rather than curly brackets or keywords), and a syntax that allows programmers to express concepts in fewer lines of code than might be used in languages such as C++ or Java. The language provides constructs intended to enable writing clear programs on both a small and large scale.

A good way to start learning about Python is https://www.python.org/about/gettingstarted/

CHAPTER

TWO

MODELING

2.1 A simple model

Let's start with a very simple model, to demonstrate the basic structure, process interaction, component definition and output:

```
# Car.py
import salabim as sim


class Car(sim.Component):
    def process(self):
        while True:
            yield self.hold(1)


env = sim.Environment(trace=True)
Car()
env.run(till=5)
```

In basic steps:

We always start by importing salabim

```
import salabim as sim
```

Now we can refer to all salabim classes and function with `sim.`. For convenience, some functions or classes can be imported with, for instance

```
from salabim import now, main, Component
```

It is also possible to import all methods, classes and globals by

```
from salabim import *
```

, but we do not recommend that method.

The main body of every salabim model usually starts with

```
env = sim.Environment()
```

For each (active) component we define a class as in

```
class Car(sim.Component):
```

The class inherits from sim.Component.

Although it is possible to define other processes within a class, the standard way is to define a generator function called `process` in the class. A generator is a function with at least one yield statement. These are used in salabim context as a signal to give control to the sequence mechanism.

In this example,

```
yield self.hold(1)
```

gives control,to the sequence mechanism and *comes back* after 1 time unit. The *self.* part means that it is this component to be held for some time. We will see later other uses of yield like passivate, request, wait and standby.

In the main body an instance of a car is created by Car(). It automatically gets the name car.0. As there is a generator function called process in Car, this process description will be activated (by default at time now, which is 0 here). It is possible to start a process later, but this is by far the most common way to start a process.

With

```
env.run(till=5)
```

we start the simulation and get back control after 5 time units. A component called *main* is defined under the hood to get access to the main process.

When we run this program, we get the following output

```
line#         time current component    action                              information
-----   ---------- -------------------- ----------------------------------  ------------------------------------------------
                                        line numbers refers to              Example - basic.py
```

```
  11                                default environment initialize
  11                                main create
  11        0.000 main              current
  12                                car.0 create
  12                                car.0 activate                  scheduled for      0.000 @    6  process=process
  13                                main run                        scheduled for      5.000 @   13+
   6        0.000 car.0             current
   8                                car.0 hold                      scheduled for      1.000 @    8+
   8+       1.000 car.0             current
   8                                car.0 hold                      scheduled for      2.000 @    8+
   8+       2.000 car.0             current
   8                                car.0 hold                      scheduled for      3.000 @    8+
   8+       3.000 car.0             current
   8                                car.0 hold                      scheduled for      4.000 @    8+
   8+       4.000 car.0             current
   8                                car.0 hold                      scheduled for      5.000 @    8+
  13+       5.000 main              current
```

2.2 A bank example

Now let's move to a more realistic model. Here customers are arriving in a bank, where there is one clerk. This clerk handles the customers in first in first out (FIFO) order. We see the following processes:

- The customer generator that creates the customers, with an inter arrival time of uniform(5,15)
- The customers
- The clerk, which serves the customers in a constant time of 30 (overloaded and non steady state system)

And we need a queue for the customers to wait for service.

The model code is:

```
1  # Bank, 1 clerk.py
2  import salabim as sim
3
4
5  class CustomerGenerator(sim.Component):
6      def process(self):
```

```
        while True:
            Customer()
            yield self.hold(sim.Uniform(5, 15).sample())


class Customer(sim.Component):
    def process(self):
        self.enter(waitingline)
        if clerk.ispassive():
            clerk.activate()
        yield self.passivate()


class Clerk(sim.Component):
    def process(self):
        while True:
            while len(waitingline) == 0:
                yield self.passivate()
            self.customer = waitingline.pop()
            yield self.hold(30)
            self.customer.activate()


env = sim.Environment(trace=True)

CustomerGenerator()
clerk = Clerk()
waitingline = sim.Queue("waitingline")

env.run(till=50)
print()
waitingline.print_statistics()
```

Let's look at some details

```
yield self.hold(sim.Uniform(5, 15).sample())
```

will do the statistical sampling and wait for that time till the next customer is created.

With

```
self.enter(waitingline)
```

the customer places itself at the tail of the waiting line.

Then, the customer checks whether the clerk is idle, and if so, activates him immediately.

```
if clerk.ispassive():
    clerk.activate()
```

Once the clerk is active (again), it gets the first customer out of the waitingline with

```
self.customer = waitingline.pop()
```

and holds for 30 time units with

```
yield self.hold(30)
```

After that hold the customer is activated and will terminate

```
self.customer.activate()
```

In the main section of the program, we create the CustomerGenerator, the Clerk and a queue called waitingline. After the simulation is finished, the statistics of the queue are presented with

```
waitingline.print_statistics()
```

The output looks like

```
line#         time current component    action                              information
-----   ---------- -------------------- ----------------------------------  ------------------------------------------------
                                        line numbers refers to              Example - bank, 1 clerk.py
   30                                   default environment initialize
   30                                   main create
   30        0.000 main                 current
   32                                   customergenerator create
   32                                   customergenerator activate          scheduled for      0.000 @    6  process=process
   33                                   clerk.0 create
   33                                   clerk.0 activate                    scheduled for      0.000 @   21  process=process
   34                                   waitingline create
   36                                   main run                            scheduled for     50.000 @   36+
```

```
  6        0.000 customergenerator    current
  8                                   customer.0 create
  8                                   customer.0 activate                scheduled for      0.000 @   13  process=process
  9                                   customergenerator hold             scheduled for     14.631 @    9+
 21        0.000 clerk.0              current
 24                                    clerk.0 passivate
 13        0.000 customer.0           current
 14                                    customer.0                         enter waitingline
 16                                    clerk.0 activate                   scheduled for      0.000 @   24+
 17                                    customer.0 passivate
 24+       0.000 clerk.0              current
 25                                    customer.0                         leave waitingline
 26                                    clerk.0 hold                       scheduled for     30.000 @   26+
  9+      14.631 customergenerator    current
  8                                   customer.1 create
  8                                   customer.1 activate                scheduled for     14.631 @   13  process=process
  9                                   customergenerator hold             scheduled for     21.989 @    9+
 13       14.631 customer.1           current
 14                                    customer.1                         enter waitingline
 17                                    customer.1 passivate
  9+      21.989 customergenerator    current
  8                                   customer.2 create
  8                                   customer.2 activate                scheduled for     21.989 @   13  process=process
  9                                   customergenerator hold             scheduled for     32.804 @    9+
 13       21.989 customer.2           current
 14                                    customer.2                         enter waitingline
 17                                    customer.2 passivate
 26+      30.000 clerk.0              current
 27                                    customer.0 activate                scheduled for     30.000 @   17+
 25                                    customer.1                         leave waitingline
 26                                    clerk.0 hold                       scheduled for     60.000 @   26+
 17+      30.000 customer.0           current
                                       customer.0 ended
  9+      32.804 customergenerator    current
  8                                   customer.3 create
  8                                   customer.3 activate                scheduled for     32.804 @   13  process=process
  9                                   customergenerator hold             scheduled for     40.071 @    9+
 13       32.804 customer.3           current
 14                                    customer.3                         enter waitingline
 17                                    customer.3 passivate
```

```
    9+      40.071 customergenerator    current
    8                                   customer.4 create
    8                                   customer.4 activate                 scheduled for     40.071 @   13  process=process
    9                                   customergenerator hold              scheduled for     54.737 @    9+
   13       40.071 customer.4           current
   14                                   customer.4                          enter waitingline
   17                                   customer.4 passivate
   36+      50.000 main                 current

Statistics of waitingline at        50
                                                                    all    excl.zero         zero
-------------------------------------------- -------------- ------------ ------------ ------------
Length of waitingline                        duration             50           35.369       14.631
                                             mean                 1.410        1.993
                                             std.deviation        1.107        0.754

                                             minimum              0            1
                                             median               2            2
                                             90% percentile       3            3
                                             95% percentile       3            3
                                             maximum              3            3

Length of stay in waitingline                entries              2            1            1
                                             mean                 7.684       15.369
                                             std.deviation        7.684        0

                                             minimum              0           15.369
                                             median              15.369       15.369
                                             90% percentile      15.369       15.369
                                             95% percentile      15.369       15.369
                                             maximum             15.369       15.369
```

Now, let's add more clerks. Here we have chosen to put the three clerks in a list

```
clerks = [Clerk() for _ in range(3)]
```

although in this case we could have also put them in a salabim queue, like

```
clerks = sim.Queue('clerks')
for _ in range(3):
```

```
    Clerk().enter(clerks)
```

And, to restart a clerk

```
for clerk in clerks:
    if clerk.ispassive():
       clerk.activate()
       break  # reactivate only one clerk
```

The complete source of a three clerk post office:

```
# Bank, 3 clerks.py
import salabim as sim


def my_sample():
    a = 1
    c = 2
    return scipy.stats.exponweib.rvs(1, 2)


for i in range(20):
    print(my_sample())


class CustomerGenerator(sim.Component):
    def process(self):
        while True:
            Customer()
            yield self.hold(sim.Uniform(5, 15).sample())


class Customer(sim.Component):
    def process(self):
        self.enter(waitingline)
        for clerk in clerks:
            if clerk.ispassive():
                clerk.activate()
                break  # activate at most one clerk
        yield self.passivate()
```

```
class Clerk(sim.Component):
    def process(self):
        while True:
            while len(waitingline) == 0:
                yield self.passivate()
            self.customer = waitingline.pop()
            yield self.hold(30)
            self.customer.activate()


env = sim.Environment(trace=False)
CustomerGenerator()
clerks = [Clerk() for _ in range(3)]

waitingline = sim.Queue("waitingline")

env.run(till=50000)
waitingline.print_histograms()

waitingline.print_info()
```

2.3 A bank office example with resources

The salabim package contains another useful concept for modelling: resources. Resources have a limited capacity and can be claimed by components and released later.

In the model of the bank with the same functionality as the above example, the clerks are defined as a resource with capacity 3.

The model code is:

```
# Bank, 3 clerks (resources).py
import salabim as sim


class CustomerGenerator(sim.Component):
    def process(self):
        while True:
```

```
            Customer()
            yield self.hold(sim.Uniform(5, 15).sample())


class Customer(sim.Component):
    def process(self):
        yield self.request(clerks)
        yield self.hold(30)
        self.release()  # not really required


env = sim.Environment(trace=False)
CustomerGenerator()
clerks = sim.Resource("clerks", capacity=3)

env.run(till=50000)

clerks.print_statistics()
clerks.print_info()
```

Let's look at some details.

```
clerks = sim.Resource('clerks', capacity=3)
```

This defines a resource with a capacity of 3.

And then, a customer, just tries to claim one unit (=clerk) from the resource with

```
yield self.request(clerks)
```

Here, we use the default of 1 unit. If the resource is not available, the customer just waits for it to become available (in order of arrival).

In contrast with the previous example, the customer now holds itself for 30 time units.

And after these 30 time units, the customer releases the resource with

```
self.release()
```

The effect is that salabim then tries to honor the next pending request, if any.

(actually, in this case this release statement is not required, as resources that were claimed are automatically released when a process terminates).

The statistics are maintained in two system queue, called clerk.requesters() and clerk.claimers().

The output is very similar to the earlier example. The statistics are exactly the same.

2.4 The bank office example with balking and reneging

Now, we assume that clients are not going to the queue when there are more than 5 clients waiting (balking). On top of that, if a client is waiting longer than 50, he/she will leave as well (reneging).

The model code is:

```
# Example - bank, 3 clerks, reneging.py
import salabim as sim


class CustomerGenerator(sim.Component):
    def process(self):
        while True:
            Customer()
            yield self.hold(sim.Uniform(5, 15).sample())


class Customer(sim.Component):
    def process(self):
        if len(waitingline) >= 5:
            env.number_balked += 1
            env.print_trace("", "", "balked")
            yield self.cancel()
        self.enter(waitingline)
        for clerk in clerks:
            if clerk.ispassive():
                clerk.activate()
                break  # activate only one clerk
        yield self.hold(50)  # if not serviced within this time, renege
        if self in waitingline:
            self.leave(waitingline)
            env.number_reneged += 1
            env.print_trace("", "", "reneged")
        else:
```

```
            yield self.passivate()  # wait for service to be completed


class Clerk(sim.Component):
    def process(self):
        while True:
            while len(waitingline) == 0:
                yield self.passivate()
            self.customer = waitingline.pop()
            self.customer.activate()  # get the customer out of it's hold(50)
            yield self.hold(30)
            self.customer.activate()  # signal the customer that's all's done


env = sim.Environment()
CustomerGenerator()
env.number_balked = 0
env.number_reneged = 0
clerks = [Clerk() for _ in range(3)]

waitingline = sim.Queue("waitingline")
waitingline.length.monitor(False)
env.run(duration=1500)  # first do a prerun of 1500 time units without collecting data
waitingline.length.monitor(True)
env.run(duration=1500)  # now do the actual data collection for 1500 time units
waitingline.length.print_histogram(30, 0, 1)
print()
waitingline.length_of_stay.print_histogram(30, 0, 10)
print("number reneged", env.number_reneged)
print("number balked", env.number_balked)
```

Let's look at some details.

```
yield self.cancel()
```

This makes the current component (a customer) a data component (and be subject to garbage collection), if the queue length is 5 or more.

The reneging is implemented by a hold of 50. If a clerk can service a customer, it will take the customer out of the waitingline and will activate it at that moment. The customer just has to check whether he/she is still in the waiting line. If so, he/she has been serviced in time and thus will renege.

```
yield self.hold(50)
if self in waitingline:
    self.leave(waitingline)
    env.number_reneged += 1
else:
     self.passivate()
```

All the clerk has to do when starting servicing a client is to get the next customer in line out of the queue (as before) and activate this customer (at time now). The effect is that the hold of the customer will end.

```
self.customer = waitingline.pop()
self.customer.activate()
```

2.5 The bank office example with balking and reneging (resources)

Now we show how the balking and reneging is implemented with resources.

The model code is:

```
# Example - bank, 3 clerks, reneging (resources).py
import salabim as sim


class CustomerGenerator(sim.Component):
    def process(self):
        while True:
            Customer()
            yield self.hold(sim.Uniform(5, 15).sample())


class Customer(sim.Component):
    def process(self):
        if len(clerks.requesters()) >= 5:
            env.number_balked += 1
            env.print_trace("", "", "balked")
            yield self.cancel()
        yield self.request(clerks, fail_delay=50)
        if self.failed():
```

```
            env.number_reneged += 1
            env.print_trace("", "", "reneged")
        else:
            yield self.hold(30)
            self.release()


env = sim.Environment()
CustomerGenerator()
env.number_balked = 0
env.number_reneged = 0
clerks = sim.Resource("clerks", 3)

env.run(till=50000)

clerks.requesters().length.print_histogram(30, 0, 1)
print()
clerks.requesters().length_of_stay.print_histogram(30, 0, 10)
print("number reneged", env.number_reneged)
print("number balked", env.number_balked)
```

As you can see, the balking part is exactly the same as in the example without resources.

For the renenging, all we have to do is add a fail_delay

```
yield self.request(clerks, fail_delay=50)
```

If the request is not honored within 50 time units, the process continues after that request statement. And then, we just check whether the request has failed

```
if self.failed():
    env.number_reneged += 1
```

This example shows clearly the advantage of the resource solution over the passivate/activate method, in this example.

2.6 The bank office example with states

The salabim package contains yet another useful concept for modelling: states. In this case, we define a state called worktodo.

The model code is:

```
# Example - bank, 3 clerks (state).py
import salabim as sim


class CustomerGenerator(sim.Component):
    def process(self):
        while True:
            Customer()
            yield self.hold(sim.Uniform(5, 15).sample())


class Customer(sim.Component):
    def process(self):
        self.enter(waitingline)
        worktodo.trigger(max=1)
        yield self.passivate()


class Clerk(sim.Component):
    def process(self):
        while True:
            if len(waitingline) == 0:
                yield self.wait(worktodo)
            self.customer = waitingline.pop()
            yield self.hold(30)
            self.customer.activate()


env = sim.Environment()
CustomerGenerator()
for i in range(3):
    Clerk()
waitingline = sim.Queue("waitingline")
worktodo = sim.State("worktodo")

env.run(till=50000)
waitingline.print_histograms()
worktodo.print_histograms()
```

Let's look at some details.

```
worktodo = sim.State('worktodo')
```

This defines a state with an initial value False.

In the code of the customer, the customer tries to trigger one clerk with

```
worktodo.trigger(max=1)
```

The effect is that if there are clerks waiting for worktodo, the first clerk's wait is honored and that clerk continues its process after

```
yield self.wait(worktodo)
```

Note that the clerk is only going to wait for worktodo after completion of a job if there are no customers waiting.

2.7 The bank office example with standby

The salabim package contains yet another powerful process mechanism, called standby. When a component is in standby mode, it will become current after *each* event. Normally, the standby will be used in a while loop where at every event one or more conditions are checked.

The model with standby is

```
.. literalinclude:: ..\..\sample models\Bank, 3 clerks (standby.py)
```

In this case, the condition is checked frequently with

```
while len(waitingline) == 0:
    yield self.standby()
```

The rest of the code is very similar to the version with states.

Warning: It is very important to realize that this mechanism can have significant impact on the performance, as after EACH event, the component becomes current and has to be checked. In general it is recommended to try and use states or a more straightforward passivate/activate construction.

CHAPTER

THREE

COMPONENT

Components are the key elements of salabim simulations.

Components can be either data or active. An active component has one or more process descriptions and is activated at some point of time. You can make a data component active with activate. And an active component can become data either with a cancel or by reaching the end of its process method.

It is easy to create a data component by:

```
data_component = sim.Component()
```

Data components may be placed in a queue. This component will not be activated as there is no associated process method.

In order to make an active component it is necessary to first define a class:

```
class Ship(sim.Component):
```

And then there has to be a (usually generator) method, normally called process:

```
class Ship(sim.Component):
    def process(self):
        ....
        yield ...
        ....
```

Normally, the process will contain at least one yield (or yield from) statement. But that's not a requirement.

Creation and activation can be combined by making a new instance of the class:

```
ship1 = Ship()
ship2 = Ship()
ship3 = Ship()
```

This causes three Ships to be created and to start them at Sim.process(). The ships will automatically get the name `ship.0`, etc., unless a name is given explicitly.

If no process method is found for Ship, the ship will be a data component. In that case, it may become active by means of an activate statement:

```
class Crane(sim.Component):
    def unload(self):
        ....
        yield ...
        ....

crane1 = Crane()
crane1.activate(process='unload')

crane2 = Crane(process='unload')
```

Effectively, creation and start of crane1 and crane2 is the same.

Although not very common, it is possible to activate a component at a certain time or with a specified delay:

```
ship1.activate(at=100)
ship2.activate(delay=50)
```

At time of creation it is sometimes useful to be able to set attributes, prepare for actions, etc. This is possible in salabim by defining an __init__ and/or a setup method:

If the __init__ method is used, it is required to call the Component.__init__ method from within the overridden method:

```
class Ship(sim.Component):
    def __init__(self, length, *args, **kwargs):
        sim.Component.__init__(self, *args, **kwargs)
        self.length = length

ship = Ship(length=250)
```

This sets ship.length to 250.

In most cases, the setup method is preferred, however. This method is called after ALL initialization code of Component is executed.

```
class Ship(sim.Component):
    def setup(self, length):
        self.length = length

ship = Ship(length=250)
```

Now, ship.length will be 250.

Note that setup gets all arguments and keyword arguments, that are not 'consumed' by __init__ and/or the process call.

Only in very specific cases, __init__ will be necessary.

Note that the setup code can be used for data components as well.

3.1 Process interaction

A component may be in one of the following states:

- data
- current
- scheduled
- passive
- requesting
- waiting
- standby
- interrupted

The scheme below shows how components can go from state to state.

from/to	data	current	scheduled	passive	requesting	waiting	standby	interrupted
data		activate[1]	activate					
current	process end		yield hold	yield passivate	yield request	yield wait	yield standby	
.	yield cancel		yield activate					
scheduled	cancel	next event	hold	passivate	request	wait	standby	interrupt
.			activate					
passive	cancel	activate[1]	activate		request	wait	standby	interrupt
.			hold[2]					
requesting	cancel	claim honor	activate[3]	passivate	request	wait	standby	interrupt
.		time out			activate[4]			
waiting	cancel	wait honor	activate[5]	passivate	wait	wait	standby	interrupt
.		timeout				activate[6]		
standby	cancel	next event	activate	passivate	request	wait		interrupt
interrupted	cancel		resume[7]	resume[7]	resume[7]	resume[7]	resume[7]	interrupt[8]
.			activate	passivate	request	wait	standby	

[1] via scheduled [2] not recommended [3] with keep_request=False (default) [4] with keep_request=True. This allows to set a new time out [5] with keep_wait=False (default) [6] with keep_wait=True. This allows to set a new time out [7] state at time of interrupt [8] increases the interrupt_level

3.1.1 Creation of a component

Although it is possible to create a component directly with *x=sim.Component()*, this makes it very hard to make that component into an active component, because there's no process method. So, nearly always we define a class based on sim.Component

```
def Car(sim.Component):
    def process(self):
        ...
```

If we then say `car=Car()`, a component is created and it activated from process. This process is nearly always, but not necessarily a generator method (i.e. it has at least one yield (or yield from) statement.

The result is that car is put on the future event list (for time now) and when it's its turn, the component becomes current.

It is also possible to set a time at which the component (car) becomes active, like *car=Car(at=10)*.

And instead of starting at process, the component may be initialized to start at another (generator) method, like `car=Car(process='wash')`.

And, finally, if there is a process method, you can disable the automatic activation (i.e. make it a data component) , by specifying `process=''`.

If there is no process method, and process= is not given, the component will be a data component.

3.1.2 activate

Activate is the way to turn a data component into a live component. If you do not specify a process, the (usually generator) function process is assumed. So you can say

```
car0 = Car(process='')  # data component
car0.activate()  # activate @ process if exists, otherwise error
car1 = Car(process='')  # data component
car1.activate(process='wash')  # activate @ wash
```

- If the component to be activated is current, always use yield self.activate. The effect is that the component becomes scheduled, thus this is essentially equivalent to the preferred hold method.
- If the component to be activated is passive, the component will be activated at the specified time.
- If the component to be activated is scheduled, the component will get a new scheduled time.
- If the component to be activated is requesting, the request will be terminated, the attribute failed set and the component will become scheduled. If keep_request=True is specified, only the fail_at will be updated and the component will stay requesting.
- If the component to be activated is waiting, the wait will be terminated, the attribute failed set and the component will become scheduled. If keep_wait=True is specified, only the fail_at will be updated and the component will stay waiting.
- If the component to be activated is standby, the component will get a new scheduled time and become scheduled.
- If the component is interrupted, the component will be activated at the specified time.

3.1.3 hold

Hold is the way to make a, usually current, component scheduled.

- If the component to be held is current, the component becomes scheduled for the specified time. Always use yield self.hold() is this case.
- If the component to be held is passive, the component becomes scheduled for the specified time.
- If the component to be held is scheduled, the component will be rescheduled for the specified time, thus essentially the same as activate.
- If the component to be held is standby, the component becomes scheduled for the specified time.
- If the component to be activated is requesting, the request will be terminated, the attribute failed set and the component will become scheduled. It is recommended to use the more versatile activate method.

- If the component to be activated is waiting, the wait will be terminated, the attribute failed set and the component will become scheduled. It is recommended to use the more versatile activate method.
- If the component is interrupted, the component will be activated at the specified time.

3.1.4 passivate

Passivate is the way to make a, usually current, component passive. This isessentially the same as scheduling for time=inf.

- If the component to be passivated is current, the component becomes passive. Always use yield self.passivate() is this case.
- If the component to be passivated is passive, the component remains passive.
- If the component to be passivated is scheduled, the component becomes passive.
- If the component to be held is standby, the component becomes passive.
- If the component to be activated is requesting, the request will be terminated, the attribute failed set and the component becomes passive. It is recommended to use the more versatile activate method.
- If the component to be activated is waiting, the wait will be terminated, the attribute failed set and the component becomes passive. It is recommended to use the more versatile activate method.
- If the component is interrupted, the component becomes passive.

3.1.5 cancel

Cancel has the effect that the component becomes a data component.

- If the component to be cancelled is current, always use yield self.cancel().
- If the component to be cancelled is passive, scheduled, interrupted or standby, the component becomes a data component.
- If the component to be cancelled is requesting, the request will be terminated, the attribute failed set and the component becomes a data component.
- If the component to be cancelled is waiting, the wait will be terminated, the attribute failed set and the component becomes a data component.

3.1.6 standby

Standby has the effect that the component will be triggered on the next simulation event.

- If the component is current, use always yield self.standby()
- Although theoretically possible, it is not recommended to use standby for non current components.

3.1.7 request

Request has the effect that the component will check whether the requested quantity from a resource is available. It is possible to check for multiple availability of a certain quantity from several resources. By default, there is no limit on the time to wait for the resource(s) to become available. But, it is possible to set a time with fail_at at which the condition has to be met. If that failed, the component becomes current at the given point of time. The code should then check whether the request had failed. That can be checked with the Component.failed() method.

If the component is canceled, activated, passivated, interrupted or held the failed flag will be set as well.

- If the component is current, always use yield self.request()
- Although theoretically possible it is not recommended to use request for non current components.

3.1.8 wait

Wait has the effect that the component will check whether the value of a state meets a given condition. available. It is possible to check for multiple states. By default, there is no limit on the time to wait for the condition(s) to be met. But, it is possible to set a time with fail_at at which the condition has to be met. If that failed, the component becomes current at the given point of time. The code should then check whether the wait had failed. That can be checked with the Component.failed() method.

If the component is canceled, activated, passivated, interrupted or held the failed flag will be set as well.

- If the component is current, use always yield self.wait()
- Although theoretically possible it is not recommended to use wait for non current components.

3.1.9 interrupt

With interrupt components that are not current or data can be temporarily be interrupted. Once a resume is called for the component, the component will continue (for scheduled with the remaining time, for waiting or requesting possibly with the remaining fail_at duration).

3.2 Usage of process interaction methods within a function or method

There is a way to put process interaction statement in another function or method. This requires a slightly different way than just calling the method.

As an example, let's assume that we want a method that holds a component for a number of minutes and that the time unit is actually seconds. So we need a method to wait 60 times the given parameter

We start with a not so elegant solution:

```
class X(sim.Component):
    def process(self):
        yield self.hold(60 * 2)
        yield self.hold(60 * 5)
```

Now we just addd a method hold_minutes:

```
def hold_minutes(self, minutes):
    yield self.hold(60 * minutes)
```

Direct calling hold_minutes is not possible. Instead we have to say:

```
class X(sim.Component):
   def hold_minutes(self, minutes):
        yield self.hold(60 * minutes)

   def process(self):
        yield from self.hold_minutes(2)
        yield from self.hold_minutes(5)
```

All process interaction statements including passivate, request and wait can be used that way!

So remember if the method contains a yield statement (technically speaking that's a generator method), it should be called with `yield from`.

CHAPTER

FOUR

QUEUE

Salabim has a class Queue for queue handling of components. The advantage over the standard list and deque are:

- double linked, resulting in easy and efficient insertion and deletion at any place
- builtin data collection and statistics
- priority sorting

Salabim uses queues internally for resources and states as well.

Definition of a queue is simple:

```
waitingline=sim.Queue('waitingline')
```

The name of a queue can retrieved with `q.name()`.

There is a set of methods for components to enter and leave a queue and retrieval:

Component	Queue	Description
c.enter(q)	q.add(c) or q.append(c)	c enters q at the tail
c.enter_to_head(q)	q.add_at_head(c)	c enters q at the head
c.enter_in_front_of(c, c1)	q.add_in_front_of(c, c1)	c enters q in front of c1
c.enter_behind(q, c1)	q.add_behind(c, c1)‘	c enters q behind c1
c.enter_sorted(q, p)	q.add_sorted(c, p)	c enters q according to priority p
c.leave(q)	q.remove(c) q.insert(c,i) q.pop() q.pop(i) q.head() or q[0] q.tail() or q[-1] q.index(c) q.component_with_name(n)	c leaves q insert c just before the i-th component in q removes head of q and returns it removes i-th component in q and returns it returns head of q returns tail of q returns the position of c in q returns the component with name n in q
c.successor(q)	q.successor(c)	successor of c in q
c.predecessor(q)	q.predecessor(c)	predecessor of c in q
c.count(q)	q.count(c)	returns 1 if c in q, 0 otherwise
c.queues()		returns a set with all queues where c is in
c.count()	returns number of queues c is in	

Queue is a standard ABC class, which means that the following methods are supported:

- `len(q)` to retrieve the length of a queue, alternatively via the level monitor with `q.length()`
- `c in q` to check whether a component is in a queue
- `for c in q:` to traverse a queue (Note that it is even possible to remove and add components in the for body).
- `reversed(q)` for the components in the queue in reverse order
- slicing is supported, so it is possible to get the 2nd, 3rd and 4th component in a queue with `q[1:4]` or `q[::-1]` for all elements in reverse order.
- `del q[i]` removes the i’th component. Also slicing is supported, so e.g. to delete the last three elements from queue, `del q[-1:-4:-1]`
- `q.append(c)` is equivalent to `q.add(c)`

It is possible to do a number of operations that work on the queues:

- `q.intersection(q1)` or `q & q1` returns a new queue with components that are both in q and q1
- `q.difference(q1)` or `q - q1`` returns a new queue with components that are in q1 but not in q2
- `q.union(q1)` or `q | q1` or `q + q1` returns a new queue with components that are in q or q1

- `q.symmetric_difference(q)` or `q ^ q1` returns a queue with components that are in q or q1, but not both
- `q.clear()` empties a queue
- `q.copy()` copies all components in q to a new queue. The queue q is untouched.
- `q.move()` copies all components in q to a new queue. The queue q is emptied.
- `q.extend(q1)` extends the q with elements in q1, that are not yet in q

Note that it is possible to rename a queue (particularly those created with +, -, ^, | or sum) with the rename() method:

```
(q0 | q1 | q2 | q3).rename('q0 - q3).print_info()
```

Salabim keeps track of the enter time in a queue: `c.enter_time (q)`

Unless disabled explicitly, the length of the queue and length of stay of components are monitored in `q.length` and `q.length_of_stay`. It is possible to obtain a number of statistics on these monitors (cf. Monitor).

With `q.print_statistics()` the key statistics of these two monitors are printed.

E.g.:

```
------------------------------------------ -------------- ------------ ------------ ------------
Length of waitingline                      duration          50000        48499.381     1500.619
                                           mean                  8.427        8.687
                                           std.deviation         4.852        4.691

                                           minimum               0            1
                                           median                9           10
                                           90% percentile       14           14
                                           95% percentile       16           16
                                           maximum              21           21

Length of stay in waitingline              entries            4995         4933           62
                                           mean                 84.345       85.405
                                           std.deviation        48.309       47.672

                                           minimum               0            0.006
                                           median               94.843       95.411
                                           90% percentile      142.751      142.975
                                           95% percentile      157.467      157.611
                                           maximum             202.153      202.153
```

The arrival rate and departure rate (number of arrivals, departures per time unit) can be found with:

- q.arrival_rate()
- q.departur_rate()

With `q.print_info()` a summary of the contents of a queue can be printed.

E.g.

```
Queue 0x20e116153c8
  name=waitingline
  component(s):
    customer.4995        enter_time 49978.472 priority=0
    customer.4996        enter_time 49991.298 priority=0
```

CHAPTER

FIVE

RESOURCE

Resources are a powerful way of process interaction.

A resource has always a capacity (which can be zero and even negative). This capacity will be specified at time of creation, but may change over time. There are two of types resources:

- standard resources, where each claim is associated with a component (the claimer). It is not necessary that the claimed quantities are integer.
- anonymous resources, where only the claimed quantity is registered. This is most useful for dealing with levels, lengths, etc.

Resources are defined like

```
clerks = Resource('clerks', capacity=3)
```

And then a component can request a clerk

```
yield self.request(clerks)  # request 1 from clerks
```

It is also possible to request for more resources at once

```
yield self.request(clerks,(assistance,2))  # request 1 from clerks AND 2 from assistance
```

Resources have a queue `requesters` containing all components trying to claim from the resource. And a queue `claimers` containing all components claiming from the resource (not for anonymous resources).

It is possible to release a quantity from a resource with c.release(), e.g.

```
self.release(r)  # releases all claimed quantity from r
self.release((r,2))  # release quantity 2 from r
```

Alternatively, it is possible to release from a resource directly, e.g.

```
r.release()  # releases the total quantity from all claiming components
r.release(10)  # releases 10 from the resource; only valid for anonymous resources
```

After a release, all requesting components will be checked whether their claim can be honored.

Resources have a number monitors:

- claimers().length
- claimers().length_of_stay
- requesters().length
- requesters().length_of_stay
- claimed_quantity
- available_quantity
- capacity
- occupancy (=claimed_quantity / capacity)

By default, all monitors are enabled.

With `r.print_statistics()` the key statistics of these all monitors are printed.

