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# **salabim Documentation**

***Release 20.0.3***

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## 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)
- PyDroid3 (Android)

The package is runs only under Python 3.4 and higher.

The following packages are required:

Platform	Base functionality	Animation	Video (mp4, avi)	Animated GIF/PNG
CPython	•	Pillow, tkinter	opencv, numpy	Pillow
PyPy	•	Pillow, tkinter	N/A	Pillow
Pythonista	•	Pillow	N/A	Pillow
PyDroid3	•	Pillow, tkinter	opencv, numpy	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](http://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
```

Alternatively, it is possible to install salabim directly from GitHub with the utility *install salabim from github.py*, which can be found in the GitHub repository.



You can find the package along with some support files and sample models on [www.github.com/salabim/salabim](https://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 salabim.py* file or *install salabim from github.py*. 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/>



## 2.1 A simple model

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

```
1 # Car.py
2 import salabim as sim
3
4
5 class Car(sim.Component):
6     def process(self):
7         while True:
8             yield self.hold(1)
9
10
11 env = sim.Environment(trace=True)
12 Car()
13 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):
7         while True:
```

```
8         Customer()
9         yield self.hold(sim.Uniform(5, 15).sample())
10
11
12 class Customer(sim.Component):
13     def process(self):
14         self.enter(waitingline)
15         if clerk.ispassive():
16             clerk.activate()
17         yield self.passivate()
18
19
20 class Clerk(sim.Component):
21     def process(self):
22         while True:
23             while len(waitingline) == 0:
24                 yield self.passivate()
25             self.customer = waitingline.pop()
26             yield self.hold(30)
27             self.customer.activate()
28
29
30 env = sim.Environment(trace=True)
31
32 CustomerGenerator()
33 clerk = Clerk()
34 waitingline = sim.Queue("waitingline")
35
36 env.run(till=50)
37 print()
38 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
-----	-----	-----	-----	-----	-----
30				line numbers refers to	Example - bank, 1 clerk.py
30				default environment initialize	
30	0.000	main		main create	
32				current	
32				customergenerator create	
33				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
9                                     customergenerator hold      scheduled for      40.071 @      13 process=process
13      40.071 customer.4             current                  scheduled for      54.737 @      9+
14                                     customer.4             enter waitingline
17      50.000 main                    customer.4 passivate
36+                                     current

Statistics of waitingline at          50

-----
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

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 not 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 reneging, 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.

## 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 is essentially the same as scheduling for `time=inf`.

- If the component to be passivated is current, the component becomes passive. Always use `yield self.passivate()` in 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.

Instead of checking for all of number of resources, it is also possible to check for any of a number of resources, by setting the oneof parameter to True.

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 add 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`.

### 3.3 Using priority and urgent to control order of execution

All process interaction methods supports a priority and urgent parameter:

With priority it is possible to sort a component before or after other components, scheduled for the same time. Note that the urgent parameters only applies to components scheduled with the same time and same priority.

The priority is 0 by default.

This is particularly useful for race conditions. It is possible to change the priority of a component by cancelling it prior to activating it with another priority.

The priority can be accessed with the new `Component.scheduled_priority()` method.

## COMPONENTGENERATOR

With ComponentGenerator components can be generated according to a given inter arrival time (distribution) or a random spread over a given interval.

### Examples

```
sim.ComponentGenerator(Car, iat=sim.Exponential(2))  
# generates Cars according to a Poisson arrival  
  
sim.ComponentGenerator(Car, iat=sim.Exponential(2), at=10, till=30, number=10)  
# generates maximum 10 Cars according to a Poisson arrival from t=10 to t=30  
  
sim.ComponentGenerator(Car, iat=sim.Exponential(2), at=10, till=30, number=10, force_at=True)  
# generates maximum 10 Cars according to a Poisson arrival from t=10 to t=30, first arrival at t=10  
  
sim.ComponentGenerator(sim.Pdf((Car, 0.7, Bus, 0.3)), iat=sim.Uniform(20,40), number=20)  
# generates maximum 20 vehicles (70% Car, 30% Bus) according to a uniform inter arrival time  
  
sim.ComponentGenerator(Car, duration=100, n=20)  
# generates exactly 20 Cars, random spread over t=now and t=now+100
```

ComponentGenerator is a subclass of Component and therefore has all the normal properties and methods of an ordinary component, although it is not recommended to use any the process methods, apart from cancel.



**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 be 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(c1)	q.add_in_front_of(c, c1)	c enters q in front of c1
c.enter_behind(c1)	q.add_behind(c, c1)	c enters q behind c1
c.enter_sorted(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.queuees()		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
```



## 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
```

AResources 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

Claimed quantity of clerk	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	
	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	
Occupancy of clerks	95% percentile	3	3	
	maximum	3	3	
	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  $\leq 0$ .

