Package ‘SpaDES.core’

February 21, 2020

Type Package

Title Core Utilities for Developing and Running Spatially Explicit Discrete Event Models

Description Provide the core framework for a discrete event system (DES) to implement a complete data-to-decisions, reproducible workflow. The core DES components facilitate modularity, and easily enable the user to include additional functionality by running user-built modules. Includes conditional scheduling, restart after interruption, packaging of reusable modules, tools for developing arbitrary automated workflows, automated interweaving of modules of different temporal resolution, and tools for visualizing and understanding the DES project.


Date 2020-02-20

Version 1.0.0

Depends R (>= 3.5), quickPlot (>= 0.1.4), reproducible (>= 1.0.0)

Imports backports, crayon, data.table (>= 1.10.4), dplyr (>= 0.5.0), fastdigest, fpCompare (>= 0.2.1), igraph (>= 1.0.1), lubridate (>= 1.3.3), methods, RCurl, R.utils (>= 2.5.0), raster (>= 2.5-8), rlang, stats, stringi (>= 1.1.3), tcltk, tools, utils, whisker

Suggests codetools, covr, devtools, DiagrammeR (>= 0.8.2), future, future.callr, htr, knitr, logging, magrittr, microbenchmark, png, RandomFields (>= 3.3.4), RColorBrewer (>= 1.1-2), rgdal, rstudioapi, sf, SpaDES.tools (>= 0.2.0), rmarkdown, testthat (>= 1.0.2)

Encoding UTF-8

Language en-CA

License GPL-3

VignetteBuilder knitr, rmarkdown

BugReports https://github.com/PredictiveEcology/SpaDES.core/issues
ByteCompile yes
Collate 'module-dependencies-class.R' 'misc-methods.R' 'environment.R'
'helpers.R' 'simList-class.R' 'cache.R' 'check.R' 'priority.R'
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RoxygenNote 7.0.2

NeedsCompilation no

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Repository CRAN

Date/Publication 2020-02-21 13:30:09 UTC

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SpaDES.core-package

Categorized overview of the SpaDES.core package

Description

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This package allows implementation a variety of simulation-type models, with a focus on spatially explicit models. The core simulation components are built upon a discrete event simulation framework that facilitates modularity, and easily enables the user to include additional functionality by running user-built simulation modules. Included are numerous tools to visualize various spatial data formats, as well as non-spatial data. Much work has been done to speed up the core of the DES, with current benchmarking as low as 56 microseconds overhead for each event (including scheduling, sorting event queue, spawning event etc.) or 38 microseconds if there is no sorting (i.e., no sorting occurs under simple conditions). Under most event conditions, therefore, the DES itself will contribute very minimally compared to the content of the events, which may often be milliseconds to many seconds each event.

Bug reports: https://github.com/PredictiveEcology/SpaDES.core/issues
Module repository: https://github.com/PredictiveEcology/SpaDES-modules
Wiki: https://github.com/PredictiveEcology/SpaDES/wiki

1 Spatial discrete event simulation (SpaDES)

A collection of top-level functions for doing spatial discrete event simulation.

1.1 Simulations: There are two workhorse functions that initialize and run a simulation, and third function for doing multiple spades runs:

- `simInit` Initialize a new simulation
- `spades` Run a discrete event simulation
- `experiment` In SpaDES.experiment package. Run multiple `spades` calls
- `experiment2` In SpaDES.experiment package. Run multiple `spades` calls

1.2 Events: Within a module, important simulation functions include:

- `scheduleEvent` Schedule a simulation event
- `scheduleConditionalEvent` Schedule a conditional simulation event
- `removeEvent` Remove an event from the simulation queue (not yet implemented)

2 The simList object class

The principle exported object class is the simList. All SpaDES simulations operate on this object class.

`simList` The 'simList' class
3 simList methods

Collections of commonly used functions to retrieve or set slots (and their elements) of a simList object are summarized further below.

3.1 Simulation parameters:

- **globals**: List of global simulation parameters.
- **params**: Nested list of all simulation parameter.
- **P**: Namespaced version of params (i.e., do not have to specify module name).

3.2 Loading from disk, saving to disk:

- **inputs**: List of loaded objects used in simulation. (advanced)
- **outputs**: List of objects to save during simulation. (advanced)

3.3 Objects in the simList:

- **ls, objects**: Names of objects referenced by the simulation environment.
- **ls.str**: List the structure of the simList objects.
- **objs**: List of objects referenced by the simulation environment.