E.g.:

```
Statistics of clerk at     50000.000
                                                                    all    excl.zero         zero
-------------------------------------------- -------------- ------------ ------------ ------------
Length of requesters of clerk                duration          50000        48499.381     1500.619
                                             mean                  8.427        8.687
                                             std.deviation         4.852        4.691

                                             minimum               0            1
                                             median                9           10
                                             90% percentile       14           14
                                             95% percentile       16           16
                                             maximum              21           21

Length of stay in requesters of clerk        entries            4995         4933           62
```

	mean	84.345	85.405	
	std.deviation	48.309	47.672	
	minimum	0	0.006	
	median	94.843	95.411	
	90% percentile	142.751	142.975	
	95% percentile	157.467	157.611	
	maximum	202.153	202.153	
Length of claimers of clerk	duration	50000	50000	0
	mean	2.996	2.996	
	std.deviation	0.068	0.068	
	minimum	1	1	
	median	3	3	
	90% percentile	3	3	
	95% percentile	3	3	
	maximum	3	3	
Length of stay in claimers of clerk	entries	4992	4992	0
	mean	30	30	
	std.deviation	0.000	0.000	
	minimum	30.000	30.000	
	median	30	30	
	90% percentile	30	30	
	95% percentile	30	30	
	maximum	30.000	30.000	
Capacity of clerk	duration	50000	50000	0
	mean	3	3	
	std.deviation	0	0	
	minimum	3	3	
	median	3	3	
	90% percentile	3	3	
	95% percentile	3	3	
	maximum	3	3	
Available quantity of clerk	duration	50000	187.145	49812.855

```
                                    mean                 0.004        1.078
                                    std.deviation        0.068        0.268

                                    minimum              0            1
                                    median               0            1
                                    90% percentile       0            1
                                    95% percentile       0            2
                                    maximum              2            2

Claimed quantity of clerk           duration         50000        50000            0
                                    mean                 2.996        2.996
                                    std.deviation        0.068        0.068

                                    minimum              1            1
                                    median               3            3
                                    90% percentile       3            3
                                    95% percentile       3            3
                                    maximum              3            3

Occupancy of clerks                 duration         50000        50000            0
                                    mean                 0.999        0.999
                                    std.deviation        0.023        0.023

                                    minimum              0.333        0.333
                                    median               1            1
                                    90% percentile       1            1
                                    95% percentile       1            1
                                    maximum              1            1
```

With `r.print_info()` a summary of the contents of the queues can be printed.

E.g.

```
Resource 0x112e8f0b8
  name=clerk
  capacity=3
  requesting component(s):
    customer.4995        quantity=1
    customer.4996        quantity=1
  claimed_quantity=3
```

```
  claimed by:
    customer.4992        quantity=1
    customer.4993        quantity=1
    customer.4994        quantity=1
```

The capacity may be changed with `r.set_capacity(x)`. Note that this may lead to requesting components to be honored.

Querying of the capacity, claimed quantity, available quantity and occupancy can be done via the label monitors: `r.capacity()`, `r.claimed_quantity()`, `r.available_quantity()` and `r.occupancy()`

If the capacity of a resource is constant, which is very common, the mean occupancy can be found with

```
r.occupancy.mean()
```

When the capacity changes over time, it is recommended to use

```
occupancy = r.claimed_quantity.mean() / r.capacity.mean()
```

to obtain the mean occupancy.

Note that the occupancy is set to 0 if the capacity of the resource is <= 0.

5.1 Additional methods for anonymous resources

For anonymous resources, it may be not allowed to exceed the capacity and have a component wait for enough (claimed) capacity to be available. That may be accomplished by using a negative quantity in the `self.request` call.

Alternatively, it possible to use the `Component.put` method, where quantities of anonymous resources are negated. For symmetry reasons, salabim also offers the `Component.get()` method, which is behaves exactly like `Component.request`.

The model below illustrates the use of get and put.

```
1  #  Gas station.py
2  import salabim as sim
3
4  #  based on SimPy example model
5
6  GAS_STATION_SIZE = 200.0  # liters
7  THRESHOLD = 25.0  # Threshold for calling the tank truck (in %)
```

```
FUEL_TANK_SIZE = 50.0  # liters
# Min/max levels of fuel tanks (in liters)
FUEL_TANK_LEVEL = sim.Uniform(5, 25)
REFUELING_SPEED = 2.0  # liters / second
TANK_TRUCK_TIME = 300.0  # Seconds it takes the tank truck to arrive
T_INTER = sim.Uniform(10, 100)  # Create a car every [min, max] seconds
SIM_TIME = 200000  # Simulation time in seconds


class Car(sim.Component):
    """
    A car arrives at the gas station for refueling.

    It requests one of the gas station's fuel pumps and tries to get the
    desired amount of gas from it. If the stations reservoir is
    depleted, the car has to wait for the tank truck to arrive.

    """

    def process(self):
        fuel_tank_level = int(FUEL_TANK_LEVEL.sample())
        yield self.request(gas_station)
        liters_required = FUEL_TANK_SIZE - fuel_tank_level
        if (fuel_pump.available_quantity() - liters_required) / fuel_pump.capacity() * 100 < THRESHOLD:
            TankTruck()
        yield self.get((fuel_pump, liters_required))
        yield self.hold(liters_required / REFUELING_SPEED)


class TankTruck(sim.Component):
    def process(self):
        yield self.hold(TANK_TRUCK_TIME)
        amount = fuel_pump.claimed_quantity()
        yield self.put((fuel_pump, amount))


class CarGenerator(sim.Component):
    """
    Generate new cars that arrive at the gas station.
    """
```

```
48
49      def process(self):
50          while True:
51              yield self.hold(T_INTER.sample())
52              Car()
53
54
55  # Setup and start the simulation
56  env = sim.Environment(trace=False)
57  print("Gas Station refuelling")
58
59  # Create environment and start processes
60  gas_station = sim.Resource("gas_station", 2)
61  fuel_pump = sim.Resource("fuel_pump", capacity=GAS_STATION_SIZE, anonymous=True)
62  tank_truck = TankTruck()
63  CarGenerator()
64
65  env.run(SIM_TIME)
66
67  fuel_pump.capacity.print_histogram()
68  fuel_pump.claimed_quantity.print_histogram()
69  fuel_pump.available_quantity.print_histogram()
70
71
72  gas_station.requesters().length.print_histogram()
73  gas_station.requesters().length_of_stay.print_histogram(30, 0, 10)
```

CHAPTER

SIX

STATE

States together with the Component.wait() method provide a powerful way of process interaction.

A state will have a certain value at a given time. In its simplest form a component can then wait for a specific value of a state. Once that value is reached, the component will be resumed.

Definition is simple, like `dooropen=sim.State('dooropen')`. The default initial value is False, meaning the door is closed.

Now we can say

```
dooropen.set()
```

to open the door.

If we want a person to wait for an open door, we could say

```
yield self.wait(dooropen)
```

If we just want at most one person to enter, we say `dooropen.trigger(max=1)`.

We can obtain the current value by just calling the state, like in

```
print('door is ',('open' if dooropen() else 'closed'))
```

Alternatively, we can get the current value with the get method

```
print('door is ',('open' if dooropen.get() else 'closed'))
```

The value of a state is automatically monitored in the state.value level monitor.

All components waiting for a state are in a salabim queue, called waiters().

States can be used also for non values other than bool type. E.g.

```
light=sim.State('light', value='red')
...
light.state.set('green')
```

Or define a int/float state

```
level=sim.State('level', value=0)
...
level.set(level()+10)
```

States have a number of monitors:

- value, where all the values are collected over time
- waiters().length
- waiters().length_of_stay

6.1 Process interaction with wait()

A component can wait for a state to get a certain value. In its most simple form

```
yield self.wait(dooropen)
```

Once the dooropen state is True, the component will continue.

As with request() it is possible to set a timeout with fail_at or fail_delay

```
yield self.wait(dooropen, fail_delay=10)
if self.failed:
    print('impatient ...')
```

In the above example we tested for a state to be True.

There are three ways to test for a value:

6.1.1 Scalar testing

It is possible to test for a certain value

```
yield self.wait((light, 'green'))
```

Or more states at once

```
yield self.wait((light, 'green'), night)  # honored as soon as light is green OR it's night
yield self.wait((light, 'green'), (light, 'yellow'))  # honored as soon is light is green OR yellow
```

It is also possible to wait for all conditions to be satisfied, by adding `all=True`:

```
yield self.wait((light,'green'), enginerunning, all=True)  # honored as soon as light is green AND engine is running
```

6.1.2 Evaluation testing

Here, we use a string containing an expression that can evaluate to True or False. This is done by specifying at least one `$` in the test-string. This `$` will be replaced at run time by `state.value()`, where state is the state under test. Here are some examples

```
yield self.wait((light, '$ in ("green","yellow")'))
    # if at run time light.value() is 'green', test for eval(state.value() in ("green,"yellow")) ==> True
yield self.wait((level, '$ < 30'))
    # if at run time level.value() is 50, test for eval(state.value() < 30) ==> False
```

During the evaluation, `self` refers to the component under test and `state` to the state under test. E.g.

```
self.limit = 30
yield self.wait((level, 'self.limit >= $'))
    # if at run time level.value() is 10, test for eval(self.limit >= state.get()) ==> True, so honored
```

6.1.3 Function testing

This is a more complicated but also more versatile way of specifying the honor-condition. In that case, a function is required to specify the condition. The function needs to accept three arguments:

- x = state.get()

- component component under test
- state under test

E.g.:

```
yield self.wait((light, lambda x, _, _: x in ('green', 'yellow'))
    # x is light.get()
yield self.wait((level, lambda x, _, _: x >= 30))
    # x is level.get()
```

And, of course, it is possible to define a function

```
def levelreached(x):
    value, component, _ = x
    return value < component.limit

...

self.limit = 30
yield self.wait((level, levelreached))
```

6.1.4 Combination of testing methods

It is possible to mix scalar, evaluation and function testing. And it's also possible to specify all=True in any case.

CHAPTER

SEVEN

MONITOR

Monitors are a way to collect data from the simulation. They are automatically collected for resources, queues and states. On top of that the user can define its own monitors.

Monitors can be used to get statistics and as a feed for graphical tools, like matplotlib.

There are two types of monitors:

- level monitors Level monitors are useful to collect data about a variable that keeps its value over a certain length of time, such as the length of a queue orcthe colour of a traffic light.
- non level monitors Non level monitors are useful to collect data about a values that occur just once. Examples, are the length of stay in a queue and the number of processing steps of a part.

For both types, the time is always collected, along with the value.

Non level monitors can be weighted, if required.

7.1 Non level monitor

Non level monitors collects values which do not refelect a level, e.g. the processing time of a part.

We define the monitor with `processingtime = sim.Monitor('processingtime')` and then collect values by `processingtime.tally(this_duration)`

By default, the collected values are stored in a list. Alternatively, it is possible to store the values in an array of one of the following types:

type	stored as	lowerbound	upperbound	number of bytes
'any'	list	N/A	N/A	depends on data
'bool'	integer	False	True	1
'int8'	integer	-128	127	1
'uint8'	integer	0	255	1
'int16'	integer	-32768	32767	2
'uint16'	integer	0	65535	2
'int32'	integer	2147483648	2147483647	4
'uint32'	integer	0	4294967295	4
'int64'	integer	-9223372036854775808	9223372036854775807	8
'uint64'	integer	0	18446744073709551615	8
'float'	float	-inf	inf	8

Monitoring with arrays takes up less space. Particularly when tallying a large number of values, this is strongly advised.

Note that if non numeric values are stored (only possible with the default setting ('any')), a tallied value is converted, if required, to a numeric value if possible, or 0 if not.

It is possible to use monitors with weighted data. In that case, just add a second parameter to tally, which defaults to 1. All statistics will take the weights into account.

There is set of statistical data available, which will be all weighed according to the tallied weights (1 by default):

- number_of_entries
- number_of_entries_zero
- weight
- weight_zero
- mean
- std
- minimum
- median
- maximum
- percentile
- bin_number_of_entries (number of entries between two given values)
- bin_weight (total weight of entries between two given values)

- value_number_of_entries (number of entries equal to a given value or set of values)
- value_weight (total weight of entries equal to a given value or set of values)

For all these statistics, it is possible to exclude zero entries, e.g. `m.mean(ex0=True)` returns the mean, excluding zero entries.

Besides, it is possible to get all collected values as an array with x(). In the case of 'any' monitors, the values might have to be converted. By specifying `force_numeric=False` the collected values will be returned as stored.

With the monitor method, the monitor can be enbled or disabled. Note that a tally is just ignored when the monitor is disabled.

Also, the current monitor status (enabled/disabled) can be retrieved.

```
proctime.monitor(False)  # disable monitoring
proctime.monitor(True)  # enable monitoring
if proctime.monitor():
    print('proctime is enabled')
```

Calling m.reset() will clear all tallied values.

The statistics of a monitor can be printed with `print_statistics()`. E.g: `waitingline.length_of_stay.print_statistics()`:

```
Statistics of Length of stay in waitingline at     50000
                        all    excl.zero         zero
-------------- ------------ ------------ ------------
entries             4995         4933           62
mean                  84.345       85.405
std.deviation         48.309       47.672

minimum                0            0.006
median                94.843       95.411
90% percentile       142.751      142.975
95% percentile       157.467      157.611
maximum              202.153      202.153
```

And, a histogram can be printed with `print_histogram()`. E.g. `waitingline.length_of_stay.print_histogram(30, 0, 10)`:

```
Histogram of Length of stay in waitingline
                        all    excl.zero         zero
-------------- ------------ ------------ ------------
entries             4995         4933           62
mean                  84.345       85.405
std.deviation         48.309       47.672
```

```
minimum               0            0.006
median               94.843       95.411
90% percentile      142.751      142.975
95% percentile      157.467      157.611
maximum             202.153      202.153

           <=       entries     %  cum%
            0            62    1.2   1.2 |
           10           169    3.4   4.6 ** |
           20           284    5.7  10.3 ****    |
           30           424    8.5  18.8 ******         |
           40           372    7.4  26.2 *****               |
           50           296    5.9  32.2 ****                    |
           60           231    4.6  36.8 ***                         |
           70           192    3.8  40.6 ***                            |
           80           188    3.8  44.4 ***                               |
           90           136    2.7  47.1 **                                  |
          100           352    7.0  54.2 *****                                    |
          110           491    9.8  64.0 *******                                        |
          120           414    8.3  72.3 ******                                             |
          130           467    9.3  81.6 *******                                                 |
          140           351    7.0  88.7 *****                                                      |
          150           224    4.5  93.2 ***                                                           |
          160           127    2.5  95.7 **                                                              |
          170            67    1.3  97.0 *                                                                 |
          180            59    1.2  98.2                                                                    |
          190            61    1.2  99.4                                                                      |
          200            24    0.5  99.9                                                                      |
          210             4    0.1 100                                                                         |
          220             0    0   100                                                                         |
          230             0    0   100                                                                         |
          240             0    0   100                                                                         |
          250             0    0   100                                                                         |
          260             0    0   100                                                                         |
          270             0    0   100                                                                         |
          280             0    0   100                                                                         |
          290             0    0   100                                                                         |
          300             0    0   100                                                                         |
              inf         0    0   100
```

If neither number_of_bins, nor lowerbound nor bin_width are specified, the histogram will be autoscaled.

Histograms can be printed with their values, instead of bins. This is particularly useful for non numeric tallied values, such as names:

```
import salabim as sim

env = sim.Environment()

monitor_names= sim.Monitor(name='names')
for _ in range(10000):
    name = sim.Pdf(('John', 30, 'Peter', 20, 'Mike', 20, 'Andrew', 20, 'Ruud', 5, 'Jan', 5)).sample()
    monitor_names.tally(name)

monitor_names.print_histograms(values=True)
```

The ouput of this:

```
Histogram of names
entries          10000

value               entries
Andrew                 2031( 20.3%) ***************
Jan                     495(  5.0%) ***
John                   2961( 29.6%) ***********************
Mike                   1989( 19.9%) ***************
Peter                  2048( 20.5%) ****************
Ruud                    476(  4.8%) ***
```

7.2 Level monitor

Level monitors tally levels along with the current (simulation) time. e.g. the number of parts a machine is working on.

A level monitor is defined by specifying `level=True` in the initialization of Monitor, e.g.

```
working_on_parts = sim.Monitor(name='working_on_parts', level=True, initial_tally=0)
```

By default, the collected x-values are stored in a list. Alternatively, it is possible to store the x-values in an array of one of the following types:

type	stored as	lowerbound	upperbound	number of bytes	do not tally (=off)
'any'	list	N/A	N/A	depends on data	N/A'
'bool'	integer	False	True	1	255
'int8'	integer	-127	127	1	-128
'uint8'	integer	0	254	1	255
'int16'	integer	-32767	32767	2	-32768
'uint16'	integer	0	65534	2	65535
'int32'	integer	2147483647	2147483647	4	2147483648
'uint32'	integer	0	4294967294	4	4294967295
'int64'	integer	-9223372036854775807	9223372036854775807	8	-9223372036854775808
'uint64'	integer	0	18446744073709551614	8	18446744073709551615
'float'	float	-inf	inf	8	-inf

Monitoring with arrays takes up less space. Particularly when tallying a large number of values, this is strongly advised.

Note that if non numeric x-values are stored (only possible with the default setting ('any')), the tallied values are converted, if required, to a numeric value if possible, or 0 if not.

During the simulation run, it is possible to retrieve the last tallied value (which represents the 'current' value) by calling Monitor.get(). It's also possible to directly call the level monitor to get the current value, e.g.

```
mylevel = sim.Monitor('level', level=True, initial_tally=0)
...
mylevel.tally(10)
yield seld.hold(1)
print(mylevel())  # will print 10
```

For the same reason, the standard length monitor of a queue can be used to get the current length of a queue: `q.length()` although the more Pythonic `len(q)` is prefered.

When Monitor.get() is called with a time parameter or a direct call with a time parameter, the value at that time will be returned

```
print (mylevel.get(4))  # will print the value at time 4
print (mylevel(4))  # will print the value at time 4
```

There is set of statistical data available, which are all weighted with their duration:

- duration
- duration_zero (time that the value was zero)

- mean
- std
- minimum
- median
- maximum
- percentile
- bin_duration (total duration of entries between two given values)
- value_duration (total duration of entries equal to a given value or set of values)

For all these statistics, it is possible to exclude zero entries, e.g. `m.mean(ex0=True)` returns the mean, excluding zero entries.

The individual x-values and their duration can be retrieved xduration(). By default, the x-values will be returned as an array, even if the type is 'any'. In case the type is 'any' (stored as a list), the tallied x-values will be converted to a numeric value or 0 if that's not possible. By specifying `force_numeric=False` the collected x-values will be returned as stored.

The individual x-values and the associated timestamps can be retrieved with xt() or tx(). By default, the x-values will be returned as an array, even if the type is 'any'. In case the type is 'any' (stored as a list), the tallied x-values will be converted to a numeric value or 0 if that's not possible. By specifying `force_numeric=False` the collected x-values will be returned as stored.

When monitoring is disabled, an off value (see table above) will be tallied. All statistics will ignore the periods from this off to a non-off value. This also holds for the xduration() method, but NOT for xt() and tx(). Thus, the x-arrays of xduration() are not necessarily the same as the x-arrays in xt() and tx(). This is the reason why there's no x() or t() method. It is easy to get just the x-array with xduration()[0] or xt()[0].

It is important that a user *never* tallies an off value! Instead use Monitor.monitor(False)

With the monitor method, a level monitor can be enbled or disabled.

Also, the current monitor status (enabled/disabled) can be retrieved.

```
mylevel.monitor(False)  # disable monitoring
mylevel.monitor(True)  # enable monitoring
if mylevel.monitor():
    print('level is enabled')
```

It is strongly advised to keep tallying even when monitoring is off, in order to be able to access the current value at any time. The values tallied when monitoring is off are not stored.

Calling m.reset() will clear all tallied values and timestamps.

The statistics of a level monitor can be printed with `print_statistics()`. E.g: `waitingline.length.print_statistics()`:

```
Statistics of Length of waitingline at     50000
                        all    excl.zero         zero
-------------- ------------ ------------ ------------
duration          50000        48499.381     1500.619
mean                  8.427        8.687
std.deviation         4.852        4.691

minimum               0            1
median                9           10
90% percentile       14           14
95% percentile       16           16
maximum              21           21
```

And, a histogram can be printed with `print_histogram()`. E.g.

```
waitingline.length.print_histogram(30, 0, 1)
```

```
Histogram of Length of waitingline
                        all    excl.zero         zero
-------------- ------------ ------------ ------------
duration          50000        48499.381     1500.619
mean                  8.427        8.687
std.deviation         4.852        4.691

minimum               0            1
median                9           10
90% percentile       14           14
95% percentile       16           16
maximum              21           21

           <=      duration     %  cum%
        0          1500.619   3.0   3.0 **|
        1          2111.284   4.2   7.2 ***  |
        2          3528.851   7.1  14.3 *****      |
        3          4319.406   8.6  22.9 ******           |
        4          3354.732   6.7  29.6 *****                |
        5          2445.603   4.9  34.5 ***                      |
        6          2090.759   4.2  38.7 ***                         |
```

```
         7          2046.126   4.1  42.8 ***                                |
         8          1486.956   3.0  45.8 **                                  |
         9          2328.863   4.7  50.4 ***                                     |
        10          4337.502   8.7  59.1 ******                                      |
        11          4546.145   9.1  68.2 *******                                         |
        12          4484.405   9.0  77.2 *******                                             |
        13          4134.094   8.3  85.4 ******                                                |
        14          2813.860   5.6  91.1 ****                                                    |
        15          1714.894   3.4  94.5 **                                                        |
        16           992.690   2.0  96.5 *                                                          |
        17           541.546   1.1  97.6                                                            |
        18           625.048   1.3  98.8 *                                                           |
        19           502.291   1.0  99.8                                                             |
        20            86.168   0.2 100.0                                                             |
        21             8.162   0.0 100                                                                |
        22             0       0   100                                                                |
        23             0       0   100                                                                |
        24             0       0   100                                                                |
        25             0       0   100                                                                |
        26             0       0   100                                                                |
        27             0       0   100                                                                |
        28             0       0   100                                                                |
        29             0       0   100                                                                |
        30             0       0   100                                                                |
     inf               0       0   100
```

If neither number_of_bins, nor lowerbound nor bin_width are specified, the histogram will be autoscaled.

Histograms can be printed with their values, instead of bins. This is particularly useful for non numeric tallied values, like names of production stages. For example

```
Histogram of Status
duration           300

value                     duration     %
idle                        70      23.3 ******************
package                     42      14.0 ***********
prepare                     48      16   ************
stage A                     12       4   ***
stage B                     50      16.7 *************
stage C                     54      18   **************
```

```
stage D                    24       8   ******
```

7.3 Merging of monitors

Monitors can be merged, to create a new monitor, nearly always to collect aggregated data.

The method Monitor.merge() is used for that, like

```
mc = m0.merge(m1, m2)
```

Then we can just get the mean of the monitors m0, m1 and m2 combined by

```
mc.mean()
```

,but also directly with :

    m0.merge(m1, m2).mean()

Alternatively, monitors can be merged with the + operator, like

```
mc = m0 + m1 + m2
```

And then get the mean of the aggregated monitors with

```
mc.mean()
```

, but also with

    (m0 + m1 + m2).mean()

It is also possible to use the sum function to merge a number of monitors. So

```
print(sum((m0, m1, m2)).mean())
```

Finally, if ms = (m0, m1, m2), it is also possible to use

```
print(sum(ms).mean())
```

A practical example of this is the case where the list waitinglines contains a number of queues.

Then to get the aggregated statistics of the length of all these queues, use

```
sum(waitingline.length for waitingline in waitinglines).print_statistics()
```

For non level monitors, all of the tallied x-values are copied from the to be merged monitors. For level monitors, the x-values are summed, for all the periods where all the monitors were on. Periods where one or more monitors were disabled, are excluded. Note that the merge only takes place at creation of the (timestamped) monitor and not dynamically later.

Sample usage:

Suppose we have three types of products (a, b, c) and that each have a queue for processing, so a.processing, b.processing, c.processing. If we want to print the histogram of the combined (=summed) length of these queues

```
a.processing.length.merge(b.processing.length, c.processing.length, name='combined processing length')).print_histogram()
```

and to get the minimum of the length_of_stay for all queues

```
(a.processing.length_of_stay + b.processing.length_of_stay + c.processing.length_of_stay).minimum()
```

Note that it is possible to rename a merged monitor (particularly those created with + or sum) with the rename() method:

```
sum(waitingline.length for waitingline in waitinglines).rename('aggregated length of waitinglines').print_statistics()
```

Merged monitors are disabled and cannot be enabled again.

7.4 Slicing of monitors

It is possible to slice a monitor with Monitor.slice(), which has two applications:

- to get statistics on a monitor with respect to a given time period, most likely a subrun
- to get statistics on a monitor with respect to a recurring time period, like hour 0-1, hour 0-2, etc.

Examples

```
for i in range(10):
    start = i * 1000
    stop = (i+1) * 1000
```

```
    print(f'mean length of q in [{start},{stop})={q.length.slice(start,stop).mean()}'
    print(f'mean length of stay in [{start},{stop})={q.length_of_stay.slice(start,stop).mean()}'

for i in range(24):
    print(f'mean length of q in hour {i}={q.length.slice(i, i+1, 24).mean()}'
    print(f'mean length of stay of q in hour {i}={q.length_of_stay.slice(i, i+1, 24).mean()}'
```

Instead of slice(), a monitor can be sliced as well with the standard slice operator [], like

```
q.length[1000:2000].print_histogram()
q.length[2:3:24].print_histogram()
print(q.length[1000].mean())
```

Note that it is possible to rename a sliced monitor (particularly those created []) with the rename() method:

```
waitingline.length[1000:2000].rename('length of waitingline between t=1000 and t-2000').print_statistics()
```

Sliced monitors are disabled and cannot be enabled again.

7.5 Using monitored values in other packages, like matplotlib

For high quality, reproduction ready, graphs, it can be useful to use additional packages, most notably matplotlib.

The sampled values from a non level monitor can be retrieved with Monitor.x(). If the moment of the sample is required as well, either Monitor.xt() or Monitor.tx() can be used.

For level monitors, there is choice of :

- Monitor.xt()
- Monitor.tx()
- Monitor.xduration()

To get a proper display of a level monitor, we advise something like

```
plt.plot(*waitingline.length.tx(), drawstyle="steps-post")
```

CHAPTER

EIGHT

DISTRIBUTIONS

8.1 Introduction

Salabim can be used with the standard random module, but it is easier to use the salabim distributions.

Internally, salabim uses the random module. There is always a seed associated with each distribution, which is normally random.random.

When a new environment is created, the random seed 1234567 will be set by default. However, it is possible to override this behaviour with the random_seed parameter:

- any hashable value, to set another seed
- null string (“”): no reseeding
- “*”: true random, non reproducible (based on current time)
- None: equivalent to 1234567

It is possible to (re)set the random seed also with the `Environment.random_seed()` method.

As a distribution is an instance of a class, it can be used in assignment, parameters, etc. E.g.

```
inter_arrival_time = sim.Uniform(10,15)
```

And then, to wait for a time sampled from this distribution

```
yield self.hold(inter_arrival_time.sample())
```

or

```
yield self.hold(inter_arrival_time())
```

or

```
yield self.hold(sim.Uniform(10,15).sample())
```

or

```
yield self.hold(sim.Uniform(10,15)())
```

All distributions are a subclass of _Distribution which supports the following methods:

- mean()
- sample()
- direct calling as an alternative to sample, like Uniform(12,15)()
- bounded_sample() # see below

8.2 Expressions with distributions

It is possible to build up a distribution with an expression containing one or more distributions. Examples

```
d0 = 5 - sim.Uniform(1, 2)  # equivalent to Uniform (3, 4)
d1 = sim.Normal(4, 1) // 1  # integer samples of a normal distribution
arrival_dis = sim.Pdf((0, 1, 2, 3, 4, 5, 6), (18, 18, 18, 18, 18, 8,2), 'days') + sim.Cdf((0,0, 8,10, 17, 90, 24, 100), 'hours')
  # this generates an arrival moment during the week, with emphasis on day 0-4. The distribution over the day concentrates␣
↪between hour 8 and 17.
```

These will make an instance of the class _Expresssion, which can be used as any other distribution

```
arrival_dis.sample()
(sim.IntUniform(1,5) * 10).sample()  # this will return 10, 20, 30, 40 or 50.
(1 / sim.Uniform(1, 2))()  # this will return values between 0.5 and 1 (not uniform!)
```

Like all distributions, the _Expression class supports the mean(), sample(), bounded_sample() and print_info() methods. If the mean can't be calculated, nan will be returned

```
(sim.Uniform(1, 2) / 10).mean()  # 0.15
(10 / sim.Uniform(1, 2)).mean()  # nan
(sim.Uniform(1, 2) / sim.Uniform(1, 2)).mean()  # nan
```

Note that the expression may contain only the operator +, -, , */, // and* *. Functions are not allowed. However the `int` function can be emulated with floor division (`\\`), as is in

```
d1 = sim.Normal(4, 1) // 1  # integer samples of a normal distribution
```

8.3 Bounded sampling

The class Bounded can be used to force a sampled value from a distribution to be within given bounds.

This realized by checking if the sampled value is within these bounds. If not, another value is sampled, until the sample meets the requirements. If after, 100 retries (customizable) the sampled value does still not meet the requirements, a fail_value will be returned.

Examples

```
dis = sim.Bounded(sim.Normal(3, 1), lowerbound=0)
sample = dis.sample()  # normal distribution, non negative
sim.Bounded(sim.Exponential(6, upperbound=20).sample()  # exponential distribution <= 20
sim.Bounded(sim.Exponential(6, upperbound=20)()  # exponential distribution <= 20
```

It is alo possible to use the bounded_sample() method, with similar functionality. However, the Bounded class is prefered.

8.4 Use of time units in a distribution specification

All distributions apart from IntUniform, Poisson and Beta have an additional parameter, time_unit. If the time_unit is specified at initialization of Environment(), the time_unit of the distribution can now be specified.

As an example, suppose env has been initialized with `env = sim.Environment(time_unit='hours')`. If we then define a duration distribution as

```
duration_dis = sim.Uniform(10, 20, 'days')
```

, the distribution is effectively uniform between 240 and 480 (hours).

This facility makes specification of duration distribution easy and intuitive.

8.5 Available distributions

8.5.1 Beta

Beta distribution with a given

- alpha (shape)
- beta (shape)

E.g.

```
processing_time = sim.Beta(2,4)  # Beta with alpha=2, beta=4`
```

8.5.2 Constant

No sampling is required for this distribution, as it always returns the same value. E.g.

```
processing_time = sim.Constant(10)
```

8.5.3 Erlang

Erlang distribution with a givenl

- shape (k)
- rate (lambda) or scale (mu)

E.g.

```
inter_arrival_time = sim.Erlang(2, rate=2)  # Erlang-2, with lambda = 2
```

8.5.4 Exponential

Exponential distribution with a given

- mean or rate (lambda)

E.g.

```
inter_arrival_time = sim.Exponential(10)  # on an average every 10 time units
```

8.5.5 Gamma

Gamma distribution with given

- shape (k)
- scale (teta) or rate (beta)

E.g.

```
processing_time = sim.Gamma(2,3)  # Gamma with k=2, teta=3
```

8.5.6 IntUniform

Integer uniform distribution between a given

- lowerbound
- upperbound (inclusive)

E.g.

```
die = sim.IntUniform(1, 6)
```

8.5.7 Normal

Normal distribution with a given

- mean
- standard deviation

E.g.

```
processing_time = sim.Normal(10, 2)  # Normal with mean=10, standard deviation=2
```

Note that this might result in negative values, which might not correct if it is a duration. In that case, use the Bound class to force a non negative value, like

```
yield self.hold(Bounded(processing_time, 0).sample())
yield self.hold(Bounded(sim.Normal(10, 2), 0)())
```

Normally, sampling is done with the random.normalvariate method. Alternatively, the random.gauss method can be used.

8.5.8 Poisson

Poisson distribution with a given lambda

E.g.

```
occurences_in_one_hour = sim.Poisson(10)  # Poisson distribution with lambda (and thus mean) = 10
```

8.5.9 Triangular

Triangular distribution with a given

- lowerbound
- upperbound
- median

E.g.

```
processing_time = sim.Triangular(5, 15, 8)
```

8.5.10 Uniform

Uniform distribution between a given

- lowerbound
- upperbound

E.g.

```
processing_time = sim.Uniform(5, 15)
```

8.5.11 Weibull

Weibull distribution with given

- scale (alpha or k)
- shape (beta or lambda)

E.g.

```
time_between_failure = sim.Weibull(2, 5)  # Weibull with k=2. lambda=5
```

8.5.12 Cdf

Cumulative distribution function, specified as a list or tuple with x[i],p[i] values, where p[i] is the cumulative probability that xn<=pn. E.g.

```
processingtime = sim.Cdf((5, 0, 10, 50, 15, 90, 30, 95, 60, 100))
```

This means that 0% is <5, 50% is < 10, 90% is < 15, 95% is < 30 and 100% is <60.

