Package ‘simmer’

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**simmer-package**  

**simmer**: Discrete-Event Simulation for R

---

**Description**

A process-oriented and trajectory-based Discrete-Event Simulation (DES) package for R. Designed to be a generic framework like SimPy or SimJulia, it leverages the power of Rcpp to boost the performance and turning DES in R feasible. As a noteworthy characteristic, simmer exploits the concept of trajectory: a common path in the simulation model for entities of the same type. It is pretty flexible and simple to use, and leverages the chaining/piping workflow introduced by the magrittr package.

**Author(s)**

Iñaki Ucar and Bart Smeets

**References**


**See Also**


**Examples**

```r
## not run:
# introduction to simmer
vignette("simmer-01-introduction")

# JSS paper available as vignette
vignette("simmer-02-jss")

# more vignettes
vignette(package = "simmer")

## End(Not run)
```
activate  

Activate/Deactivate Sources

Description

Activities for activating or deactivating the generation of arrivals by name.

Usage

activate(.trj, source)

deactivate(.trj, source)

Arguments

.trj  the trajectory object.

source  the name of the source or a function returning a name.

Value

Returns the trajectory object.

See Also

set_trajectory, set_source.

add_dataframe  

Add a Data Frame

Description

Attach a new source of arrivals to a trajectory from a data frame.

Usage

add_dataframe(.env, name_prefix, trajectory, data, mon = 1, batch = 50,  
col_time = "time", time = c("interarrival", "absolute"),  
col_attributes = NULL, col_priority = "priority",  
col_preemptible = col_priority, col_restart = "restart")
Arguments

.env the simulation environment.
name_prefix the name prefix of the generated arrivals.
trajectory the trajectory that the generated arrivals will follow (see trajectory).
data a data frame with, at least, a column of (inter)arrival times (see details).
mon whether the simulator must monitor the generated arrivals or not (0 = no monitoring, 1 = simple arrival monitoring, 2 = level 1 + arrival attribute monitoring)
batch number of arrivals generated at a time. Arrivals are read from the data frame and attached to the trajectory in batches depending on this value. In general, it should not be changed.
col_time name of the time column in the data frame.
time type of time column: interarrival, if the time column contains interarrival times, or absolute, if the time column contains absolute arrival times.
col_attributes vector of names of the attributes columns (see details).
col_priority name of the priority column.
col_preemptible name of the preemptible column.
col_restart name of the restart column.

Details

The data frame provided must have, at least, a column of (inter)arrival times. This method will look for it under the name "time" by default, although this can be changed with the col_time parameter.

If there is any column named col_priority="priority", col_preemptible=priority or col_restart="restart", they will be used to set the prioritization values for each arrival (see add_generator).

If there are additional columns (with col_attributes=NULL, by default), they will be assigned to arrival attributes named after each column name. All these columns must be numeric (or logical). Otherwise, if a vector of column names is specified, only these will be assigned as attributes and the rest of the columns will be ignored.

A value of batch=Inf means that the whole data frame will be attached at the beginning of the simulation. This is not desirable in general, because the performance of the event queue is degraded when it is populated with too many events. On the other hand, a low value results in an increased overhead due to many function calls. The default value has been tested to provide a good trade-off.

Value

Returns the simulation environment.

See Also

Other sources: add_generator.
add_generator | Add a Generator

Description

Attach a new source of arrivals to a trajectory from a generator function.

Usage

```r
add_generator(.env, name_prefix, trajectory, distribution, mon = 1,
priority = 0, preemptible = priority, restart = FALSE)
```

Arguments

- `.env` the simulation environment.
- `name_prefix` the name prefix of the generated arrivals.
- `trajectory` the trajectory that the generated arrivals will follow (see `trajectory`).
- `distribution` a function modelling the interarrival times (returning a negative value stops the generator).
- `mon` whether the simulator must monitor the generated arrivals or not (0 = no monitoring, 1 = simple arrival monitoring, 2 = level 1 + arrival attribute monitoring)
- `priority` the priority of each arrival (a higher integer equals higher priority; defaults to the minimum priority, which is 0).
- `preemptible` if a seize occurs in a preemptive resource, this parameter establishes the minimum incoming priority that can preempt these arrivals (an arrival with a priority greater than `preemptible` gains the resource). In any case, `preemptible` must be equal or greater than `priority`, and thus only higher priority arrivals can trigger preemption.
- `restart` whether the activity must be restarted after being preempted.