3.4 Simulation paths: Accessor functions for the paths slot and its elements.

- **cachePath**: Global simulation cache path.
- **modulePath**: Global simulation module path.
- **inputPath**: Global simulation input path.
- **outputPath**: Global simulation output path.
- **rasterPath**: Global simulation temporary raster path.
- **paths**: Global simulation paths (cache, modules, inputs, outputs, rasters).

3.5 Simulation times: Accessor functions for the simtimes slot and its elements.

- **time**: Current simulation time, in units of longest module.
- **start**: Simulation start time, in units of longest module.
- **end**: Simulation end time, in units of longest module.
- **times**: List of all simulation times (current, start, end), in units of longest module.

3.6 Simulation event queues: Accessor functions for the events and completed slots. By default, the event lists are shown when the simList object is printed, thus most users will not require direct use of these methods.

- **events**: Scheduled simulation events (the event queue). (advanced)
- **current**: Currently executing event. (advanced)
- **completed**: Completed simulation events. (advanced)
SpaDES.core-package

elapsedTime  The amount of clock time that modules & events use

3.7 Modules, dependencies, packages:  Accessor functions for the depends, modules, and .loadOrder slots. These are included for advanced users.

- depends       List of simulation module dependencies. (advanced)
- modules       List of simulation modules to be loaded. (advanced)
- packages      Vector of required R libraries of all modules. (advanced)

3.8 simList environment:  The simList has a slot called .xData which is an environment. All objects in the simList are actually in this environment, i.e., the simList is not a list. In R, environments use pass-by-reference semantics, which means that copying a simList object using normal R assignment operation (e.g., sim2 <- sim1), will not copy the objects contained within the .xData slot. The two objects (sim1 and sim2) will share identical objects within that slot. Sometimes, this not desired, and a true copy is required.

- envir         Access the environment of the simList directly (advanced)
- copy          Deep copy of a simList. (advanced)

3.9 Checkpointing:

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4 Module operations

4.1 Creating, distributing, and downloading modules:  Modules are the basic unit of SpaDES. These are generally created and stored locally, or are downloaded from remote repositories, including our SpaDES-modules repository on GitHub.

- checksums            Verify (and optionally write) checksums for a module’s data files.
- downloadModule       Open all modules nested within a base directory.
- getModuleVersion     Get the latest module version # from module repository.
- newModule            Create new module from template.
- newModuleDocumentation Create empty documentation for a new module.
- openModules          Open all modules nested within a base directory.
moduleMetadata
zipModule

4.2 Module metadata: Each module requires several items to be defined. These comprise the metadata for that module (including default parameter specifications, inputs and outputs), and are currently written at the top of the module’s .R file.

defineModule Define the module metadata
defineParameter Specify a parameter’s name, value and set a default
epectsInput Specify an input object’s name, class, description, sourceURL and other specifications
createsOutput Specify an output object’s name, class, description and other specifications

There are also accessors for many of the metadata entries:

timeunit Accesses metadata of same name
citation Accesses metadata of same name
documentation Accesses metadata of same name
reqdPkgs Accesses metadata of same name
inputObjects Accesses metadata of same name
outputObjects Accesses metadata of same name

4.3 Module dependencies: Once a set of modules have been chosen, the dependency information is automatically calculated once simInit is run. There are several functions to assist with dependency information:

depsEdgeList Build edge list for module dependency graph
depsGraph Build a module dependency graph using igraph

5 Module functions

A collection of functions that help with making modules can be found in the suggested SpaDES.tools package, and are summarized below.

5.1 Spatial spreading/distances methods: Spatial contagion is a key phenomenon for spatially explicit simulation models. Contagion can be modelled using discrete approaches or continuous approaches. Several SpaDES.tools functions assist with these:

adj An optimized (i.e., faster) version of adjacent
cir Identify pixels in a circle around a SpatialPoints* object
directionFromEachPoint Fast calculation of direction and distance surfaces
distanceFromEachPoint Fast calculation of distance surfaces
rings Identify rings around focal cells (e.g., buffers and donuts)
spokes Identify outward radiating spokes from initial points
5.2 Spatial agent methods: Agents have several methods and functions specific to them:

- **crw**: Simple correlated random walk function
- **heading**: Determines the heading between `SpatialPoints`
- **makeLines**: Makes `SpatialLines` object for, e.g., drawing arrows
- **move**: A meta function that can currently only take "crw"
- **specificNumPerPatch**: Initiate a specific number of agents per patch

5.3 GIS operations: In addition to the vast amount of GIS operations available in R (mostly from contributed packages such as `sp`, `raster`, `maps`, `maptools` and many others), we provide the following GIS-related functions:

- **equalExtent**: Assess whether a list of extents are all equal

5.4 'Map-reduce'–type operations: These functions convert between reduced and mapped representations of the same data. This allows compact representation of, e.g., rasters that have many individual pixels that share identical information.