Note: It is required that p[0] is 0 and that p[i]<=p[i+1] and that x[i]<=x[i+1].

It is not required that the last p[] is 100, as all p[]'s are automatically scaled. This means that the two distributions below are identical to the first example

```
processingtime = sim.Cdf((5, 0.00, 10, 0.50, 15, 0.90, 30, 0.95, 60, 1.00))
processingtime = sim.Cdf((5,    0, 10,   10, 15,   18, 30,   19, 60,   20))
```

8.5.13 Pdf

Probability density function, specified as:

1. list or tuple of x[i], p[i] where p[i] is the probability (density)

2. list or tuple of x[i] followed by a list or tuple p[i]
3. list or tuple of x[i] followed by a scalar (value not important)

Note: It is required that the sum of p[i]'s is **greater than** 0.

E.g.

```
processingtime = sim.Pdf((5, 10, 10, 50, 15, 40))
```

This means that 10% is 5, 50% is 10 and 40% is 15.

It is not required that the sum of the p[i]'s is 100, as all p[]'s are automatically scaled. This means that the two distributions below are identical to the first example

```
processingtime = sim.Pdf((5, 0.10, 10, 0.50, 15, 0.40))
processingtime = sim.Pdf((5,    2, 10,   10, 15,    8))
```

And the same with the second form

```
processingtime = sim.Pdf((5, 10, 15), (10, 50, 40))
```

If all x[i]'s have the same probability, the third form is very useful

```
dice = sim.Pdf((1,2,3,4,5,6),1)  # the distribution IntUniform(1,6) does the job as well
dice = sim.Pdf(range(1,7),1)  # same as above
```

x[i] may be of any type, so it possible to use

```
color = sim.Pdf(('Green', 45, 'Yellow', 10, 'Red', 45))
cartype = sim.Pdf(ordertypes,1)
```

If the x-value is a salabim distribution, not the distribution but a sample of that distribution is returned when sampling

```
processingtime = sim.Pdf((sim.Uniform(5, 10), 50, sim.Uniform(10, 15), 40, sim.Uniform(15, 20), 10))
proctime=processingtime.sample()
```

Here proctime will have a probability of 50% being between 5 and 10, 40% between 10 and 15 and 10% between 15 and 20.

Pdf supports also sampling a number of items from a pdf without replacement. In that case, the probabilities for all items have to be the same. If that is the case, multiple sampling can be done by specifying the number of items to sampled as a parameters to sample.

Examples

```
colors_dis = sim.Pdf(("red", "green", "blue", "yellow"), 1)
colors_dis.sample(4)  # e.g. ["yellow", "green", "blue", "red"]
colors_dis.sample(2)  # e.g. ["green", "blue"]
colors_dis,sample(1)  # e.g. ["blue"], so not "blue" !
```

8.5.14 CumPdf

Probability density function, specified as:

1. list or tuple of x[i], p[i] where p[i] is the cumulative probability (density)
2. list or tuple of x[i] followed by a list or tuple of probabilities p[i]

Note: It is required that p[i]<=p[i+1].

E.g.

```
processingtime = sim.CumPdf((5, 10, 10, 60, 15, 100))
```

This means that 10% is 5, 50% is 10 and 40% is 15.

It is not required that the sum of the p[i]'s is 100, as all p[]'s are automatically scaled. This means that the two distributions below are identical to the first example

```
processingtime = sim.CumPdf((5, 0.10, 10, 0.60, 15, 1.00))
processingtime = sim.CumPdf((5,    2, 10,   12, 15,   20))
```

And the same with the second form

```
processingtime = sim.CumPdf((5, 10, 15), (10, 60, 100))
```

x[i] may be of any type, so it possible to use

```
color = sim.CumPdf(('Green', 45, 'Red', 100))
```

If the x-value is a salabim distribution, not the distribution but a sample of that distribution is returned when sampling

```
processingtime = sim.CumPdf((sim.Uniform(5, 10), 50, sim.Uniform(10, 15), 90, sim.Uniform(15, 20), 100))
proctime=processingtime.sample()
```

Here proctime will have a probability of 50% being between 5 and 10, 40% between 10 and 15 and 10% between 15 and 20.

8.5.15 Distribution

A special distribution is the Distribution class. Here, a string will contain the specification of the distribution. This is particularly useful when the distributions are specified in an external file. E.g.

```
with open('experiment1.txt', 'r') as f:
    interarrivaltime = sim.Distribution(read(f))
    processingtime = sim.Distribution(read(f))
    numberofparcels = sim.Distribution(read(f))
```

With a file experiment.txt

```
Uniform(10,15)
Triangular(1,5,2)
IntUniform(10,20)
```

or with abbreviation

```
Uni(10,15)
Tri(1,5,2)
Int(10,20)
```

or even

```
U(10,15)
T(1,5,2)
I(10,20)
```

CHAPTER

NINE

MISCELLANEOUS

9.1 Run control

Normally, a simulation is run for a given duration with

```
env.run(duration=100)
```

If you do not specify a till or duration parameter, like :: env.run()

, the simulation will run till there are no events left, or otherwise infinitely.

If it required that the simulation does not stop when there are no more events, which can be useful for animation, issue

```
env.run(till=sim.inf)
```

Finally, it is possible to return control to 'main' from a component with

```
env.main().activate()
```

For instance, if we want to stop a simulation after 50 ships are created

```
class ShipGenerator(sim.Component):
    def process(self):
        for _ in range(50):
            yield self.hold(iat.sample())
            Ship()
        env.main().activate
```

Or, if you want to terminate a run based upon a condition

```
class RunChecker(sim.Component):
    def process(self):
        while True:
            if len(q0) + len(q1) > 10:
                env.main.activate()
            yield self.standby()
```

It is perfectly possible and sometimes very useful to continue a simulation after a run statement, like

```
env.run(100)
q.reset_statistics()
env.run(1000)
q.print_statistics()
```

The salabim time (now) can be reset to 0 (or another time) with

```
env.reset_now()
```

Please note that in this case, user time values has to be corrected accordingly.

9.2 Time units

By default, salabim time does not have a specific dimension, which means that is up to the modeller what time unit is used, be it seconds, hours, days or whatever.

It can be useful to work in specific time unit, as this opens the possibility to specify times and durations in another time unit.

In order to use time unit, the environment has to be initialized with a time_unit parameter, like

```
env = sim.Environment(time_unit='hours')
```

From then on, the simulation runs in hours. Standard output is in then in hours and for instance

```
self.enter(q)
yield self.hold(48)
print(env.now() - self.queuetime())
```

means hold for 48 (hours) and 48 will be printed.

But, now we also specify a time in another time unit and get times in a specific time unit

```
self.enter(q)
yield self.hold(env.days(2))
print(env.to_minutes(env.now() - self.queuetime()))
```

means hold for 2 days = 48 hours and 2880 (48 * 60) will be printed.

With this, it is possible to set the speed of the animation. For instance if we want one second of real time to correspond to 5 minutes

```
env.speed(sim.minutes(5))
```

The following time units are available:

- 'years'
- 'weeks'
- 'days'
- 'hours'
- 'minutes'
- 'seconds'
- 'milliseconds'
- 'microseconds'
- 'n/a' which means nothing is assigned and conversions are not supported

For conversion from a given time unit to the simulation time unit, the following calls are available:

- years()
- weeks()
- days()
- hours()
- minutes()
- seconds()
- milliseconds()

- microseconds()

For conversion from the simulation time unit to a given time unit, the following calls are available:

- to_years()
- to_weeks()
- to_days()
- to_hours()
- to_minutes()
- to_seconds()
- to_milliseconds()
- to_microseconds()
- to_time_unit()

Distributions (apart from IntUniform, Poisson and Beta) can also specify the time unit, like

```
env = sim.Environment(time_unit='seconds')
processingtime_dis = sim.Uniform(10, 20, 'minutes')
dryingtime_dis = sim.Normal(2, 0.1, 'hours')
```

Note that the conversion to the current time unit is made immediately and that all related output is therefore in the current simulation time unit, so

```
processingtime_dis.print_info()
dryingtime_dis.print_info()
```

will print

```
Uniform distribution 0x25783c11358
  lowerbound=600.0
  upperbound=1200.0
  randomstream=0x25783b89818
Normal distribution 0x25783bff8d0
  mean=7200.0
  standard_deviation=360.0
  coefficient_of_variation=0.05
  randomstream=0x25783b89818
```

It is possible to scale a non level monitor (particularly length_of_stay of a queue) to another time unit, which is particularly useful for print_histogram. For example

```
waitingline.length_of_stay.to_minutes().print_histogram()
```

will use minutes as the time unit.

This is equivalent to

```
waitingline.length_of_stay.to_time_unit('minutes').print_histogram()
```

And if the environment's time unit is seconds, equivalent to

```
(waitingline.length_of_stay * 60).print_histogram()
```

9.3 Usage of the the trace facility

9.3.1 Control

Tracing can be turned on at time of creating an environment

```
env = sim.Environment(trace=True)
```

and can be turned on during a simulation run with `env.trace(True)` and likewise turned off with `env.trace(False)`. The current status can be queried with `env.trace(False)`.

9.3.2 Interpretation of the trace

A trace ouput looks like

```
line#         time current component    action                              information
-----   ---------- -------------------- ----------------------------------  ------------------------------------------------
                                        line numbers refers to              Example - basic.py
   11                                   default environment initialize
   11                                   main create
   11        0.000 main                 current
   12                                   car.0 create
```

```
  12                                car.0 activate                    scheduled for      0.000 @    6  process=process
  13                                main run                          scheduled for      5.000 @   13+
   6        0.000 car.0             current
   8                                car.0 hold                        scheduled for      1.000 @    8+
   8+       1.000 car.0             current
   8                                car.0 hold                        scheduled for      2.000 @    8+
   8+       2.000 car.0             current
   8                                car.0 hold                        scheduled for      3.000 @    8+
   8+       3.000 car.0             current
   8                                car.0 hold                        scheduled for      4.000 @    8+
   8+       4.000 car.0             current
   8                                car.0 hold                        scheduled for      5.000 @    8+
  13+       5.000 main              current
```

The texts are pretty self explanatory. If a mode is given, that will be shown as well.

Note that line numbers sometimes has an added +, which means that the activation is actually the statement following the given line number. When there is more than one source file involved, the line number may be preceded by a letter. In that case, the trace will contain an information line to which file that letter refers to.

The text 'process=' refers to the activation process, which is quite often just process.

When a time is followed by an exclamation mark (!), it means that the component is scheduled urgent, i.e. before all other events for the same moment.

9.3.3 Suppressing components from being shown in the trace

It is possible to suppress the trace when a specific component becomes or is current. This can be either indicated at creation of a component with

```
c = sim.Component(suppress_trace=True)
```

or later with

```
c.suppress_trace(True)
```

Note that this suppresses all trace output during the time a component is current.

9.3.4 Showing standby components in the trace

By default standby components are (apart from when they become non standby) suppressed from the trace. With `env.suppress_trace_standby(False)` standby components are fully traced.

9.3.5 Changing the format of times and durations

It is possible to change the format of times in trace, animation, etc. with the method `Environment.time_to_str_format()`

For instance, if 5 decimals in the trace are to be shown instead of the default 3, issue

```
env.time_to_str_format('{:10.5f}')
```

Make sure that the format represents 10 characters.

9.3.6 Adding lines to the trace output

A model can add additional information to the trace with the `Environment.print_trace()` method. This methods accepts up to five parameters to be show on one line. When trace is False, nothing will be displayed.

Example

```
env.print_trace('', '**ALERT**', 'Houston, we have a problem with', c.name())
```

Refer to the reference section for details.

9.3.7 Redirecting trace output

Trace output (as all other salabim output) will be written to stdout. It is possible to use standard Python functionality to send all output to another file with

```
save_stdout = sys.stdout
sys.stdout = open('output.txt', 'w')
```

If required, it is possible to revert to the original stdout

```
sys.stdout.close()
sys.stdout = save_stdout
```

All trace output is also written to logging.

CHAPTER

TEN

ANIMATION

Animation is a powerful tool to debug, test and demonstrate simulations.

It is possible to show a number of shapes (lines, rectangles, circles, etc), texts as well (images) in a window. These objects can be dynamically updated. Monitors may be animated by showing the current value against the time. Furthermore the components in a queue may be shown in a highly customizable way. As text animation may be dynamically updated, it is even possible to show the current state, (monitor) statistics, etc. in the animation windows.

Salabim's animation engine also allows some user input.

It is important to realize that animation calls can be still given when animation is actually off. In that case, there is hardly any impact on the performance.

Salabim animations can be

- synchronized with the simulation clock and run in real time (synchronized)
- advanced per simulation event (non synchronized)

In synchronized mode, one time unit in the simulation can correspond to any period in real time, e.g.

- 1 time unit in simulation time –> 1 second real time (speed = 1) (default)
- 1 time unit in simulation time –> 4 seconds real time (speed = 0.25)
- 4 time units in simulation time –> 1 second real time (speed = 4)

The most common way to start an animation is by calling '' env.animate(True)'' or with a call to `animation_parameters(animate=True)`.

Animations can be started en stopped during execution (i.e. run). When main is active, the animation is always stopped.

The animation uses a coordinate system that -by default- is in screen pixels. The lower left corner is (0,0). But, the user can change both the coordinate of the lower left corner (translation) as well as set the x-coordinate of the lower right hand corner (scaling). Note that x- and y-scaling are always the same. Furthermore, it is possible to specify the colour of the background with `animation_parameters`.

Prior to version 2.3.0 there was actually just one animation object class: Animate. This interface is described later as the new animation classes are easier to use and even offer some additional functionality.

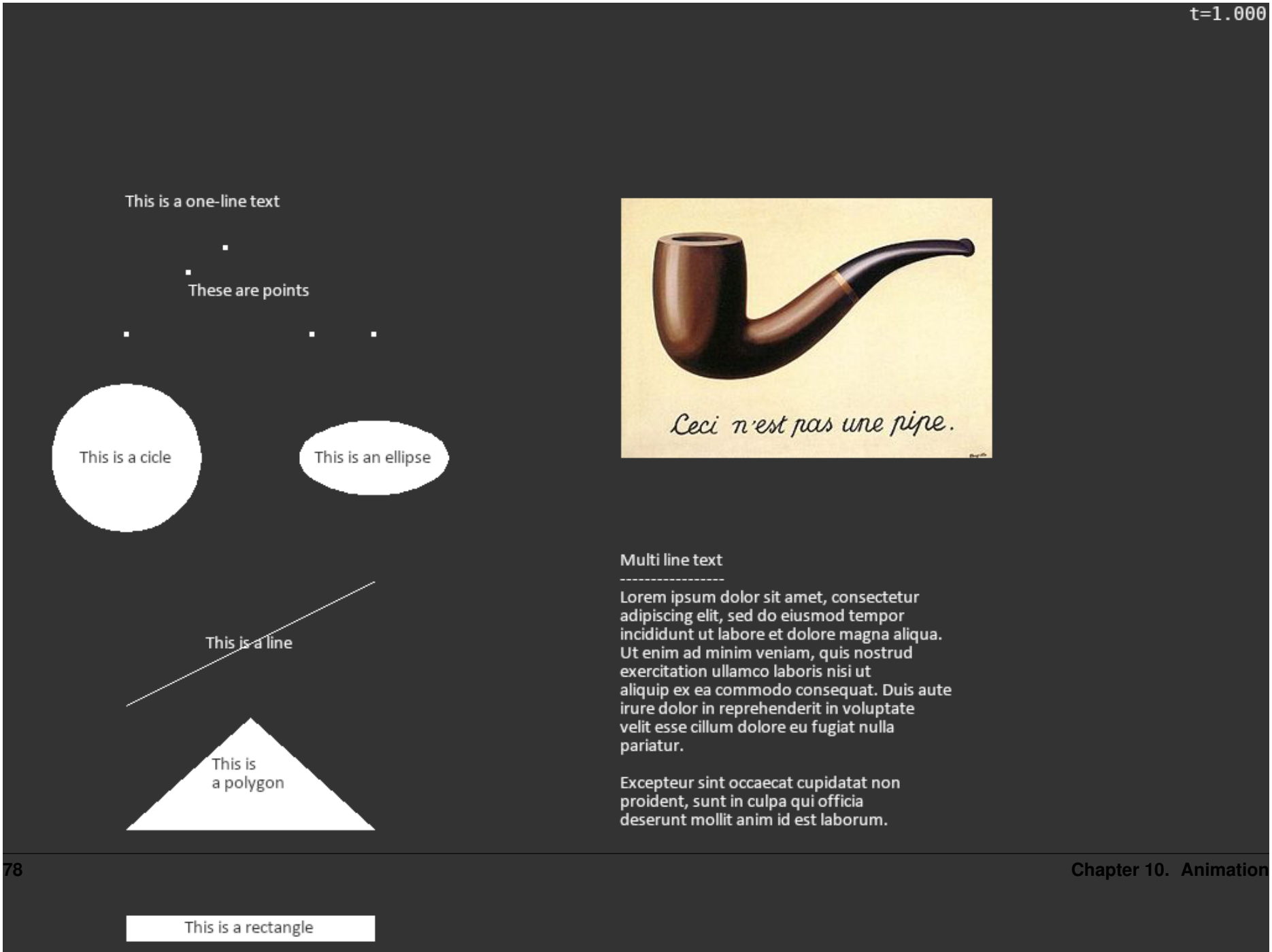
New style animation classes can be used to put texts, rectangles, polygon, lines, series of points, circles or images on the screen. All types can be connected to an optional text.

Here is a sample program to show of all the new style animation classes:

```
# Animate classes.py

"""
This program demonstrates the various animation classes available in salabim.
"""
import salabim as sim

env = sim.Environment(trace=False)
env.animate(True)
env.modelname("Demo animation classes")
env.background_color("20%gray")

sim.AnimatePolygon(spec=(100, 100, 300, 100, 200, 190), text="This is\na polygon")
sim.AnimateLine(spec=(100, 200, 300, 300), text="This is a line")
sim.AnimateRectangle(spec=(100, 10, 300, 30), text="This is a rectangle")
sim.AnimateCircle(radius=60, x=100, y=400, text="This is a cicle")
sim.AnimateCircle(radius=60, radius1=30, x=300, y=400, text="This is an ellipse")
sim.AnimatePoints(spec=(100, 500, 150, 550, 180, 570, 250, 500, 300, 500), text="These are points")
sim.AnimateText(text="This is a one-line text", x=100, y=600)
sim.AnimateText(
    text="""\
Multi line text
-----------------
Lorem ipsum dolor sit amet, consectetur
adipiscing elit, sed do eiusmod tempor
incididunt ut labore et dolore magna aliqua.
Ut enim ad minim veniam, quis nostrud
exercitation ullamco laboris nisi ut
aliquip ex ea commodo consequat. Duis aute
irure dolor in reprehenderit in voluptate
velit esse cillum dolore eu fugiat nulla
pariatur.

Excepteur sint occaecat cupidatat non
```

```
proident, sunt in culpa qui officia
deserunt mollit anim id est laborum.
""",
    x=500,
    y=100,
)

sim.AnimateImage("Pas un pipe.jpg", x=500, y=400)
env.run(100)
```

Resulting in:


t=1.000
This is a one-line text
These are points
This is a cicle
This is an ellipse
Ceci n'est pas une pipe.
This is a line
Multi line text

Lorem ipsum dolor sit amet, consectetur
adipiscing elit, sed do eiusmod tempor
incididunt ut labore et dolore magna aliqua.
Ut enim ad minim veniam, quis nostrud
exercitation ullamco laboris nisi ut
aliquip ex ea commodo consequat. Duis aute
irure dolor in reprehenderit in voluptate
velit esse cillum dolore eu fugiat nulla
pariatur.
Excepteur sint occaecat cupidatat non
proident, sunt in culpa qui officia
deserunt mollit anim id est laborum.
This is
a polygon
This is a rectangle

Animation of the components of a queue is accomplished with `AnimateQueue()`. It is possible to use the standard shape of components, which is a rectangle with the sequence number or define your own shape(s). The queue can be build up in west, east, north or south directions. It is possible to limit the number of component shown.

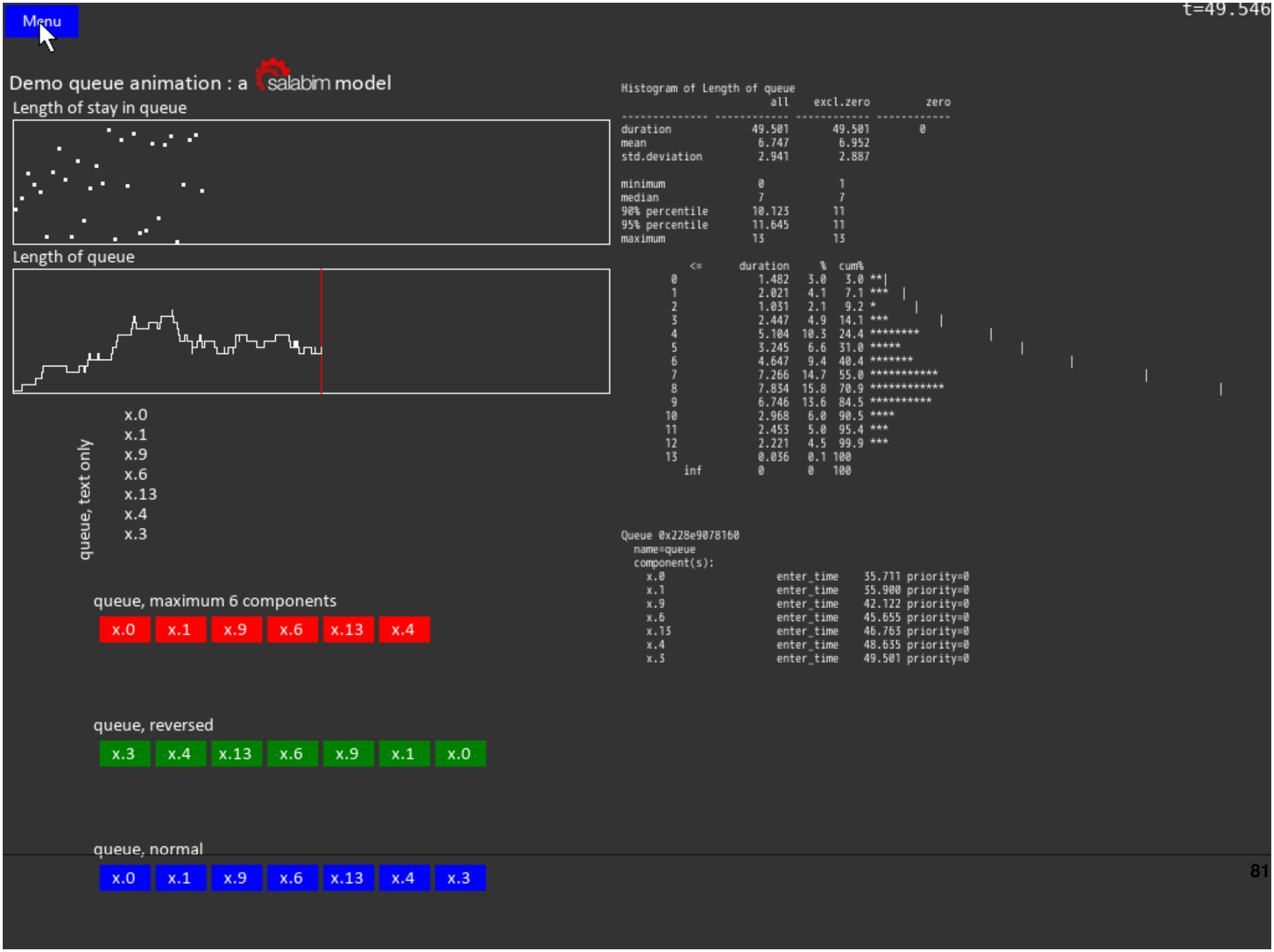
Monitors can be visualized dynamically with `AnimateMonitor()`.

These features are demonstrated in *Demo queue animation.py*

```
import salabim as sim

'''
This us a demonstration of several ways to show queues dynamically and the corresponding statistics
The model simply generates components that enter a queue and leave after a certain time.

Note that the actual model code (in the process description of X does not contain any reference
to the animation!
'''


class X(sim.Component):
    def setup(self, i):
        self.i = i

    def animation_objects(self, id):
        '''
        the way the component is determined by the id, specified in AnimateQueue
        'text' means just the name
        any other value represents the colour
        '''
        if id == 'text':
            ao0 = sim.AnimateText(text=self.name(), textcolor='fg', text_anchor='nw')
            return 0, 16, ao0
        else:
            ao0 = sim.AnimateRectangle((-20, 0, 20, 20),
                text=self.name(), fillcolor=id, textcolor='white', arg=self)
            return 45, 0, ao0

    def process(self):
        while True:
            yield self.hold(sim.Uniform(0, 20)())
            self.enter(q)
            yield self.hold(sim.Uniform(0, 20)())
```

```
            self.leave()


env = sim.Environment(trace=False)
env.background_color('20%gray')

q = sim.Queue('queue')

qa0 = sim.AnimateQueue(q, x=100, y=50, title='queue, normal', direction='e', id='blue')
qa1 = sim.AnimateQueue(q, x=100, y=250, title='queue, maximum 6 components', direction='e', max_length=6, id='red')
qa2 = sim.AnimateQueue(q, x=100, y=150, title='queue, reversed', direction='e', reverse=True, id='green')
qa3 = sim.AnimateQueue(q, x=100, y=440, title='queue, text only', direction='s', id='text')

sim.AnimateMonitor(q.length, x=10, y=450, width=480, height=100, horizontal_scale=5, vertical_scale=5)

sim.AnimateMonitor(q.length_of_stay, x=10, y=570, width=480, height=100, horizontal_scale=5, vertical_scale=5)

sim.AnimateText(text=lambda: q.length.print_histogram(as_str=True), x=500, y=700,
    text_anchor='nw', font='narrow', fontsize=10)

sim.AnimateText(text=lambda: q.print_info(as_str=True), x=500, y=340,
    text_anchor='nw', font='narrow', fontsize=10)

[X(i=i) for i in range(15)]
env.animate(True)
env.modelname('Demo queue animation')
env.run()
```

Here is snapshot of this powerful, dynamics (including the histogram!):


Menu
t=49.546
Demo queue animation : a salabim model
Length of stay in queue
Length of queue
queue, text only
x.0
x.1
x.9
x.6
x.13
x.4
x.3
queue, maximum 6 components
x.0 x.1 x.9 x.6 x.13 x.4
queue, reversed
x.3 x.4 x.13 x.6 x.9 x.1 x.0
queue, normal
x.0 x.1 x.9 x.6 x.13 x.4 x.3
Histogram of Length of queue
all excl.zero zero
duration 49.501 49.501 0
mean 6.747 6.952
std.deviation 2.941 2.887
minimum 0 1
median 7 7
90% percentile 10.123 11
95% percentile 11.645 11
maximum 13 13
<= duration % cum%
0 1.482 3.0 3.0 **
1 2.021 4.1 7.1 ***
2 1.031 2.1 9.2 *
3 2.447 4.9 14.1 ***
4 5.104 10.3 24.4 ********
5 3.245 6.6 31.0 *****
6 4.647 9.4 40.4 *******
7 7.266 14.7 55.0 ***********
8 7.834 15.8 70.9 ************
9 6.746 13.6 84.5 **********
10 2.968 6.0 90.5 ****
11 2.453 5.0 95.4 ***
12 2.221 4.5 99.9 ***
13 0.036 0.1 100
inf 0 0 100
Queue 0x228e9078160
name=queue
component(s):
x.0 enter_time 35.711 priority=0
x.1 enter_time 35.900 priority=0
x.9 enter_time 42.122 priority=0
x.6 enter_time 45.655 priority=0
x.13 enter_time 46.763 priority=0
x.4 enter_time 48.635 priority=0
x.3 enter_time 49.501 priority=0

10.1 Advanced

The various classes have a lot of parameters, like color, line width, font, etc.

These parameters can be given just as a scalar, like:

```
sim.AnimateText(text='Hello world', x=200, y=300, textcolor='red')
```

But each of these parameters may also be a:

- function with zero arguments
- function with one argument being the time t
- function with two arguments being 'arg' and the time t
- a method with instance 'arg' and the time t

The function or method is called at each animation frame update (maximum of 30 frames per second).

This makes it for instance possible to show dynamically the mean of monitor m, like in

```
sim.AnimateRectangle(spec=(10, 10, 200, 30), text=lambda:  str(m.mean())
```

10.2 Class Animate

This class can be used to show:

- line (if line0 is specified)
- rectangle (if rectangle0 is specified)
- polygon (if polygon0 is specified)
- circle (if circle0 is specified)
- text (if text is specified)
- image (if image is specified)

Note that only one type is allowed per instance of Animate.

Nearly all attributes of an Animate object are interpolated between time t0 and t1. If t0 is not specified, now() is assumed. If t1 is not specified inf is assumed, which means that the attribute will be the '0' attribute.

E.g.:

`Animate(x0=100,y0=100,rectangle0=(-10,-10,10,10))` will show a square around (100,100) for ever `Animate(x0=100,y0=100,x1=200,y1=0,rectangle0=(-10,-10,10,10))` will still show the same square around (100,100) as t1 is not specified `Animate(t1=env.now()+10,x0=100,y0=100,x1=200,y1=0,rectangle0=(-10,-10,10,10))` will show a square moving from (100,100) to (200,0) in 10 units of time.

It also possible to let the rectangle change shape over time:

`Animate(t1=env.now(),x0=100,y0=100,x1=200,y1=0,rectangle0=(-10,-10,10,10),rectangle1=(-20,-20,20,20))` will show a moving and growing rectangle.

By default, the animation object will not change anymore after t1, but will remain visible. Alternatively, if keep=False is specified, the object will disappear at time t1.

Also, colors, fontsizes, angles can be changed in a linear way over time.

E.g.:

`Animate(t1=env.now()+10,text='Test',textcolor0='red',textcolor1='blue',angle0=0,angle1=360)` will show a rotating text changing from red to blue in 10 units of time.

The animation object can be updated with the update method. Here, once again, all the attributes can be specified to change over time. Note that the defaults for the '0' values are the actual values at t=now().

Thus,

`an=Animate(t0=0,t1=10,x0=0,x1=100,y0=0,circle0=(10,),circle1=(20,))` will show a horizontally moving, growing circle.

Now, at time t=5, we issue `an.update(t1=10,y1=50,circle1=(10,))` Then x0 will be set 50 (halfway 0 an 100) and cicle0 to (15,) (halfway 10 and 20). Thus the circle will shrink to its original size and move vertically from (50,0) to (50,50). This concept is very useful for moving objects whose position and orientation are controlled by the simulation.

Here we explain how an attribute changes during time. We use x as an example. Normally, x=x0 at t=t0 and x=x1 at t>=t1. between t=t0 and t=t1, x is linearly interpolated. An application can however override the x method. The prefered way is to subclass the Animate class:

```
# Demo animate 1
import salabim as sim


class AnimateMovingText(sim.Animate):
    def __init__(self):
        sim.Animate.__init__(self, text="", x0=100, x1=1000, y0=100, t1=env.now() + 10)

    def x(self, t):
        return sim.interpolate(sim.interpolate(t, self.t0, self.t1, 0, 1) ** 2, 0, 1, self.x0, self.x1)
```

```
    def y(self, t):
        return int(t) * 50

    def text(self, t):
        return "{:0.1f}".format(t)


sim.reset()
env = sim.Environment()

env.animate(True)

AnimateMovingText()

env.run(till=sim.inf)  # otherwise the simulation will end at t=0, because there are no events left
```

This code will show the current simulation time moving from left to right, uniformly accelerated. And the text will be shown a bit higher up, every second. It is not necessary to use t0, t1, x0, x1, but is a convenient way of setting attributes.

The following methods may be overridden:

method	circle	image	line	polygon	rectangle	text
anchor		•				
angle	•	•	•	•	•	•
circle	•					
fillcolor	•			•	•	
fontsize						•
image		•				
layer	•	•	•	•	•	•
line			•			
linecolor	•		•	•	•	
linewidth	•		•	•	•	
max_lines						•
offsetx	•	•	•	•	•	•
offsety	•	•	•	•	•	•
polygon				•		
rectangle					•	
text						•

text_anchor						•
textcolor						•

Dashboard animation

Here we present an example model where the simulation code is completely separated from the animation code. This makes communication and debugging and switching off animation much easier.

The example below generates 15 persons starting at time 0, 1, ... These persons enter a queue called q and stay there 15 time units.