Value

Returns the simulation environment.

See Also

- Convenience functions: `at`, `from`, `to`, `from_to`
- Other sources: `add_dataframe`
add_global

Description

Attach a global variable to the simulation.

Usage

```
add_global(.env, key, value)
```

Arguments

- `.env` the simulation environment.
- `key` the attribute name.
- `value` the value to set, either a numeric or a `schedule`, so that the global may change during the simulation.

Value

Returns the simulation environment.

See Also

Convenience functions: `schedule`.

add_resource

Description

Define a new resource in a simulation environment.

Usage

```
add_resource(.env, name, capacity = 1, queue.size = Inf, mon = TRUE,
             preemptive = FALSE, preempt.order = c("fifo", "lifo"),
             queue.size.strict = FALSE)
```
Arguments

- env: the simulation environment.
- name: the name of the resource.
- capacity: the capacity of the server, either a numeric or a schedule, so that the value may change during the simulation.
- queue_size: the size of the queue, either a numeric or a schedule, so that the value may change during the simulation.
- mon: whether the simulator must monitor this resource or not.
- preemptive: whether arrivals in the server can be preempted or not based on seize priorities.
- preempt_order: if the resource is preemptive and preemption occurs with more than one arrival in the server, this parameter defines which arrival should be preempted first. It must be fifo (First In First Out: older preemptible tasks are preempted first) or lifo (Last In First Out: newer preemptible tasks are preempted first).
- queue_size_strict: if the resource is preemptive and preemption occurs, this parameter controls whether the queue_size is a hard limit. By default, preempted arrivals go to a dedicated queue, so that queue_size may be exceeded. If this option is TRUE, preempted arrivals go to the standard queue, and the maximum queue_size is guaranteed (rejection may occur).

Value

Returns the simulation environment.

See Also

Convenience functions: schedule.

---

batch

Batch/Separate Arrivals

Description

Activities for collecting a number of arrivals before they can continue processing and splitting a previously established batch.

Usage

```
batch(.trj, n, timeout = 0, permanent = FALSE, name = "", rule = NULL)
```

```
separate(.trj)
```
branch

Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>.trj</td>
<td>the trajectory object.</td>
</tr>
<tr>
<td>n</td>
<td>batch size, accepts a numeric.</td>
</tr>
<tr>
<td>timeout</td>
<td>set an optional timer which triggers batches every timeout time units even if the batch size has not been fulfilled, accepts a numeric or a callable object (a function) which must return a numeric (0 = disabled).</td>
</tr>
<tr>
<td>permanent</td>
<td>if TRUE, batches cannot be split.</td>
</tr>
<tr>
<td>name</td>
<td>optional string. Unnamed batches from different batch activities are independent. However, if you want to feed arrivals from different trajectories into a same batch, you need to specify a common name across all your batch activities.</td>
</tr>
<tr>
<td>rule</td>
<td>an optional callable object (a function) which will be applied to every arrival to determine whether it should be included into the batch, thus</td>
</tr>
</tbody>
</table>

Value

Returns the trajectory object.

branch

Fork the Trajectory Path

Description

Activity for defining a fork with N alternative sub-trajectories.

Usage

branch(.trj, option, continue, ...)

Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>.trj</td>
<td>the trajectory object.</td>
</tr>
<tr>
<td>option</td>
<td>a callable object (a function) which must return an integer between 0 and N. A return value equal to 0 skips the branch and continues to the next activity. A returning value between 1 to N makes the arrival to follow the corresponding sub-trajectory.</td>
</tr>
<tr>
<td>continue</td>
<td>a vector of N booleans that indicate whether the arrival must continue to the main trajectory after each sub-trajectory or not (if only one value is provided, it will be recycled to match the number of sub-trajectories).</td>
</tr>
<tr>
<td>...</td>
<td>N trajectory objects (or a list of N trajectory objects) describing each sub-trajectory.</td>
</tr>
</tbody>
</table>

Value

Returns the trajectory object.
**clone**  
*Clone/Synchronize Arrivals*

**Description**

Activities for defining a parallel fork and removing the copies. `clone` replicates an arrival \( n \) times (the original one + \( n-1 \) copies). `synchronize` removes all but one clone for each set of clones.