## 6.1 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 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 %)
8 FUEL_TANK_SIZE = 50.0 # liters

```

```
9  # Min/max levels of fuel tanks (in liters)
10 FUEL_TANK_LEVEL = sim.Uniform(5, 25)
11 REFUELING_SPEED = 2.0 # liters / second
12 TANK_TRUCK_TIME = 300.0 # Seconds it takes the tank truck to arrive
13 T_INTER = sim.Uniform(10, 100) # Create a car every [min, max] seconds
14 SIM_TIME = 200000 # Simulation time in seconds
15
16
17 class Car(sim.Component):
18     """
19     A car arrives at the gas station for refueling.
20
21     It requests one of the gas station's fuel pumps and tries to get the
22     desired amount of gas from it. If the stations reservoir is
23     depleted, the car has to wait for the tank truck to arrive.
24
25     """
26
27     def process(self):
28         fuel_tank_level = int(FUEL_TANK_LEVEL.sample())
29         yield self.request(gas_station)
30         liters_required = FUEL_TANK_SIZE - fuel_tank_level
31         if (fuel_pump.available_quantity() - liters_required) / fuel_pump.capacity() * 100 < THRESHOLD:
32             TankTruck()
33         yield self.get((fuel_pump, liters_required))
34         yield self.hold(liters_required / REFUELING_SPEED)
35
36
37 class TankTruck(sim.Component):
38     def process(self):
39         yield self.hold(TANK_TRUCK_TIME)
40         amount = fuel_pump.claimed_quantity()
41         yield self.put((fuel_pump, amount))
42
43
44 class CarGenerator(sim.Component):
45     """
46     Generate new cars that arrive at the gas station.
47     """
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)
```





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`

## 7.1 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:

### 7.1.1 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 as 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'), engine_running, all=True) # honored as soon as light is green AND engine is running
```

### 7.1.2 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
```

### 7.1.3 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 under test
- state under test

E.g.:

```
yield self.wait((light, lambda x, component, state x in ('green', 'yellow'))
    # x is light.get()
yield self.wait((level, lambda x, _: x >= 30))
    # x is level.get(), other two parameters are 'dummied'
```

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

```
def levelreached(value, component, state):
    return value < component.limit

...

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

### 7.1.4 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.

## 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 or the 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.

### 8.1 Non level monitor

Non level monitors collects values which do not reflect 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 enabled 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 output 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%) ***
```

## 8.2 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 preferred.

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 enabled 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      *****
```

## 8.3 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.

## 8.4 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.

## 8.5 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")
```

## 8.6 Pickling a monitor

Monitor.freeze() returns a ‘frozen’ monitor that can be used to store the results not depending on the current environment.

This is particularly useful for pickling a monitor.

E.g. use



```
with open("mon.pickle", "wb") as f:
    pickle.dump(f, mon.freeze())
```

to save the monitor mon, and

```
with open("mon.pickle", "rb") as f:
    mon_retrieved = pickle.load(f)
```

to retrieve the monitor, later.

Both level and non level monitors are supported. Frozen monitors get the name of the original monitor padded with ‘.frozen’ unless specified differently.



## DISTRIBUTIONS

## 9.1 Introduction

Salabim can be used with the standard random module, but it is usually 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)())
```

Furthermore, all time related parameters of component methods accept the distribution itself instead of a float (from a sample). That means that in the above setup, we can also say

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

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

## 9.2 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 `_Expression`, 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
```

## 9.3 Bounded sampling

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

This is 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 also possible to use the `bounded_sample()` method, with similar functionality. However, the `Bounded` class is preferred.

## 9.4 Use of time units in a distribution specification

All distributions apart from `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.

## 9.5 Available distributions

### 9.5.1 Beta

Beta distribution with a given

- alpha (shape)
- beta (shape)

E.g.

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

### 9.5.2 Constant

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

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

### 9.5.3 Erlang

Erlang distribution with a given

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

E.g.

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

### 9.5.4 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
```

### 9.5.5 Gamma

Gamma distribution with given

- shape ( $k$ )
- scale ( $\theta$ ) or rate ( $\beta$ )

E.g.

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

### 9.5.6 IntUniform

Integer uniform distribution between a given

- lowerbound
- upperbound (inclusive)

E.g.

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

### 9.5.7 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 be 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.

### 9.5.8 Poisson

Poisson distribution with a given lambda

E.g.

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

### 9.5.9 Triangular

Triangular distribution with a given

- lowerbound
- upperbound
- median

E.g.

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

### 9.5.10 Uniform

Uniform distribution between a given

- lowerbound
- upperbound

E.g.



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

### 9.5.11 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
```

### 9.5.12 Cdf

Cumulative distribution function, specified as a list or tuple with  $x[i], p[i]$  values, where  $p[i]$  is the cumulative probability that  $x \leq p_n$ . 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  $p[i] \leq p[i+1]$  and that  $x[i] \leq x[i+1]$ .

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))
```

### 9.5.13 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" !
```

### 9.5.14 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  $p[i] \leq p[i+1]$ .

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  $p[i]$ '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.

### 9.5.15 External

The External distribution makes it possible to use a distribution from the modules

- random
- numpy.random
- scipy.stats

as were it a salabim distribution.

The class takes at least one parameter (dis) that specifies the distribution to use, like

- random.uniform
- numpy.random.uniform
- scipy.stats.uniform

Next, all positional and keyword parameters are used for sampling. In case of random and numpy.random by calling the method itself, in case of a scipy.stats distribution by calling rvs().

Examples

```
d = sim.External(random.lognormvariate, mu=5, sigma=1)
d = sim.External(numpy.random.laplace, loc=5, scale=1)
d = sim.External(SciPy.beta, a=1, loc=4, scale=1)
```

Then sampling with

```
d.sample()
```

or

```
d()
```

If the size is given (only for numpy.random and scipy.stats distributions), salabim will return the sampled values successively. This can be useful to increase performance.

The mean() method returns the proper mean for scipy.stats distributions, nan otherwise.

If a time\_unit parameter is given, the sampled values will be multiplied by the applicable factor, e.g.