The animation dashboard shows the first 10 persons in the queue q, along with the length of that q.

```
# Demo animate 2.py
import salabim as sim


class AnimateWaitSquare(sim.Animate):
    def __init__(self, i):
        self.i = i
        sim.Animate.__init__(
            self, rectangle0=(-12, -10, 12, 10), x0=300 - 30 * i, y0=100, fillcolor0="red", linewidth0=0
        )

    def visible(self, t):
        return q[self.i] is not None


class AnimateWaitText(sim.Animate):
    def __init__(self, i):
        self.i = i
        sim.Animate.__init__(self, text="", x0=300 - 30 * i, y0=100, textcolor0="white")

    def text(self, t):
        component_i = q[self.i]

        if component_i is None:
            return ""
        else:
            return component_i.name()


def do_animation():
    env.animate(True)
    for i in range(10):
        AnimateWaitSquare(i)
```

```
        AnimateWaitText(i)
    show_length = sim.Animate(text="", x0=330, y0=100, textcolor0="black", anchor="w")
    show_length.text = lambda t: "Length= " + str(len(q))


class Person(sim.Component):
    def process(self):
        self.enter(q)
        yield self.hold(15)
        self.leave(q)


env = sim.Environment(trace=True)

q = sim.Queue("q")
for i in range(15):
    Person(name="{:02d}".format(i), at=i)

do_animation()

env.run()
```

All animation initialization is in `do_animation`, where first 10 rectangle and text Animate objects are created. These are classes that are inherited from sim.Animate.

The AnimateWaitSquare defines a red rectangle at a specific position in the `sim.Animate.__init__()` call. Note that normally these squares should be displayed. But, here we have overridden the visible method. If there is no i-th component in the q, the square will be made invisible. Otherwise, it is visible.

The AnimateWaitText is more or less defined in a similar way. It defines a text in white at a specific position. Only the text method is overridden and will return the name of the i-th component in the queue, if any. Otherwise the null string will be returned.

The length of the queue q could be defined also by subclassing sim.Animate, but here we just make a direct instance of Animate with the null string as the text to be displayed. And then we immediately override the text method with a lambda function. Note that in this case, self is not available!

10.3 Using colours

When a colour has to be specified in one of the animation methods, salabim offers a choice of specification:

- *#rrggbb* rr, gg, bb in hex, alpha=255

- *#rrggbbaa* rr, gg, bb, aa in hex, alpha=aa
- *(r, g, b)* r, g, b in 0-255, alpha=255
- *(r, g, b, a)* r, g, b in 0-255, alpha=a
- *"fg"* current foreground color
- *"bg"* current background color
- *colorname* alpha=255
- *colorname, a* alpha=a

The colornames are defined as follows:

<null string>
10%gray
20%gray
30%gray
40%gray
50%gray
60%gray
70%gray
80%gray
90%gray
aliceblue
antiquewhite
aqua
aquamarine
azure
beige
bisque
black
blanchedalmond
blue
blueviolet
brown
burlywood
cadetblue
chartreuse
chocolate
coral
cornflowerblue
cornsilk
crimson
cyan
darkblue
darkcyan
darkgoldenrod
darkgray
darkgreen
darkkhaki
darkmagenta
darkolivegreen
darkorange
darkorchid
darkred
darksalmon
darkseagreen
darkslateblue
darkslategray
darkturquoise
darkviolet
deeppink
deepskyblue
dimgray
dodgerblue
firebrick
floralwhite
forestgreen
fuchsia
gainsboro
ghostwhite
gold
goldenrod
gray
green
greenyellow
honeydew
hotpi
indianred
indigo
ivory
khaki
lavender
lavenderblush
lawngreen
lemonchiffon
lightblue
lightcoral
lightcyan
lightgoldenrodyellow
lightgray
lightgreen
lightpink
lightsalmon
lightseagreen
lightskyblue
lightslategray
lightsteelblue
lightyellow
lime
limegreen
linen
magenta
maroon
mediumaquamarine
mediumblue
mediumorchid
mediumpurple
mediumseagreen
mediumslateblue
mediumspringgreen
mediumturquoise
mediumvioletred
midnightblue
mintcream
mistyrose
moccasin
navajowhite
navy
none
oldlace
olive
olivedrab
orange
orangered
orchid
palegoldenrod
palegreen
paleturquoise
palevioletred
papayawhip
peachpuff
peru
pink
plum
powderblue
purple
red
rosybrown
royalblue
saddlebrown
salmon
sandybrown
seagreen
seashell
sienna
silver
skyblue
slateblue
slategray
snow
springgreen
steelblue
tan
teal
thistle
tomato
transparent
turquoise
violet
wheat
white
whitesmoke
yellow
yellowgreen

This output can be generated with the following program:

```
# Show colornames

import salabim as sim

env = sim.Environment()
names = sorted(sim.colornames().keys())
env.modelname("show colornames")
env.background_color("20%gray")
env.animate(True)
x = 10
y = env.height() - 110
sx = 165
sy = 21

for name in names:
    sim.Animate(rectangle0=(x, y, x + sx, y + sy), fillcolor0=name)
    sim.Animate(
        text=(name, "<null string>")[name == ""],
        x0=x + sx / 2,
        y0=y + sy / 2,
        anchor="c",
        textcolor0=("black", "white")[env.is_dark(name)],
        fontsize0=15,
    )
    x += sx + 4
    if x + sx > 1024:
        y -= sy + 4
        x = 10

env.run()
```

10.4 Avoiding crashes in tkinter

When animating a large number of objects, it is possible that tkinter crashes because there are too many tkinter bitmaps aka canvas objects, sometimes by issuing a 'Fail to allocate bitmap', sometimes without any message. Salabim limits the number of bitmap automatically by combining animation objects in one aggregated bitmap if the number of bitmaps exceeds a given maximum. Unfortunately it is not possible to detect this 'Fail to allocate bitmap', so it may take some experimentation to find a workable maximum

(maybe going as low as 1000).

By default, salabim sets the maximum number of bitmaps to 4000, but may be changed with the Environment.maximum_number_of_bitmaps() method, or the maximum_number_of_bitmaps parameter of Environment.animation_parameters(). Choosing a too low maximum (particularly 0), may result in a performance degradation. The bitmap aggregation process is transparent to the user.

Note that does this not apply to the Pythonista implementation, where bitmaps are always aggregated.

10.5 Video production and snapshots

An animation can be recorded as an .mp4 video by specifying `video=filename` in the call to animation_parameters. The effect is that 30 time per second (scaled animation time) a frame is written. In this case, the animation does not run synchronized with the wall clock any more. Depending on the complexity of the animation, the simulation might run faster of slower than real time. In contrast to an ordinary animation, frames are never skipped.

Once control is given back to main, the .mp4 file is closed.

It is also possible to create an animated gif file by specifying a .gif file. In that case, repeat and pingpong are additional options.

Video production supports also the creation of a series of individual frames, in .jpg, .png, .tiff or .bmp format. By specifying video with one of these extension, the filename will be padded with 6 increasing digits, e.g.

```
env.video('test.jpg')
```

will write individual autonumbered frames named

```
test000000.jpg
test000001.jpg
test000002.jpg
...
```

Prior to creating the frames, all files matching the specification will be removed, in order to get only the required frames, most likely for post processing with ffmpeg or similar.

Note that individual frame video production is available on all platforms, including Pythonista.

Salabim also supports taking a snapshot of an animated screen with `Environment.snapshot()`.

10.6 Audio support

On Windows platforms, it is possible to add an audio track to a video. With `Environment.audio()` an audio track (usually an mp3 file) will be added. The audio may stopped by issueing `audio("")`. If another audio is started, the current audio, if any, will be stopped.

Adding audio to a video requires that ffmpeg is installed and in the search path. Refer to *www.ffmpeg.org* for downloads and instructions.

In order to develop lip synced videos, it is possible to play audios parallel to a simulation, provided the animation speed is equal to the audio_speed (1 by default). Audio playback is supported on Pythonista and Windows platforms only.

CHAPTER

ELEVEN

READING ITEMS FROM A FILE

Salabim models often need to read input values from a file.

As these data are quite often quite unstructured, using the standard read facilities of text files can be rather tedious.

Therefore, salabim offers the possibility to read a file item by item.

Example usage

```
with sim.ItemFile(filename) as f:
    run_length = f.read_item_float()
    run_name = f.read_item()
```

Or (not recommended)

```
f = sim.InputFile(filename)
run_length = f.read_item_float()
run_name = f.read_item()
f.close()
```

The input file is read per item, where blanks, linefeeds, tabs are treated as separators. Any text on a line after a # character is ignored. Any text within curly brackets ({}) is ignored (and treated as an item separator). Note that this strictly on a per line basis. If a blank or tab is to be included in a string, use single or double quotes. The recommended way to end a list of values is //

So, a typical input file is

```
# Typical experiment file for a salabim model
1000              # run length
'Experiment 2.0'  # run name
```

```
#Model           speed color
#--------------- ----- ------

'Peugeot 208'       150 red
'Peugeot 3008'      175 orange
'Citroen C5'        160 blue
'Renault "Twingo"'  165 green
//

France {country} Europe {continent}

#end of file
```

Instead of the filename as a parameter to ItemFile, also a string with the content can be given. In that case, at least one linefeed has to be in the content string. Usually, the content string will be triple quoted. This can be very useful during testing as the input is part of the source file and not external, e.g.

```
test_input = '''
one two
three four
five
'''
with sim.ItemFile(test_input) as f:
    while True:
        try:
            print(f.read_item())
        except EOFError:
            break
```

CHAPTER

TWELVE

REFERENCE

12.1 Animation

class salabim.**Animate**(*parent=None*, *layer=0*, *keep=True*, *visible=True*, *screen_coordinates=False*, *t0=None*, *x0=0*, *y0=0*, *offsetx0=0*, *offsety0=0*, *circle0=None*, *line0=None*, *polygon0=None*, *rectangle0=None*, *points0=None*, *image=None*, *text=None*, *font=''*, *anchor='c'*, *as_points=False*, *max_lines=0*, *text_anchor=None*, *linewidth0=None*, *fillcolor0=None*, *linecolor0='fg'*, *textcolor0='fg'*, *angle0=0*, *alpha0=255*, *fontsize0=20*, *width0=None*, *t1=None*, *x1=None*, *y1=None*, *offsetx1=None*, *offsety1=None*, *circle1=None*, *line1=None*, *polygon1=None*, *rectangle1=None*, *points1=None*, *linewidth1=None*, *fillcolor1=None*, *linecolor1=None*, *textcolor1=None*, *angle1=None*, *alpha1=None*, *fontsize1=None*, *width1=None*, *xy_anchor=''*, *env=None*)

defines an animation object

Parameters

- **parent** (Component) – component where this animation object belongs to (default None) if given, the animation object will be removed automatically upon termination of the parent
- **layer** (*int*) – layer value lower layer values are on top of higher layer values (default 0)
- **keep** (*bool*) – keep if False, animation object is hidden after t1, shown otherwise (default True)
- **visible** (*bool*) – visible if False, animation object is not shown, shown otherwise (default True)
- **screen_coordinates** (*bool*) – use screen_coordinates normally, the scale parameters are use for positioning and scaling objects. if True, screen_coordinates will be used instead.
- **xy_anchor** (*str*) – specifies where x and y (i.e. x0, y0, x1 and y1) are relative to possible values are (default: sw) : `nw n ne w c e sw s se` If null string, the given coordimates are used untranslated
- **t0** (*float*) – time of start of the animation (default: now)

- **x0** (*float*) – x-coordinate of the origin at time t0 (default 0)
- **y0** (*float*) – y-coordinate of the origin at time t0 (default 0)
- **offsetx0** (*float*) – offsets the x-coordinate of the object at time t0 (default 0)
- **offsety0** (*float*) – offsets the y-coordinate of the object at time t0 (default 0)
- **circle0** (*float or tuple/list*) – the circle spec of the circle at time t0 - radius - one item tuple/list containing the radius - five items tuple/list cntaining radius, radius1, arc_angle0, arc_angle1 and draw_arc (see class AnimateCircle for details)
- **line0** (*tuple*) – the line(s) (xa,ya,xb,yb,xc,yc, ...) at time t0
- **polygon0** (*tuple*) – the polygon (xa,ya,xb,yb,xc,yc, ...) at time t0 the last point will be auto connected to the start
- **rectangle0** (*tuple*) – the rectangle (xlowerleft,ylowerleft,xupperright,yupperright) at time t0
- **image** (*str or PIL image*) – the image to be displayed This may be either a filename or a PIL image
- **text** (*str, tuple or list*) – the text to be displayed if text is str, the text may contain linefeeds, which are shown as individual lines
- **max_lines** (*int*) – the maximum of lines of text to be displayed if positive, it refers to the first max_lines lines if negative, it refers to the first -max_lines lines if zero (default), all lines will be displayed
- **font** (*str or list/tuple*) – font to be used for texts Either a string or a list/tuple of fontnames. If not found, uses calibri or arial
- **anchor** (*str*) – anchor position specifies where to put images or texts relative to the anchor point possible values are (default: c): `nw n ne w c e sw s se`
- **as_points** (*bool*) – if False (default), lines in line, rectangle and polygon are drawn if True, only the end points are shown in line, rectangle and polygon
- **linewidth0** (*float*) – linewidth of the contour at time t0 (default 0 for polygon, rectangle and circle, 1 for line) if as_point is True, the default size is 3
- **fillcolor0** (*colorspec*) – color of interior at time t0 (default foreground_color) if as_points is True, fillcolor0 defaults to transparent
- **linecolor0** (*colorspec*) – color of the contour at time t0 (default foreground_color)
- **textcolor0** (*colorspec*) – color of the text at time 0 (default foreground_color)
- **angle0** (*float*) – angle of the polygon at time t0 (in degrees) (default 0)
- **alpha0** (*float*) – alpha of the image at time t0 (0-255) (default 255)
- **fontsize0** (*float*) – fontsize of text at time t0 (default 20)
- **width0** (*float*) – width of the image to be displayed at time t0 if omitted or None, no scaling

- **t1** (*float*) – time of end of the animation (default inf) if keep=True, the animation will continue (frozen) after t1
- **x1** (*float*) – x-coordinate of the origin at time t1(default x0)
- **y1** (*float*) – y-coordinate of the origin at time t1 (default y0)
- **offsetx1** (*float*) – offsets the x-coordinate of the object at time t1 (default offsetx0)
- **offsety1** (*float*) – offsets the y-coordinate of the object at time t1 (default offsety0)
- **circle1** (*float or tuple/list*) – the circle spec of the circle at time t1 (default: circle0) - radius - one item tuple/list containing the radius - five items tuple/list cntaining radius, radius1, arc_angle0, arc_angle1 and draw_arc (see class AnimateCircle for details)
- **line1** (*tuple*) – the line(s) at time t1 (xa,ya,xb,yb,xc,yc, ...) (default: line0) should have the same number of elements as line0
- **polygon1** (*tuple*) – the polygon at time t1 (xa,ya,xb,yb,xc,yc, ...) (default: polygon0) should have the same number of elements as polygon0
- **rectangle1** (*tuple*) – the rectangle (xlowerleft,ylowerleft,xupperright,yupperright) at time t1 (default: rectangle0)
- **linewidth1** (*float*) – linewidth of the contour at time t1 (default linewidth0)
- **fillcolor1** (*colorspec*) – color of interior at time t1 (default fillcolor0)
- **linecolor1** (*colorspec*) – color of the contour at time t1 (default linecolor0)
- **textcolor1** (*colorspec*) – color of text at time t1 (default textcolor0)
- **angle1** (*float*) – angle of the polygon at time t1 (in degrees) (default angle0)
- **alpha1** (*float*) – alpha of the image at time t1 (0-255) (default alpha0)
- **fontsize1** (*float*) – fontsize of text at time t1 (default: fontsize0)
- **width1** (*float*) – width of the image to be displayed at time t1 (default: width0)

Note:

one (and only one) of the following parameters is required:

- circle0
- image
- line0
- polygon0
- rectangle0

- text

colors may be specified as a

- valid colorname
- hexname
- tuple (R,G,B) or (R,G,B,A)
- “fg” or “bg”

colornames may contain an additional alpha, like `red#7f` hexnames may be either 3 of 4 bytes long (`#rrggbb` or `#rrggbbaa`) both colornames and hexnames may be given as a tuple with an additional alpha between 0 and 255, e.g. `(255,0,255,128)`, (“red”,127)‘‘ or `("#ff00ff",128)` fg is the foreground color bg is the background color

Permitted parameters

parameter	circle	image	line	polygon	rectangle	text
parent	•	•	•	•	•	•
layer	•	•	•	•	•	•
keep	•	•	•	•	•	•
screen_coordinates	•	•	•	•	•	•
xy_anchor	•	•	•	•	•	•
t0,t1	•	•	•	•	•	•
x0,x1	•	•	•	•	•	•
y0,y1	•	•	•	•	•	•
offsetx0,offsetx1	•	•	•	•	•	•
offsety0,offsety1	•	•	•	•	•	•
circle0,circle1	•					
image		•				
line0,line1			•			
polygon0,polygon1				•		
rectangle0,rectangle1						

alpha (*t=None*)
alpha of an animate object. May be overridden.

Parameters **t** (*float*) – current time

Returns **alpha** – default behaviour: linear interpolation between self.alpha0 and self.alpha1

Return type float

anchor (*t=None*)
anchor of an animate object. May be overridden.

Parameters **t** (*float*) – current time

Returns **anchor** – default behaviour: self.anchor0 (anchor given at creation or update)

Return type str

angle (*t=None*)
angle of an animate object. May be overridden.

Parameters **t** (*float*) – current time

Returns **angle** – default behaviour: linear interpolation between self.angle0 and self.angle1

Return type float

as_points (*t=None*)
as_points of an animate object. May be overridden.

Parameters **t** (*float*) – current time

Returns **as_points** – default behaviour: self.as_points (text given at creation or update)

Return type bool

circle (*t=None*)
circle of an animate object. May be overridden.

Parameters **t** (*float*) – current time

Returns **circle** – either - radius - one item tuple/list containing the radius - five items tuple/list cntaining radius, radius1, arc_angle0, arc_angle1 and draw_arc (see class AnimateCircle for details) default behaviour: linear interpolation between self.circle0 and self.circle1

Return type float or tuple/list

fillcolor(*t=None*)
fillcolor of an animate object. May be overridden.

Parameters **t** (*float*) – current time

Returns **fillcolor** – default behaviour: linear interpolation between self.fillcolor0 and self.fillcolor1

Return type colorspec

font(*t=None*)
font of an animate object. May be overridden.

Parameters **t** (*float*) – current time

Returns **font** – default behaviour: self.font0 (font given at creation or update)

Return type str

fontsize(*t=None*)
fontsize of an animate object. May be overridden.

Parameters **t** (*float*) – current time

Returns **fontsize** – default behaviour: linear interpolation between self.fontsize0 and self.fontsize1

Return type float

image(*t=None*)
image of an animate object. May be overridden.

Parameters **t** (*float*) – current time

Returns **image** – use function spec_to_image to load a file default behaviour: self.image0 (image given at creation or update)

Return type PIL.Image.Image

layer(*t=None*)
layer of an animate object. May be overridden.

Parameters **t** (*float*) – current time

Returns **layer** – default behaviour: self.layer0 (layer given at creation or update)

Return type int or float

line(*t=None*)
line of an animate object. May be overridden.

Parameters **t** (*float*) – current time

Returns **line** – series of x- and y-coordinates (xa,ya,xb,yb,xc,yc, ...) default behaviour: linear interpolation between self.line0 and self.line1

Return type tuple

linecolor(*t=None*)
linecolor of an animate object. May be overridden.

Parameters **t** (*float*) – current time

Returns **linecolor** – default behaviour: linear interpolation between self.linecolor0 and self.linecolor1

Return type colorspec

linewidth(*t=None*)
linewidth of an animate object. May be overridden.

Parameters **t** (*float*) – current time

Returns **linewidth** – default behaviour: linear interpolation between self.linewidth0 and self.linewidth1

Return type float

max_lines(*t=None*)
maximum number of lines to be displayed of text. May be overridden.

Parameters **t** (*float*) – current time

Returns **max_lines** – default behaviour: self.max_lines0 (max_lines given at creation or update)

Return type int

offsetx(*t=None*)
offsetx of an animate object. May be overridden.

Parameters **t** (*float*) – current time

Returns **offsetx** – default behaviour: linear interpolation between self.offsetx0 and self.offsetx1

Return type float

offsety(*t=None*)
offsety of an animate object. May be overridden.

Parameters **t** (*float*) – current time

Returns **offsety** – default behaviour: linear interpolation between self.offsety0 and self.offsety1

Return type float

points(*t=None*)
points of an animate object. May be overridden.

Parameters **t** (*float*) – current time

Returns **points** – series of x- and y-coordinates (xa,ya,xb,yb,xc,yc, ...) default behaviour: linear interpolation between self.points0 and self.points1

Return type tuple

polygon(*t=None*)
polygon of an animate object. May be overridden.

Parameters **t** (*float*) – current time

Returns **polygon** – series of x- and y-coordinates describing the polygon (xa,ya,xb,yb,xc,yc, ...) default behaviour: linear interpolation between self.polygon0 and self.polygon1

Return type tuple

rectangle(*t=None*)
rectangle of an animate object. May be overridden.

Parameters **t** (*float*) – current time

Returns **rectangle** – (xlowerleft,ylowerlef,xupperright,yupperright) default behaviour: linear interpolation between self.rectangle0 and self.rectangle1

Return type tuple

remove()
removes the animation object from the animation queue, so effectively ending this animation.

Note: The animation object might be still updated, if required

---

text(*t=None*)
text of an animate object. May be overridden.

Parameters **t** (*float*) – current time

Returns **text** – default behaviour: self.text0 (text given at creation or update)

Return type str

text_anchor(*t=None*)
text_anchor of an animate object. May be overridden.

Parameters **t** (*float*) – current time

Returns **text_anchor** – default behaviour: self.text_anchor0 (text_anchor given at creation or update)

Return type str

textcolor(*t=None*)
textcolor of an animate object. May be overridden.

Parameters **t** (*float*) – current time

Returns **textcolor** – default behaviour: linear interpolation between self.textcolor0 and self.textcolor1

Return type colorspec

update(*layer=None*, *keep=None*, *visible=None*, *t0=None*, *x0=None*, *y0=None*, *offsetx0=None*, *offsety0=None*, *circle0=None*, *line0=None*, *polygon0=None*, *rectangle0=None*, *points0=None*, *image=None*, *text=None*, *font=None*, *anchor=None*, *max_lines=None*, *text_anchor=None*, *linewidth0=None*, *fillcolor0=None*, *linecolor0=None*, *textcolor0=None*, *angle0=None*, *alpha0=None*, *fontsize0=None*, *width0=None*, *as_points=None*, *t1=None*, *x1=None*, *y1=None*, *offsetx1=None*, *offsety1=None*, *circle1=None*, *line1=None*, *polygon1=None*, *rectangle1=None*, *points1=None*, *linewidth1=None*, *fillcolor1=None*, *linecolor1=None*, *textcolor1=None*, *angle1=None*, *alpha1=None*, *fontsize1=None*, *width1=None*, *xy_anchor=None*)
updates an animation object

Parameters

- **layer** (*int*) – layer value lower layer values are on top of higher layer values (default see below)
- **keep** (*bool*) – keep if False, animation object is hidden after t1, shown otherwise (default see below)
- **visible** (*bool*) – visible if False, animation object is not shown, shown otherwise (default see below)
- **xy_anchor** (*str*) – specifies where x and y (i.e. x0, y0, x1 and y1) are relative to possible values are: `nw n ne w c e sw s se` If null string, the given coordimates are used untranslated default see below
- **t0** (*float*) – time of start of the animation (default: now)
- **x0** (*float*) – x-coordinate of the origin at time t0 (default see below)
- **y0** (*float*) – y-coordinate of the origin at time t0 (default see below)
- **offsetx0** (*float*) – offsets the x-coordinate of the object at time t0 (default see below)
- **offsety0** (*float*) – offsets the y-coordinate of the object at time t0 (default see below)

- **circle0** (*float or tuple/list*) – the circle spec of the circle at time t0 - radius - one item tuple/list containing the radius - five items tuple/list cntaining radius, radius1, arc_angle0, arc_angle1 and draw_arc (see class AnimateCircle for details)
- **line0** (*tuple*) – the line(s) at time t0 (xa,ya,xb,yb,xc,yc, ...) (default see below)
- **polygon0** (*tuple*) – the polygon at time t0 (xa,ya,xb,yb,xc,yc, ...) the last point will be auto connected to the start (default see below)
- **rectangle0** (*tuple*) – the rectangle at time t0 (xlowerleft,ylowerlef,xupperright,yupperright) (default see below)
- **points0** (*tuple*) – the points(s) at time t0 (xa,ya,xb,yb,xc,yc, ...) (default see below)
- **image** (*str or PIL image*) – the image to be displayed This may be either a filename or a PIL image (default see below)
- **text** (*str*) – the text to be displayed (default see below)
- **font** (*str or list/tuple*) – font to be used for texts Either a string or a list/tuple of fontnames. (default see below) If not found, uses calibri or arial
- **max_lines** (*int*) – the maximum of lines of text to be displayed if positive, it refers to the first max_lines lines if negative, it refers to the first -max_lines lines if zero (default), all lines will be displayed
- **anchor** (*str*) – anchor position specifies where to put images or texts relative to the anchor point (default see below) possible values are (default: c): `nw n ne w c e sw s se`
- **linewidth0** (*float*) – linewidth of the contour at time t0 (default see below)
- **fillcolor0** (*colorspec*) – color of interior/text at time t0 (default see below)
- **linecolor0** (*colorspec*) – color of the contour at time t0 (default see below)
- **angle0** (*float*) – angle of the polygon at time t0 (in degrees) (default see below)
- **fontsize0** (*float*) – fontsize of text at time t0 (default see below)
- **width0** (*float*) – width of the image to be displayed at time t0 (default see below) if None, the original width of the image will be used
- **t1** (*float*) – time of end of the animation (default: inf) if keep=True, the animation will continue (frozen) after t1
- **x1** (*float*) – x-coordinate of the origin at time t1 (default x0)
- **y1** (*float*) – y-coordinate of the origin at time t1 (default y0)
- **offsetx1** (*float*) – offsets the x-coordinate of the object at time t1 (default offsetx0)
- **offsety1** (*float*) – offsets the y-coordinate of the object at time t1 (default offset0)
- **circle1** (*float or tuple/ist*) – the circle spec of the circle at time t1 - radius - one item tuple/list containing the radius - five items tuple/list cntaining radius, radius1, arc_angle0, arc_angle1 and draw_arc (see class AnimateCircle for details)

- **line1** (*tuple*) – the line(s) at time t1 (xa,ya,xb,yb,xc,yc, ...) (default: line0) should have the same number of elements as line0
- **polygon1** (*tuple*) – the polygon at time t1 (xa,ya,xb,yb,xc,yc, ...) (default: polygon0) should have the same number of elements as polygon0
- **rectangle1** (*tuple*) – the rectangle at time t (xlowerleft,ylowerleft,xupperright,yupperright) (default: rectangle0)
- **points1** (*tuple*) – the points(s) at time t1 (xa,ya,xb,yb,xc,yc, ...) (default: points0) should have the same number of elements as points1
- **linewidth1** (*float*) – linewidth of the contour at time t1 (default linewidth0)
- **fillcolor1** (*colorspec*) – color of interior/text at time t1 (default fillcolor0)
- **linecolor1** (*colorspec*) – color of the contour at time t1 (default linecolor0)
- **angle1** (*float*) – angle of the polygon at time t1 (in degrees) (default angle0)
- **fontsize1** (*float*) – fontsize of text at time t1 (default: fontsize0)
- **width1** (*float*) – width of the image to be displayed at time t1 (default: width0)

Note: The type of the animation cannot be changed with this method. The default value of most of the parameters is the current value (at time now)

visible (*t=None*)
visible attribute of an animate object. May be overridden.

Parameters **t** (*float*) – current time

Returns **visible** – default behaviour: self.visible0 (visible given at creation or update)

Return type bool

width (*t=None*)
width position of an animated image object. May be overridden.

Parameters **t** (*float*) – current time

Returns **width** – default behaviour: linear interpolation between self.width0 and self.width1 if None, the original width of the image will be used

Return type float

x (*t=None*)
x-position of an animate object. May be overridden.

Parameters **t** (*float*) – current time

Returns **x** – default behaviour: linear interpolation between self.x0 and self.x1

Return type float

xy_anchor(*t=None*)
xy_anchor attribute of an animate object. May be overridden.

Parameters **t** (*float*) – current time

Returns **xy_anchor** – default behaviour: self.xy_anchor0 (xy_anchor given at creation or update)

Return type str

y(*t=None*)
y-position of an animate object. May be overridden.

Parameters **t** (*float*) – current time

Returns **y** – default behaviour: linear interpolation between self.y0 and self.y1

Return type float

class salabim.**AnimateButton**(*x=0*, *y=0*, *width=80*, *height=30*, *linewidth=0*, *fillcolor='fg'*, *linecolor='fg'*, *color='bg'*, *text=''*, *font=''*, *fontsize=15*, *action=None*, *env=None*, *xy_anchor='sw'*)
defines a button

Parameters

- **x** (*int*) – x-coordinate of centre of the button in screen coordinates (default 0)
- **y** (*int*) – y-coordinate of centre of the button in screen coordinates (default 0)
- **width** (*int*) – width of button in screen coordinates (default 80)
- **height** (*int*) – height of button in screen coordinates (default 30)
- **linewidth** (*int*) – width of contour in screen coordinates (default 0=no contour)
- **fillcolor** (*colorspec*) – color of the interior (foreground_color)
- **linecolor** (*colorspec*) – color of contour (default foreground_color)
- **color** (*colorspec*) – color of the text (default background_color)
- **text** (*str or function*) – text of the button (default null string) if text is an argumentless function, this will be called each time; the button is shown/updated
- **font** (*str*) – font of the text (default Helvetica)
- **fontsize** (*int*) – fontsize of the text (default 15)

- **action** (*function*) – action to take when button is pressed executed when the button is pressed (default None) the function should have no arguments
- **xy_anchor** (*str*) – specifies where x and y are relative to possible values are (default: sw): `nw n ne w c e sw s se`
- **env** (Environment) – environment where the component is defined if omitted, default_env will be used

---

Note: All measures are in screen coordinates On Pythonista, this functionality is emulated by salabim On other platforms, the tkinter functionality is used.

---

remove()
removes the button object. the ui object is removed from the ui queue, so effectively ending this ui

class salabim.**AnimateCircle**(*radius=100*, *radius1=None*, *arc_angle0=0*, *arc_angle1=360*, *draw_arc=False*, *x=0*, *y=0*, *fillcolor='fg'*, *linecolor=''*, *linewidth=1*, *text=''*, *fontsize=15*, *textcolor='bg'*, *font=''*, *angle=0*, *xy_anchor=''*, *layer=0*, *max_lines=0*, *offsetx=0*, *offsety=0*, *text_anchor='c'*, *text_offsetx=0*, *text_offsety=0*, *arg=None*, *parent=None*, *visible=True*, *env=None*, *screen_coordinates=False*)

Displays a (partial) circle or (partial) ellipse , optionally with a text

Parameters

- **radius** (*float*) – radius of the circle
- **radius1** (*float*) – the 'height' of the ellipse. If None (default), a circle will be drawn
- **arc_angle0** (*float*) – start angle of the circle (default 0)
- **arc_angle1** (*float*) – end angle of the circle (default 360) when arc_angle1 > arc_angle0 + 360, only 360 degrees will be shown
- **draw_arc** (*bool*) – if False (default), no arcs will be drawn if True, the arcs from and to the center will be drawn
- **x** (*float*) – position of anchor point (default 0)
- **y** (*float*) – position of anchor point (default 0)
- **xy_anchor** (*str*) – specifies where x and y are relative to possible values are (default: sw) : `nw n ne w c e sw s se` If null string, the given coordimates are used untranslated The positions corresponds to a full circle even if arc_angle0 and/or arc_angle1 are specified.
- **offsetx** (*float*) – offsets the x-coordinate of the circle (default 0)
- **offsety** (*float*) – offsets the y-coordinate of the circle (default 0)
- **linewidth** (*float*) – linewidth of the contour default 1
- **fillcolor** (*colorspec*) – color of interior (default foreground_color) default transparent

- **linecolor** (*colorspec*) – color of the contour (default transparent)
- **angle** (*float*) – angle of the circle/ellipse and/or text (in degrees) default: 0
- **text** (*str, tuple or list*) – the text to be displayed if text is str, the text may contain linefeeds, which are shown as individual lines
- **max_lines** (*int*) – the maximum of lines of text to be displayed if positive, it refers to the first max_lines lines if negative, it refers to the last -max_lines lines if zero (default), all lines will be displayed
- **font** (*str or list/tuple*) – font to be used for texts Either a string or a list/tuple of fontnames. If not found, uses calibri or arial
- **text_anchor** (*str*) – anchor position of text|n| specifies where to texts relative to the polygon point possible values are (default: c): `nw n ne w c e sw s se`
- **textcolor** (*colorspec*) – color of the text (default foreground_color)
- **textoffsetx** (*float*) – extra x offset to the text_anchor point
- **textoffsety** (*float*) – extra y offset to the text_anchor point
- **fontsize** (*float*) – fontsize of text (default 15)
- **arg** (*any*) – this is used when a parameter is a function with two parameters, as the first argument or if a parameter is a method as the instance default: self (instance itself)
- **parent** (Component) – component where this animation object belongs to (default None) if given, the animation object will be removed automatically upon termination of the parent

---

Note: All measures are in screen coordinates

All parameters, apart from queue and arg can be specified as: - a scalar, like 10 - a function with zero arguments, like lambda: title - a function with one argument, being the time t, like lambda t: t + 10 - a function with two parameters, being arg (as given) and the time, like lambda comp, t: comp.state - a method instance arg for time t, like self.state, actually leading to arg.state(t) to be called

---

class salabim.**AnimateEntry**(*x=0*, *y=0*, *number_of_chars=20*, *value=''*, *fillcolor='fg'*, *color='bg'*, *text=''*, *action=None*, *env=None*, *xy_anchor='sw'*)

defines a button

Parameters

- **x** (*int*) – x-coordinate of centre of the button in screen coordinates (default 0)
- **y** (*int*) – y-coordinate of centre of the button in screen coordinates (default 0)
- **number_of_chars** (*int*) – number of characters displayed in the entry field (default 20)

- **fillcolor** (*colorspec*) – color of the entry background (default foreground_color)
- **color** (*colorspec*) – color of the text (default background_color)
- **value** (*str*) – initial value of the text of the entry (default null string)
- **action** (*function*) – action to take when the Enter-key is pressed the function should have no arguments
- **xy_anchor** (*str*) – specifies where x and y are relative to possible values are (default: sw): `nw n ne w c e sw s se`
- **env** (Environment) – environment where the component is defined if omitted, default_env will be used

---

Note: All measures are in screen coordinates This class is not available under Pythonista.