- **rasterizeReduced**: Convert reduced representation to full raster.

5.5 Colors in `Raster*` objects: We likely will not want the default colours for every map. Here are several helper functions to add to, set and get colors of `Raster*` objects:

- **setColors**: Set colours for plotting `Raster*` objects
- **getColors**: Get colours in a `Raster*` objects
- **divergentColors**: Create a color palette with diverging colors around a middle

5.6 Random Map Generation: It is often useful to build dummy maps with which to build simulation models before all data are available. These dummy maps can later be replaced with actual data maps.

- **gaussMap**: Creates a random map using Gaussian random fields
- **randomPolygons**: Creates a random polygon with specified number of classes

5.7 Checking for the existence of objects: SpaDES modules will often require the existence of objects in the `simList`. These are helpers for assessing this:

- **checkObject**: Check for a existence of an object within a `simList`
- **checkPath**: Checks the specified filepath for formatting consistencies
5.8 SELES-type approach to simulation: These functions are essentially skeletons and are not fully implemented. They are intended to make translations from SELES. You must know how to use SELES for these to be useful:

- **agentLocation** / Agent location
- **initiateAgents** / Initiate agents into a SpatialPointsDataFrame
- **numAgents** / Number of agents
- **probInit** / Probability of initiating an agent or event
- **transitions** / Transition probability

5.9 Miscellaneous: Functions that may be useful within a SpaDES context:

- **inRange** / Test whether a number lies within range \([a,b]\)
- **layerNames** / Get layer names for numerous object classes
- **loadPackages** / Simple wrapper for loading packages
- **numLayers** / Return number of layers
- **paddedFloatToChar** / Wrapper for padding (e.g., zeros) floating numbers to character
- **updateList** / Update values in a named list

6 Caching simulations and simulation components

Simulation caching uses the reproducible package.

Caching can be done in a variety of ways, most of which are up to the module developer. However, the one most common usage would be to cache a simulation run. This might be useful if a simulation is very long, has been run once, and the goal is just to retrieve final results. This would be an alternative to manually saving the outputs.

See example in spades, achieved by using cache = TRUE argument.

- **Cache** / Caches a function, but often accessed as arg in spades
- **cache** / deprecated. Please use Cache
- **showCache** / Shows information about the objects in the cache
- **clearCache** / Removes objects from the cache
- **keepCache** / Keeps only the objects described
- **clearStubArtifacts** / Removes any erroneous items in a cache repository

A module developer can build caching into their module by creating cached versions of their functions.

7 Plotting

Much of the underlying plotting functionality is provided by the quickPlot package.
There are several user-accessible plotting functions that are optimized for modularity and speed of plotting:

Commonly used:

- **Plot**  The workhorse plotting function

Simulation diagrams:

- **eventDiagram**  Gantt chart representing the events in a completed simulation.
- **moduleDiagram**  Network diagram of simplified module (object) dependencies.
- **objectDiagram**  Sequence diagram of detailed object dependencies.

Other useful plotting functions:

- **clearPlot**  Helpful for resolving many errors
- **clickValues**  Extract values from a raster object at the mouse click location(s)
- **clickExtent**  Zoom into a raster or polygon map that was plotted with `Plot`
- **clickCoordinates**  Get the coordinates, in map units, under mouse click
- **dev**  Specify which device to plot on, making a non-RStudio one as default
- **newPlot**  Open a new default plotting device
- **rePlot**  Replots all elements of device for refreshing or moving plot

---

### 8 File operations

In addition to R’s file operations, we have added several here to aid in bulk loading and saving of files for simulation purposes:

- **loadFiles**  Load simulation objects according to a filelist
- **rasterToMemory**  Read a raster from file to RAM
- **saveFiles**  Save simulation objects according to outputs and params

---

### 9 Sample modules included in package

Several dummy modules are included for testing of functionality. These can be found with `file.path(find.package("SpaDES.core"), "sampleModules")`.