```
env = sim.Environment(time_unit='seconds')
d = sim.External(SciPy.norm, loc=2, time_unit='minutes')
print(d.mean())
```

will print out

```
120
```

### 9.5.16 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('experiment.txt', 'r') as f:
    interarrivaltime = sim.Distribution(read(f))
    processingtime = sim.Distribution(read(f))
    numberofparcels = sim.Distribution(read(f))
    delay = sim.Distribution(read(f))
```

With a file experiment.txt

```
Uniform(10, 15)
Triangular(1, 5, 2, time_unit='minutes')
IntUniform(10, 20)
External(random.uniform, 2, 6)
```

or with abbreviation

```
Uni(10,15)
Tri(1, 5, 2, time_unit='minutes')
Int(10, 20)
Extern(random.uniform, 2, 6)
```

or even

```
U(10, 15)
T(1, 5, 2, time_unit='minutes')
I(10, 20)
Ext(random.uniform, 2, 6)
```

The specification of `sim.Distribution` also accepts a `time_unit` parameter. Note that if the specification string contains a `time_unit` parameter as well, the `time_unit` parameter of `Distribution` is ignored, e.g.

```
d = sim.Distribution('uniform(1, 2)', time_unit='minutes') # 1-2 minutes
d = sim.Distribution('uniform(1, 2, time_unit='hours')') # 1-2 hours, same as before
d = sim.Distribution('uniform(1, 2, time_unit='hours')', time_unit='minutes') # 1-2 hours, ignore minutes
```

### 9.5.17 Map

With the `Map` distribution is it possible to the sampled values of a distribution to a given function. E.g.

```
round_normal = sim.Map(sim.Normal(10, 4), lambda x: round(x))
```

or, equivalently

```
round_normal = sim.Map(sim.Normal(10, 4), round)
```

The sampled values from the normal distribution will be rounded in either case.

Another example

```
positive_normal = sim.Map(sim.Normal(10, 4), lambda x: x if x > 0 else 0)
```

In this case, negative sampled values will be set to zero, positive values are not affected.

Note that this is different from

```
sim.Bounded(sim.Normal(10, 4), lowerbound=0)
```

as in the latter case resampling will be done when a negative value is sampled, in other words, virtually no zero samples.

## MISCELLANEOUS

## 10.1 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.

## 10.2 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 distribution keep the time unit information and therefore salabim is able to present information on the distribution in pretty format: So

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

will print

```
Uniform distribution 0x2bfb4d14c50
  lowerbound=10 minutes
  upperbound=20 minutes
  randomstream=0x2bfb2cc0c78
Normal distribution 0x2bfb42ce630
  mean=2 hours
  standard_deviation=0.1 hours
  coefficient_of_variation=0.05
  randomstream=0x2bfb2cc0c78
```

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()
```

## 10.3 Usage of the the trace facility

### 10.3.1 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)`.

It is also possible to direct the trace output to file, by using

```
with open('output.txt', 'w') as out:
    env = sim.Environment(trace=out)
```

or

```
out = open('output.txt', 'w')
env.trace(out)
...
out.close()
```

### 10.3.2 Interpretation of the trace

A trace output looks like

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

### 10.3.3 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.

### 10.3.4 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.

### 10.3.5 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.

### 10.3.6 Adding lines to the trace output

A model can add additional information to the trace with the `Environment.print_trace()` method. This method accepts up to five parameters to be shown 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.

### 10.3.7 Redirecting trace output

Normally, all trace output is written to stdout.

However, if the trace parameter of `Environment()` or `Environment.trace()` is a file handle (open for write), then the trace output will go to the specified file. Note that it is required to close the file handle at the end, so a context manager ('with') is recommended. Example

```
with open('output.txt', 'w') as out:
    env = sim.Environment(trace=out)
    ...
    env.run()
```

Alternatively, stdout can be set to a file, in which case ALL salabim output will be redirected. This can be done like

```
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
```

### 10.3.8 Suppressing line numbers in the trace

Particularly when the trace output is written to a file, it may be useful to suppress line numbers in the trace. This can result in dramatic (up to 50 times!) performance increase, because the calculation of line numbers is very demanding.

The method *Environment.suppress\_trace\_linenumbers()* can be used to disable/enable line number in the trace

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

By default, line numbers are not suppressed in the trace. The current status can be queried with

```
print(env.suppress_trace_linenumbers())
```

## 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\ana 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

This is a line

This is  
a polygon

This is a rectangle



#### 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.

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 is 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()
```

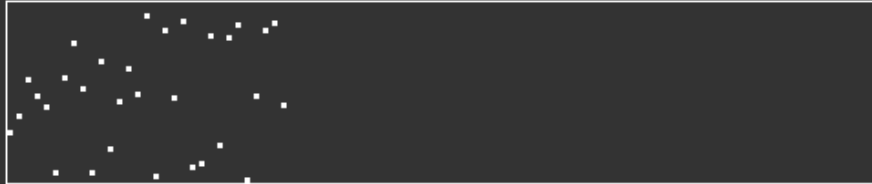
Here is snapshot of this powerful, dynamics (including the histogram!):

t=49.546

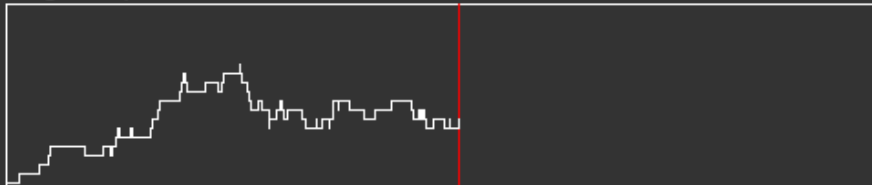
Menu

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

## 11.1 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()))
```

## 11.2 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  $t_0$  and  $t_1$ . If  $t_0$  is not specified, now() is assumed. If  $t_1$  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 and 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 preferred 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						•
<b>11.2. Class Animate</b>						<b>91</b>
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!

## 11.3 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	hotpink	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(sim.inf)
```