---

get()
get the current value of the entry

Returns **Current value of the entry**

Return type str

remove()
removes the entry object. the ui object is removed from the ui queue, so effectively ending this ui

class salabim.**AnimateImage**(*spec=''*, *x=0*, *y=0*, *width=None*, *text=''*, *fontsize=15*, *textcolor='bg'*, *font=''*, *angle=0*, *alpha=255*, *xy_anchor=''*, *layer=0*, *max_lines=0*, *offsetx=0*, *offsety=0*, *text_anchor='c'*, *text_offsetx=0*, *text_offsety=0*, *arg=None*, *parent=None*, *anchor='sw'*, *visible=True*, *env=None*, *screen_coordinates=False*)
Displays an image, optionally with a text

Parameters

- **image** (*str*) – image to be displayed if used as function or method or in direct assigmnent, the image should be a PIL image (most likely via spec_to_image)
- **x** (*float*) – position of anchor point (default 0)
- **y** (*float*) – position of anchor point (default 0)
- **xy_anchor** (*str*) – specifies where x and y are relative to possible values are (default: sw) : `nw n ne w c e sw s se` If null string, the given coordimates are used untranslated
- **anchor** (*str*) – specifies where the x and refer to possible values are (default: sw) : `nw n ne w c e sw s se`
- **offsetx** (*float*) – offsets the x-coordinate of the circle (default 0)

- **offsety** (*float*) – offsets the y-coordinate of the circle (default 0)
- **angle** (*float*) – angle of the image (in degrees) (default 0)
- **alpha** (*float*) – alpha of the image (0-255) (default 255)
- **text** (*str, tuple or list*) – the text to be displayed if text is str, the text may contain linefeeds, which are shown as individual lines
- **max_lines** (*int*) – the maximum of lines of text to be displayed if positive, it refers to the first max_lines lines if negative, it refers to the last -max_lines lines if zero (default), all lines will be displayed
- **font** (*str or list/tuple*) – font to be used for texts Either a string or a list/tuple of fontnames. If not found, uses calibri or arial
- **text_anchor** (*str*) – anchor position of text|n| specifies where to texts relative to the polygon point possible values are (default: c): `nw n ne w c e sw s se`
- **textcolor** (*colorspec*) – color of the text (default foreground_color)
- **textoffsetx** (*float*) – extra x offset to the text_anchor point
- **textoffsety** (*float*) – extra y offset to the text_anchor point
- **fontsize** (*float*) – fontsize of text (default 15)
- **arg** (*any*) – this is used when a parameter is a function with two parameters, as the first argument or if a parameter is a method as the instance default: self (instance itself)
- **parent** (Component) – component where this animation object belongs to (default None) if given, the animation object will be removed automatically upon termination of the parent

---

Note: All measures are in screen coordinates

All parameters, apart from queue and arg can be specified as: - a scalar, like 10 - a function with zero arguments, like lambda: title - a function with one argument, being the time t, like lambda t: t + 10 - a function with two parameters, being arg (as given) and the time, like lambda comp, t: comp.state - a method instance arg for time t, like self.state, actually leading to arg.state(t) to be called

---

class salabim.**AnimateLine**(*spec=()*, *x=0*, *y=0*, *linecolor='fg'*, *linewidth=1*, *text=''*, *fontsize=15*, *textcolor='fg'*, *font=''*, *angle=0*, *xy_anchor=''*, *layer=0*, *max_lines=0*, *offsetx=0*, *offsety=0*, *as_points=False*, *text_anchor='c'*, *text_offsetx=0*, *text_offsety=0*, *arg=None*, *parent=None*, *visible=True*, *env=None*, *screen_coordinates=False*)

Displays a line, optionally with a text

Parameters

- **spec** (*tuple or list*) – should specify x0, y0, x1, y1, ...

- **x** (*float*) – position of anchor point (default 0)
- **y** (*float*) – position of anchor point (default 0)
- **xy_anchor** (*str*) – specifies where x and y are relative to possible values are (default: sw) : `nw n ne w c e sw s se` If null string, the given coordimates are used untranslated
- **offsetx** (*float*) – offsets the x-coordinate of the line (default 0)
- **offsety** (*float*) – offsets the y-coordinate of the line (default 0)
- **linewidth** (*float*) – linewidth of the contour default 1
- **linecolor** (*colorspec*) – color of the contour (default foreground_color)
- **angle** (*float*) – angle of the line (in degrees) default: 0
- **as_points** (*bool*) – if False (default), the contour lines are drawn if True, only the corner points are shown
- **text** (*str, tuple or list*) – the text to be displayed if text is str, the text may contain linefeeds, which are shown as individual lines
- **max_lines** (*int*) – the maximum of lines of text to be displayed if positive, it refers to the first max_lines lines if negative, it refers to the last -max_lines lines if zero (default), all lines will be displayed
- **font** (*str or list/tuple*) – font to be used for texts Either a string or a list/tuple of fontnames. If not found, uses calibri or arial
- **text_anchor** (*str*) – anchor position of text|n| specifies where to texts relative to the polygon point possible values are (default: c): `nw n ne w c e sw s se`
- **textcolor** (*colorspec*) – color of the text (default foreground_color)
- **textoffsetx** (*float*) – extra x offset to the text_anchor point
- **textoffsety** (*float*) – extra y offset to the text_anchor point
- **fontsize** (*float*) – fontsize of text (default 15)
- **arg** (*any*) – this is used when a parameter is a function with two parameters, as the first argument or if a parameter is a method as the instance default: self (instance itself)
- **parent** (Component) – component where this animation object belongs to (default None) if given, the animation object will be removed automatically upon termination of the parent

---

Note: All measures are in screen coordinates

All parameters, apart from queue and arg can be specified as: - a scalar, like 10 - a function with zero arguments, like lambda: title - a function with one argument, being the time t, like lambda t: t + 10 - a function with two parameters, being arg (as given) and the time, like lambda comp, t: comp.state - a method instance arg for time t, like self.state, actually leading to arg.state(t) to be called

---

class salabim.**AnimateMonitor**(*monitor*, *linecolor='fg'*, *linewidth=None*, *fillcolor=''*, *bordercolor='fg'*, *borderlinewidth=1*, *titlecolor='fg'*, *nowcolor='red'*, *titlefont=''*, *titlefontsize=15*, *title=None*, *x=0*, *y=0*, *vertical_offset=2*, *parent=None*, *vertical_scale=5*, *horizontal_scale=None*, *width=200*, *height=75*, *xy_anchor='sw'*, *layer=0*)

animates a monitor in a panel

Parameters

- **linecolor** (*colorspec*) – color of the line or points (default foreground color)
- **linewidth** (*int*) – width of the line or points (default 1 for line, 3 for points)
- **fillcolor** (*colorspec*) – color of the panel (default transparent)
- **bordercolor** (*colorspec*) – color of the border (default foreground color)
- **borderlinewidth** (*int*) – width of the line around the panel (default 1)
- **nowcolor** (*colorspec*) – color of the line indicating now (default red)
- **titlecolor** (*colorspec*) – color of the title (default foreground color)
- **titlefont** (font) – font of the title (default null string)
- **titlefontsize** (*int*) – size of the font of the title (default 15)
- **title** (*str*) – title to be shown above panel default: name of the monitor
- **x** (*int*) – x-coordinate of panel, relative to xy_anchor, default 0
- **y** (*int*) – y-coordinate of panel, relative to xy_anchor. default 0
- **xy_anchor** (*str*) – specifies where x and y are relative to possible values are (default: sw): nw n ne w c e sw s se
- **vertical_offset** (*float*) –

  the vertical position of x within the panel is vertical_offset + x * vertical_scale (default 0)
- **vertical_scale** (*float*) – the vertical position of x within the panel is vertical_offset + x * vertical_scale (default 5)
- **horizontal_scale** (*float*) – the relative horizontal position of time t within the panel is on t * horizontal_scale, possibly shifted (default 1)|n|
- **width** (*int*) – width of the panel (default 200)

- **height** (*int*) – height of the panel (default 75)
- **layer** (*int*) – layer (default 0)
- **parent** (Component) – component where this animation object belongs to (default None) if given, the animation object will be removed automatically upon termination of the parent

---

Note: All measures are in screen coordinates

---

remove()
removes the animate object and thus closes this animation

class salabim.**AnimatePoints**(*spec=()*, *x=0*, *y=0*, *linecolor='fg'*, *linewidth=4*, *text=''*, *fontsize=15*, *textcolor='fg'*, *font=''*, *angle=0*, *xy_anchor=''*, *layer=0*, *max_lines=0*, *offsetx=0*, *offsety=0*, *text_anchor='c'*, *text_offsetx=0*, *text_offsety=0*, *arg=None*, *parent=None*, *visible=True*, *env=None*, *screen_coordinates=False*)
Displays a series of points, optionally with a text

Parameters

- **spec** (*tuple or list*) – should specify x0, y0, x1, y1, ...
- **x** (*float*) – position of anchor point (default 0)
- **y** (*float*) – position of anchor point (default 0)
- **xy_anchor** (*str*) – specifies where x and y are relative to possible values are (default: sw) : `nw n ne w c e sw s se` If null string, the given coordimates are used untranslated
- **offsetx** (*float*) – offsets the x-coordinate of the points (default 0)
- **offsety** (*float*) – offsets the y-coordinate of the points (default 0)
- **linewidth** (*float*) – width of the points default 1
- **linecolor** (*colorspec*) – color of the points (default foreground_color)
- **angle** (*float*) – angle of the points (in degrees) default: 0
- **as_points** (*bool*) – if False (default), the contour lines are drawn if True, only the corner points are shown
- **text** (*str, tuple or list*) – the text to be displayed if text is str, the text may contain linefeeds, which are shown as individual lines
- **max_lines** (*int*) – the maximum of lines of text to be displayed if positive, it refers to the first max_lines lines if negative, it refers to the last -max_lines lines if zero (default), all lines will be displayed

- **font** (*str or list/tuple*) – font to be used for texts Either a string or a list/tuple of fontnames. If not found, uses calibri or arial
- **text_anchor** (*str*) – anchor position of text|n| specifies where to texts relative to the polygon point possible values are (default: c): `nw n ne w c e sw s se`
- **textcolor** (*colorspec*) – color of the text (default foreground_color)
- **textoffsetx** (*float*) – extra x offset to the text_anchor point
- **textoffsety** (*float*) – extra y offset to the text_anchor point
- **fontsize** (*float*) – fontsize of text (default 15)
- **arg** (*any*) – this is used when a parameter is a function with two parameters, as the first argument or if a parameter is a method as the instance default: self (instance itself)
- **parent** (Component) – component where this animation object belongs to (default None) if given, the animation object will be removed automatically upon termination of the parent

---

Note: All measures are in screen coordinates

All parameters, apart from queue and arg can be specified as: - a scalar, like 10 - a function with zero arguments, like lambda: title - a function with one argument, being the time t, like lambda t: t + 10 - a function with two parameters, being arg (as given) and the time, like lambda comp, t: comp.state - a method instance arg for time t, like self.state, actually leading to arg.state(t) to be called

---

class salabim.**AnimatePolygon**(*spec=()*, *x=0*, *y=0*, *fillcolor='fg'*, *linecolor=''*, *linewidth=1*, *text=''*, *fontsize=15*, *textcolor='bg'*, *font=''*, *angle=0*, *xy_anchor=''*, *layer=0*, *max_lines=0*, *offsetx=0*, *offsety=0*, *as_points=False*, *text_anchor='c'*, *text_offsetx=0*, *text_offsety=0*, *arg=None*, *parent=None*, *visible=True*, *env=None*, *screen_coordinates=False*)

Displays a polygon, optionally with a text

Parameters

- **spec** (*tuple or list*) – should specify x0, y0, x1, y1, ...
- **x** (*float*) – position of anchor point (default 0)
- **y** (*float*) – position of anchor point (default 0)
- **xy_anchor** (*str*) – specifies where x and y are relative to possible values are (default: sw) : `nw n ne w c e sw s se` If null string, the given coordimates are used untranslated
- **offsetx** (*float*) – offsets the x-coordinate of the polygon (default 0)
- **offsety** (*float*) – offsets the y-coordinate of the polygon (default 0)

- **linewidth** (*float*) – linewidth of the contour default 1
- **fillcolor** (*colorspec*) – color of interior (default foreground_color) default transparent
- **linecolor** (*colorspec*) – color of the contour (default transparent)
- **angle** (*float*) – angle of the polygon (in degrees) default: 0
- **as_points** (*bool*) – if False (default), the contour lines are drawn if True, only the corner points are shown
- **text** (*str, tuple or list*) – the text to be displayed if text is str, the text may contain linefeeds, which are shown as individual lines
- **max_lines** (*int*) – the maximum of lines of text to be displayed if positive, it refers to the first max_lines lines if negative, it refers to the last -max_lines lines if zero (default), all lines will be displayed
- **font** (*str or list/tuple*) – font to be used for texts Either a string or a list/tuple of fontnames. If not found, uses calibri or arial
- **text_anchor** (*str*) – anchor position of text|n| specifies where to texts relative to the polygon point possible values are (default: c): `nw n ne w c e sw s se`
- **textcolor** (*colorspec*) – color of the text (default foreground_color)
- **textoffsetx** (*float*) – extra x offset to the text_anchor point
- **textoffsety** (*float*) – extra y offset to the text_anchor point
- **fontsize** (*float*) – fontsize of text (default 15)
- **arg** (*any*) – this is used when a parameter is a function with two parameters, as the first argument or if a parameter is a method as the instance default: self (instance itself)
- **parent** (Component) – component where this animation object belongs to (default None) if given, the animation object will be removed automatically upon termination of the parent

---

Note: All measures are in screen coordinates

All parameters, apart from queue and arg can be specified as: - a scalar, like 10 - a function with zero arguments, like lambda: title - a function with one argument, being the time t, like lambda t: t + 10 - a function with two parameters, being arg (as given) and the time, like lambda comp, t: comp.state - a method instance arg for time t, like self.state, actually leading to arg.state(t) to be called

---

class salabim.**AnimateQueue**(*queue*, *x=50*, *y=50*, *direction='w'*, *max_length=None*, *xy_anchor='sw'*, *reverse=False*, *title=None*, *titlecolor='fg'*, *titlefontsize=15*, *titlefont=''*, *titleoffsetx=None*, *titleoffsety=None*, *layer=0*, *id=None*, *arg=None*, *parent=None*)

Animates the component in a queue.

Parameters

- **queue** (Queue) –
- **x** (*float*) – x-position of the first component in the queue default: 50
- **y** (*float*) – y-position of the first component in the queue default: 50
- **direction** (*str*) – if "w", waiting line runs westwards (i.e. from right to left) if "n", waiting line runs northeards (i.e. from bottom to top) if "e", waiting line runs eastwards (i.e. from left to right) (default) if "s", waiting line runs southwards (i.e. from top to bottom)
- **reverse** (*bool*) – if False (default), display in normal order. If True, reversed.
- **max_length** (*int*) – maximum number of components to be displayed
- **xy_anchor** (*str*) – specifies where x and y are relative to possible values are (default: sw): `nw n ne w c e sw s se`
- **titlecolor** (*colorspec*) – color of the title (default foreground color)
- **titlefont** (font) – font of the title (default null string)
- **titlefontsize** (*int*) – size of the font of the title (default 15)
- **title** (*str*) – title to be shown above queue default: name of the queue
- **titleoffsetx** (*float*) – x-offset of the title relative to the start of the queue default: 25 if direction is w, -25 otherwise
- **titleoffsety** (*float*) – y-offset of the title relative to the start of the queue default: -25 if direction is s, -25 otherwise
- **layer** (*int*) – layer (default 0)
- **id** (*any*) – the animation works by calling the animation_objects method of each component, optionally with id. By default, this is self, but can be overriden, particularly with the queue
- **arg** (*any*) – this is used when a parameter is a function with two parameters, as the first argument or if a parameter is a method as the instance default: self (instance itself)
- **parent** (Component) – component where this animation object belongs to (default None) if given, the animation object will be removed automatically upon termination of the parent

---

Note: All measures are in screen coordinates

All parameters, apart from queue, id, arg and parent can be specified as: - a scalar, like 10 - a function with zero arguments, like lambda: title - a function with one argument, being the time t, like lambda t: t + 10 - a function with two parameters, being arg (as given) and the time, like lambda comp, t: comp.state - a method instance arg for time t, like self.state, actually leading to arg.state(t) to be called

---

class salabim.**AnimateRectangle**(*spec=()*, *x=0*, *y=0*, *fillcolor='fg'*, *linecolor=''*, *linewidth=1*, *text=''*, *fontsize=15*, *textcolor='bg'*, *font=''*, *angle=0*, *xy_anchor=''*, *layer=0*, *max_lines=0*, *offsetx=0*, *offsety=0*, *as_points=False*, *text_anchor='c'*, *text_offsetx=0*, *text_offsety=0*, *arg=None*, *parent=None*, *visible=True*, *env=None*, *screen_coordinates=False*)

Displays a rectangle, optionally with a text

Parameters

- **spec** (*four item tuple or list*) – should specify xlowerleft, ylowerleft, xupperright, yupperright
- **x** (*float*) – position of anchor point (default 0)
- **y** (*float*) – position of anchor point (default 0)
- **xy_anchor** (*str*) – specifies where x and y are relative to possible values are (default: sw) : `nw n ne w c e sw s se` If null string, the given coordimates are used untranslated
- **offsetx** (*float*) – offsets the x-coordinate of the rectangle (default 0)
- **offsety** (*float*) – offsets the y-coordinate of the rectangle (default 0)
- **linewidth** (*float*) – linewidth of the contour default 1
- **fillcolor** (*colorspec*) – color of interior (default foreground_color) default transparent
- **linecolor** (*colorspec*) – color of the contour (default transparent)
- **angle** (*float*) – angle of the rectangle (in degrees) default: 0
- **as_points** (*bool*) – if False (default), the contour lines are drawn if True, only the corner points are shown
- **text** (*str, tuple or list*) – the text to be displayed if text is str, the text may contain linefeeds, which are shown as individual lines
- **max_lines** (*int*) – the maximum of lines of text to be displayed if positive, it refers to the first max_lines lines if negative, it refers to the last -max_lines lines if zero (default), all lines will be displayed
- **font** (*str or list/tuple*) – font to be used for texts Either a string or a list/tuple of fontnames. If not found, uses calibri or arial
- **text_anchor** (*str*) – anchor position of text|n| specifies where to texts relative to the rectangle point possible values are (default: c): `nw n ne w c e sw s se`
- **textcolor** (*colorspec*) – color of the text (default foreground_color)
- **textoffsetx** (*float*) – extra x offset to the text_anchor point
- **textoffsety** (*float*) – extra y offset to the text_anchor point
- **fontsize** (*float*) – fontsize of text (default 15)

- **arg** (*any*) – this is used when a parameter is a function with two parameters, as the first argument or if a parameter is a method as the instance default: self (instance itself)
- **parent** (Component) – component where this animation object belongs to (default None) if given, the animation object will be removed automatically upon termination of the parent

---

Note: All measures are in screen coordinates

All parameters, apart from queue and arg can be specified as: - a scalar, like 10 - a function with zero arguments, like lambda: title - a function with one argument, being the time t, like lambda t: t + 10 - a function with two parameters, being arg (as given) and the time, like lambda comp, t: comp.state - a method instance arg for time t, like self.state, actually leading to arg.state(t) to be called

---

class salabim.**AnimateSlider**(*layer=0*, *x=0*, *y=0*, *width=100*, *height=20*, *vmin=0*, *vmax=10*, *v=None*, *resolution=1*, *linecolor='fg'*, *labelcolor='fg'*, *label=''*, *font=''*, *fontsize=12*, *action=None*, *xy_anchor='sw'*, *env=None*)

defines a slider

Parameters

- **x** (*int*) – x-coordinate of centre of the slider in screen coordinates (default 0)
- **y** (*int*) – y-coordinate of centre of the slider in screen coordinates (default 0)
- **vmin** (*float*) – minimum value of the slider (default 0)
- **vmax** (*float*) – maximum value of the slider (default 0)
- **v** (*float*) – initial value of the slider (default 0) should be between vmin and vmax
- **resolution** (*float*) – step size of value (default 1)
- **width** (*float*) – width of slider in screen coordinates (default 100)
- **height** (*float*) – height of slider in screen coordinates (default 20)
- **linewidth** (*float*) – width of contour in screen coordinate (default 0 = no contour)
- **linecolor** (*colorspec*) – color of contour (default foreground_color)
- **labelcolor** (*colorspec*) – color of the label (default foreground_color)
- **label** (*str*) – label if the slider (default null string) if label is an argumentless function, this function will be used to display as label, otherwise the label plus the current value of the slider will be shown
- **font** (*str*) – font of the text (default Helvetica)

- **fontsize** (*int*) – fontsize of the text (default 12)
- **action** (*function*) – function executed when the slider value is changed (default None) the function should one arguments, being the new value if None (default), no action
- **xy_anchor** (*str*) – specifies where x and y are relative to possible values are (default: sw): `nw n ne w c e sw s se`
- **env** (Environment) – environment where the component is defined if omitted, default_env will be used

---

Note: The current value of the slider is the v attibute of the slider. All measures are in screen coordinates On Pythonista, this functionality is emulated by salabim On other platforms, the tkinter functionality is used.

---

remove()
removes the slider object The ui object is removed from the ui queue, so effectively ending this ui

v(*value=None*)
value

Parameters **value** (*float*) – new value if omitted, no change

Returns **Current value of the slider**

Return type float

class salabim.**AnimateText**(*text=''*, *x=0*, *y=0*, *fontsize=15*, *textcolor='fg'*, *font=''*, *text_anchor='sw'*, *angle=0*, *visible=True*, *xy_anchor=''*, *layer=0*, *env=None*, *screen_coordinates=False*, *arg=None*, *parent=None*, *offsetx=0*, *offsety=0*, *max_lines=0*)
Displays a text

Parameters

- **text** (*str, tuple or list*) – the text to be displayed if text is str, the text may contain linefeeds, which are shown as individual lines if text is tple or list, each item is displayed on a separate line
- **x** (*float*) – position of anchor point (default 0)
- **y** (*float*) – position of anchor point (default 0)
- **xy_anchor** (*str*) – specifies where x and y are relative to possible values are (default: sw) : `nw n ne w c e sw s se` If null string, the given coordimates are used untranslated
- **offsetx** (*float*) – offsets the x-coordinate of the rectangle (default 0)
- **offsety** (*float*) – offsets the y-coordinate of the rectangle (default 0)
- **angle** (*float*) – angle of the text (in degrees) default: 0

- **max_lines** (*int*) – the maximum of lines of text to be displayed if positive, it refers to the first max_lines lines if negative, it refers to the last -max_lines lines if zero (default), all lines will be displayed
- **font** (*str or list/tuple*) – font to be used for texts Either a string or a list/tuple of fontnames. If not found, uses calibri or arial
- **text_anchor** (*str*) – anchor position of text|n| specifies where to texts relative to the rectangle point possible values are (default: c): `nw n ne w c e sw s se`
- **textcolor** (*colorspec*) – color of the text (default foreground_color)
- **fontsize** (*float*) – fontsize of text (default 15)
- **arg** (*any*) – this is used when a parameter is a function with two parameters, as the first argument or if a parameter is a method as the instance default: self (instance itself)
- **parent** (Component) – component where this animation object belongs to (default None) if given, the animation object will be removed automatically upon termination of the parent

---

Note: All measures are in screen coordinates

All parameters, apart from queue and arg can be specified as: - a scalar, like 10 - a function with zero arguments, like lambda: title - a function with one argument, being the time t, like lambda t: t + 10 - a function with two parameters, being arg (as given) and the time, like lambda comp, t: comp.state - a method instance arg for time t, like self.state, actually leading to arg.state(t) to be called

---

12.2 Component

class salabim.**Component**(*name=None*, *at=None*, *delay=None*, *urgent=None*, *process=None*, *suppress_trace=False*, *suppress_pause_at_step=False*, *skip_standby=False*, *mode=None*, *env=None*, ***kwargs*)

Component object

A salabim component is used as component (primarily for queueing) or as a component with a process Usually, a component will be defined as a subclass of Component.

Parameters

- **name** (*str*) – name of the component. if the name ends with a period (.), auto serializing will be applied if the name end with a comma, auto serializing starting at 1 will be applied if omitted, the name will be derived from the class it is defined in (lowercased)
- **at** (*float*) – schedule time if omitted, now is used
- **delay** (*float*) – schedule with a delay if omitted, no delay

- **urgent** (*bool*) – urgency indicator if False (default), the component will be scheduled behind all other components scheduled for the same time if True, the component will be scheduled in front of all components scheduled for the same time
- **process** (*str*) – name of process to be started. if None (default), it will try to start self.process() if null string, no process will be started even if self.process() exists, i.e. become a data component. note that the function *must* be a generator, i.e. contains at least one yield.
- **suppress_trace** (*bool*) – suppress_trace indicator if True, this component will be excluded from the trace If False (default), the component will be traced Can be queried or set later with the suppress_trace method.
- **suppress_pause_at_step** (*bool*) – suppress_pause_at_step indicator if True, if this component becomes current, do not pause when stepping If False (default), the component will be paused when stepping Can be queried or set later with the suppress_pause_at_step method.
- **skip_standby** (*bool*) – skip_standby indicator if True, after this component became current, do not activate standby components If False (default), after the component became current activate standby components Can be queried or set later with the skip_standby method.
- **mode** (*str preferred*) – mode will be used in trace and can be used in animations if omitted, the mode will be None. also mode_time will be set to now.
- **env** (Environment) – environment where the component is defined if omitted, default_env will be used

activate(*at=None*, *delay=0*, *urgent=False*, *process=None*, *keep_request=False*, *keep_wait=False*, *mode=None*, ***kwargs*)

activate component

Parameters

- **at** (*float*) – schedule time if omitted, now is used inf is allowed
- **delay** (*float*) – schedule with a delay if omitted, no delay
- **urgent** (*bool*) – urgency indicator if False (default), the component will be scheduled behind all other components scheduled for the same time if True, the component will be scheduled in front of all components scheduled for the same time
- **process** (*str*) – name of process to be started. if None (default), process will not be changed if the component is a data component, the generator function process will be used as the default process. note that the function *must* be a generator, i.e. contains at least one yield.
- **keep_request** (*bool*) – this affects only components that are requesting. if True, the requests will be kept and thus the status will remain requesting if False (the default), the request(s) will be canceled and the status will become scheduled
- **keep_wait** (*bool*) – this affects only components that are waiting. if True, the waits will be kept and thus the status will remain waiting if False (the default), the wait(s) will be canceled and the status will become scheduled
- **mode** (*str preferred*) – mode will be used in the trace and can be used in animations if nothing specified, the mode will be unchanged. also mode_time will be set to now, if mode is set.

Note: if to be applied to the current component, use `yield self.activate()`. if both at and delay are specified, the component becomes current at the sum of the two values.

animation_objects(*id*)
defines how to display a component in AnimateQueue

Parameters **id** (*any*) – id as given by AnimateQueue. Note that by default this the reference to the AnimateQueue object.

Returns size_x : how much to displace the next component in x-direction, if applicable size_y : how much to displace the next component in y-direction, if applicable animation objects : instances of Animate class default behaviour: square of size 40 (displacements 50), with the sequence number centered.

Return type List or tuple containg

Note: If you override this method, be sure to use the same header, either with or without the id parameter.

base_name()

Returns **base name of the component (the name used at initialization)**

Return type str

cancel(*mode=None*)
cancel component (makes the component data)

Parameters **mode** (*str preferred*) – mode will be used in trace and can be used in animations if nothing specified, the mode will be unchanged. also mode_time will be set to now, if mode is set.

Note: if to be used for the current component, use `yield self.cancel()`.

claimed_quantity(*resource*)

Parameters **resource** (*Resoure*) – resource to be queried

Returns **the claimed quantity from a resource** – if the resource is not claimed, 0 will be returned

Return type float or int

claimed_resources()

Returns **list of claimed resources**

Return type list

count(*q=None*)
queue count

Parameters **q** (Queue) – queue to check or if omitted, the number of queues where the component is in

Returns **1 if component is in q, 0 otherwise** – if q is omitted, the number of queues where the component is in

Return type int

creation_time()

Returns **time the component was created**

Return type float

deregister(*registry*)
deregisters the component in the registry

Parameters **registry** (*list*) – list of registered components

Returns **component (self)**

Return type *Component*

enter(*q*)
enters a queue at the tail

Parameters **q** (Queue) – queue to enter

Note: the priority will be set to the priority of the tail component of the queue, if any or 0 if queue is empty

---

enter_at_head(*q*)
enters a queue at the head

Parameters **q** (Queue) – queue to enter

Note: the priority will be set to the priority of the head component of the queue, if any or 0 if queue is empty

---

enter_behind(*q*, *poscomponent*)
enters a queue behind a component

Parameters

- **q** (Queue) – queue to enter
- **poscomponent** (Component) – component to be entered behind

Note: the priority will be set to the priority of poscomponent

enter_in_front_of(*q*, *poscomponent*)
enters a queue in front of a component

Parameters

- **q** (Queue) – queue to enter
- **poscomponent** (Component) – component to be entered in front of

Note: the priority will be set to the priority of poscomponent

enter_sorted(*q*, *priority*)
enters a queue, according to the priority

Parameters

- **q** (Queue) – queue to enter
- **priority** (*type that can be compared with other priorities in the queue*) – priority in the queue

Note: The component is placed just before the first component with a priority > given priority

enter_time(*q*)

Parameters **q** (Queue) – queue where component belongs to

Returns **time the component entered the queue**

Return type float

failed()

Returns

- **True, if the latest request/wait has failed (either by timeout or external)** (*bool*)
- *False, otherwise*

get (**args*, ***kwargs*)
equivalent to request

hold (*duration=None*, *till=None*, *urgent=False*, *mode=None*)
hold the component

Parameters

- **duration** (*float*) – specifies the duration if omitted, 0 is used inf is allowed
- **till** (*float*) – specifies at what time the component will become current if omitted, now is used inf is allowed
- **urgent** (*bool*) – urgency indicator if False (default), the component will be scheduled behind all other components scheduled for the same time if True, the component will be scheduled in front of all components scheduled for the same time
- **mode** (*str preferred*) – mode will be used in trace and can be used in animations if nothing specified, the mode will be unchanged. also mode_time will be set to now, if mode is set.

Note: if to be used for the current component, use `yield self.hold(...)`.

if both duration and till are specified, the component will become current at the sum of these two.

---

index (*q*)

Parameters **q** (Queue) – queue to be queried

Returns **index of component in q** – if component belongs to q -1 if component does not belong to q

Return type int

interrupt (*mode=None*)
interrupt the component

Parameters **mode** (*str preferred*) – mode will be used in trace and can be used in animations if nothing is specified, the mode will be unchanged. also mode_time will be set to now, if mode is set.

Note: Cannot be applied on the current component. Use resume() to resume

---

interrupt_level()
returns interrupt level of an interrupted component non interrupted components return 0

interrupted_status()
returns the original status of an interrupted component

possible values are

- passive
- scheduled
- requesting
- waiting
- standby

iscurrent()

Returns True if status is current, False otherwise

Return type bool

Note: Be sure to always include the parentheses, otherwise the result will be always True!

---

isdata()

Returns True if status is data, False otherwise

Return type bool

Note: Be sure to always include the parentheses, otherwise the result will be always True!