- **randomLandscapes**  Imports, updates, and plots several raster map layers
- **caribouMovement**  A simple agent-based (a.k.a., individual-based) model
- **fireSpread**  A simple model of a spatial spread process
10 Package options

SpaDES packages use the following options to configure behaviour:

- **spades.browserOnError**: If TRUE, the default, then any error rerun the same event with debugonce called on it to allow editing to be done. When that browser is continued (e.g., with \`c\'), then it will save it reparse it into the simList and rerun the edited version. This may allow a spades call to be recovered on error, though in many cases that may not be the correct behaviour. For example, if the simList gets updated inside that event in an iterative manner, then each run through the event will cause that iteration to occur. When this option is TRUE, then the event will be run at least 3 times: the first time makes the error, the second time has debugonce and the third time is after the error is addressed. TRUE is likely somewhat slower.

- **reproducible.cachePath**: The default local directory in which to cache simulation outputs. Default is a temporary directory (typically /tmp/RtmpXXX/SpaDES/cache).

- **spades.inputPath**: The default local directory in which to look for simulation inputs. Default is a temporary directory (typically /tmp/RtmpXXX/SpaDES/inputs).

- **spades.debug**: The default debugging value debug argument in spades(). Default is TRUE.

- **spades.lowMemory**: If true, some functions will use more memory efficient (but slower) algorithms. Default FALSE.

- **spades.moduleCodeChecks**: Should the various code checks be run during simInit. These are passed to codetools::checkUsage. Default is given by the function, plus these:\{suppressParamUnused = FALSE, suppressUndefined = TRUE, suppressPartialMatchArgs = FALSE, suppressNoLocalFun = TRUE, skipWith = TRUE\}.

- **spades.modulePath**: The default local directory where modules and data will be downloaded and stored. Default is a temporary directory (typically /tmp/RtmpXXX/SpaDES/modules).

- **spades.moduleRepo**: The default GitHub repository to use when downloading modules via downloadModule. Default "PredictiveEcology/SpaDES-modules".

- **spades.nCompleted**: The maximum number of completed events to retain in the completed event queue. Default 1000L.

- **spades.outputPath**: The default local directory in which to save simulation outputs. Default is a temporary directory (typically /tmp/RtmpXXX/SpaDES/outputs).

- **spades.recoveryMode**: If this a numeric > 0 or TRUE, then the discrete event simulator will take a snapshot of the objects in the simList that might change (based on metadata outputObjects for that module), prior to initiating every event. This will allow the user to be able to recover in case of an error or manual interruption (e.g., Esc). If this is numeric, a copy of that number of "most recent events" will be maintained so that the user can recover and restart > 1 event in the past, i.e., redo some of the "completed" events. Default is TRUE, i.e., it will keep the state of the simList at the start of the current event. This can be recovered with restartSpades and the differences can be seen in a hidden object in the stashed simList. There is a message which describes how to find that.

- **spades.switchPkgNamespaces**: Should the search path be modified to ensure a module's required packages are listed first? Default FALSE to keep computational overhead down. If TRUE, there should be no name conflicts among package objects, but it is much slower, especially if the events are themselves fast.
• **spades.tolerance**: The default tolerance value used for floating point number comparisons. Default `.Machine$double.eps^0.5`.

• **spades.useragent**: The default user agent to use for downloading modules from GitHub.com. Default "http://github.com/PredictiveEcology/SpaDES".

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**See Also**

`spadesOptions`

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`.addChangedAttr.simList-method

`.addChangedAttr for simList objects`

---

**Description**

This will evaluate which elements in the `simList` object changed following this Cached function call. It will add a named character string as an attribute `attr(x,".Cache")$changed`, indicating which ones changed. When this function is subsequently called again, only these changed objects will be returned. All other `simList` objects will remain unchanged.

**Usage**

```r
## S4 method for signature 'simList'
.addChangedAttr(object, preDigest, origArguments, ...)
```

**Arguments**

- **object**: Any R object returned from a function

- **preDigest**: The full, element by element hash of the input arguments to that same function, e.g., from `.robustDigest`

- **origArguments**: These are the actual arguments (i.e., the values, not the names) that were the source for `preDigest`

- **...**: Anything passed to methods.
See Also

- `addChangedAttr`
- `addChangedAttr`

---

### `.addTagsToOutput, simList-method`

`.addTagsToOutput for simList objects`

---

**Description**

See `.addTagsToOutput`.

**Usage**

```r
## S4 method for signature 'simList'
.addTagsToOutput(object, outputObjects, FUN, preDigestByClass)
```

**Arguments**

- `object` Any R object.
- `outputObjects` Optional character vector indicating which objects to return. This is only relevant for list, environment (or similar) objects.
- `FUN` A function.
- `preDigestByClass` A list, usually from `.preDigestByClass`.