**Usage**

```r
clone(.trj, n, ...)
```

```r
synchronize(.trj, wait = TRUE, mon_all = FALSE)
```

**Arguments**

- `.trj` the trajectory object.
- `n` number of clones, accepts either a numeric or a callable object (a function) which must return a numeric.
- `...` a number of optional parallel sub-trajectories (or a list of sub-trajectories). Each clone will follow a different sub-trajectory if available.
- `wait` if FALSE, all clones but the first to arrive are removed. if TRUE (default), all clones but the last to arrive are removed.
- `mon_all` if TRUE, `get_mon_arrivals` will show one line per clone.

**Value**

Returns the trajectory object.

---

**Extract.trajectory**  
*Extract or Replace Parts of a Trajectory*

**Description**

Operators acting on trajectories to extract or replace parts.

**Usage**

```r
# S3 method for class 'trajectory'
x[i]
```

```r
# S3 method for class 'trajectory'
x[[i]]
```
## S3 replacement method for class 'trajectory'
x[i] <- value

## S3 replacement method for class 'trajectory'
x[[i]] <- value

### Arguments

- **x**: the trajectory object.
- **i**: indices specifying elements to extract. Indices are numeric or character or logical vectors or empty (missing) or NULL. Numeric values are coerced to integer as by `as.integer` (and hence truncated towards zero). Negative integers indicate elements/slices to leave out the selection.
- **value**: another trajectory object.

### Value

Returns a new trajectory object.

### See Also

- `length.trajectory`
- `get_n_activities`
- `join`

### Examples

```r
x <- join(lapply(1:12, function(i) trajectory() %>% timeout(i))

x

x[10] # the tenth element of x
x[-1] # delete the 1st element of x
x[c(TRUE, FALSE)] # logical indexing
x[c(1, 5, 2, 12, 4)] # numeric indexing
x[c(FALSE, TRUE)] <- x[c(TRUE, FALSE)] # replacing

x
```
Convenience Functions for Generators

Description

These convenience functions facilitate the definition of generators of arrivals for some common cases.

Usage

\[
\text{at}(\ldots)
\]

\[
\text{from}(\text{start\_time}, \text{dist}, \text{arrive} = \text{TRUE})
\]

\[
\text{to}(\text{stop\_time}, \text{dist})
\]

\[
\text{from\_to}(\text{start\_time}, \text{stop\_time}, \text{dist}, \text{arrive} = \text{TRUE}, \text{every} = \text{NULL})
\]

\[
\text{when\_activated}(n = 1)
\]

Arguments

\[
\ldots \quad \text{a vector or multiple parameters of times at which to initiate an arrival.}
\]

\[
\text{start\_time} \quad \text{the time at which to launch the initial arrival.}
\]

\[
\text{dist} \quad \text{a function modelling the interarrival times.}
\]

\[
\text{arrive} \quad \text{if set to TRUE (default) the first arrival will be generated at start\_time and will follow dist from then on. If set to FALSE, will initiate dist at start\_time (and the first arrival will most likely start at a time later than start\_time).}
\]

\[
\text{stop\_time} \quad \text{the time at which to stop the generator.}
\]

\[
\text{every} \quad \text{repeat with this time cycle.}
\]

\[
n \quad \text{number of arrivals to generate when activated.}
\]

Details

\text{at} \quad \text{generates arrivals at specific absolute times.}

\text{from} \quad \text{generates inter-arrivals following a given distribution with a specified start time. union of the last two.}

\text{to} \quad \text{generates inter-arrivals following a given distribution with a specified stop time.}

\text{from\_to} \quad \text{is the union of from and to.}

\text{when\_activated} \quad \text{sets up an initially inactive generator which generates n arrivals each time it is activated from any trajectory using the activity activate.}

Value

Returns a generator function (a closure).
See Also

add_generator.

Examples

```r
## common to all examples below
# some trajectory
t0 <- trajectory()
  timeout(0)
# some distribution
distr <- function() runif(1, 1, 2)

# arrivals at 0, 1, 10, 30, 40 and 43
simmer()
  add_generator("dummy", t0, at(0, c(1, 10, 30, 40, 43)))
  run(100)
  get_mon_arrivals()

# apply distribution starting at 5 (and no end)
simmer()
  add_generator("dummy", t0, from(5, distr))
  run(10)
  get_mon_arrivals()

# apply distribution until 5 (starting at 0)
simmer()
  add_generator("dummy", t0, to(5, distr))
  run(10)
  get_mon_arrivals()

# apply distribution from 8 to 16 h every 24 h:
simmer()
  add_generator("dummy", t0, from_to(8, 16, distr, every=24))
  run(48)
  get_mon_arrivals()

# triggering arrivals on demand from a trajectory
t1 <- trajectory()
  activate("dummy")
  simmer()
  add_generator("dummy", t0, when_activated())
  add_generator("trigger", t1, at(2))
  run()
  get_mon_arrivals()
```
Description
Getters for resources: server capacity/count and queue size/count.