---

isinterrupted()

Returns True if status is interrupted, False otherwise

Return type bool

Note: Be sure to always include the parentheses, otherwise the result will be always True

---

ispassive()

Returns True if status is passive, False otherwise

Return type bool

Note: Be sure to always include the parentheses, otherwise the result will be always True!

isrequesting()

Returns True if status is requesting, False otherwise

Return type bool

Note: Be sure to always include the parentheses, otherwise the result will be always True!

isscheduled()

Returns True if status is scheduled, False otherwise

Return type bool

Note: Be sure to always include the parentheses, otherwise the result will be always True!

isstandby()

Returns True if status is standby, False otherwise

Return type bool

Note: Be sure to always include the parentheses, otherwise the result will be always True

iswaiting()

Returns True if status is waiting, False otherwise

Return type bool

Note: Be sure to always include the parentheses, otherwise the result will be always True!

leave(*q=None*)
leave queue

Parameters **q** (Queue) – queue to leave

Note: statistics are updated accordingly

mode(*value=None*)

Parameters **value** (*any, str recommended*) – new mode if omitted, no change mode_time will be set if a new mode is specified

Returns **mode of the component** – the mode is useful for tracing and animations. Usually the mode will be set in a call to passivate, hold, activate, request or standby.

Return type any, usually str

mode_time()

Returns **time the component got it's latest mode** – For a new component this is the time the component was created. this function is particularly useful for animations.

Return type float

name(*value=None*)

Parameters **value** (*str*) – new name of the component if omitted, no change

Returns **Name of the component**

Return type str

Note: base_name and sequence_number are not affected if the name is changed

passivate(*mode=None*)
passivate the component

Parameters **mode** (*str preferred*) – mode will be used in trace and can be used in animations if nothing is specified, the mode will be unchanged. also mode_time will be set to now, if mode is set.

Note: if to be used for the current component (nearly always the case), use `yield self.passivate()`.

predecessor(*q*)

Parameters

- **q** (Queue) – queue where the component belongs to
- **Returns** (Component) – predecessor of the component in the queue if component is not at the head. returns None if component is at the head.

print_info(*as_str=False*, *file=None*)
prints information about the component

Parameters

- **as_str** (*bool*) – if False (default), print the info if True, return a string containing the info
- **file** (*file*) – if None(default), all output is directed to stdout otherwise, the output is directed to the file

Returns **info (if as_str is True)**

Return type str

priority(*q*, *priority=None*)
gets/sets the priority of a component in a queue

Parameters

- **q** (Queue) – queue where the component belongs to
- **priority** (*type that can be compared with other priorities in the queue*) – priority in queue if omitted, no change

Returns **the priority of the component in the queue**

Return type float

Note: if you change the priority, the order of the queue may change

put(**args*, ***kwargs*)
equivalent to request, but anonymous quantities are negated

queues()

Returns set of queues where the component belongs to

Return type *set*

register(*registry*)
registers the component in the registry

Parameters **registry** (*list*) – list of (to be) registered objects

Returns component (self)

Return type *Component*

Note: Use Component.deregister if component does not longer need to be registered.

release(**args*)
release a quantity from a resource or resources

Parameters **args** (*sequence of items, where each items can be*) –

- a resources, where quantity=current claimed quantity
- a tuple/list containing a resource and the quantity to be released

Note: It is not possible to release from an anonymous resource, this way. Use Resource.release() in that case.

Example

yield self.request(r1,(r2,2),(r3,3,100)) –> requests 1 from r1, 2 from r2 and 3 from r3 with priority 100

c1.release –> releases 1 from r1, 2 from r2 and 3 from r3

yield self.request(r1,(r2,2),(r3,3,100)) c1.release((r2,1)) –> releases 1 from r2

yield self.request(r1,(r2,2),(r3,3,100)) c1.release((r2,1),r3) –> releases 2 from r2,and 3 from r3

remaining_duration(*value=None*, *urgent=False*)

Parameters

- **value** (*float*) – set the remaining_duration The action depends on the status where the component is in: - passive: the remaining duration is update according to the given value - standby and current: not allowed - scheduled: the component is rescheduled according to the given value - waiting or requesting: the fail_at is set according to the given value - interrupted: the remaining_duration is updated according to the given value
- **urgent** (*bool*) – urgency indicator if False (default), the component will be scheduled behind all other components scheduled for the same time if True, the component will be scheduled in front of all components scheduled for the same time

Returns **remaining duration** – if passive, remaining time at time of passivate if scheduled, remaing time till scheduled time if requesting or waiting, time till fail_at time else: 0

Return type float

Note: This method is useful for interrupting a process and then resuming it, after some (breakdown) time

---

request (**args*, ***kwargs*)

request from a resource or resources

Parameters

- **args** (*sequence of items where each item can be:*) –
  - resource, where quantity=1, priority=tail of requesters queue
  - **tuples/list containing a resource, a quantity and optionally a priority.** if the priority is not specified, the request for the resource be added to the tail of the requesters queue
- **fail_at** (*float*) – time out if the request is not honored before fail_at, the request will be cancelled and the parameter failed will be set. if not specified, the request will not time out.
- **fail_delay** (*float*) – time out if the request is not honored before now+fail_delay, the request will be cancelled and the parameter failed will be set. if not specified, the request will not time out.
- **mode** (*str preferred*) – mode will be used in trace and can be used in animations if nothing specified, the mode will be unchanged. also mode_time will be set to now, if mode is set.

Note: Not allowed for data components or main.

If to be used for the current component (which will be nearly always the case), use `yield self.request(...)`.

If the same resource is specified more that once, the quantities are summed

The requested quantity may exceed the current capacity of a resource

The parameter failed will be reset by a calling request or wait

Example

`yield self.request(r1)` –> requests 1 from r1 `yield self.request(r1,r2)` –> requests 1 from r1 and 1 from r2 `yield self.request(r1,(r2,2),(r3,3,100))` –> requests 1 from r1, 2 from r2 and 3 from r3 with priority 100 `yield self.request((r1,1),(r2,2))` –> requests 1 from r1, 2 from r2

requested_quantity(*resource*)

Parameters **resource** (*Resoure*) – resource to be queried

Returns **the requested (not yet honored) quantity from a resource** – if there is no request for the resource, 0 will be returned

Return type float or int

requested_resources()

Returns **list of requested resources**

Return type list

resume(*all=False*, *mode=None*, *urgent=False*)
resumes an interrupted component

Parameters

- **all** (*bool*) – if True, the component returns to the original status, regardless of the number of interrupt levels if False (default), the interrupt level will be decremented and if the level reaches 0, the component will return to the original status.
- **mode** (*str preferred*) – mode will be used in trace and can be used in animations if nothing is specified, the mode will be unchanged. also mode_time will be set to now, if mode is set.
- **urgent** (*bool*) – urgency indicator if False (default), the component will be scheduled behind all other components scheduled for the same time if True, the component will be scheduled in front of all components scheduled for the same time

Note: Can be only applied to interrupted components.

running_process()

Returns **name of the running process** – if data component, None

Return type str

scheduled_time()

Returns **time the component scheduled for, if it is scheduled** – returns inf otherwise

Return type float

sequence_number()

Returns **sequence_number of the component** – (the sequence number at initialization) normally this will be the integer value of a serialized name, but also non serialized names (without a dotcomma at the end) will be numbered)

Return type int

setup()

called immediately after initialization of a component.

by default this is a dummy method, but it can be overridden.

only keyword arguments will be passed

Example

class Car(sim.Component):

def setup(self, color): self.color = color

def process(self): ...

redcar=Car(color="red") bluecar=Car(color="blue")

skip_standby(*value=None*)

Parameters **value** (*bool*) – new skip_standby value if omitted, no change

Returns **skip_standby indicator** – components with the skip_standby indicator of True, will not activate standby components after the component became current.

Return type bool

standby(*mode=None*)

puts the component in standby mode

Parameters **mode** (*str preferred*) – mode will be used in trace and can be used in animations if nothing specified, the mode will be unchanged. also mode_time will be set to now, if mode is set.

Note: Not allowed for data components or main.

if to be used for the current component (which will be nearly always the case), use `yield self.standby()`.

---

status()

returns the status of a component

possible values are

- data
- passive
- scheduled
- requesting
- waiting
- current
- standby
- interrupted

successor(*q*)

Parameters **q** (Queue) – queue where the component belongs to

Returns **the successor of the component in the queue** – if component is not at the tail. returns None if component is at the tail.

Return type *Component*

suppress_pause_at_step(*value=None*)

Parameters **value** (*bool*) – new suppress_trace value if omitted, no change

Returns **suppress_pause_at_step** – components with the suppress_pause_at_step of True, will be ignored in a step

Return type bool

suppress_trace(*value=None*)

Parameters **value** (*bool*) – new suppress_trace value if omitted, no change

Returns **suppress_trace** – components with the suppress_status of True, will be ignored in the trace

Return type bool

wait(**args*, ***kwargs*)

wait for any or all of the given state values are met

Parameters

- **args** (*sequence of items, where each item can be*) –
  - a state, where value=True, priority=tail of waiters queue)
  - **a tuple/list containing** state, a value and optionally a priority. if the priority is not specified, this component will be added to the tail of the waiters queue
- **fail_at** (*float*) – time out if the wait is not honored before fail_at, the wait will be cancelled and the parameter failed will be set. if not specified, the wait will not time out.
- **fail_delay** (*float*) – time out if the wait is not honored before now+fail_delay, the request will be cancelled and the parameter failed will be set. if not specified, the wait will not time out.
- **all** (*bool*) – if False (default), continue, if any of the given state/values is met if True, continue if all of the given state/values are met
- **mode** (*str preferred*) – mode will be used in trace and can be used in animations if nothing specified, the mode will be unchanged. also mode_time will be set to now, if mode is set.

Note: Not allowed for data components or main.

If to be used for the current component (which will be nearly always the case), use `yield self.wait(...)`.

It is allowed to wait for more than one value of a state the parameter failed will be reset by a calling wait

If you want to check for all components to meet a value (and clause), use Component.wait(..., all=True)

The value may be specified in three different ways:

- constant, that value is just compared to state.value() yield self.wait((light,"red"))
- an expression, containg one or more $-signs the $ is replaced by state.value(), each time the condition is tested. self refers to the component under test, state refers to the state under test. yield self.wait((light,'$ in ("red","yellow")')) yield self.wait((level,"$<30"))

- a function. In that case the parameter should function that should accept three arguments: the value, the component under test and the state under test. usually the function will be a lambda function, but that's not a requirement. yield self.wait((light,lambda t, comp, state: t in ("red","yellow"))) yield self.wait((level,lambda t, comp, state: t < 30))

Example

`yield self.wait(s1)` –> waits for s1.value()==True `yield self.wait(s1,s2)` –> waits for s1.value()==True or s2.value==True `yield self.wait((s1,False,100),(s2,"on"),s3)` –> waits for s1.value()==False or s2.value=="on" or s3.value()==True s1 is at the tail of waiters, because of the set priority `yield self.wait(s1,s2,all=True)` –> waits for s1.value()==True and s2.value==True

12.3 Distributions

class salabim.**_Distribution**

bounded_sample(*lowerbound=None*, *upperbound=None*, *fail_value=None*, *number_of_retries=None*, *include_lowerbound=True*, *include_upperbound=True*)

Parameters

- **lowerbound** (*float*) – sample values < lowerbound will be rejected (at most 100 retries) if omitted, no lowerbound check
- **upperbound** (*float*) – sample values > upperbound will be rejected (at most 100 retries) if omitted, no upperbound check
- **fail_value** (*float*) – value to be used if. after number_of_tries retries, sample is still not within bounds default: lowerbound, if specified, otherwise upperbound
- **number_of_tries** (*int*) – number of tries before fail_value is returned default: 100
- **include_lowerbound** (*bool*) – if True (default), the lowerbound may be included. if False, the lowerbound will be excluded.
- **include_upperbound** (*bool*) – if True (default), the upperbound may be included. if False, the upperbound will be excluded.

Returns **Bounded sample of a distribution**

Return type depending on distribution type (usually float)

Note: If, after number_of_tries retries, the sampled value is still not within the given bounds, fail_value will be returned Samples that cannot be converted (only possible with Pdf and CumPdf) to float are assumed to be within the bounds.

class salabim.**_Expression**(*dis0*, *dis1*, *op*)
expression distribution

This class is only created when using an expression with one ore more distributions.

Note: The randomstream of the distribution(s) in the expression are used.

mean()

Returns **Mean of the expression of distribution(s)** – returns nan if mean can't be calculated

Return type float

print_info(*as_str=False*, *file=None*)
prints information about the expression of distribution(s)

Parameters

- **as_str** (*bool*) – if False (default), print the info if True, return a string containing the info
- **file** (*file*) – if None(default), all output is directed to stdout otherwise, the output is directed to the file

Returns **info (if as_str is True)**

Return type str

sample()

Returns **Sample of the expression of distribution(s)**

Return type float

class salabim.**Beta**(*alpha*, *beta*, *randomstream=None*)
beta distribution

Parameters

- **alpha** (*float*) – alpha shape of the distribution should be >0
- **beta** (*float*) – beta shape of the distribution should be >0

- **randomstream** (*randomstream*) – randomstream to be used if omitted, random will be used if used as random.Random(12299) it assigns a new stream with the specified seed

mean()

Returns Mean of the distribution

Return type float

print_info(*as_str=False*, *file=None*)
prints information about the distribution

Parameters

- **as_str** (*bool*) – if False (default), print the info if True, return a string containing the info
- **file** (*file*) – if None(default), all output is directed to stdout otherwise, the output is directed to the file

Returns info (if as_str is True)

Return type str

sample()

Returns Sample of the distribution

Return type float

class salabim.**Cdf**(*spec*, *time_unit=None*, *randomstream=None*, *env=None*)
Cumulative distribution function

Parameters

- **spec** (*list or tuple*) – list with x-values and corresponding cumulative density (x1,c1,x2,c2, ... xn,cn) Requirements:

  x1<=x2<= ... <=xn c1<=c2<=cn c1=0 cn>0 all cumulative densities are auto scaled according to cn, so no need to set cn to 1 or 100.
- **time_unit** (*str*) – specifies the time unit must be one of "years", "weeks", "days", "hours", "minutes", "seconds", "milliseconds", "microseconds" default : no conversion
- **randomstream** (*randomstream*) – if omitted, random will be used if used as random.Random(12299) it defines a new stream with the specified seed
- **env** (Environment) – environment where the distribution is defined if omitted, default_env will be used

mean()

Returns Mean of the distribution

Return type float

print_info(*as_str=False*, *file=None*)
prints information about the distribution

Parameters

- **as_str** (*bool*) – if False (default), print the info if True, return a string containing the info
- **file** (*file*) – if None(default), all output is directed to stdout otherwise, the output is directed to the file

Returns **info (if as_str is True)**

Return type str

sample()

Returns **Sample of the distribution**

Return type float

class salabim.**Constant**(*value*, *time_unit=None*, *randomstream=None*, *env=None*)
constant distribution

Parameters

- **value** (*float*) – value to be returned in sample
- **time_unit** (*str*) – specifies the time unit must be one of “years”, “weeks”, “days”, “hours”, “minutes”, “seconds”, “milliseconds”, “microseconds” default : no conversion
- **randomstream** (*randomstream*) – randomstream to be used if omitted, random will be used if used as random.Random(12299) it assigns a new stream with the specified seed Note that this is only for compatibility with other distributions
- **env** (Environment) – environment where the distribution is defined if omitted, default_env will be used

mean()

Returns **mean of the distribution (= the specified constant)**

Return type float

print_info(*as_str=False*, *file=None*)
prints information about the distribution

Parameters

- **as_str** (*bool*) – if False (default), print the info if True, return a string containing the info

- **file** (*file*) – if None(default), all output is directed to stdout otherwise, the output is directed to the file

Returns info (if as_str is True)

Return type str

sample()

Returns sample of the distribution (= the specified constant)

Return type float

class salabim.**Distribution**(*spec*, *randomstream=None*)

Generate a distribution from a string

Parameters

- **spec** (*str*) –
  - string containing a valid salabim distribution, where only the first letters are relevant and casing is not important. Note that Erlang, Cdf, CumPdf and Poisson require at least two letters (Er, Cd, Cu and Po)
  - string containing one float (c1), resulting in Constant(c1)
  - string containing two floats seperated by a comma (c1,c2), resulting in a Uniform(c1,c2)
  - string containing three floats, separated by commas (c1,c2,c3), resulting in a Triangular(c1,c2,c3)
- **randomstream** (*randomstream*) – if omitted, random will be used if used as random.Random(12299) it assigns a new stream with the specified seed

---

Note: The randomstream in the specifying string is ignored. It is possible to use expressions in the specification, as long these are valid within the context of the salabim module, which usually implies a global variable of the salabim package.

Examples

Uniform(13) ==> Uniform(13) Uni(12,15) ==> Uniform(12,15) UNIF(12,15) ==> Uniform(12,15) N(12,3) ==> Normal(12,3) Tri(10,20). ==> Triangular(10,20,15) 10. ==> Constant(10) 12,15 ==> Uniform(12,15) (12,15) ==> Uniform(12,15) Exp(a) ==> Exponential(100), provided sim.a=100 E(2) ==> Exponential(2) Er(2,3) ==> Erlang(2,3)

mean()

Returns **Mean of the distribution**

Return type float

print_info(*as_str=False*, *file=None*)
prints information about the distribution

Parameters

- **as_str** (*bool*) – if False (default), print the info if True, return a string containing the info
- **file** (*file*) – if None(default), all output is directed to stdout otherwise, the output is directed to the file

Returns **info (if as_str is True)**

Return type str

sample()

Returns **Sample of the distribution**

Return type any (usually float)

class salabim.**Erlang**(*shape*, *rate=None*, *time_unit=None*, *scale=None*, *randomstream=None*, *env=None*)
erlang distribution

Parameters

- **shape** (*int*) – shape of the distribution (k) should be >0
- **rate** (*float*) – rate parameter (lambda) if omitted, the scale is used should be >0
- **time_unit** (*str*) – specifies the time unit must be one of “years”, “weeks”, “days”, “hours”, “minutes”, “seconds”, “milliseconds”, “microseconds” default : no conversion
- **scale** (*float*) – scale of the distribution (mu) if omitted, the rate is used should be >0
- **randomstream** (*randomstream*) – randomstream to be used if omitted, random will be used if used as random.Random(12299) it assigns a new stream with the specified seed
- **env** (Environment) – environment where the distribution is defined if omitted, default_env will be used

---

Note: Either rate or scale has to be specified, not both.

---

mean()

Returns **Mean of the distribution**

Return type float

print_info(*as_str=False*, *file=None*)
prints information about the distribution

Parameters

- **as_str** (*bool*) – if False (default), print the info if True, return a string containing the info
- **file** (*file*) – if None(default), all output is directed to stdout otherwise, the output is directed to the file

Returns **info (if as_str is True)**

Return type str

sample()

Returns **Sample of the distribution**

Return type float

class salabim.**Exponential**(*mean=None*, *time_unit=None*, *rate=None*, *randomstream=None*, *env=None*)
exponential distribution

Parameters

- **mean** (*float*) – mean of the distribtion (beta)|n| if omitted, the rate is used must be >0
- **time_unit** (*str*) – specifies the time unit must be one of “years”, “weeks”, “days”, “hours”, “minutes”, “seconds”, “milliseconds”, “microseconds” default : no conversion
- **rate** (*float*) – rate of the distribution (lambda)|n| if omitted, the mean is used must be >0
- **randomstream** (*randomstream*) – randomstream to be used if omitted, random will be used if used as random.Random(12299) it assigns a new stream with the specified seed
- **env** (Environment) – environment where the distribution is defined if omitted, default_env will be used

---

Note: Either mean or rate has to be specified, not both

---

mean()

Returns **Mean of the distribution**

Return type float

print_info(*as_str=False*, *file=None*)
prints information about the distribution

Parameters

- **as_str** (*bool*) – if False (default), print the info if True, return a string containing the info
- **file** (*file*) – if None(default), all output is directed to stdout otherwise, the output is directed to the file

Returns **info (if as_str is True)**

Return type str

sample()

Returns **Sample of the distribution**

Return type float

class salabim.**Gamma**(*shape*, *scale=None*, *time_unit=None*, *rate=None*, *randomstream=None*, *env=None*)
gamma distribution

Parameters

- **shape** (*float*) – shape of the distribution (k) should be >0
- **scale** (*float*) – scale of the distribution (teta) should be >0
- **time_unit** (*str*) – specifies the time unit must be one of “years”, “weeks”, “days”, “hours”, “minutes”, “seconds”, “milliseconds”, “microseconds” default : no conversion
- **rate** (*float*) – rate of the distribution (beta) should be >0
- **randomstream** (*randomstream*) – randomstream to be used if omitted, random will be used if used as random.Random(12299) it assigns a new stream with the specified seed

env [Environment] environment where the distribution is defined if omitted, default_env will be used

---

Note: Either scale or rate has to be specified, not both.

---

mean()

Returns **Mean of the distribution**

Return type float

print_info(*as_str=False*, *file=None*)
prints information about the distribution

Parameters

- **as_str** (*bool*) – if False (default), print the info if True, return a string containing the info
- **file** (*file*) – if None(default), all output is directed to stdout otherwise, the output is directed to the file

Returns **info (if as_str is True)**

Return type str

sample()

Returns **Sample of the distribution**

Return type float

class salabim.**Normal**(*mean*, *standard_deviation=None*, *time_unit=None*, *coefficient_of_variation=None*, *use_gauss=False*, *randomstream=None*, *env=None*)
normal distribution

Parameters

- **mean** (*float*) – mean of the distribution
- **standard_deviation** (*float*) – standard deviation of the distribution if omitted, coefficient_of_variation, is used to specify the variation if neither standard_devation nor coefficient_of_variation is given, 0 is used, thus effectively a contant distribution must be >=0
- **coefficient_of_variation** (*float*) – coefficient of variation of the distribution if omitted, standard_deviation is used to specify variation the resulting standard_deviation must be >=0
- **use_gauss** (*bool*) – if False (default), use the random.normalvariate method if True, use the random.gauss method the documentation for random states that the gauss method should be slightly faster, although that statement is doubtful.
- **randomstream** (*randomstream*) – randomstream to be used if omitted, random will be used if used as random.Random(12299) it assigns a new stream with the specified seed
- **env** (Environment) – environment where the distribution is defined if omitted, default_env will be used

mean()

Returns **Mean of the distribution**

Return type float

print_info(*as_str=False*, *file=None*)
prints information about the distribution

Parameters

- **as_str** (*bool*) – if False (default), print the info if True, return a string containing the info
- **file** (*file*) – if None(default), all output is directed to stdout otherwise, the output is directed to the file

Returns **info (if as_str is True)**

Return type str

sample()

Returns **Sample of the distribution**

Return type float

class salabim.**Pdf**(*spec*, *probabilities=None*, *time_unit=None*, *randomstream=None*, *env=None*)
Probability distribution function

Parameters

- **spec** (*list or tuple*) – either
  - if no probabilities specified: list with x-values and corresponding probability (x0, p0, x1, p1, ... xn,pn)
  - if probabilities is specified: list with x-values
- **probabilities** (*list, tuple or float*) – if omitted, spec contains the probabilities the list (p0, p1, ... pn) contains the probabilities of the corresponding x-values from spec. alternatively, if a float is given (e.g. 1), all x-values have equal probability. The value is not important.
- **time_unit** (*str*) – specifies the time unit must be one of "years", "weeks", "days", "hours", "minutes", "seconds", "milliseconds", "microseconds" default : no conversion
- **randomstream** (*randomstream*) – if omitted, random will be used if used as random.Random(12299) it assigns a new stream with the specified seed
- **env** (Environment) – environment where the distribution is defined if omitted, default_env will be used

---

Note: p0+p1=...+pn>0 all densities are auto scaled according to the sum of p0 to pn, so no need to have p0 to pn add up to 1 or 100. The x-values can be any type. If it is a salabim distribution, not the distribution, but a sample will be returned when calling sample.

---

mean()

Returns **mean of the distribution** – if the mean can't be calculated (if not all x-values are scalars or distributions), nan will be returned.

Return type float

print_info(*as_str=False*, *file=None*)
prints information about the distribution

Parameters

- **as_str** (*bool*) – if False (default), print the info if True, return a string containing the info
- **file** (*file*) – if None(default), all output is directed to stdout otherwise, the output is directed to the file

Returns **info (if as_str is True)**

Return type str

sample(*n=None*)

Parameters **n** (*number of samples : int*) – if not specified, specifies just return one sample, as usual if specified, return a list of n sampled values from the distribution without replacement. This requires that all probabilities are equal. If n > number of values in the Pdf distribution, n is assumed to be the number of values in the distribution. If a sampled value is a distribution, a sample from that distribution will be returned.

Returns **Sample of the distribution** – In case n is specified, returns a list of n values

Return type any (usually float) or list

class salabim.**Poisson**(*mean*, *randomstream=None*)
Poisson distribution

Parameters

- **mean** (*float*) – mean (lambda) of the distribution
- **randomstream** (*randomstream*) – randomstream to be used if omitted, random will be used if used as random.Random(12299) it assigns a new stream with the specified seed

---

Note: The run time of this function increases when mean (lambda) increases. It is not recommended to use mean (lambda) > 100

---

mean()

Returns **Mean of the distribution**

Return type float

print_info(*as_str=False*, *file=None*)
prints information about the distribution

Parameters

- **as_str** (*bool*) – if False (default), print the info if True, return a string containing the info
- **file** (*file*) – if None(default), all output is directed to stdout otherwise, the output is directed to the file

Returns **info (if as_str is True)**

Return type str

sample()

Returns **Sample of the distribution**

Return type int

class salabim.**Triangular**(*low*, *high=None*, *mode=None*, *time_unit=None*, *randomstream=None*, *env=None*)
triangular distribution

Parameters

- **low** (*float*) – lowerbound of the distribution
- **high** (*float*) – upperbound of the distribution if omitted, low will be used, thus effectively a constant distribution high must be >= low
- **mode** (*float*) – mode of the distribution if omitted, the average of low and high will be used, thus a symmetric triangular distribution mode must be between low and high
- **time_unit** (*str*) – specifies the time unit must be one of “years”, “weeks”, “days”, “hours”, “minutes”, “seconds”, “milliseconds”, “microseconds” default : no conversion
- **randomstream** (*randomstream*) – randomstream to be used if omitted, random will be used if used as random.Random(12299) it assigns a new stream with the specified seed
- **env** (Environment) – environment where the distribution is defined if omitted, default_env will be used

mean()

Returns **Mean of the distribution**

Return type float

print_info(*as_str=False*, *file=None*)
prints information about the distribution

Parameters

- **as_str** (*bool*) – if False (default), print the info if True, return a string containing the info
- **file** (*file*) – if None(default), all output is directed to stdout otherwise, the output is directed to the file

Returns **info (if as_str is True)**

Return type str

sample()

Returns **Sample of the distribtion**

Return type float

class salabim.**Uniform**(*lowerbound*, *upperbound=None*, *time_unit=None*, *randomstream=None*, *env=None*)
uniform distribution

Parameters

- **lowerbound** (*float*) – lowerbound of the distribution
- **upperbound** (*float*) – upperbound of the distribution if omitted, lowerbound will be used must be >= lowerbound
- **time_unit** (*str*) – specifies the time unit must be one of “years”, “weeks”, “days”, “hours”, “minutes”, “seconds”, “milliseconds”, “microseconds” default : no conversion
- **randomstream** (*randomstream*) – randomstream to be used if omitted, random will be used if used as random.Random(12299) it assigns a new stream with the specified seed
- **env** (Environment) – environment where the distribution is defined if omitted, default_env will be used

mean()

Returns **Mean of the distribution**

Return type float

print_info(*as_str=False*, *file=None*)
prints information about the distribution

Parameters

- **as_str** (*bool*) – if False (default), print the info if True, return a string containing the info

- **file** (*file*) – if None(default), all output is directed to stdout otherwise, the output is directed to the file

Returns info (if as_str is True)

Return type str

sample()

Returns Sample of the distribution

Return type float

class salabim.**Weibull**(*scale*, *shape*, *time_unit=None*, *randomstream=None*, *env=None*)

weibull distribution

Parameters

- **scale** (*float*) – scale of the distribution (alpha or k)
- **shape** (*float*) – shape of the distribution (beta or lambda)|n| should be >0
- **time_unit** (*str*) – specifies the time unit must be one of “years”, “weeks”, “days”, “hours”, “minutes”, “seconds”, “milliseconds”, “microseconds” default : no conversion
- **randomstream** (*randomstream*) – randomstream to be used if omitted, random will be used if used as random.Random(12299) it assigns a new stream with the specified seed
- **env** (Environment) – environment where the distribution is defined if omitted, default_env will be used

mean()

Returns Mean of the distribution

Return type float

print_info(*as_str=False*, *file=None*)

prints information about the distribution

Parameters

- **as_str** (*bool*) – if False (default), print the info if True, return a string containing the info
- **file** (*file*) – if None(default), all output is directed to stdout otherwise, the output is directed to the file

Returns info (if as_str is True)

Return type str

sample()

Returns **Sample of the distribution**

Return type float

12.4 Environment

class salabim.**Environment**(*trace=False*, *random_seed=None*, *time_unit='n/a'*, *name=None*, *print_trace_header=True*, *isdefault_env=True*, *retina=False*, **args*, ***kwargs*)

environment object

Parameters

- **trace** (*bool*) – defines whether to trace or not if omitted, False
- **random_seed** (*hashable object, usually int*) – the seed for random, equivalent to random.seed() if "*", a purely random value (based on the current time) will be used (not reproducable) if the null string, no action on random is taken if None (the default), 1234567 will be used.
- **time_unit** (*str*) – Supported time_units: "years", "weeks", "days", "hours", "minutes", "seconds", "milliseconds", "microseconds", "n/a"
- **name** (*str*) – name of the environment if the name ends with a period (.), auto serializing will be applied if the name end with a comma, auto serializing starting at 1 will be applied if omitted, the name will be derived from the class (lowercased) or "default environment" if isdefault_env is True.
- **print_trace_header** (*bool*) – if True (default) print a (two line) header line as a legend if False, do not print a header note that the header is only printed if trace=True
- **isdefault_env** (*bool*) – if True (default), this environment becomes the default environment if False, this environment will not be the default environment if omitted, this environment becomes the default environment

---

Note: The trace may be switched on/off later with trace The seed may be later set with random_seed() Initially, the random stream will be seeded with the value 1234567. If required to be purely, not not reproducable, values, use random_seed="*".

---

an_clocktext()
function to initialize the system clocktext called by run(), if animation is True. may be overridden to change the standard behaviour.

an_menu_buttons()
function to initialize the menu buttons may be overridden to change the standard behaviour.

an_modelname()
function to show the modelname called by run(), if animation is True. may be overridden to change the standard behaviour.

an_synced_buttons()
function to initialize the synced buttons may be overridden to change the standard behaviour.

an_unsynced_buttons()
function to initialize the unsynced buttons may be overridden to change the standard behaviour.

animate(*value=None*)
animate indicator

Parameters **value** (*bool*) – new animate indicator if not specified, no change

Returns **animate status**

Return type bool

Note: When the run is not issued, no acction will be taken.

---

animation_parameters(*animate=None*, *synced=None*, *speed=None*, *width=None*, *height=None*, *x0=None*, *y0=None*, *x1=None*, *background_color=None*, *foreground_color=None*, *fps=None*, *modelname=None*, *use_toplevel=None*, *show_fps=None*, *show_time=None*, *maximum_number_of_bitmaps=None*, *video=None*, *video_repeat=None*, *video_pingpong=None*, *audio=None*, *audio_speed=None*)
set animation parameters

animate [bool] animate indicator new animate indicator if not specified, no change

synced [bool] specifies whether animation is synced if omitted, no change. At init of the environment synced will be set to True

speed [float] speed specifies how much faster or slower than real time the animation will run. e.g. if 2, 2 simulation time units will be displayed per second.

width [int] width of the animation in screen coordinates if omitted, no change. At init of the environment, the width will be set to 1024 for non Pythonista and the current screen width for Pythonista.

height [int] height of the animation in screen coordinates if omitted, no change. At init of the environment, the height will be set to 768 for non Pythonista and the current screen height for Pythonista.

x0 [float] user x-coordinate of the lower left corner if omitted, no change. At init of the environment, x0 will be set to 0.

y0 [float] user y_coordinate of the lower left corner if omitted, no change. At init of the environment, y0 will be set to 0.

x1 [float] user x-coordinate of the lower right corner if omitted, no change. At init of the environment, x1 will be set to 1024 for non Pythonista and the current screen width for Pythonista.

background_color [colorspec] color of the background if omitted, no change. At init of the environment, this will be set to white.

foreground_color [colorspec] color of foreground (texts) if omitted and background_color is specified, either white of black will be used, in order to get a good contrast with the background color. if omitted and background_color is also omitted, no change. At init of the environment, this will be set to black.

fps [float] number of frames per second

modelname [str] name of model to be shown in upper left corner, along with text "a salabim model" if omitted, no change. At init of the environment, this will be set to the null string, which implies suppression of this feature.

use_toplevel [bool] if salabim animation is used in parallel with other modules using tkinter, it might be necessary to initialize the root with tkinter.TopLevel(). In that case, set this parameter to True. if False (default), the root will be initialized with tkinter.Tk()

show_fps [bool] if True, show the number of frames per second if False, do not show the number of frames per second (default)

show_time: bool if True, show the time (default) if False, do not show the time

maximum_number_of_bitmaps [int] maximum number of tkinter bitmaps (default 4000)

video [str] if video is not omitted, a video with the name video will be created. Normally, use .mp4 as extension. If the extension is .gif, an animated gif file will be written If the extension is .jpg, .png, .bmp or .tiff, individual frames will be written with a six digit sequence added to the file name. If the video extension is not .gif, .jpg, .png, .bmp or .tiff, a codec may be added by appending a plus sign and the four letter code name, like "myvideo.avi+DIVX". If no codec is given, mp4v will be used as codec.

video_repeat [int] number of times gif should be repeated 0 means inifinite at init of the environment video_repeat is 1 this only applies to gif files production.

video_pingpong [bool] if True, all frames will be added reversed at the end of the video (useful for smooth loops) at init of the environment video_pingpong is False this only applies to gif files production.