**Author(s)**

Eliot McIntire

**See Also**

- `.addTagsToOutput`
Description

See `.cacheMessage`.

Usage

```r
## S4 method for signature 'simList'
.cacheMessage(
  object,
  functionName,
  fromMemoise = getOption("reproducible.useMemoise", TRUE)
)
```

Arguments

- `object` Any R object.
- `functionName` A character string indicating the function name
- `fromMemoise` Logical. If TRUE, the message will be about recovery from memoised copy

See Also

`.cacheMessage`

Description

See `.checkCacheRepo`.

Usage

```r
## S4 method for signature 'list'
.checkCacheRepo(object, create = FALSE)
```

Arguments

- `object` An R object
- `create` Logical. If TRUE, then it will create the path for cache.
Description

How to load various types of files in R.

This function has two roles: 1) to proceed with the loading of files that are in a simList or 2) as a short cut to simInit(inputs = filelist). Generally not to be used by a user.

A data.frame with information on how to load various types of files in R, containing the columns:

- exts: the file extension;
- fun: the function to use for files with this file extension;
- package: the package from which to load fun.

Usage

.fileExtensions()

loadFiles(sim, filelist, ...)

## S4 method for signature 'simList,missing'
loadFiles(sim, filelist, ...)

## S4 method for signature 'missing,ANY'
loadFiles(sim, filelist, ...)

## S4 method for signature 'missing,missing'
loadFiles(sim, filelist, ...)

.saveFileExtensions()

Arguments

sim simList object.
filelist list or data.frame to call loadFiles directly from the filelist as described in Details
...

Author(s)

Eliot McIntire and Alex Chubaty
### Not run:

```r
# Load random maps included with package
filelist <- data.frame(
  files = dir(system.file("maps", package = "quickPlot"),
              full.names = TRUE, pattern = "tif"),
  functions = "rasterToMemory", package = "quickPlot"
)
sim1 <- loadFiles(filelist = filelist)
clearPlot()
if (interactive()) Plot(sim1$DEM)

# Second, more sophisticated. All maps loaded at time = 0, and the last one is reloaded
# at time = 10 and 20 (via "intervals").
# Also, pass the single argument as a list to all functions...
# specifically, when add "native = TRUE" as an argument to the raster function
files = dir(system.file("maps", package = "quickPlot"),
            full.names = TRUE, pattern = "tif")
arguments = I(rep(list(native = TRUE), length(files)))
filelist = data.frame(
  files = files,
  functions = "raster::raster",
  objectName = NA,
  arguments = arguments,
  loadTime = 0,
  intervals = c(rep(NA, length(files)-1), 10)
)
sim2 <- loadFiles(filelist = filelist)

# if we extend the end time and continue running, it will load an object scheduled
# at time = 10, and it will also schedule a new object loading at 20 because
# interval = 10
end(sim2) <- 20
sim2 <- spades(sim2) # loads the percentPine map 2 more times, once at 10, once at 20
```

```r
## End(Not run)
```

---

### Description

This is recursive, so it will find the all simLists even if they are deeply nested.
Usage

.preDigestByClass.simList-method

Arguments

object Any R object.

Description

Pre-digesting method for simList

Usage

## S4 method for signature 'simList'
.object$preDigestByClass(object)

Arguments

object Any R object.

Description

Takes a snapshot of simList objects.
.prepareOutput, simList-method

Details

See .preDigestByClass.

Author(s)

Eliot McIntire

See Also

.preDigestByClass

Description

See .prepareOutput.

Usage

## S4 method for signature 'simList'
prepareOutput(object, cacheRepo, ...)

Arguments

  object            Any R object
  cacheRepo        A repository used for storing cached objects. This is optional if Cache is used inside a SpaDES module.
  ...              Arguments passed to FUN

See Also

.prepareOutput
Description

A variable that can be used by module developers and model users to switch between a quick check of functions like downloadData, Cache. The module developer must actually use this in their code.

Usage

quickCheck

Format

An object of class logical of length 1.

Description

This is intended to be used within the Cache function, but can be used to evaluate what a simList would look like once it is converted to a repeatably digestible object.