## 11.4 Ruuning animations on PyDroid3

In order to run animations on PyDroid3 platforms, it required that the main program imports tkinter

```
import tkinter
```

Note that it can't harm to include this import on non PyDroid3 platforms, apart from Pythonista, where tkinter is not available. In order to make a platform independent animation, you could use

```
if not sim.Pythonista:
    import tkinter
```

or

```
try:
    import tkinter
except ImportError:
    pass
```

## 11.5 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.

## 11.6 Video production and snapshots

An animation can be recorded as an .mp4 (not under PyDroid3) or .avi video by specifying `video=filename` in the call to `animation_parameters`, or issue `video(filename)`. The effect is that 30 times 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 or slower than real time. In contrast to an ordinary animation, frames are never skipped.

The video *has* to be closed explicitly with

```
env.video(False)
```

or it is possible to use a context manager to automatically close a video file, like:

```
with env.video('myvideo.mp4') :  
    ...  
    env.run(10)
```

This will automatically close the file myvideo.mp4 upon leaving the with block.

It is also possible to create an animated gif or animated png files by specifying a .gif or .png file. In that case, repeat and pingpong are additional options. Note that animated gif/png are considerable bigger than ordinary video files. So, try and limit the length to 10 seconds. Animated pngs may be written with a transparent background (alpha < 255).

Video production supports also the creation of a series of individual frames, in .jpg, .gif, .png, .tiff or .bmp format. In this case, the video name has to contain an asterisk (\*) which will be expanded at runtime to a 6 digit zero padded frame number, 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 and animated gif/png production are available on all platforms, including Pythonista.

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

## 11.7 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 be stopped by issuing `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](http://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.



## 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
```

## 13.1 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, al-
    pha0=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, an-
    gle1=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 when the parent component is no longer accessible
- **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 new 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 containing 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 new 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 containing 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 containing 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, fill\_color0=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, fill\_color1=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 new c e sw s se If null string, the given coordinates 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 containing 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 new c esw 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 containing 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** (*colourspec*) – color of interior/text at time t1 (default fillcolor0)
- **linecolor1** (*colourspec*) – 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** (*colourspec*) – color of the interior (foreground\_color)
- **linecolor** (*colourspec*) – color of contour (default foreground\_color)
- **color** (*colourspec*) – 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 new 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, off-  
                             setx=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 new c e sw s se If null string, the given coordinates 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** (*colourspec*) – 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; specifies where to texts relative to the polygon point possible values are (default: c): nw n new c e sw s se
- **textcolor** (*colourspec*) – 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 when the parent component is no longer accessible

---

**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** (*colourspec*) – color of the entry background (default foreground\_color)
- **color** (*colourspec*) – 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 new 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 assignment, 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 new c e sw s se If null string, the given coordinates are used untranslated
- **anchor** (*str*) – specifies where the x and refer to possible values are (default: sw) : nw n new 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)
- **width** (*float*) – width of the image (default: None = no scaling)
- **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 textnl specifies where to texts relative to the polygon point possible values are (default: c): nw n new  
c e sw s se
- **textcolor** (*colourspec*) – 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 when the parent component is no longer accessible

---

**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 new c e sw s se If null string, the given coordinates 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 specifies where to texts relative to the polygon point possible values are (default: c): nw n new 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 when the parent component is no longer accessible

---

**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, offsetx=0, offsety=0, angle=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** (*colourspec*) – color of the line or points (default foreground color)
- **linewidth** (*int*) – width of the line or points (default 1 for level, 3 for non level monitors)
- **fillcolor** (*colourspec*) – color of the panel (default transparent)
- **bordercolor** (*colourspec*) – color of the border (default foreground color)
- **borderlinewidth** (*int*) – width of the line around the panel (default 1)
- **nowcolor** (*colourspec*) – color of the line indicating now (default red)
- **titlecolor** (*colourspec*) – 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
- **offsetx** (*float*) – offsets the x-coordinate of the panel (default 0)
- **offsety** (*float*) – offsets the y-coordinate of the panel (default 0)
- **angle** (*float*) – rotation angle in degrees, default 0
- **xy\_anchor** (*str*) – specifies where x and y are relative to possible values are (default: sw): nw n new 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  $\text{vertical\_offset} + x * \text{vertical\_scale}$  (default 5)