‘ audio [str]

name of file to be played (mp3 or wav files) if "", the audio will be stopped default: no change for more information, see Environment.audio()

The y-coordinate of the upper right corner is determined automatically in such a way that the x and scaling are the same.

animation_post_tick(*t*)

called just after the animation object loop. Default behaviour: just return

Parameters **t** (*float*) – Current (animation) time.

animation_pre_tick(*t*)
called just before the animation object loop. Default behaviour: just return

Parameters **t** (*float*) – Current (animation) time.

audio(*filename*)
Play audio during animation

Parameters **filename** (*str*) – name of file to be played (mp3 or wav files) if "", the audio will be stopped optionaly, a start time in seconds may be given by appending the filename a > followed by the start time, like 'mytune.mp3>12.5' if not specified (None), no change

Returns **filename being played ("" if nothing is being played)**

Return type str

Note: Only supported on Windows and Pythonista platforms. On other platforms, no effect. Variable bit rate mp3 files may be played incorrectly on Windows platforms. Try and use fixed bit rates (e.g. 128 or 320 kbps)

---

audio_speed(*speed*)
Play audio during animation

Parameters **speed** (*float*) – animation speed at which the audio should be played default: no change initially: 1

Returns **speed being played**

Return type int

background_color(*value=None*)
background_color of the animation

Parameters **value** (*colorspec*) – new background_color if not specified, no change

Returns **background_color of animation**

Return type colorspec

base_name()
returns the base name of the environment (the name used at initialization)

beep()
Beeps

Works only on Windows and iOS (Pythonista). For other platforms this is just a dummy method.

colorinterpolate(*t*, *t0*, *t1*, *v0*, *v1*)
does linear interpolation of colorspecs

Parameters

- **t** (*float*) – value to be interpolated from
- **t0** (*float*) – f(t0)=v0
- **t1** (*float*) – f(t1)=v1
- **v0** (*colorspec*) – f(t0)=v0
- **v1** (*colorspec*) – f(t1)=v1

Returns **linear interpolation between v0 and v1 based on t between t0 and t**

Return type colorspec

Note: Note that no extrapolation is done, so if t<t0 ==> v0 and t>t1 ==> v1 This function is heavily used during animation

---

colorspec_to_tuple(*colorspec*)
translates a colorspec to a tuple

Parameters **colorspec** (*tuple, list or str*) – `#rrggbb` ==> alpha = 255 (rr, gg, bb in hex) `#rrggbbaa` ==> alpha = aa (rr, gg, bb, aa in hex) `colorname` ==> alpha = 255 `(colorname, alpha)` `(r, g, b)` ==> alpha = 255 `(r, g, b, alpha)` `"fg"` ==> foreground_color `"bg"` ==> background_color

Returns

Return type (r, g, b, a)

current_component()

Returns **the current_component**

Return type *Component*

days(*t*)
convert the given time in days to the current time unit

Parameters **t** (*float*) – time in days

Returns **time in days, converted to the current time_unit**

Return type float

delete_video(*video*)
deletes video file(s), if any

Parameters **video** (*str*) – name of video to be deleted if the extension is .jpg, .png, .bmp or .tiff, all autonumbered files will be deleted, if any. otherwise, the function is equivalent to os.remove() if the file exists, otherwise no action is taken

foreground_color(*value=None*)
foreground_color of the animation

Parameters **value** (*colorspec*) – new foreground_color if not specified, no change

Returns **foreground_color of animation**

Return type colorspec

fps(*value=None*)

Parameters **value** (*int*) – new fps if not specified, no change

Returns **fps**

Return type bool

get_time_unit()
gets time unit

Returns **Current time unit dimension (default "n/a")**

Return type str

height(*value=None*)
height of the animation in screen coordinates

Parameters **value** (*int*) – new height if not specified, no change

Returns **height of animation**

Return type int

hours(*t*)
convert the given time in hours to the current time unit

Parameters **t** (*float*) – time in hours

Returns **time in hours, converted to the current time_unit**

Return type float

is_dark(*colorspec*)

Parameters **colorspec** (*colorspec*) – color to check

Returns True, if the colorspec is dark (rather black than white) False, if the colorspec is light (rather white than black if colorspec has alpha=0 (total transparent), the background_color will be tested

Return type bool

main()

Returns **the main component**

Return type *Component*

maximum_number_of_bitmaps(*value=None*)
maximum number of bitmaps (applies to animation with tkinter only)

Parameters **value** (*bool*) – new maximum_number_of_bitmaps if not specified, no change

Returns **show_fps**

Return type bool

microseconds(*t*)
convert the given time in microseconds to the current time unit

Parameters **t** (*float*) – time in microseconds

Returns **time in microseconds, converted to the current time_unit**

Return type float

milliseconds(*t*)
convert the given time in milliseconds to the current time unit

Parameters **t** (*float*) – time in milliseconds

Returns **time in milliseconds, converted to the current time_unit**

Return type float

minutes(*t*)
convert the given time in minutes to the current time unit

Parameters **t** (*float*) – time in minutes

Returns time in minutes, converted to the current time_unit

Return type float

modelname(*value=None*)

Parameters **value** (*str*) – new modelname if not specified, no change

Returns modelname

Return type str

Note: If modelname is the null string, nothing will be displayed.

---

name(*value=None*)

Parameters **value** (*str*) – new name of the environment if omitted, no change

Returns Name of the environment

Return type str

Note: base_name and sequence_number are not affected if the name is changed

---

now()

Returns the current simulation time

Return type float

peek()
returns the time of the next component to become current if there are no more events, peek will return inf Only for advance use with animation / GUI event loops

print_info(*as_str=False*, *file=None*)
prints information about the environment

Parameters

- **as_str** (*bool*) – if False (default), print the info if True, return a string containing the info
- **file** (*file*) – if None(default), all output is directed to stdout otherwise, the output is directed to the file

Returns info (if as_str is True)

Return type str

print_trace(*s1=''*, *s2=''*, *s3=''*, *s4=''*, *s0=None*, *_optional=False*)
prints a trace line

Parameters

- **s1** (*str*) – part 1 (usually formatted now), padded to 10 characters
- **s2** (*str*) – part 2 (usually only used for the compoent that gets current), padded to 20 characters
- **s3** (*str*) – part 3, padded to 35 characters
- **s4** (*str*) – part 4
- **s0** (*str*) – part 0. if omitted, the line number from where the call was given will be used at the start of the line. Otherwise s0, left padded to 7 characters will be used at the start of the line.
- **_optional** (*bool*) – for internal use only. Do not set this flag!

Note: if self.trace is False, nothing is printed if the current component's suppress_trace is True, nothing is printed

---

print_trace_header()
print a (two line) header line as a legend also the legend for line numbers will be printed not that the header is only printed if trace=True

reset_now(*new_now=0*)
reset the current time

Parameters **new_now** (*float*) – now will be set to new_now default: 0

Note: Internally, salabim still works with the 'old' time. Only in the interface from and to the user program, a correction will be applied.

The registered time in monitors will be always is the 'old' time. This is only relevant when using the time value in Monitor.xt() or Monitor.tx().

---

run(*duration=None*, *till=None*, *urgent=False*)
start execution of the simulation

Parameters

- **duration** (*float*) – schedule with a delay of duration if 0, now is used
- **till** (*float*) – schedule time if omitted, inf is assumed. See also not below

- **urgent** (*bool*) – urgency indicator if False (default), main will be scheduled behind all other components scheduled for the same time if True, main will be scheduled in front of all components scheduled for the same time

---

Note: if neither till nor duration is specified, the main component will be reactivated at the time there are no more events on the eventlist, i.e. possibly not at inf. if you want to run till inf (particularly when animating), issue run(sim.inf) only issue run() from the main level

---

scale()
scale of the animation, i.e. width / (x1 - x0)

Returns **scale**

Return type float

Note: It is not possible to set this value explicitely.

---

screen_to_usercoordinates_size(*screensize*)
converts a screen size to a value to be used with user coordinates

Parameters **screensize** (*float*) – screen size to be converted

Returns **value corresponding with screensize in user coordinates**

Return type float

screen_to_usercoordinates_x(*screenx*)
converts a screen x coordinate to a user x coordinate

Parameters **screenx** (*float*) – screen x coordinate to be converted

Returns **user x coordinate**

Return type float

screen_to_usercoordinates_y(*screeny*)
converts a screen x coordinate to a user x coordinate

Parameters **screeny** (*float*) – screen y coordinate to be converted

Returns **user y coordinate**

Return type float

seconds(*t*)
convert the given time in seconds to the current time unit

Parameters **t** (*float*) – time in seconds

Returns **time in secoonds, converted to the current time_unit**

Return type float

sequence_number()

Returns **sequence_number of the environment** – (the sequence number at initialization) normally this will be the integer value of a serialized name, but also non serialized names (without a dot or a comma at the end) will be numbered)

Return type int

setup()
called immediately after initialization of an environment.

by default this is a dummy method, but it can be overridden.

only keyword arguments are passed

show_fps(*value=None*)

Parameters **value** (*bool*) – new show_fps if not specified, no change

Returns **show_fps**

Return type bool

show_time(*value=None*)

Parameters **value** (*bool*) – new show_time if not specified, no change

Returns **show_time**

Return type bool

snapshot(*filename*)
Takes a snapshot of the current animated frame (at time = now()) and saves it to a file

Parameters **filename** (*str*) – file to save the current animated frame to. The following formats are accepted: .png, .jpg, .bmp, .gif and .tiff are supported. Other formats are not possible. Note that, apart from .JPG files. the background may be semi transparent by setting the alpha value to something else than 255.

speed(*value=None*)

Parameters **value** (*float*) – new speed if not specified, no change

Returns **speed**

Return type float

step()
executes the next step of the future event list

for advanced use with animation / GUI loops

suppress_trace_standby(*value=None*)
suppress_trace_standby status

Parameters **value** (*bool*) – new suppress_trace_standby status if omitted, no change

Returns **suppress trace status**

Return type bool

Note: By default, suppress_trace_standby is True, meaning that standby components are (apart from when they become non standby) suppressed from the trace. If you set suppress_trace_standby to False, standby components are fully traced.

---

synced(*value=None*)

Parameters **value** (*bool*) – new synced if not specified, no change

Returns **synced**

Return type bool

time_to_str_format(*format=None*)
sets / gets the the format to display times in trace, animation, etc.

Parameters **format** (*str*) – specifies how the time should be displayed in trace, animation, etc. the format specifier should result in 10 characters. Examples: "{:10.3f}", "{:10.4f}", "{:10.0f}" and "{:8.1f} h" Make sure that the returned length is exactly 10 characters.

Returns **current specifier (initialized to "{**

Return type 10.3f}")

to_days(*t*)
convert time t to days

Parameters **t** (*time*) –

Returns **Time t converted to days**

Return type float

to_hours(*t*)
convert time t to hours

Parameters **t** (*time*) –

Returns **Time t converted to hours**

Return type float

to_microseconds(*t*)
convert time t to microseconds

Parameters **t** (*time in microseconds*) –

Returns **Time t converted to microseconds**

Return type float

to_milliseconds(*t*)
convert time t to milliseconds

Parameters **t** (*time in milliseconds*) –

Returns **Time t converted to milliseconds**

Return type float

to_minutes(*t*)
convert time t to minutes

Parameters **t** (*time*) –

Returns **Time t converted to minutes**

Return type float

to_seconds(*t*)
convert time t to seconds

Parameters **t** (*time*) –

Returns **Time t converted to seconds**

Return type float

to_time_unit (*time_unit*, *t*)
convert time t to the time_unit specified

Parameters

- **time_unit** (*str*) – Supported time_units: “years”, “weeks”, “days”, “hours”, “minutes”, “seconds”, “milliseconds”, “microseconds”
- **t** (*time*) –

Returns Time t converted to the time_unit specified

Return type float

to_weeks (*t*)
convert time t to weeks

Parameters **t** (*time*) –

Returns Time t converted to weeks

Return type float

to_years (*t*)
convert time t to years

Parameters **t** (*time*) –

Returns Time t converted to years

Return type float

trace (*value=None*)
trace status

Parameters **value** (*bool*) – new trace status if omitted, no change

Returns trace status

Return type bool

Note: If you want to test the status, always include parentheses, like

```
if env.trace():
```

---

user_to_screencoordinates_size(*usersize*)
converts a user size to a value to be used with screen coordinates

Parameters **usersize** (*float*) – user size to be converted

Returns **value corresponding with usersize in screen coordinates**

Return type float

user_to_screencoordinates_x(*userx*)
converts a user x coordinate to a screen x coordinate

Parameters **userx** (*float*) – user x coordinate to be converted

Returns **screen x coordinate**

Return type float

user_to_screencoordinates_y(*usery*)
converts a user x coordinate to a screen x coordinate

Parameters **usery** (*float*) – user y coordinate to be converted

Returns **screen y coordinate**

Return type float

video(*value=None*)
video name

Parameters **value** (*str, list or tuple*) – new video name if not specified, no change for explanation see animation_parameters()

Returns **video**

Return type str, list or tuple

Note: If video is the null string, the video (if any) will be closed.

---

video_close()
closes the current animation video recording, if any.

video_pingpong(*value=None*)
video pingponf

Parameters **value** (*bool*) – new video pingpong if not specified, no change

Returns **video pingpong**

Return type bool

Note: Applies only to gif animation.

---

video_repeat (*value=None*)
video repeat

Parameters **value** (*int*) – new video repeat if not specified, no change

Returns **video repeat**

Return type int

Note: Applies only to gif animation.

---

weeks (*t*)
convert the given time in weeks to the current time unit

Parameters **t** (*float*) – time in weeks

Returns **time in weeks, converted to the current time_unit**

Return type float

width (*value=None*)
width of the animation in screen coordinates

Parameters **value** (*int*) – new width if not specified, no change

Returns **width of animation**

Return type int

x0 (*value=None*)
x coordinate of lower left corner of animation

Parameters **value** (*float*) – new x coordinate

Returns **x coordinate of lower left corner of animation**

Return type float

x1 (*value=None*)
x coordinate of upper right corner of animation : float

Parameters **value** (*float*) – new x coordinate if not specified, no change

Returns **x coordinate of upper right corner of animation**

Return type float

y0 (*value=None*)
y coordinate of lower left corner of animation

Parameters **value** (*float*) – new y coordinate if not specified, no change

Returns **y coordinate of lower left corner of animation**

Return type float

y1 ()
y coordinate of upper right corner of animation

Returns **y coordinate of upper right corner of animation**

Return type float

Note: It is not possible to set this value explicitely.

---

years (*t*)
convert the given time in years to the current time unit

Parameters **t** (*float*) – time in years

Returns **time in years, converted to the current time_unit**

Return type float

12.5 ItemFile

class salabim.**ItemFile** (*filename*)
define an item file to be used with read_item, read_item_int, read_item_float and read_item_bool

Parameters **filename** (*str*) – file to be used for subsequent read_item, read_item_int, read_item_float and read_item_bool calls or content to be interpreted used in subsequent read_item calls. The content should have at least one linefeed character and will be usually triple quoted.

Note: It is advised to use ItemFile with a context manager, like

```
with sim.ItemFile("experiment0.txt") as f:
    run_length = f.read_item_float() |n|
    run_name = f.read_item() |n|
```

Alternatively, the file can be opened and closed explicitely, like

```
f = sim.ItemFile("experiment0.txt")
run_length = f.read_item_float()
run_name = f.read_item()
f.close()
```

Item files consist of individual items separated by whitespace (blank or tab)|n| If a blank or tab is required in an item, use single or double quotes All text following # on a line is ignored All texts on a line within curly brackets {} is ignored and considered white space. Curly braces cannot spawn multiple lines and cannot be nested.

Example

```
Item1
"Item 2"
    Item3 Item4 # comment
Item5 {five} Item6 {six}
'Double quote" in item'
"Single quote' in item"
True
```

---

read_item()
read next item from the ItemFile

if the end of file is reached, EOFError is raised

read_item_bool()
read next item from the ItemFile as bool

A value of False (not case sensitive) will return False A value of 0 will return False The null string will return False Any other value will return True

if the end of file is reached, EOFError is raised

read_item_float()
read next item from the ItemFile as float

if the end of file is reached, EOFError is raised

read_item_int()
read next field from the ItemFile as int.

if the end of file is reached, EOFError is raised

12.6 Monitor

class salabim.**Monitor**(*name=None*, *monitor=True*, *level=False*, *initial_tally=None*, *type=None*, *weight_legend=None*, *fill=None*, *env=None*, **args*, ***kwargs*)

Monitor object

Parameters

- **name** (*str*) – name of the monitor if the name ends with a period (.), auto serializing will be applied if the name end with a comma, auto serializing starting at 1 will be applied if omitted, the name will be derived from the class it is defined in (lowercased)
- **monitor** (*bool*) – if True (default), monitoring will be on. if False, monitoring is disabled it is possible to control monitoring later, with the monitor method
- **level** (*bool*) – if False (default), individual values are tallied, optionally with weight if True, the tallied vslues are interpreted as levels
- **initial_tally** (*any, preferably int, float or translatable into int or float*) – initial value for the a level monitor it is important to set the value correctly. default: 0 not available for non level monitors
- **type** (*str*) –

  specifies how tallied values are to be stored

  - **"any" (default) stores values in a list. This allows** non numeric values. In calculations the values are forced to a numeric value (0 if not possible)
  - "bool" (True, False) Actually integer >= 0 <= 255 1 byte
  - "int8" integer >= -128 <= 127 1 byte
  - "uint8" integer >= 0 <= 255 1 byte
  - "int16" integer >= -32768 <= 32767 2 bytes

- ”uint16” integer >= 0 <= 65535 2 bytes
- ”int32” integer >= -2147483648<= 2147483647 4 bytes
- ”uint32” integer >= 0 <= 4294967295 4 bytes
- ”int64” integer >= -9223372036854775808 <= 9223372036854775807 8 bytes
- ”uint64” integer >= 0 <= 18446744073709551615 8 bytes
- ”float” float 8 bytes

- **weight_legend** (*str*) – used in print_statistics and print_histogram to indicate the dimension of weight or duration (for level monitors, e.g. minutes. Default: weight for non level monitors, duration for level monitors.
- **fill** (*list or tuple*) – can be used to fill the tallied values (all at time now). fill is only available for non level monitors.
- **env** (Environment) – environment where the monitor is defined if omitted, default_env will be used

animate (**args*, ***kwargs*)

animates the monitor in a panel

Parameters

- **linecolor** (*colorspec*) – color of the line or points (default foreground color)
- **linewidth** (*int*) – width of the line or points (default 1 for line, 3 for points)
- **fillcolor** (*colorspec*) – color of the panel (default transparent)
- **bordercolor** (*colorspec*) – color of the border (default foreground color)
- **borderlinewidth** (*int*) – width of the line around the panel (default 1)
- **nowcolor** (*colorspec*) – color of the line indicating now (default red)
- **titlecolor** (*colorspec*) – color of the title (default foreground color)
- **titlefont** (font) – font of the title (default null string)
- **titlefontsize** (*int*) – size of the font of the title (default 15)
- **title** (*str*) – title to be shown above panel default: name of the monitor
- **x** (*int*) – x-coordinate of panel, relative to xy_anchor, default 0
- **y** (*int*) – y-coordinate of panel, relative to xy_anchor. default 0
- **xy_anchor** (*str*) – specifies where x and y are relative to possible values are (default: sw): `nw n ne w c e sw s se`

- **vertical_offset** (*float*) –

  the vertical position of x within the panel is vertical_offset + x * vertical_scale (default 0)

- **vertical_scale** (*float*) – the vertical position of x within the panel is vertical_offset + x * vertical_scale (default 5)
- **horizontal_scale** (*float*) – for timescaled monitors the relative horizontal position of time t within the panel is on t * horizontal_scale, possibly shifted (default 1)|n| for non timescaled monitors, the relative horizontal position of index i within the panel is on i * horizontal_scale, possibly shifted (default 5)|n|
- **width** (*int*) – width of the panel (default 200)
- **height** (*int*) – height of the panel (default 75)
- **layer** (*int*) – layer (default 0)

Returns **reference to AnimateMonitor object**

Return type *AnimateMonitor*

Note: It is recommended to use sim.AnimateMonitor instead

All measures are in screen coordinates

---

base_name()

Returns **base name of the monitor (the name used at initialization)**

Return type str

bin_duration(*lowerbound*, *upperbound*)
total duration of tallied values in range (lowerbound,upperbound]

Parameters

- **lowerbound** (*float*) – non inclusive lowerbound
- **upperbound** (*float*) – inclusive upperbound
- **ex0** (*bool*) – if False (default), include zeroes. if True, exclude zeroes

Returns **total duration of values >lowerbound and <=upperbound**

Return type int

Note: Not available for level monitors

bin_number_of_entries (*lowerbound*, *upperbound*, *ex0=False*)
count of the number of tallied values in range (lowerbound,upperbound]

Parameters

- **lowerbound** (*float*) – non inclusive lowerbound
- **upperbound** (*float*) – inclusive upperbound
- **ex0** (*bool*) – if False (default), include zeroes. if True, exclude zeroes

Returns **number of values >lowerbound and <=upperbound**

Return type int

Note: Not available for level monitors

bin_weight (*lowerbound*, *upperbound*)
total weight of tallied values in range (lowerbound,upperbound]

Parameters

- **lowerbound** (*float*) – non inclusive lowerbound
- **upperbound** (*float*) – inclusive upperbound
- **ex0** (*bool*) – if False (default), include zeroes. if True, exclude zeroes

Returns **total weight of values >lowerbound and <=upperbound**

Return type int

Note: Not available for level monitors

deregister (*registry*)
deregisters the monitor in the registry

Parameters **registry** (*list*) – list of registered objects

Returns **monitor (self)**

Return type *Monitor*

duration(*ex0=False*)
total duration

Parameters **ex0** (*bool*) – if False (default), include zeroes. if True, exclude zeroes

Returns **total duration**

Return type float

Note: Not available for non level monitors

duration_zero()
total duratiom of zero entries

Returns **total duration of zero entries**

Return type float

Note: Not available for non level monitors

get(*t=None*)
get the value of a monitor

Parameters **t** (*float*) – time at which the value of the level is to be returned default: now

Returns

last tallied value – Instead of this method, the level monitor can also be called directly, like

level = sim.Monitor("level", level=True) ... print(level()) print(level.get()) # identical

Return type any, usually float

Note: If the value is not available, self.off will be returned.

histogram_autoscale(*ex0=False*)
used by histogram_print to autoscale may be overridden.

Parameters **ex0** (*bool*) – if False (default), include zeroes. if True, exclude zeroes

Returns **bin_width, lowerbound, number_of_bins**

Return type tuple

maximum(*ex0=False*)
maximum of tallied values

Parameters **ex0** (*bool*) – if False (default), include zeroes. if True, exclude zeroes

Returns **maximum**

Return type float

mean(*ex0=False*)
mean of tallied values

Parameters **ex0** (*bool*) – if False (default), include zeroes. if True, exclude zeroes

Returns **mean**

Return type float

Note: For weighs are applied , the weighted mean is returned

---

median(*ex0=False*)
median of tallied values

Parameters **ex0** (*bool*) – if False (default), include zeroes. if True, exclude zeroes

Returns **median**

Return type float

Note: If weight are applied, the weighted median is returned

---

merge(**monitors*, ***kwargs*)
merges this monitor with other monitors

Parameters

- **monitors** (*sequence*) – zero of more monitors to be merged to this monitor
- **name** (*str*) – name of the merged monitor default: name of this monitor + ".merged"

Returns **merged monitor**

Return type *Monitor*

Note: Level monitors can only be merged with level monitors Non level monitors can only be merged with non level monitors Only monitors with the same type can be merged If no monitors are specified, a copy is created. For level monitors, merging means summing the available x-values|n|

---

minimum(*ex0=False*)
minimum of tallied values

Parameters **ex0** (*bool*) – if False (default), include zeroes. if True, exclude zeroes

Returns **minimum**

Return type float

monitor(*value=None*)
enables/disables monitor

Parameters **value** (*bool*) – if True, monitoring will be on. if False, monitoring is disabled if omitted, no change

Returns **True, if monitoring enabled. False, if not**

Return type bool

multiply(*scale=1*, *name=None*)
makes a monitor with all x-values multiplied with scale

Parameters

- **scale** (*float*) – scale to be applied
- **name** (*str*) – name of the multiplied monitor default: name of this monitor

Returns **multiplied monitor**

Return type *Monitor*

Note: Only non level monitors with type float can be multiplied

name(*value=None*)

Parameters **value** (*str*) – new name of the monitor if omitted, no change

Returns **Name of the monitor**

Return type str

Note: base_name and sequence_number are not affected if the name is changed

number_of_entries(*ex0=False*)
count of the number of entries

Parameters **ex0** (*bool*) – if False (default), include zeroes. if True, exclude zeroes

Returns **number of entries**

Return type int

Note: Not available for level monitors

number_of_entries_zero()
count of the number of zero entries

Returns **number of zero entries**

Return type int

Note: Not available for level monitors

percentile(*q*, *ex0=False*)
q-th percentile of tallied values

Parameters

- **q** (*float*) – percentage of the distribution values <0 are treated a 0 values >100 are treated as 100

- **ex0** (*bool*) – if False (default), include zeroes. if True, exclude zeroes

Returns q-th percentile 0 returns the minimum, 50 the median and 100 the maximum

Return type float

Note: If weights are applied, the weighted percentile is returned

---

print_histogram(*number_of_bins=None*, *lowerbound=None*, *bin_width=None*, *values=False*, *ex0=False*, *as_str=False*, *file=None*)
print monitor statistics and histogram

Parameters

- **number_of_bins** (*int*) – number of bins default: 30 if <0, also the header of the histogram will be surpressed
- **lowerbound** (*float*) – first bin default: 0
- **bin_width** (*float*) – width of the bins default: 1
- **values** (*bool*) – if False (default), bins will be used if True, the individual values will be shown (in the right order). in that case, no cumulative values will be given
- **ex0** (*bool*) – if False (default), include zeroes. if True, exclude zeroes

as_str: bool if False (default), print the histogram if True, return a string containing the histogram

file: file if None(default), all output is directed to stdout otherwise, the output is directed to the file

Returns **histogram (if as_str is True)**

Return type str

Note: If number_of_bins, lowerbound and bin_width are omitted, the histogram will be autoscaled, with a maximum of 30 classes.

---

print_histograms(*number_of_bins=None*, *lowerbound=None*, *bin_width=None*, *values=False*, *ex0=False*, *as_str=False*, *file=None*)
print monitor statistics and histogram

Parameters

- **number_of_bins** (*int*) – number of bins default: 30 if <0, also the header of the histogram will be surpressed

- **lowerbound** (*float*) – first bin default: 0
- **bin_width** (*float*) – width of the bins default: 1
- **values** (*bool*) – if False (default), bins will be used if True, the individual values will be shown (sorted on the value). in that case, no cumulative values will be given
- **ex0** (*bool*) – if False (default), include zeroes. if True, exclude zeroes
- **as_str** (*bool*) – if False (default), print the histogram if True, return a string containing the histogram
- **file** (*file*) – if None(default), all output is directed to stdout otherwise, the output is directed to the file

Returns **histogram (if as_str is True)**

Return type str

Note: If number_of_bins, lowerbound and bin_width are omitted, the histogram will be autoscaled, with a maximum of 30 classes. Exactly same functionality as Monitor.print_histogram()

---

print_statistics(*show_header=True*, *show_legend=True*, *do_indent=False*, *as_str=False*, *file=None*)
print monitor statistics

Parameters

- **show_header** (*bool*) – primarily for internal use
- **show_legend** (*bool*) – primarily for internal use
- **do_indent** (*bool*) – primarily for internal use
- **as_str** (*bool*) – if False (default), print the statistics if True, return a string containing the statistics
- **file** (*file*) – if Noneb(default), all output is directed to stdout otherwise, the output is directed to the file

Returns **statistics (if as_str is True)**

Return type str

register(*registry*)
registers the monitor in the registry

Parameters **registry** (*list*) – list of (to be) registered objects

Returns **monitor (self)**

Return type *Monitor*

Note: Use Monitor.deregister if monitor does not longer need to be registered.

---

rename(*value=None*)

Parameters **value** (*str*) – new name of the monitor if omitted, no change

Returns **self**

Return type *monitor*

Note: in contrast to name(), this method returns itself, so can used to chain, e.g. (m0 + m1 + m2+ m3).rename('m0-m3').print_histograms() m0[1000 : 2000].rename('m between t=1000 and t=2000').print_histograms()

---

reset(*monitor=None*)
resets monitor

Parameters **monitor** (*bool*) – if True, monitoring will be on. if False, monitoring is disabled if omitted, no change of monitoring state

reset_monitors(*monitor=None*)
resets monitor

Parameters **monitor** (*bool*) – if True (default), monitoring will be on. if False, monitoring is disabled if omitted, the monitor state remains unchanged

---

Note: Exactly same functionality as Monitor.reset()

---

sequence_number()

Returns **sequence_number of the monitor** – (the sequence number at initialization) normally this will be the integer value of a serialized name, but also non serialized names (without a dot or a comma at the end) will be numbered)

Return type int

setup()
called immediately after initialization of a monitor.

by default this is a dummy method, but it can be overridden.

only keyword arguments are passed

slice(*start=None*, *stop=None*, *modulo=None*, *name=None*)
slices this monitor (creates a subset)

Parameters

- **start** (*float*) – if modulo is not given, the start of the slice if modulo is given, this is indicates the slice period start (modulo modulo)
- **stop** (*float*) – if modulo is not given, the end of the slice if modulo is given, this is indicates the slice period end (modulo modulo) note that stop is excluded from the slice (open at right hand side)
- **modulo** (*float*) – specifies the distance between slice periods if not specified, just one slice subset is used.
- **name** (*str*) – name of the sliced monitor default: name of this monitor + ".sliced"

Returns **sliced monitor**

Return type *Monitor*

std(*ex0=False*)
standard deviation of tallied values

Parameters **ex0** (*bool*) – if False (default), include zeroes. if True, exclude zeroes

Returns **standard deviation**

Return type float

Note: For weights are applied, the weighted standard deviation is returned

---

t
get the time of last tally of a level monitor

Getter gets the last tallied value : any (often float)

Note: t is only available for level monitors t is available even if the monitor is turned off

---

tally(*value*, *weight=1*)

Parameters

- **x** (*any, preferably int, float or translatable into int or float*) – value to be tallied

- **weight** (*float*) – weight to be tallied default : 1

to_days (*name=None*)
makes a monitor with all x-values converted to days

Parameters **name** (*str*) – name of the converted monitor default: name of this monitor

Returns **converted monitor**

Return type *Monitor*

Note: Only non level monitors with type float can be converted. It is required that a time_unit is defined for the environment.

to_hours (*name=None*)
makes a monitor with all x-values converted to hours

Parameters **name** (*str*) – name of the converted monitor default: name of this monitor

Returns **converted monitor**

Return type *Monitor*

Note: Only non level monitors with type float can be converted. It is required that a time_unit is defined for the environment.

to_microseconds (*name=None*)
makes a monitor with all x-values converted to microseconds

Parameters **name** (*str*) – name of the converted monitor default: name of this monitor

Returns **converted monitor**

Return type *Monitor*

Note: Only non level monitors with type float can be converted. It is required that a time_unit is defined for the environment.

to_milliseconds (*name=None*)
makes a monitor with all x-values converted to milliseconds

Parameters **name** (*str*) – name of the converted monitor default: name of this monitor

Returns converted monitor

Return type *Monitor*

Note: Only non level monitors with type float can be converted. It is required that a time_unit is defined for the environment.

to_minutes(*name=None*)
makes a monitor with all x-values converted to minutes

Parameters **name** (*str*) – name of the converted monitor default: name of this monitor

Returns converted monitor

Return type *Monitor*

Note: Only non level monitors with type float can be converted. It is required that a time_unit is defined for the environment.

to_seconds(*name=None*)
makes a monitor with all x-values converted to seconds

Parameters **name** (*str*) – name of the converted monitor default: name of this monitor

Returns converted monitor

Return type *Monitor*

Note: Only non level monitors with type float can be converted. It is required that a time_unit is defined for the environment.

to_time_unit(*time_unit*, *name=None*)
makes a monitor with all x-values converted to the specified time unit

Parameters

- **time_unit** (*str*) – Supported time_units: “years”, “weeks”, “days”, “hours”, “minutes”, “seconds”, “milliseconds”, “microseconds”
- **name** (*str*) – name of the converted monitor default: name of this monitor

Returns converted monitor

Return type *Monitor*

Note: Only non level monitors with type float can be converted. It is required that a time_unit is defined for the environment.

to_weeks(*name=None*)
makes a monitor with all x-values converted to weeks

Parameters **name** (*str*) – name of the converted monitor default: name of this monitor

Returns **converted monitor**

Return type *Monitor*

Note: Only non level monitors with type float can be converted. It is required that a time_unit is defined for the environment.

to_years(*name=None*)
makes a monitor with all x-values converted to years

Parameters **name** (*str*) – name of the converted monitor default: name of this monitor

Returns **converted monitor**

Return type *Monitor*

Note: Only non level monitors with type float can be converted. It is required that a time_unit is defined for the environment.

tx(*ex0=False*, *exoff=False*, *force_numeric=False*, *add_now=True*)
tuple of array with timestamps and array/list with x-values

Parameters

- **ex0** (*bool*) – if False (default), include zeroes. if True, exclude zeroes
- **exoff** (*bool*) – if False (default), include self.off. if True, exclude self.off's non level monitors will return all values, regardless of exoff
- **force_numeric** (*bool*) – if True (default), convert non numeric tallied values numeric if possible, otherwise assume 0 if False, do not interpret x-values, return as list if type is list
- **add_now** (*bool*) – if True (default), the last tallied x-value and the current time is added to the result if False, the result ends with the last tallied value and the time that was tallied non level monitors will never add now

Returns **array with timestamps and array/list with x-values**

Return type tuple

Note: The value self.off is stored when monitoring is turned off The timestamps are not corrected for any reset_now() adjustment.