Usage

## S4 method for signature 'simList'

robustDigest(object, .objects, length, algo, quick, classOptions)

Arguments

- object: an object to digest.
- .objects: Character vector of objects to be digested. This is only applicable if there is a list, environment (or similar) named objects within it. Only this/these objects will be considered for caching, i.e., only use a subset of the list, environment or similar objects.
- length: Numeric. If the element passed to Cache is a Path class object (from e.g., asPath(filename)) or it is a Raster with file-backing, then this will be passed to digest::digest, essentially limiting the number of bytes to digest (for speed). This will only be used if quick = FALSE. Default is getOption("reproducible.length"), which is set to Inf.
The algorithms to be used; currently available choices are md5, which is also the default, sha1, crc32, sha256, sha512, xxhash32, xxhash64, murmur32 and spookyhash.

Logical. If TRUE, little or no disk-based information will be assessed, i.e., mostly its memory content. This is relevant for objects of class character, Path and Raster currently. For class character, it is ambiguous whether this represents a character string or a vector of file paths. The function will assess if it is a path to a file or directory first. If not, it will treat the object as a character string. If it is known that character strings should not be treated as paths, then quick = TRUE will be much faster, with no loss of information. If it is file or directory, then it will digest the file content, or basename(object). For class Path objects, the file's metadata (i.e., filename and file size) will be hashed instead of the file contents if quick = TRUE. If set to FALSE (default), the contents of the file(s) are hashed. If quick = TRUE, length is ignored. Raster objects are treated as paths, if they are file-backed.

Optional list. This will pass into .robustDigest for specific classes. Should be options that the .robustDigest knows what to do with.

See robustDigest. This method strips out stuff from a simList class object that would make it otherwise not reproducibly digestible between sessions, operating systems, or machines. This will likely still not allow identical digest results across R versions.

Eliot McIntire

See Also

robustDigest

Description

See .tagsByClass. Adds current moduleName, eventType, eventTime, and function:spades as userTags.

Usage

## S4 method for signature 'simList'
.tagsByClass(object)
Arguments

object Any R object.

Author(s)

Eliot McIntire

See Also

.tagsByClass

Description

This function removes a few attributes that are added internally by SpaDES.core and are not relevant to the all.equal. One key element removed is any time stamps, as these are guaranteed to be different.

Usage

## S3 method for class 'equal.simList'
all(target, current, ...)

Arguments

target R object.
current other R object, to be compared with target.
... further arguments for different methods, notably the following two, for numerical comparison:

Value

See all.equal
**append_attr**

Add a module to a moduleList

---

**Description**

Ordinary base lists and vectors do not retain their attributes when subsetted or appended. This function appends items to a list while preserving the attributes of items in the list (but not of the list itself).

**Usage**

```r
append_attr(x, y)
```

## S4 method for signature 'list,list'

```r
append_attr(x, y)
```

**Arguments**

- `x, y` A list of items with optional attributes.

**Details**

Similar to `updateList` but does not require named lists.

**Value**

An updated list with attributes.

**Author(s)**

Alex Chubaty and Eliot McIntire

**Examples**

```r
library(igraph) # igraph exports magrittr's pipe operator
tmp1 <- list("apple", "banana") %>% lapply(.x, `attributes<-=`, list(type = "fruit"))
tmp2 <- list("carrot") %>% lapply(.x, `attributes<-=`, list(type = "vegetable"))
append_attr(tmp1, tmp2)
rm(tmp1, tmp2)
```
checkModule

Check for the existence of a remote module

Description

Looks in the remote repo for a module named name.

Usage

checkModule(name, repo)

## S4 method for signature 'character,character'
checkModule(name, repo)

## S4 method for signature 'character,missing'
checkModule(name)

Arguments

name   Character string giving the module name.
repo   GitHub repository name. Default is "PredictiveEcology/SpaDES-modules", which is specified by the global option spades.moduleRepo.

Author(s)

Eliot McIntire and Alex Chubaty

checkModuleLocal

Check for the existence of a module locally

Description

Looks the module path for a module named name, and checks for existence of all essential module files listed below.

Usage

checkModuleLocal(name, path, version)

## S4 method for signature 'character,character,character'
checkModuleLocal(name, path, version)

## S4 method for signature 'character,ANY,ANY'
checkModuleLocal(name, path, version)
checkObject

Arguments

name  Character string giving the module name.
path  Local path to modules directory. Default is specified by the global option spades.modulePath.
version  Character specifying the desired module version.

Details

- ‘data/CHECKSUMS.txt’
- ‘name.R’

Value

Logical indicating presence of the module (invisibly).