Usage
get_capacity(.env, resources)
get_capacity_selected(.env, id = 0)
get_queue_size(.env, resources)
get_queue_size_selected(.env, id = 0)
get_server_count(.env, resources)
get_server_count_selected(.env, id = 0)
get_queue_count(.env, resources)
get_queue_count_selected(.env, id = 0)
get_selected(.env, id = 0)

Arguments
.env the simulation environment.
resources one or more resource names.
id selection identifier (a negative number causes the function to return the required parameter for all the selected resources).

Value
Return a vector (character for get_selected, numeric for the rest of them).

See Also
get_resources, set_capacity, set_queue_size.

get_mon Monitoring Statistics

Description
Getters for obtaining monitored data (if any) about arrivals, attributes and resources.
get_n_generated

Usage

get_mon_arrivals(NenvsL per_resource = FALSE, ongoing = FALSE)

get_mon_attributes(Nenvs)

get_mon_resources(.envs)

Arguments

.envs          the simulation environment (or a list of environments).
.per_resource  if TRUE, statistics will be reported on a per-resource basis.
.ongoing       if TRUE, ongoing arrivals will be reported. The columns end_time and finished
               of these arrivals are reported as NAs.

Value

Returns a data frame.

description

Getters for processes (sources and arrivals) number of arrivals generated by a source, the name of
the active arrival, an attribute from the active arrival or a global one, and prioritization values.

Usage

get_n_generated(.env, sources)

get_trajectory(.env, sources)

get_name(.env)

get_attribute(.env, keys)

get_global(.env, keys)

get_prioritization(.env)

Arguments

.env          the simulation environment.
.sources      one or more resource names.
.keys         the attribute name(s).
Details

get_n_generated returns the number of arrivals generated by the given sources. get_trajectory returns the trajectory to which they are attached (as a list).

get_name returns the number of the running arrival. get_attribute returns a running arrival’s attributes. If a provided key was not previously set, it returns a missing value. get_global returns a global attribute. get_prioritization returns a running arrival’s prioritization values. get_name, get_attribute and get_prioritization are meant to be used inside a trajectory; otherwise, there will be no arrival running and these functions will throw an error.

See Also

get_sources, set_trajectory, set_attribute, set_global, set_prioritization.

---

get_sources

Get Sources and Resources Defined

Description

Get a list of names of sources or resources defined in a simulation environment.

Usage

get_sources(.env)

get_resources(.env)

Arguments

.env the simulation environment.

Value

A character vector.

---

join

Join Trajectories

Description

Concatenate any number of trajectories in the specified order.

Usage

join(...)
Arguments

... trajectory objects.

Value

Returns a new trajectory object.

See Also

Extract.trajectory, length.trajectory, get_n_activities.

Examples

t1 <- trajectory() %>% seize("dummy", 1)
t2 <- trajectory() %>% timeout(1)
t3 <- trajectory() %>% release("dummy", 1)

## join can be used alone
join(t1, t2, t3)

## or can be chained in a trajectory definition
trajectory() %>%
  join(t1) %>%
  timeout(1) %>%
  join(t3)

---

leave Leave the Trajectory

Description

Activity for leaving the trajectory with some probability.

Usage

leave(.trj, prob)

Arguments

.trj the trajectory object.
prob a probability or a function returning a probability.

Value

Returns the trajectory object.
length.trajectory  \hspace{1cm} Number of Activities in a Trajectory

**Description**

Get the number of activities in a trajectory. `length` returns the number of first-level activities (sub-trajectories not included). `get_n_activities` returns the total number of activities (sub-trajectories included).

**Usage**

```r
## S3 method for class 'trajectory'
length(x)
get_n_activities(x)
```

**Arguments**

- `x` the trajectory object.

**Value**

Returns a non-negative integer of length 1.

**See Also**

`Extract.trajectory`, `join`.

**Examples**

```r
x <- trajectory() %>%
  timeout(1)

x <- x %>%
  clone(2, x, x)

x

## length does not account for subtrajectories
length(x)
get_n_activities(x)
```
### log

**Logging**

**Description**

Activity for displaying messages preceded by the simulation time and the name of the arrival.