---

value

get/set the value of a level monitor

Getter gets the last tallied value : any (often float)

Setter equivalent to m.tally()

Note: value is only available for level monitors value is available even if the monitor is turned off

---

value_duration(*value*)

total duration of tallied values equal to value or in value

Parameters **value** (*any*) – if list, tuple or set, check whether the tallied value is in value otherwise, check whether the tallied value equals the given value

Returns **total of duration of tallied values in value or equal to value**

Return type int

Note: Not available for non level monitors

---

value_number_of_entries(*value*)

count of the number of tallied values equal to value or in value

Parameters **value** (*any*) – if list, tuple or set, check whether the tallied value is in value otherwise, check whether the tallied value equals the given value

Returns **number of tallied values in value or equal to value**

Return type int

Note: Not available for level monitors

---

value_weight(*value*)
total weight of tallied values equal to value or in value

Parameters **value** (*any*) – if list, tuple or set, check whether the tallied value is in value otherwise, check whether the tallied value equals the given value

Returns **total of weights of tallied values in value or equal to value**

Return type int

Note: Not available for level monitors

weight(*ex0=False*)
sum of weights

Parameters **ex0** (*bool*) – if False (default), include zeroes. if True, exclude zeroes

Returns **sum of weights**

Return type float

Note: Not available for level monitors

weight_zero()
sum of weights of zero entries

Returns **sum of weights of zero entries**

Return type float

Note: Not available for level monitors

x(*ex0=False*, *force_numeric=True*)
array/list of tallied values

Parameters

- **ex0** (*bool*) – if False (default), include zeroes. if True, exclude zeroes

- **force_numeric** (*bool*) – if True (default), convert non numeric tallied values numeric if possible, otherwise assume 0 if False, do not interpret x-values, return as list if type is any (list)

Returns all tallied values

Return type array/list

Note: Not available for level monitors. Use xduration(), xt() or tx() instead.

---

xduration(*ex0=False*, *force_numeric=True*)
array/list of tallied values

Parameters

- **ex0** (*bool*) – if False (default), include zeroes. if True, exclude zeroes
- **force_numeric** (*bool*) – if True (default), convert non numeric tallied values numeric if possible, otherwise assume 0 if False, do not interpret x-values, return as list if type is list

Returns all tallied values

Return type array/list

Note: not available for non level monitors

---

xt(*ex0=False*, *exoff=False*, *force_numeric=True*, *add_now=True*)
tuple of array/list with x-values and array with timestamp

Parameters

- **ex0** (*bool*) – if False (default), include zeroes. if True, exclude zeroes
- **exoff** (*bool*) – if False (default), include self.off. if True, exclude self.off's non level monitors will return all values, regardless of exoff
- **force_numeric** (*bool*) – if True (default), convert non numeric tallied values numeric if possible, otherwise assume 0 if False, do not interpret x-values, return as list if type is list
- **add_now** (*bool*) – if True (default), the last tallied x-value and the current time is added to the result if False, the result ends with the last tallied value and the time that was tallied non level monitors will never add now if now is <= last tallied value, nothing will be added, even if add_now is True

Returns array/list with x-values and array with timestamps

Return type tuple

Note: The value self.off is stored when monitoring is turned off The timestamps are not corrected for any reset_now() adjustment.

xweight(*ex0=False*, *force_numeric=True*)
array/list of tallied values

Parameters

- **ex0** (*bool*) – if False (default), include zeroes. if True, exclude zeroes
- **force_numeric** (*bool*) – if True (default), convert non numeric tallied values numeric if possible, otherwise assume 0 if False, do not interpret x-values, return as list if type is list

Returns **all tallied values**

Return type array/list

Note: not available for level monitors

12.7 Queue

class salabim.**Queue**(*name=None*, *monitor=True*, *fill=None*, *env=None*, **args*, ***kwargs*)
Queue object

Parameters

- **fill** (*Queue, list or tuple*) – fill the queue with the components in fill if omitted, the queue will be empty at initialization
- **name** (*str*) – name of the queue if the name ends with a period (.), auto serializing will be applied if the name end with a comma, auto serializing starting at 1 will be applied if omitted, the name will be derived from the class it is defined in (lowercased)
- **monitor** (*bool*) – if True (default) , both length and length_of_stay are monitored if False, monitoring is disabled.
- **env** (*Environment*) – environment where the queue is defined if omitted, default_env will be used

add(*component*)
adds a component to the tail of a queue

Parameters **component** (Component) – component to be added to the tail of the queue may not be member of the queue yet

---

Note: the priority will be set to the priority of the tail of the queue, if any or 0 if queue is empty This method is equivalent to append()

---

add_at_head(*component*)
adds a component to the head of a queue

Parameters **component** (Component) – component to be added to the head of the queue may not be member of the queue yet

---

Note: the priority will be set to the priority of the head of the queue, if any or 0 if queue is empty

---

add_behind(*component*, *poscomponent*)
adds a component to a queue, just behind a component

Parameters

- **component** (Component) – component to be added to the queue may not be member of the queue yet
- **poscomponent** (Component) – component behind which component will be inserted must be member of the queue

---

Note: the priority of component will be set to the priority of poscomponent

---

add_in_front_of(*component*, *poscomponent*)
adds a component to a queue, just in front of a component

Parameters

- **component** (Component) – component to be added to the queue may not be member of the queue yet
- **poscomponent** (Component) – component in front of which component will be inserted must be member of the queue

---

Note: the priority of component will be set to the priority of poscomponent

---

add_sorted(*component*, *priority*)
adds a component to a queue, according to the priority

Parameters

- **component** (Component) – component to be added to the queue may not be member of the queue yet
- **priority** (*type that can be compared with other priorities in the queue*) – priority in the queue

Note: The component is placed just before the first component with a priority > given priority

animate (**args*, ***kwargs*)

Animates the components in the queue.

Parameters

- **x** (*float*) – x-position of the first component in the queue default: 50
- **y** (*float*) – y-position of the first component in the queue default: 50
- **direction** (*str*) – if "w", waiting line runs westwards (i.e. from right to left) if "n", waiting line runs northeards (i.e. from bottom to top) if "e", waiting line runs eastwards (i.e. from left to right) (default) if "s", waiting line runs southwards (i.e. from top to bottom)
- **reverse** (*bool*) – if False (default), display in normal order. If True, reversed.
- **max_length** (*int*) – maximum number of components to be displayed
- **xy_anchor** (*str*) – specifies where x and y are relative to possible values are (default: sw): `nw n ne w c e sw s se`
- **id** (*any*) – the animation works by calling the animation_objects method of each component, optionally with id. By default, this is self, but can be overriden, particularly with the queue
- **arg** (*any*) – this is used when a parameter is a function with two parameters, as the first argument or if a parameter is a method as the instance default: self (instance itself)

Returns reference to AnimationQueue object

Return type AnimationQueue

Note: It is recommended to use sim.AnimateQueue instead

All measures are in screen coordinates

All parameters, apart from queue and arg can be specified as: - a scalar, like 10 - a function with zero arguments, like lambda: title - a function with one argument, being the time t, like lambda t: t + 10 - a function with two parameters, being arg (as given) and the time, like lambda comp, t: comp.state - a method instance arg for time t, like self.state, actually leading to arg.state(t) to be called

append(*component*)
appends a component to the tail of a queue

Parameters **component** (Component) – component to be appened to the tail of the queue may not be member of the queue yet

Note: the priority will be set to the priority of the tail of the queue, if any or 0 if queue is empty This method is equivalent to add()

arrival_rate(*reset=False*)
returns the arrival rate When the queue is created, the registration is reset.

Parameters **reset** (*bool*) – if True, number_of_arrivals is set to 0 since last reset and the time of the last reset to now default: False ==> no reset

Returns **arrival rate** – number of arrivals since last reset / duration since last reset nan if duration is zero

Return type float

base_name()

Returns **base name of the queue (the name used at initialization)**

Return type str

clear()
empties a queue

removes all components from a queue

component_with_name(*txt*)
returns a component in the queue according to its name

Parameters **txt** (*str*) – name of component to be retrieved

Returns **the first component in the queue with name txt** – returns None if not found

Return type Component

copy(*name=None*, *monitor=<function Queue.monitor>*)
returns a copy of a queue

Parameters

- **name** (*str*) – name of the new queue if omitted, “copy of ” + self.name()
- **monitor** (*bool*) – if True, monitor the queue if False (default), do not monitor the queue

Returns **queue with all elements of self**

Return type *Queue*

Note: The priority will be copied from original queue. Also, the order will be maintained.

count (*component*)
component count

Parameters **component** (Component) – component to count

Returns

Return type number of occurences of component in the queue

Note: The result can only be 0 or 1

departure_rate (*reset=False*)
returns the departure rate When the queue is created, the registration is reset.

Parameters **reset** (*bool*) – if True, number_of_departures is set to 0 since last reset and the time of the last reset to now default: False ==> no reset

Returns **departure rate** – number of departures since last reset / duration since last reset nan if duration is zero

Return type float

deregister (*registry*)
deregisters the queue in the registry

Parameters **registry** (*list*) – list of registered queues

Returns **queue (self)**

Return type *Queue*

difference (*q*, *name=None*, *monitor=<function Queue.monitor>*)
returns the difference of two queues

Parameters

- **q** (Queue) – queue to be 'subtracted' from self
- **name** (*str*) – name of the new queue if omitted, self.name() - q.name()

- **monitor** (*bool*) – if True, monitor the queue if False (default), do not monitor the queue

Returns

Return type queue containing all elements of self that are not in q

---

Note: the priority will be copied from the original queue. Also, the order will be maintained. Alternatively, the more pythonic - operator is also supported, e.g. q1 - q2

---

extend(*source*, *clear_source=False*)

extends the queue with components of source that are not already in self (at the end of self)

Parameters

- **source** (*queue, list or tuple*) –
- **clear_source** (*bool*) – if False (default), the elements will remain in source if True, source will be cleared, so effectively moving all elements in source to self. If source is not a queue, but a list or tuple, the clear_source flag may not be set.

Note: The components in source added to the queue will get the priority of the tail of self.

---

head()

Returns **the head component of the queue, if any. None otherwise**

Return type *Component*

Note: q[0] is a more Pythonic way to access the head of the queue

---

index(*component*)

get the index of a component in the queue

Parameters **component** (Component) – component to be queried does not need to be in the queue

Returns **index of component in the queue** – 0 denotes the head, returns -1 if component is not in the queue

Return type int

insert(*index*, *component*)

Insert component before index-th element of the queue

Parameters

- **index** (*int*) – component to be added just before index'th element should be >=0 and <=len(self)
- **component** (Component) – component to be added to the queue

---

Note: the priority of component will be set to the priority of the index'th component, or 0 if the queue is empty

---

intersection(*q*, *name=None*, *monitor=False*)
returns the intersect of two queues

Parameters

- **q** (Queue) – queue to be intersected with self
- **name** (*str*) – name of the new queue if omitted, self.name() + q.name()
- **monitor** (*bool*) – if True, monitor the queue if False (default), do not monitor the queue

Returns queue with all elements that are in self and q

Return type *Queue*

Note: the priority will be set to 0 for all components in the resulting queue the order of the resulting queue is as follows: in the same order as in self. Alternatively, the more pythonic & operator is also supported, e.g. q1 & q2

---

monitor(*value*)
enables/disables monitoring of length_of_stay and length

Parameters **value** (*bool*) – if True, monitoring will be on. if False, monitoring is disabled

---

Note: it is possible to individually control monitoring with length_of_stay.monitor() and length.monitor()

---

move(*name=None*, *monitor=<function Queue.monitor>*)
makes a copy of a queue and empties the original

Parameters

- **name** (*str*) – name of the new queue

- **monitor** (*bool*) – if True, monitor the queue if False (default), do not monitor the yqueue

Returns **queue containing all elements of self**

Return type *Queue*

Note: Priorities will be kept self will be emptied

---

name(*value=None*)

Parameters **value** (*str*) – new name of the queue if omitted, no change

Returns **Name of the queue**

Return type str

Note: base_name and sequence_number are not affected if the name is changed All derived named are updated as well.

---

pop(*index=None*)
removes a component by its position (or head)

Parameters **index** (*int*) – index-th element to remove, if any if omitted, return the head of the queue, if any

Returns **The i-th component or head** – None if not existing

Return type *Component*

predecessor(*component*)
predecessor in queue

Parameters **component** (Component) – component whose predecessor to return must be member of the queue

Returns **predecessor of component, if any** – None otherwise.

Return type Component

print_histograms(*exclude=()*, *as_str=False*, *file=None*)
prints the histograms of the length and length_of_stay monitor of the queue

Parameters

- **exclude** (*tuple or list*) – specifies which monitors to exclude default: ()

- **as_str** (*bool*) – if False (default), print the histograms if True, return a string containing the histograms
- **file** (*file*) – if None(default), all output is directed to stdout otherwise, the output is directed to the file

Returns **histograms (if as_str is True)**

Return type str

print_info(*as_str=False*, *file=None*)
prints information about the queue

Parameters

- **as_str** (*bool*) – if False (default), print the info if True, return a string containing the info
- **file** (*file*) – if None(default), all output is directed to stdout otherwise, the output is directed to the file

Returns **info (if as_str is True)**

Return type str

print_statistics(*as_str=False*, *file=None*)
prints a summary of statistics of a queue

Parameters

- **as_str** (*bool*) – if False (default), print the statistics if True, return a string containing the statistics
- **file** (*file*) – if None(default), all output is directed to stdout otherwise, the output is directed to the file

Returns **statistics (if as_str is True)**

Return type str

register(*registry*)
registers the queue in the registry

Parameters **registry** (*list*) – list of (to be) registered objects

Returns **queue (self)**

Return type *Queue*

Note: Use Queue.deregister if queue does not longer need to be registered.

---

remove (*component=None*)
removes component from the queue

Parameters **component** (Component) – component to be removed if omitted, all components will be removed.

Note: component must be member of the queue

rename (*value=None*)

Parameters **value** (*str*) – new name of the queue if omitted, no change

Returns **self**

Return type queue

Note: in contrast to name(), this method returns itself, so can used to chain, e.g. (q0 + q1 + q2 + q3).rename('q0 - q3').print_statistics() (q1 - q0).rename('difference of q1 and q0)').print_histograms()

reset_monitors (*monitor=None*)
resets queue monitor length_of_stay and length

Parameters **monitor** (*bool*) – if True, monitoring will be on. if False, monitoring is disabled if omitted, no change of monitoring state

Note: it is possible to reset individual monitoring with length_of_stay.reset() and length.reset()

sequence_number ()

Returns **sequence_number of the queue** – (the sequence number at initialization) normally this will be the integer value of a serialized name, but also non serialized names (without a dot or a comma at the end) will be numbered)

Return type int

setup ()
called immediately after initialization of a queue.

by default this is a dummy method, but it can be overridden.

only keyword arguments are passed

successor(*component*)
successor in queue

Parameters **component** (Component) – component whose successor to return must be member of the queue

Returns **successor of component, if any** – None otherwise

Return type *Component*

symmetric_difference(*q*, *name=None*, *monitor=<function Queue.monitor>*)
returns the symmetric difference of two queues

Parameters

- **q** (Queue) – queue to be 'subtracted' from self
- **name** (*str*) – name of the new queue if omitted, self.name() - q.name()
- **monitor** (*bool*) – if True, monitor the queue if False (default), do not monitor the queue

Returns

Return type queue containing all elements that are either in self or q, but not in both

---

Note: the priority of all elements will be set to 0 for all components in the new queue. Order: First, elelements in self (in that order), then elements in q (in that order) Alternatively, the more pythonic ^ operator is also supported, e.g. q1 ^ q2

---

tail()

Returns **the tail component of the queue, if any. None otherwise**

Return type *Component*

Note: q[-1] is a more Pythonic way to access the tail of the queue

---

union(*q*, *name=None*, *monitor=False*)

Parameters

- **q** (Queue) – queue to be unioned with self
- **name** (*str*) – name of the new queue if omitted, self.name() + q.name()

- **monitor** (*bool*) – if True, monitor the queue if False (default), do not monitor the queue

Returns **queue containing all elements of self and q**

Return type *Queue*

Note: the priority will be set to 0 for all components in the resulting queue the order of the resulting queue is as follows: first all components of self, in that order, followed by all components in q that are not in self, in that order. Alternatively, the more pythonic | operator is also supported, e.g. q1 | q2

12.8 Resource

class salabim.**Resource**(*name=None*, *capacity=1*, *anonymous=False*, *monitor=True*, *env=None*, **args*, ***kwargs*)

Parameters

- **name** (*str*) – name of the resource if the name ends with a period (.), auto serializing will be applied if the name end with a comma, auto serializing starting at 1 will be applied if omitted, the name will be derived from the class it is defined in (lowercased)
- **capacity** (*float*) – capacity of the resouce if omitted, 1
- **anonymous** (*bool*) – anonymous specifier if True, claims are not related to any component. This is useful if the resource is actually just a level. if False, claims belong to a component.
- **monitor** (*bool*) – if True (default) , the requesters queue, the claimers queue, the capacity, the available_quantity and the claimed_quantity are monitored if False, monitoring is disabled.
- **env** (Environment) – environment to be used if omitted, default_env is used

base_name()

Returns **base name of the resource (the name used at initialization)**

Return type str

claimers()

Returns **queue with all components claiming from the resource** – will be an empty queue for an anonymous resource

Return type *Queue*

deregister(*registry*)
deregisters the resource in the registry

Parameters **registry** (*list*) – list of registered components

Returns **resource (self)**

Return type *Resource*

monitor(*value*)
enables/disables the resource monitors

Parameters **value** (*bool*) – if True, monitoring is enabled if False, monitoring is disabled

---

Note: it is possible to individually control monitoring with claimers().monitor() and requesters().monitor(), capacity.monitor(), available_quantity.monitor), claimed_quantity.monitor() or occupancy.monitor()

---

name(*value=None*)

Parameters **value** (*str*) – new name of the resource if omitted, no change

Returns **Name of the resource**

Return type str

Note: base_name and sequence_number are not affected if the name is changed All derived named are updated as well.

---

print_histograms(*exclude=()*, *as_str=False*, *file=None*)
prints histograms of the requesters and claimers queue as well as the capacity, available_quantity and claimed_quantity timstamped monitors of the resource

Parameters

- **exclude** (*tuple or list*) – specifies which queues or monitors to exclude default: ()
- **as_str** (*bool*) – if False (default), print the histograms if True, return a string containing the histograms
- **file** (*file*) – if None(default), all output is directed to stdout otherwise, the output is directed to the file

Returns **histograms (if as_str is True)**

Return type str

print_info(*as_str=False*, *file=None*)
prints info about the resource

Parameters

- **as_str** (*bool*) – if False (default), print the info if True, return a string containing the info
- **file** (*file*) – if None(default), all output is directed to stdout otherwise, the output is directed to the file

Returns **info (if as_str is True)**

Return type str

print_statistics(*as_str=False*, *file=None*)
prints a summary of statistics of a resource

Parameters

- **as_str** (*bool*) – if False (default), print the statistics if True, return a string containing the statistics
- **file** (*file*) – if None(default), all output is directed to stdout otherwise, the output is directed to the file

Returns **statistics (if as_str is True)**

Return type str

register(*registry*)
registers the resource in the registry

Parameters **registry** (*list*) – list of (to be) registered objects

Returns **resource (self)**

Return type *Resource*

Note: Use Resource.deregister if resource does not longer need to be registered.

---

release(*quantity=None*)
releases all claims or a specified quantity

Parameters **quantity** (*float*) – quantity to be released if not specified, the resource will be emptied completely for non-anonymous resources, all components claiming from this resource will be released.

Note: quantity may not be specified for a non-anonymous resoure

---

requesters()

Returns **queue containing all components with not yet honored requests**

Return type *Queue*

reset_monitors(*monitor=None*)
resets the resource monitors

Parameters **monitor** (*bool*) – if True, monitoring will be on. if False, monitoring is disabled if omitted, no change of monitoring state

---

Note: it is possible to reset individual monitoring with claimers().reset_monitors(), requesters().reset_monitors, capacity.reset(), available_quantity.reset() or claimed_quantity.reset() or occupancy.reset()

---

sequence_number()

Returns **sequence_number of the resource** – (the sequence number at initialization) normally this will be the integer value of a serialized name, but also non serialized names (without a dot or a comma at the end) will be numbered)

Return type int

set_capacity(*cap*)

Parameters **cap** (*float or int*) – capacity of the resource this may lead to honoring one or more requests. if omitted, no change

setup()
called immediately after initialization of a resource.

by default this is a dummy method, but it can be overridden.

only keyword arguments are passed

12.9 State

class salabim.**State**(*name=None*, *value=False*, *type='any'*, *monitor=True*, *animation_objects=None*, *env=None*, **args*, ***kwargs*)

Parameters

- **name** (*str*) – name of the state if the name ends with a period (.), auto serializing will be applied if the name end with a comma, auto serializing starting at 1 will be applied if omitted, the name will be derived from the class it is defined in (lowercased)
- **value** (*any, preferably printable*) – initial value of the state if omitted, False
- **monitor** (*bool*) – if True (default) , the waiters queue and the value are monitored if False, monitoring is disabled.

- **type** (*str*) – specifies how the state values are monitored. Using a int, uint of float type results in less memory usage and better performance. Note that you should avoid the number not to use as this is used to indicate 'off'
  - "any" (default) stores values in a list. This allows for non numeric values. In calculations the values are forced to a numeric value (0 if not possible) do not use -inf
  - "bool" bool (False, True). Actually integer >= 0 <= 254 1 byte do not use 255
  - "int8" integer >= -127 <= 127 1 byte do not use -128
  - "uint8" integer >= 0 <= 254 1 byte do not use 255
  - "int16" integer >= -32767 <= 32767 2 bytes do not use -32768
  - "uint16" integer >= 0 <= 65534 2 bytes do not use 65535
  - "int32" integer >= -2147483647 <= 2147483647 4 bytes do not use -2147483648
  - "uint32" integer >= 0 <= 4294967294 4 bytes do not use 4294967295
  - "int64" integer >= -9223372036854775807 <= 9223372036854775807 8 bytes do not use -9223372036854775808
  - "uint64" integer >= 0 <= 18446744073709551614 8 bytes do not use 18446744073709551615
  - "float" float 8 bytes do not use -inf
- **animation_objects** (*list or tuple*) – overrides the default animation_object method the method should have a header like `def animation_objects(self, value):` and should return a list or tuple of animation objects, which will be used when the state changes value. The default method displays a square of size 40. If the value is a valid color, that will be the color of the square. Otherwise, the square will be black with the value displayed in white in the centre.
- **env** (Environment) – environment to be used if omitted, default_env is used

base_name()

Returns base name of the state (the name used at initialization)

Return type str

deregister(*registry*)

deregisters the state in the registry

Parameters **registry** (*list*) – list of registered states

Returns state (self)

Return type *State*

get()
get value of the state

Returns

value of the state – Instead of this method, the state can also be called directly, like

level = sim.State("level") ... print(level()) print(level.get()) # identical

Return type any

monitor(*value=None*)
enables/disables the state monitors and value monitor

Parameters **value** (*bool*) – if True, monitoring will be on. if False, monitoring is disabled if not specified, no change

---

Note:

it is possible to individually control requesters().monitor(), value.monitor()

---

name(*value=None*)

Parameters **value** (*str*) – new name of the state if omitted, no change

Returns **Name of the state**

Return type str

Note: base_name and sequence_number are not affected if the name is changed All derived named are updated as well.

---

print_histograms(*exclude=()*, *as_str=False*, *file=None*)
print histograms of the waiters queue and the value monitor

Parameters

- **exclude** (*tuple or list*) – specifies which queues or monitors to exclude default: ()
- **as_str** (*bool*) – if False (default), print the histograms if True, return a string containing the histograms
- **file** (*file*) – if None(default), all output is directed to stdout otherwise, the output is directed to the file

Returns **histograms (if as_str is True)**

Return type str

print_info(*as_str=False*, *file=None*)
prints info about the state

Parameters

- **as_str** (*bool*) – if False (default), print the info if True, return a string containing the info
- **file** (*file*) – if None(default), all output is directed to stdout otherwise, the output is directed to the file

Returns **info (if as_str is True)**

Return type str

print_statistics(*as_str=False*, *file=None*)
prints a summary of statistics of the state

Parameters

- **as_str** (*bool*) – if False (default), print the statistics if True, return a string containing the statistics
- **file** (*file*) – if None(default), all output is directed to stdout otherwise, the output is directed to the file

Returns **statistics (if as_str is True)**

Return type str

register(*registry*)
registers the state in the registry

Parameters **registry** (*list*) – list of (to be) registered objetcs

Returns **state (self)**

Return type *State*

Note: Use State.deregister if state does not longer need to be registered.

---

reset(*value=False*)
reset the value of the state

Parameters **value** (*any (preferably printable)*) – if omitted, False if there is a change, the waiters queue will be checked to see whether there are waiting components to be honored

Note: This method is identical to set, except the default value is False.

reset_monitors(*monitor=None*)
resets the monitor for the state's value and the monitors of the waiters queue

Parameters **monitor** (*bool*) – if True, monitoring will be on. if False, monitoring is disabled if omitted, no change of monitoring state

sequence_number()

Returns **sequence_number of the state** – (the sequence number at initialization) normally this will be the integer value of a serialized name, but also non serialized names (without a dot or a comma at the end) will be numbered)

Return type int

set(*value=True*)
set the value of the state

Parameters **value** (*any (preferably printable)*) – if omitted, True if there is a change, the waiters queue will be checked to see whether there are waiting components to be honored

Note: This method is identical to reset, except the default value is True.

setup()
called immediately after initialization of a state.

by default this is a dummy method, but it can be overridden.

only keyword arguments will be passed

trigger(*value=True*, *value_after=None*, *max=inf*)
triggers the value of the state

Parameters

- **value** (*any (preferably printable)*) – if omitted, True
- **value_after** (*any (preferably printable)*) – after the trigger, this will be the new value. if omitted, return to the the before the trigger.
- **max** (*int*) – maximum number of components to be honored for the trigger value default: inf

Note: The value of the state will be set to value, then at most max waiting components for this state will be honored and next the value will be set to value_after and again checked for possible honors.

waiters()

Returns queue containing all components waiting for this state

Return type *Queue*

12.10 Miscellaneous

salabim.**arrow_polygon**(*size*)
creates a polygon tuple with a centerd arrow for use with sim.Animate

Parameters **size** (*float*) – length of the arrow

salabim.**audio_duration**(*filename*)
duration of a audio file (usually mp3)

Parameters **filename** (*str*) – must be a valid audio file (usually mp3)

Returns duration in seconds

Return type float

Note: Only supported on Windows and Pythonista. On other platform returns 0

salabim.**can_animate**(*try_only=True*)
Tests whether animation is supported.

Parameters **try_only** (*bool*) – if True (default), the function does not raise an error when the required modules cannot be imported if False, the function will only return if the required modules could be imported.

Returns True, if required modules could be imported, False otherwise

Return type bool

salabim.**can_video**(*try_only=True*)
Tests whether video is supported.

Parameters **try_only** (*bool*) – if True (default), the function does not raise an error when the required modules cannot be imported if False, the function will only return if the required modules could be imported.

Returns **True, if required modules could be imported, False otherwise**

Return type bool

salabim.**centered_rectangle**(*width*, *height*)
creates a rectangle tuple with a centered rectangle for use with sim.Animate

Parameters

- **width** (*float*) – width of the rectangle
- **height** (*float*) – height of the rectangle

salabim.**colornames**()
available colornames

Returns **dict with name of color as key, #rrggbb or #rrggbbaa as value**

Return type dict

salabim.**default_env**()

Returns **default environment**

Return type *Environment*

salabim.**interpolate**(*t*, *t0*, *t1*, *v0*, *v1*)
does linear interpolation

Parameters

- **t** (*float*) – value to be interpolated from
- **t0** (*float*) – f(t0)=v0
- **t1** (*float*) – f(t1)=v1
- **v0** (*float, list or tuple*) – f(t0)=v0
- **v1** (*float, list or tuple*) – f(t1)=v1 if list or tuple, len(v0) should equal len(v1)

Returns **linear interpolation between v0 and v1 based on t between t0 and t1**

Return type float or tuple

Note: Note that no extrapolation is done, so if t<t0 ==> v0 and t>t1 ==> v1 This function is heavily used during animation.

salabim.**random_seed**(*seed=None*, *randomstream=None*)
Reseeds a randomstream

Parameters

- **seed** (*hashable object, usually int*) – the seed for random, equivalent to random.seed() if "*", a purely random value (based on the current time) will be used (not reproducable) if the null string, no action on random is taken if None (the default), 1234567 will be used.
- **randomstream** (*randomstream*) – randomstream to be used if omitted, random will be used

salabim.**regular_polygon**(*radius=1*, *number_of_sides=3*, *initial_angle=0*)
creates a polygon tuple with a regular polygon (within a circle) for use with sim.Animate

Parameters

- **radius** (*float*) – radius of the corner points of the polygon default : 1
- **number_of_sides** (*int*) – number of sides (corners) must be >= 3 default : 3
- **initial_angle** (*float*) – angle of the first corner point, relative to the origin default : 0

salabim.**reset**()
resets global variables

used internally at import of salabim

might be useful for REPLs or for Pythonista

salabim.**show_colornames**()
show (print) all available color names and their value.

salabim.**show_fonts**()
show (print) all available fonts on this machine

salabim.**spec_to_image**(*spec*)
convert an image specification to an image

Parameters **image** (*str or PIL.Image.Image*) – if str: filename of file to be loaded if null string: dummy image will be returned if PIL.Image.Image: return this image untranslated

Returns **image**

Return type PIL.Image.Image

CHAPTER

THIRTEEN

ABOUT

13.1 Who is behind salabim?

Ruud van der Ham is the core developer of salabim. He has a long history in simulation, both in applications and tool building.

It all started in the mid 70's when modeling container terminals in Prosim, a package in PL/1 that was inspired by Simula and run on big IBM 360/370 mainframes. In the eighties, Prosim was ported to smaller computers, but at the same time he developed a discrete event simulation tool called Must to run on CP/M machines, later on MSDOS machines, again under PL/1. A bit later, Must was ported to Pascal and was used in many projects. Must was never ported to Windows. Instead, Hans Veeke (Delft University) came with Tomas, a package that is still available and runs under Delphi. End 2016, an easy to use and open source package for a project, preferably in Python, was wanted. Unfortunately, the other Python DES package Simpy (particularly version 3) does not support the essential process interaction methods activate, hold, passivate and standby. First he tried to build a wrapper around Simpy 3, but that didn't work too well.

That was the start of a new package, called salabim. One of the key features of salabim is the powerful animation engine that is heavily inspired by some of my creative projects where every animation object can change position, shape, colour, orientation over time. Although rarely used in normal simulation models, all that functionality is available in salabim. Then, gradually, a lot of functionality was added as well bugs were fixed. Also, the package became available on PyPI and GitHub and the documentation was made available. Large parts of salabim were actually developed on an iPad on the excellent Pythonista platform. Pratically the full functionality is thus available under iOS as well.

13.2 Why is the package called salabim?

The name is derived from the magic words *Sim Salabim*, where Sim is actually short for simulation !

Note that the name should be written in all lowercase, unless it is at the start of a sentence, like a normal noun.

13.3 Contributing and reporting issues

It is very much appreciated to contribute to the salabim, by issuing a pull request or issue on GitHub.

Alternatively, the Google group can be used for this.

13.4 Support

Ruud van der Ham is able and willing to help users with issues with the package or modelling in general.

He is also available for code and model reviews, consultancy, training.

Contact him or other users via the Google group or ruud@salabim.org.

13.5 License

The MIT License (MIT)

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