Author(s)

Alex Chubaty

---

checkObject  Check for existence of object(s) referenced by a objects slot of a simList object

Description

Check that a named object exists in the provide simList environment slot, and optionally has desired attributes.

Usage

checkObject(sim, name, object, layer, ...)

## S4 method for signature 'simList,missing,Raster,character'
checkObject(sim, name, object, layer, ...)

## S4 method for signature 'simList,missing,ANY,missing'
checkObject(sim, name, object, layer, ...)

## S4 method for signature 'simList,character,missing,missing'
checkObject(sim, name, object, layer, ...)

## S4 method for signature 'simList,character,missing,character'
checkObject(sim, name, object, layer, ...)

## S4 method for signature 'missing,ANY,missing,ANY'
checkObject(sim, name, object, layer, ...)
Arguments

sim A `simList` object.
name A character string specifying the name of an object to be checked.
object An object. This is mostly used internally, or with layer, because it will fail if the object does not exist.
layer Character string, specifying a layer name in a Raster, if the name is a `Raster*` object.
... Additional arguments. Not implemented.

Value

Invisibly return `TRUE` indicating object exists; `FALSE` if not.

Author(s)

Alex Chubaty and Eliot McIntire

See Also

`library`.

checkParams  Check use and existence of params passed to simulation.

Description

Checks that all parameters passed are used in a module, and that all parameters used in a module are passed.

Usage

checkParams(sim, coreParams, ...)

## S4 method for signature 'simList,list'
checkParams(sim, coreParams, ...)

Arguments

sim A `simList` simulation object.
coreParams List of default core parameters.
... Additional arguments. Not implemented.

Value

Invisibly return `TRUE` indicating object exists; `FALSE` if not. Sensible messages are be produced identifying missing parameters.
Author(s)
Alex Chubaty

checkums

Description
Verify (and optionally write) checksums for data files in a module's 'data/' subdirectory. The file 'data/CHECKSUMS.txt' contains the expected checksums for each data file. Checksums are computed using reproducible:::.digest, which is simply a wrapper around digest:::digest.

Usage
checkums(module, path, ...)

Arguments
module Character string giving the name of the module.
path Character string giving the path to the module directory.
... Passed to Checkums, notably, write, quickCheck, checksumFile and files.

Details
Modules may require data that for various reasons cannot be distributed with the module source code. In these cases, the module developer should ensure that the module downloads and extracts the data required. It is useful to not only check that the data files exist locally but that their checksums match those expected.

Note
In version 1.2.0 and earlier, two checksums per file were required because of differences in the checksum hash values on Windows and Unix-like platforms. Recent versions use a different (faster) algorithm and only require one checksum value per file. To update your 'CHECKSUMS.txt' files using the new algorithm:

1. specify your module (moduleName <- "my_module");
2. use a temp dir to ensure all modules get fresh copies of the data (tmpdir <- file.path(tempdir(),"SpaDES_modules"));
3. download your module's data to the temp dir (downloadData(moduleName,tmpdir));
4. initialize a dummy simulation to ensure any 'data prep' steps in the .inputObjects section are run (simInit(modules = moduleName));
5. recalculate your checksums and overwrite the file (checkums(moduleName,tmpdir,write = TRUE));
6. copy the new checksums file to your working module directory (the one not in the temp dir) (file.copy(from = file.path(tmpdir,moduleName,'data','CHECKSUMS.txt'),to = file.path('path/to/my/module','data',"CHECKSUMS.txt"),overwrite = TRUE)).
classFilter  

Filter objects by class

Description


Usage

classFilter(x, include, exclude, envir)

## S4 method for signature 'character,character,character,environment'
classFilter(x, include, exclude, envir)

## S4 method for signature 'character,character,character,missing'
classFilter(x, include, exclude)

## S4 method for signature 'character,character,missing,environment'
classFilter(x, include, envir)

## S4 method for signature 'character,character,missing,missing'
classFilter(x, include)

Arguments

x  Character vector of object names to filter, possibly from ls.
include  Class(es) to include, as a character vector.
exclude  Optional class(es) to exclude, as a character vector.
envir  The environment ins which to search for objects. Default is the calling environment.

Value

Vector of object names matching the class filter.

Note

`inherits` is used internally to check the object class, which can, in some cases, return results inconsistent with `is`. See [http://stackoverflow.com/a/27923346/1380598](http://stackoverflow.com/a/27923346/1380598). These (known) cases are checked manually and corrected.