- **horizontal\_scale** (*float*) – the relative horizontal position of time  $t$  within the panel is on  $t * \text{horizontal\_scale}$ , possibly shifted (default 1)
- **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 when the parent component is no longer accessible

---

**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  $x_0, y_0, x_1, y_1, \dots$
- **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 new c e sw s se If null string, the given coordinates 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** (*colourspec*) – 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; specifies where to texts relative to the polygon point possible values are (default: c): nw n new c e sw s se
- **textcolor** (*colorespec*) – 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 when the parent component is no longer accessible

---

**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 new c e sw s se If null string, the given coordinates 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 specifies where to texts relative to the polygon point possible values are (default: c): nw n new 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 when the parent component is no longer accessible

---

**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', titlefont-size=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 northwards (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 new 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 overridden, 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 when the parent component is no longer accessible

---

**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

---

**queue()**

**Returns** the queue this object refers to. Can be useful in `Component.animation_objects`

**Return type** *queue*

**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 new c e sw s se If null string, the given coordinates 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 textInl specifies where to texts relative to the rectangle point possible values are (default: c): nw n ne w c esw s se
- **textcolor** (*colorespec*) – 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 when the parent component is no longer accessible

---

**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 new 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 attribute 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 new 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 textnl specifies where to texts relative to the rectangle point possible values are (default: c): nw n new 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 when the parent component is no longer accessible

---

**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

---

## 13.2 Component

**class** `salabim.Component` (*name=None, at=None, delay=None, priority=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 ends 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 or distribution*) – schedule time if omitted, now is used if distribution, the distribution is sampled
- **delay** (*float or distribution*) – schedule with a delay if omitted, no delay if distribution, the distribution is sampled
- **priority** (*float*) – priority default: 0 if a component has the same time on the event list, this component is sorted according to the priority.
- **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 and priority
- **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.
- **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, priority=0, urgent=False, process=None, keep\_request=False, keep\_wait=False, mode=None, \*\*kwargs*)

activate component

### Parameters

- **at** (*float or distribution*) – schedule time if omitted, now is used if distribution, the distribution is sampled

- **delay** (*float or distribution*) – schedule with a delay if omitted, no delay if distribution, the distribution is sampled
- **priority** (*float*) – priority default: 0 if a component has the same time on the event list, this component is sorted according to the priority.
- **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 and priority
- **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 containing

---

**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** (*Resource*) – 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, priority=0, urgent=False, mode=None*)

hold the component

**Parameters**

- **duration** (*float or distribution*) – specifies the duration if omitted, 0 is used inf is allowed if distribution, the distribution is sampled
- **till** (*float or distribution*) – specifies at what time the component will become current if omitted, now is used inf is allowed if distribution, the distribution is sampled
- **priority** (*float*) – priority default: 0 if a component has the same time on the event list, this component is sorted according to the priority.
- **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 and priority

- **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

**isbumped** (*resource=None*)

check whether component is bumped from resource

**Parameters** **resource** (*Resource*) – resource to be checked if omitted, checks whether component belongs to any resource claimers

**Returns** **True if this component is not in the resource claimers** – False otherwise

**Return type** bool

**isclaiming** (*resource=None*)

check whether component is claiming from resource

**Parameters** **resource** (*Resource*) – resource to be checked if omitted, checks whether component is in any resource claimers

**Returns** **True if this component is in the resource claimers** – False otherwise

**Return type** bool

**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, priority=0, 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
- **priority** (*float*) – priority default: 0 if a component has the same time on the event list, this component is sorted accoring to the priority.
- **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 and priority

**Returns remaining duration** – if passive, remaining time at time of passivate if scheduled, remainig 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 or distribution*) – 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. if distribution, the distribution is sampled
- **fail\_delay** (*float or distribution*) – 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. if distribution, the distribution is sampled
- **oneof** (*bool*) – if oneof is True, just one of the requests has to be met (or condition), where honoring follows the order given. if oneof is False (default), all requests have to be met to be honored
- **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
yield self.request(r1, r2, r3, oneoff=True) -> requests 1 from r1, r2 or r3
```