**Usage**

```r
log_(.trj, message, level = 0)
```

**Arguments**

- `.trj`: the trajectory object.
- `message`: the message to display, accepts either a string or a callable object (a function) which must return a string.
- `level`: debugging level. The message will be printed if, and only if, the level provided is less or equal to the log_level defined in the simulation environment (see simmer).

**Value**

Returns the trajectory object.

### monitor

**Create a Monitor**

**Description**

Methods for creating monitor objects for simulation environments.

**Usage**

```r
monitor(name, xptr, get_arrivals, get_attributes, get_resources, handlers = NULL, finalize = function() { })

monitor_mem()

monitor_delim(path = tempdir(), keep = FALSE, sep = " ", ext = ".txt", reader = read.delim, args = list(stringsAsFactors = FALSE))

monitor_csv(path = tempdir(), keep = FALSE, reader = read.csv, args = list(stringsAsFactors = FALSE))
```
Arguments

name
an identifier to show when printed.

xptr
an external pointer pointing to a C++ object derived from the abstract class simmer::Monitor. See C++ API for further details and, in particular, the simmer/monitor.h header.

get_arrivals
a function to retrieve the arrivals tables. It must accept the xptr as a first argument, even if it is not needed, and a boolean per_resource as a second argument (see get_mon_arrivals).

get_attributes
a function to retrieve the attributes table. It must accept the xptr as a first argument, even if it is not needed.

get_resources
a function to retrieve the resources table. It must accept the xptr as a first argument, even if it is not needed.

handlers
an optional list of handlers that will be stored in a slot of the same name. For example, monitor_mem does not use this slot, but monitor_delim and monitor_csv store the path to the created files.

finalize
an optional function to be called when the object is destroyed. For example, monitor_mem does not require any finalizer, but monitor_delim and monitor_csv use this to remove the created files when the monitor is destroyed.

path
directory where files will be created (must exist).

keep
whether to keep files on exit. By default, files are removed.

sep
separator character.

ext
file extension to use.

reader
function that will be used to read the files.

args
a list of further arguments for reader.

Details

The monitor method is a generic function to instantiate a monitor object. It should not be used in general unless you want to extend simmer with a custom monitor.

The in-memory monitor is enabled by default (memory_mem), and it should be the fastest.

For large simulations, or if the RAM footprint is an issue, you may consider monitoring to disk. To that end, monitor_delim stores the values in flat delimited files. The usual get_mon_* methods retrieve data frames from such files using the reader provided. By default, read.delim is used, but you may consider using faster alternatives from other packages. It is also possible to keep the files in a custom directory to read and post-process them in a separate workflow.

monitor_csv is a special case of monitor_delim with sep=""," and ext=".csv".

Value

A monitor object.
Examples

```r
mon <- monitor_csv()
mon

env <- simmer(mon = mon) %>%
  add_generator("dummy", trajectory() %>% timeout(1), function() 1) %>%
  run(10)
env

read.csv(mon$handlers$arrivals) # direct access
get_mon_arrivals(env) # adds the "replication" column
```

Simulation Time

Description
Get the current simulation time.

Usage
```r
now(.env)
```

Arguments
.env the simulation environment.

Value
Returns a numeric value.

See Also
peek.

Peek Next Events

Description
Look for future events in the event queue and (optionally) obtain info about them.

Usage
```r
peek(.env, steps = 1, verbose = FALSE)
```
Arguments

.env the simulation environment.
.steps number of steps to peek.
.verbose show additional information (i.e., the name of the process) about future events.

Value

Returns numeric values if verbose=F and a data frame otherwise.

See Also

now.

renege_in

Renege on some Condition

Description

Activities for setting or unsetting a timer or a signal after which the arrival will abandon.

Usage

renege_in(.trj, t, out = NULL)
renege_if(.trj, signal, out = NULL)
renege_abort(.trj)

Arguments

.trj the trajectory object.
.t timeout to trigger reneging, accepts either a numeric or a callable object (a function) which must return a numeric.
.out optional sub-trajectory in case of reneging.
.signal signal to trigger reneging, accepts either a string or a callable object (a function) which must return a string.

Value

Returns the trajectory object.

See Also

send
reset  

Reset a Simulator

Description
Reset the following components of a simulation environment: time, event queue, resources, sources and statistics.