**requested\_quantity** (*resource*)

**Parameters** **resource** (*Resource*) – 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, priority=0, 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.
- **priority** (*float*) – priority default: 0 if a component has the same time on the event list, this component is sorted accoring to the priority.

**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 and priority

---

**Note:** Can be only applied to interrupted components.

---

**running\_process()**

**Returns** name of the running process – if data component, None

**Return type** str

**scheduled\_priority()**

**Returns** priority the component is scheduled with – returns None otherwise

**Return type** float

---

**Note:** The method has to traverse the event list, so performance may be an issue.

---

**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 or distribution*) – 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. if distribution, the distribution is sampled
- **fail\_delay** (*float or distribution*) – 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. if distribution, the distribution is sampled
- **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, containing 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 be a 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
```

## 13.3 ComponentGenerator

```
class salabim.ComponentGenerator(component_class, name=None, at=None, delay=None, till=None, duration=None, number=None, iat=None,
                                force_at=False, force_till=False, suppress_trace=False, suppress_pause_at_step=False, env=None)
```

Component generator object

A component generator can be used to generate components. There are two ways of generating components: - according to a given inter arrival time (iat) value or distribution - random spread over a given time interval

### Parameters

- **component\_class** (*callable, usually a subclass of Component or Pdf or Cdf distribution*) – the type of components to be generated in case of a distribution, the Pdf or Cdf should return a subclass of Component
- **name** (*str*) – name of the component generator. if the name ends with a period (`.`), auto serializing will be applied if the name ends with a comma, auto serializing starting at 1 will be applied if omitted, the name will be derived from the name of the `component_class`, padded with `‘.generator’`
- **at** (*float or distribution*) – time where the generator starts time if omitted, now is used if distribution, the distribution is sampled

- **delay** (*float or distribution*) – delay where the generator starts (at = now + delay) if omitted, no delay if distribution, the distribution is sampled
- **till** (*float or distribution*) – time up to which components should be generated if omitted, no end if distribution, the distribution is sampled
- **duration** (*float or distribution*) – duration to which components should be generated (till = now + duration) if omitted, no end if distribution, the distribution is sampled
- **number** (*int or distribution*) – (maximum) number of components to be generated if distribution, the distribution is sampled
- **iat** (*float or distribution*) – inter arrival time (distribution). if None (default), a random spread over the interval (at, till) will be used
- **force\_at** (*bool*) –  
 for iat generation: if False (default), the first component will be generated at time = at + sample from the iat if True, the first component will be generated at time = at  
 for random spread generation: if False (default), no force for time = at if True, force the first generation at time = at
- **force\_till** (*bool*) – only possible for random spread generation: if False (default), no force for time = till if True, force the last generated component at time = till
- **suppress\_trace** (*bool*) – suppress\_trace indicator if True, the component generator events will be excluded from the trace If False (default), the component generator 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 generator becomes current, do not pause when stepping If False (default), the component generator will be paused when stepping Can be queried or set later with the suppress\_pause\_at\_step method.
- **env** (*Environment*) – environment where the component is defined if omitted, default\_env will be used

---

**Note:** For iat distributions: if till/duration and number are specified, the generation stops whichever condition comes first.

---

**print\_info** (*as\_str=False, file=None*)  
 prints information about the component generator

#### 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

## 13.4 Distributions

**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.Bounded (*dis, lowerbound=None, upperbound=None, fail\_value=None, number\_of\_retries=None, include\_lowerbound=None, include\_upperbound=None, time\_unit=None, env=None*)

**Parameters**

- **dis** (*distribution*) – distribution to be bounded
- **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.

- **time\_unit** (*str*) – specifies the time unit of the lowerbound or upperbound. It must be one of “years”, “weeks”, “days”, “hours”, “minutes”, “seconds”, “milliseconds”, “microseconds” default : no conversion

---

**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 to float (only possible with Pdf and CumPdf) are assumed to be within the bounds.

---

**mean()**

**Returns** Mean of the expression of bounded distribution – unless no bounds are specified, returns nan

**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

**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, *time\_unit*=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 separated 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*)
- **time\_unit** (*str*) – Supported time\_units: “years”, “weeks”, “days”, “hours”, “minutes”, “seconds”, “milliseconds”, “microseconds” if *spec* has a *time\_unit* as well, this parameter is ignored
- **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 distribution (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.**External** (*dis, \*args, \*\*kwargs*)  
External distribution function

This distribution allows distributions from other modules, notably random, numpy.random and scipy.stats to be used as were they salabim distributions.

**Parameters**

- **dis** (*external distribution*) – either
  - random.xxx
  - numpy.random.xxx
  - scipy.stats.xxx
- **\*args** (*any*) – positional arguments to be passed to the dis distribution
- **\*\*kwargs** (*any*) – keyword arguments to be passed to the dis distribution
- **time\_unit** (*str*) – specifies the time unit must be one of “years”, “weeks”, “days”, “hours”, “minutes”, “seconds”, “milliseconds”, “microseconds” default : no conversion
- **env** (*Environment*) – environment where the distribution is defined if omitted, default\_env will be used

**mean** ()

**Returns** mean of the distribution – only available for scipy.stats distribution. Otherwise 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** ()

**Returns** Sample of the distribution via external distribution method

**Return type** any (usually 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\_deviation* nor *coefficient\_of\_variation* is given, 0 is used, thus effectively a constant distribution must be  $\geq 0$
- **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  $\geq 0$
- **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.
- **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.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 ( $x_0, p_0, x_1, p_1, \dots, x_n, p_n$ )
  - if probabilities is specified: list with x-values
- **probabilities** (*list, tuple or float*) – if omitted, `spec` contains the probabilities the list ( $p_0, p_1, \dots, p_n$ ) 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:**  $p_0+p_1+\dots+p_n>0$  all densities are auto scaled according to the sum of  $p_0$  to  $p_n$ , so no need to have  $p_0$  to  $p_n$  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 distribution

**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  $\geq$  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)lnl 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

## 13.5 Environment

**class** salabim.**Environment** (*trace=False, random\_seed=None, set\_numpy\_random\_seed=True, time\_unit='n/a', name=None, print\_trace\_header=True, isdefault\_env=True, retina=False, do\_reset=None, \*args, \*\*kwargs*)  
environment object

### Parameters

- **trace** (*bool or file handle*) – defines whether to trace or not if this a file handle (open for write), the trace output will be sent to this file. 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 reproducible) 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” default: “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
- **set\_numpy\_random\_seed** (*bool*) – if True (default), numpy.random.seed() will be called with the given seed. This is particularly useful when using External distributions. If numpy is not installed, this parameter is ignored if False, numpy.random.seed is not called.

- **reset** (*bool*) – if True, reset the simulation environment if False, do not reset the simulation environment if None (default), reset the simulation environment when run under Pythonista, otherwise no reset\*

---

**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 reproducible, 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 action will be taken.

---

**animate\_debug** (*value=None*)

Animate debug

**Parameters** **value** (*bool*) – animate\_debug default: no change initially: False

**Returns** **animate\_debug**

**Return type** bool



**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, animate\_debug=None*)

set animation parameters

### 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** (*colourspec*) – color of the background if omitted, no change. At init of the environment, this will be set to white.
- **foreground\_color** (*colourspec*) – color of foreground (texts) if omitted and background\_color is specified, either white or 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.Tk(). 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 or .png an animated gif / png file will be written, unless there is a \* in the filename. If the extension is .gif, .jpg, .png, .bmp or .tiff and one \* appears in the filename, individual frames will be written with a six digit sequence at the place of the asteriks in 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, MJPG will be used for .avi files, otherwise .mp4v. Under PyDroid only .avi files are supported.
- **video\_repeat** (*int*) – number of times animated gif or png should be repeated. 0 means infinite. At init of the environment video\_repeat is 1. This only applies to gif and png 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 and png files production.
- **audio** (*str*) – name of file to be played (mp3 or wav files). If the none string, the audio will be stopped. Default: no change. For more information, see Environment.audio()

---

**Note:** The y-coordinate of the upper right corner is determined automatically in such a way that the x and y 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. Optionally, 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** (*value=None*)

Play audio during animation

**Parameters** **value** (*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** (*colourspec*) – new background\_color if not specified, no change

**Returns** **background\_color of animation**

**Return type** *colourspec*

**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 colourspecs

**Parameters**

- **t** (*float*) – value to be interpolated from
- **t0** (*float*) –  $f(t_0)=v_0$
- **t1** (*float*) –  $f(t_1)=v_1$
- **v0** (*colourspec*) –  $f(t_0)=v_0$
- **v1** (*colourspec*) –  $f(t_1)=v_1$

**Returns** **linear interpolation between v0 and v1 based on t between t0 and t**

**Return type** *colourspec*

---

**Note:** Note that no extrapolation is done, so if  $t < t_0 \implies v_0$  and  $t > t_1 \implies v_1$  This function is heavily used during animation

---

**colorspec\_to\_tuple** (*colorspec*)

translates a colorspec to a tuple

**Parameters** **colorspec** (*tuple, list or str*) –  $\#rrggbb \implies \alpha = 255$  (rr, gg, bb in hex)  $\#rrggbb\alpha \implies \alpha = \alpha$  (rr, gg, bb,  $\alpha$  in hex) *colorname*  $\implies \alpha = 255$  (*colorname*,  $\alpha$ ) (*r*, *g*, *b*)  $\implies \alpha = 255$  (*r*, *g*, *b*,  $\alpha$ ) "fg"  $\implies$  foreground\_color "bg"  $\implies$  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 or distribution*) – time in days if distribution, the distribution is sampled

**Returns** time in days, converted to the current time\_unit

**Return type** float

**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 or distribution*) – time in hours if distribution, the distribution is sampled

**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 or distribution*) – time in microseconds if distribution, the distribution is sampled

**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 or distribution*) – time in milliseconds if distribution, the distribution is sampled

**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 or distribution*) – time in minutes if distribution, the distribution is sampled

**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 or distribution*) – now will be set to new\_now default: 0 if distribution, the distribution is sampled

---

**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, priority=0, urgent=False*)

start execution of the simulation

**Parameters**

- **duration** (*float or distribution*) – schedule with a delay of duration if 0, now is used if distribution, the distribution is sampled
  - **till** (*float or distribution*) – schedule time if omitted, inf is assumed. See also note below if distribution, the distribution is sampled
  - **priority** (*float*) – priority default: 0 if a component has the same time on the event list, main is sorted accoring to the priority.
  - **urgent** (*bool*) – urgency indicator if False (default), main will be scheduled behind all other components scheduled with the same time and priority if True, main will be scheduled in front of all components scheduled for the same time and priority
- 

**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 explicitly.

---



**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 y coordinate to a user y 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 or distribution*) – time in seconds if distribution, the distribution is sampled

**Returns** time in seconds, 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\_linenumbers** (*value=None*)

indicates whether line numbers should be suppressed (False by default)

**Parameters** **value** (*bool*) – new suppress\_trace\_linenumbers status if omitted, no change

**Returns** suppress\_trace\_linenumbers status

**Return type** bool

---

**Note:** By default, `suppress_trace_linenumbers` is `False`, meaning that line numbers are shown in the trace. In order to improve performance, line numbers can be suppressed.

---

**`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** (*float or distribution*) – time to be converted if distribution, the distribution is sampled

**Returns** `Time t converted to days`

**Return type** `float`

**to\_hours** (*t*)

convert time *t* to hours

**Parameters** *t* (*float or distribution*) – time to be converted if distribution, the distribution is sampled

**Returns** Time *t* converted to hours

**Return type** float

**to\_microseconds** (*t*)

convert time *t* to microseconds

**Parameters** *t* (*float or distribution*) – time to be converted if distribution, the distribution is sampled

**Returns** Time *t* converted to microseconds

**Return type** float

**to\_milliseconds** (*t*)

convert time *t* to milliseconds

**Parameters** *t* (*float or distribution*) – time to be converted if distribution, the distribution is sampled

**Returns** Time *t* converted to milliseconds

**Return type** float

**to\_minutes** (*t*)

convert time *t* to minutes

**Parameters** *t* (*float or distribution*) – time to be converted if distribution, the distribution is sampled

**Returns** Time *t* converted to minutes

**Return type** float

**to\_seconds** (*t*)

convert time *t* to seconds

**Parameters** *t* (*float or distribution*) – time to be converted if distribution, the distribution is sampled

**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** (*float or distribution*) – time to be converted if distribution, the distribution is sampled

**Returns** Time **t** converted to the **time\_unit** specified**Return type** float**to\_weeks** (*t*)convert time **t** to weeks**Parameters** **t** (*float or distribution*) – time to be converted if distribution, the distribution is sampled**Returns** Time **t** converted to weeks**Return type** float**to\_years** (*t*)convert time **t** to years**Parameters** **t** (*float or distribution*) – time to be converted if distribution, the distribution is sampled**Returns** Time **t** converted to years**Return type** float**trace** (*value=None*)

trace status