Usage
reset(.env)

Arguments
.env the simulation environment.

Value
Returns the simulation environment.

See Also
stepn, run.

rollback  

Rollback a Number of Activities

Description
Activity for going backwards to a previous point in the trajectory. Useful to implement loops.

Usage
rollback(.trj, amount, times = Inf, check = NULL)

Arguments
.trj the trajectory object.
amount the amount of activities (of the same or parent trajectories) to roll back.
times the number of repetitions until an arrival may continue.
check a callable object (a function) which must return a boolean. If present, the times parameter is ignored, and the activity uses this function to check whether the rollback must be done or not.

Value
Returns the trajectory object.
**run**  
*Run a Simulation*

**Description**
Execute steps until a given criterion.

**Usage**
```r
run(.env, until = Inf, progress = NULL, steps = 10)
stepn(.env, n = 1)
```

**Arguments**
- `.env`  
  the simulation environment.
- `until`  
  stop time.
- `progress`  
  optional callback to show the progress of the simulation. The completed ratio is periodically passed as argument to the callback.
- `steps`  
  number of steps to show as progress (it takes effect only if `progress` is provided).
- `n`  
  number of events to simulate.

**Value**
Returns the simulation environment.

**See Also**
- `reset`.

---

**schedule**  
*Generate a Scheduling Object*

**Description**
Resource convenience function to generate a scheduling object from a timetable specification.

**Usage**
```r
schedule(timetable, values, period = Inf)
```
Arguments

- **timetable**: absolute points in time in which the desired value changes.
- **values**: one value for each point in time.
- **period**: period of repetition.

Value

Returns a schedule object.

See Also

- `add_resource`.

Examples

```r
# Schedule 3 units from 8 to 16 h
# 2 units from 16 to 24 h
# 1 units from 24 to 8 h
capacity_schedule <- schedule(c(8L, 16L, 24L), c(3L, 2L, 1L), period=24L)

env <- simmer() %>%
  add_resource("dummy", capacity_schedule)
```

Seize/Release Resources

Description

Activities for seizing/releasing a resource, by name or a previously selected one.

Usage

- `seize(trj, resource, amount = 1L, continue = NULL, post.seize = NULL, reject = NULL)`
- `seize_selected(trj, amount = 1L, id = 0L, continue = NULL, post.seize = NULL, reject = NULL)`
- `release(trj, resource, amount = 1L)`
- `release_selected(trj, amount = 1L, id = 0L)`
Arguments

- **.trj**: the trajectory object.
- **resource**: the name of the resource.
- **amount**: the amount to seize/release, accepts either a numeric or a callable object (a function) which must return a numeric.
- **continue**: a boolean (if `post.seize` OR `reject` is defined) or a pair of booleans (if `post.seize` AND `reject` are defined; if only one value is provided, it will be recycled) to indicate whether these subtrajectories should continue to the next activity in the main trajectory.
- **post.seize**: an optional trajectory object which will be followed after a successful seize.
- **reject**: an optional trajectory object which will be followed if the arrival is rejected.
- **id**: selection identifier for nested usage.

Value

Returns the trajectory object.

See Also

`select`, `set_capacity`, `set_queue_size`, `set_capacity_selected`, `set_queue_size_selected`.

---

### select

<table>
<thead>
<tr>
<th>Select Resources</th>
</tr>
</thead>
</table>

**Description**

Activity for selecting a resource for a subsequent seize/release or setting its parameters (capacity or queue size).

**Usage**

```r
g select(.trj, resources, policy = c("shortest-queue", "shortest-queue-available", "round-robin", "round-robin-available", "first-available", "random", "random-available"), id = 0)
```

**Arguments**

- **.trj**: the trajectory object.
- **resources**: one or more resource names, or a callable object (a function) which must return one or more resource names.
- **policy**: if `resources` is a character vector, this parameter determines the criteria for selecting a resource among the set of policies available (see details).
- **id**: selection identifier for nested usage.
send

Details

The `shortest-queue` policy selects the least busy resource; `round-robin` selects resources in cyclic order; `first-available` selects the first resource available, and `random` selects a resource randomly.

All the `available`-ending policies (`first-available`, but also `shortest-queue-available`, `round-robin-available` and `random-available`) check for resource availability (i.e., whether the capacity is non-zero), and exclude from the selection procedure those resources with capacity set to zero. This means that, for these policies, an error will be raised if all resources are unavailable.