**Parameters** **value** (*bool of file handle*) – new trace status defines whether to trace or not if this a file handle (open for write), the trace output will be sent to this file. if omitted, no change**Returns** trace status**Return type** bool or file handle

---

**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 or distribution*) – time in weeks if distribution, the distribution is sampled

**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 explicitly.

---

**years** (*t*)

convert the given time in years to the current time unit

**Parameters** **t** (*float or distribution*) – time in years if distribution, the distribution is sampled

**Returns** time in years, converted to the current time\_unit

**Return type** float

## 13.6 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 explicitly, 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). 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.h

if the end of file is reached, EOFError is raised

## 13.7 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  $\geq 0 \leq 255$  1 byte
- **”int8”** integer  $\geq -128 \leq 127$  1 byte
- **”uint8”** integer  $\geq 0 \leq 255$  1 byte
- **”int16”** integer  $\geq -32768 \leq 32767$  2 bytes
- **”uint16”** integer  $\geq 0 \leq 65535$  2 bytes
- **”int32”** integer  $\geq -2147483648 \leq 2147483647$  4 bytes

- "uint32" integer  $\geq 0 \leq 4294967295$  4 bytes
- "int64" integer  $\geq -9223372036854775808 \leq 9223372036854775807$  8 bytes
- "uint64" integer  $\geq 0 \leq 18446744073709551615$  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 level, 3 for non level monitors)
- **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
- **offsetx** (*float*) – offsets the x-coordinate of the panel (default 0)
- **offsety** (*float*) – offsets the y-coordinate of the panel (default 0)
- **angle** (*float*) – rotation angle in degrees, default 0

- **xy\_anchor** (*str*) – specifies where x and y are relative to possible values are (default: sw): nw n new c e sw s se
- **vertical\_offset** (*float*) –  
the vertical position of x within the panel is  $\text{vertical\_offset} + x * \text{vertical\_scale}$  (default 0)
- **vertical\_scale** (*float*) – the vertical position of x within the panel is  $\text{vertical\_offset} + x * \text{vertical\_scale}$  (default 5)
- **horizontal\_scale** (*float*) – for timescaled monitors the relative horizontal position of time t within the panel is on  $t * \text{horizontal\_scale}$ , possibly shifted (default 1)|n| for non timescaled monitors, the relative horizontal position of index i within the panel is on  $i * \text{horizontal\_scale}$ , 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  $>\text{lowerbound}$  and  $\leq \text{upperbound}$

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 duration of zero entries

**Returns** `total duration of zero entries`

**Return type** `float`

---

**Note:** Not available for non level monitors

---

**freeze** (*name=None*)

freezes this monitor (particularly useful for pickling)

**Parameters** `name` (*str*) – name of the frozen monitor default: name of this monitor + “.frozen”

**Returns** `frozen monitor`

**Return type** *Monitor*

## Notes

The env attribute will become a partial copy of the original environment, with the name of the original environment, padded with ‘.copy.<serial number>’

**get** (*t=None*)

get the value of a level 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. Only available for level monitors

---

**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:** If weights 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 weights are applied, the weighted median is returned

---

**merge** (*\*monitors, \*\*kwargs*)

merges this monitor with other monitors

**Parameters**

- **monitors** (*sequence*) – zero or 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

---

**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 suppressed
- **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 suppressed
- **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 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 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 indicates the slice period start (modulo modulo)
- **stop** (*float*) – if modulo is not given, the end of the slice if modulo is given, this 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:** If weights are applied, the weighted standard deviation is returned

---

**t**

get the time of last tally of a level monitor

**Getter** gets the time of the last tallied value : 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

---

## 13.8 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 northwards (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 new 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 overridden, 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 occurrences 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.

**Returns**

**Return type** None

---

**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  $\geq 0$  and  $\leq \text{len}(\text{self})$
- **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, elements 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`

---

## 13.9 Resource

**class** `salabim.Resource` (*name=None*, *capacity=1*, *anonymous=False*, *preemptive=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 resource 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*

**ispreemptive** ()

**Returns** True if preemptive, False otherwise

**Return type** bool

**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 timestamped 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 resource

---

**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

## 13.10 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  $\geq 0 \leq 254$  1 byte do not use 255
  - “int8” integer  $\geq -127 \leq 127$  1 byte do not use -128
  - “uint8” integer  $\geq 0 \leq 254$  1 byte do not use 255
  - “int16” integer  $\geq -32767 \leq 32767$  2 bytes do not use -32768
  - “uint16” integer  $\geq 0 \leq 65534$  2 bytes do not use 65535
  - “int32” integer  $\geq -2147483647 \leq 2147483647$  4 bytes do not use -2147483648
  - “uint32” integer  $\geq 0 \leq 4294967294$  4 bytes do not use 4294967295
  - “int64” integer  $\geq -9223372036854775807 \leq 9223372036854775807$  8 bytes do not use -9223372036854775808
  - “uint64” integer  $\geq 0 \leq 18446744073709551614$  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 objects

**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*

## 13.11 Miscellaneous

**salabim.arrow\_polygon** (*size*)

creates a polygon tuple with a centered 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*) –  $f(t_0)=v_0$
- **t1** (*float*) –  $f(t_1)=v_1$
- **v0** (*float, list or tuple*) –  $f(t_0)=v_0$
- **v1** (*float, list or tuple*) –  $f(t_1)=v_1$  if list or tuple,  $\text{len}(v_0)$  should equal  $\text{len}(v_1)$

**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  $t < t_0 \implies v_0$  and  $t > t_1 \implies v_1$ . This function is heavily used during animation.

---

`salabim.random_seed(seed=None, randomstream=None, set_numpy_random_seed=True)`

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 reproducible) if the null string, no action on random is taken if None (the default), 1234567 will be used.
- **set\_numpy\_random\_seed** (*bool*) – if True (default), `numpy.random.seed()` will be called with the given seed. This is particularly useful when using External distributions. If numpy is not installed, this parameter is ignored if False, `numpy.random.seed` is not called.
- **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  $\geq 3$  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*

## 14.1 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 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 his 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. Practically the full functionality is thus available under iOS as well.

## 14.2 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.

## 14.3 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.

## 14.4 Support

Ruud van der Ham is able and willing to help users with issues with the package and 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](mailto:ruud@salabim.org).

## 14.5 License

The MIT License (MIT)

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