Value

Returns the trajectory object.

See Also

`seize_selected`, `release_selected`, `set_capacity_selected`, `set_queue_size_selected`.

---

send Inter-arrival Communication

Description

These activities enable asynchronous programming. `send()` broadcasts a signal or a list of signals. Arrivals can subscribe to signals and (optionally) assign a handler with `trap()`. Note that, while inside a batch, all the signals subscribed before entering the batch are ignored. Upon a signal reception, the arrival stops the current activity and executes the handler (if provided). Then, the execution returns to the activity following the point of the interruption. `untrap()` can be used to unsubscribe from signals. `wait()` blocks until a signal is received.

Usage

```plaintext
send(.trj, signals, delay = 0)

trap(.trj, signals, handler = NULL, interruptible = TRUE)

untrap(.trj, signals)

wait(.trj)
```

Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>.trj</td>
<td>the trajectory object.</td>
</tr>
<tr>
<td>signals</td>
<td>signal or list of signals, accepts either a string, a list of strings or a callable object (a function) which must return a string or a list of strings.</td>
</tr>
<tr>
<td>delay</td>
<td>optional timeout to trigger the signals, accepts either a numeric or a callable object (a function) which must return a numeric.</td>
</tr>
<tr>
<td>handler</td>
<td>optional trajectory object to handle a signal received.</td>
</tr>
<tr>
<td>interruptible</td>
<td>whether the handler can be interrupted by signals.</td>
</tr>
</tbody>
</table>
set_attribute

Returns the trajectory object.

See Also
renege_if

set_attribute  Set Attributes

Description
Activity for modifying an arrival’s attributes.

Usage

set_attribute(.trj, keys, values, mod = c(NA, "*", "*"), init = 0)
set_global(.trj, keys, values, mod = c(NA, "*", "*"), init = 0)

Arguments

.trj  the trajectory object.
keys  the attribute name(s), or a callable object (a function) which must return attribute name(s).
values  numeric value(s) to set, or a callable object (a function) which must return numeric value(s).
mod  if set, values modify the attributes rather than substituting them.
init  initial value, applied if mod is set and the attribute was not previously initialised. Useful for counters or indexes.

Value
Returns the trajectory object.

See Also
get_attribute, get_global, timeout_from_attribute, timeout_from_global.
set_capacity  

**Set Resource Parameters**

**Description**

Activities for modifying a resource’s server capacity or queue size, by name or a previously selected one.

**Usage**

```
set_capacity(.trj, resource, value, mod = c(NA, "+", "*"))
set_capacity_selected(.trj, value, id = 0, mod = c(NA, "+", "*"))
set_queue_size(.trj, resource, value, mod = c(NA, "+", "*"))
set_queue_size_selected(.trj, value, id = 0, mod = c(NA, "+", "*"))
```

**Arguments**

- `.trj` the trajectory object.
- `resource` the name of the resource.
- `value` new value to set.
- `mod` if set, values modify the attributes rather than substituting them.
- `id` selection identifier for nested usage.

**Value**

Returns the trajectory object.

**See Also**

`select, seize, release, seize_selected, release_selected, get_capacity, get_queue_size`.

---

set_prioritization  

**Set Prioritization Values**

**Description**

Activity for modifying an arrival’s prioritization values.

**Usage**

```
set_prioritization(.trj, values, mod = c(NA, "+", "*"))
```
Arguments

- `.trj` the trajectory object.
- `values` expects either a vector/list or a callable object (a function) returning a vector/list of three values `c(priority, preemptible, restart)`. A negative value leaves the corresponding parameter unchanged. See `add_generator` for more information about these parameters.
- `mod` if set, `values` modify the attributes rather than substituting them.

Value

Returns the trajectory object.

See Also

- `get_prioritization`.

---

`set_trajectory` Set Source Parameters

**Description**

Activities for modifying a source’s trajectory or source object by name.

**Usage**

```r
set_trajectory(.trj, source, trajectory)
```

```r
set_source(.trj, source, object)
```

**Arguments**

- `.trj` the trajectory object.
- `source` the name of the source or a function returning a name.
- `trajectory` the trajectory that the generated arrivals will follow.
- `object` a function modelling the interarrival times (if the source type is a generator; returning a negative value stops the generator) or a data frame (if the source type is a data source).

**Value**

Returns the trajectory object.

**See Also**

- `activate, deactivate`.
Create a Simulator

Description

This method initialises a simulation environment.

Usage

simmer(name = "anonymous", verbose = FALSE, mon = monitor_mem(),
        log_level = 0)

Arguments

- **name**: the name of the simulator.
- **verbose**: enable showing activity information.
- **mon**: monitor (in memory by default); see monitor for other options.
- **log_level**: debugging level (see log_).

Value

Returns a simulation environment.

See Also

Available methods by category:

- Simulation control: stepn, run, now, peek, reset
- Resources: add_resource, get_resources, get_capacity, get_queue_size, get_server_count,
  get_queue_count, get_capacity_selected, get_queue_size_selected, get_server_count_selected,
  get_queue_count_selected, get_selected
- Sources: add_generator, add_dataframe, get_sources, get_n_generated, get_trajectory
- Globals: add_global, get_global.
- Data retrieval: get_mon_arrivals, get_mon_attributes, get_mon_resources

Examples

```r
## a simple trajectory that prints a message
t0 <- trajectory("my trajectory") %>%
    log_("arrival generated")

## create an empty simulation environment
env <- simmer("SuperDuperSim")
env

## add a generator and attach it to the trajectory above
env %>% add_generator("dummy", t0, function() 1)
```
timeout

### Description

Activity for inserting delays and execute user-defined tasks.

### Usage

```r
timeout(.trj, task)
```

```r
timeout_from_attribute(.trj, key)
```

```r
timeout_from_global(.trj, key)
```

### Arguments

- **.trj**: the trajectory object.
- **task**: the timeout duration supplied by either passing a numeric or a callable object (a function) which must return a numeric (negative values are automatically coerced to positive).
- **key**: the attribute name, or a callable object (a function) which must return the attribute name.

### Value

Returns the trajectory object.

### See Also

- `set_attribute`
- `set_global`
Create a Trajectory

Description

This method initialises a trajectory object, which comprises a chain of activities that can be attached to a generator. See below for a complete list of available activities by category.

Usage

trajectory(name = "anonymous", verbose = FALSE)

Arguments

name the name of the trajectory.
verbose enable showing additional information.

Value

Returns an environment that represents the trajectory.

See Also

Available activities by category:

- Debugging: log_
- Delays: timeout, timeout_from_attribute, timeout_from_global
- Arrival properties: set_attribute, set_global, set_prioritization
- Interaction with resources: select, seize, release, seize_selected, release_selected, set_capacity, set_queue_size, set_capacity_selected, set_queue_size_selected
- Interaction with generators: activate, deactivate, set_trajectory, set_source
- Branching: branch, clone, synchronize
- Loops: rollback
- Batching: batch, separate
- Asynchronous programming: send, trap, untrap, wait
- Reneging: leave, renege_in, renege_if, renege_abort

Manage trajectories:

- Extract or Replace Parts of a Trajectory: Extract.trajectory
- Join Trajectories: join
- Number of Activities in a Trajectory: length.trajectory, get_n_activities
## Examples

```r
## create an empty trajectory
x <- trajectory("my trajectory")

## add some activities by chaining them
x <- x \%>\%
  log_("here I am!") \%>\%
  timeout(5) \%>\%
  log_("leaving!")

## join trajectories
x <- join(x, x)

## extract and replace
x[c(3, 4)] <- x[2]
```

### wrap

**Wrap a Simulation Environment**

### Description

This function extracts the monitored data from a simulation environment making it accessible through the same methods. Only useful if you want to parallelize heavy replicas (see the example below), because the C++ simulation backend is destroyed when the threads exit.

### Usage

```r
wrap(.env)
```

### Arguments

- **.env** the simulation environment.

### Value

Returns a simulation wrapper.

### See Also

Methods for dealing with a simulation wrapper: `get_mon_arrivals`, `get_mon_attributes`, `get_mon_resources`, `get_n_generated`, `get_capacity`, `get_queue_size`, `get_server_count`, `get_queue_count`. 

---

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wrap
Examples

```r
## Not run:
library(parallel)

mm1 <- trajectory() %>%
  seize("server", 1) %>%
  timeout(function() rexp(1, 2)) %>%
  release("server", 1)

envs <- mclapply(1:4, function(i) {
  simmer("M/M/1 example") %>%
    add_resource("server", 1) %>%
    add_generator("customer", mm1, function() rexp(1, 1)) %>%
    run(100) %>%
    wrap()
})

## End(Not run)
```
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