Author(s)

Alex Chubaty
Examples

## Not run:
```r
define global environment
```a` <- `list(1:10)`  # class 'list'
`b` <- `letters`  # class 'character'
`d` <- `stats::runif(10)`  # class 'numeric'
`f` <- `sample(1L:10L)`  # class 'numeric', 'integer'
`g` <- `lm(jitter(d) ~ d)`  # class 'lm'
`h` <- `glm(jitter(d) ~ d)`  # class 'lm', 'glm'
```classFilter(ls(), include=c("character", "list"))
classFilter(ls(), include = "numeric")
classFilter(ls(), include = "numeric", exclude = "integer")
classFilter(ls(), include = "lm")
classFilter(ls(), include = "lm", exclude = "glm")
```rm(a, b, d, f, g, h)

## End(Not run)

## from local (e.g., function) environment
```r
define local environment
local({
  `e` <- `environment()`
  ```a` <- `list(1:10)`  # class 'list'
    `b` <- `letters`  # class 'character'
    `d` <- `stats::runif(10)`  # class 'numeric'
    `f` <- `sample(1L:10L)`  # class 'numeric', 'integer'
    `g` <- `lm(jitter(d) ~ d)`  # class 'lm'
    `h` <- `glm(jitter(d) ~ d)`  # class 'lm', 'glm'
  ```classFilter(ls(), include=c("character", "list"), envir = e)
  classFilter(ls(), include = "numeric", envir = e)
  classFilter(ls(), include = "numeric", exclude = "integer", envir = e)
  classFilter(ls(), include = "lm", envir = e)
  classFilter(ls(), include = "lm", exclude = "glm", envir = e)
  ```rm(a, b, d, e, f, g, h)
})
```

## from another environment
```r
define another environment
`e` <- `new.env(parent = emptyenv())`
```a` <- `list(1:10)`  # class 'list'
`b` <- `letters`  # class 'character'
`d` <- `stats::runif(10)`  # class 'numeric'
`f` <- `sample(1L:10L)`  # class 'numeric', 'integer'
`g` <- `lm(jitter(e$d) ~ e$d)`  # class 'lm'
`h` <- `glm(jitter(e$d) ~ e$d)`  # class 'lm', 'glm'
```classFilter(ls(e), include=c("character", "list"), envir = e)
classFilter(ls(e), include = "numeric", envir = e)
classFilter(ls(e), include = "numeric", exclude = "integer", envir = e)
classFilter(ls(e), include = "lm", envir = e)
classFilter(ls(e), include = "lm", exclude = "glm", envir = e)
```rm(a, b, d, f, g, h, envir = e)
```rm(e)
```
clearCache, simList-method

clearCache for simList objects

Description

This will take the cachePath(object) and pass

Usage

```r
## S4 method for signature 'simList'
clearCache(
x,
userTags = character(),
after = NULL,
before = NULL,
ask = getOption("reproducible.ask"),
useCloud = FALSE,
cloudFolderID = getOption("reproducible.cloudFolderID", NULL),
drv = getOption("reproducible.drv", RSQLite::SQLite()),
conn = getOption("reproducible.conn", NULL),
...
)
```

```r
## S4 method for signature 'simList'
showCache(
x,
userTags = character(),
after = NULL,
before = NULL,
drv = getOption("reproducible.drv", RSQLite::SQLite()),
conn = getOption("reproducible.conn", NULL),
...
)
```

```r
## S4 method for signature 'simList'
keepCache(
x,
userTags = character(),
after = NULL,
before = NULL,
ask = getOption("reproducible.ask"),
drv = getOption("reproducible.drv", RSQLite::SQLite()),
conn = getOption("reproducible.conn", NULL),
...)```
Arguments

**x**
A simList or a directory containing a valid archivist repository. Note: For compatibility with Cache argument, cacheRepo can also be used instead of x, though x will take precedence.

**userTags**
Character vector. If used, this will be used in place of the after and before. Specifying one or more userTag here will clear all objects that match those tags. Matching is via regular expression, meaning partial matches will work unless strict beginning (^) and end ($) of string characters are used. Matching will be against any of the 3 columns returned by showCache(), i.e., artifact, tagValue or tagName. Also, length userTags > 1, then matching is by ‘and’. For ‘or’ matching, use | in a single character string. See examples.

**after**
A time (POSIX, character understandable by data.table). Objects cached after this time will be shown or deleted.

**before**
A time (POSIX, character understandable by data.table). Objects cached before this time will be shown or deleted.

**ask**
Logical. If FALSE, then it will not ask to confirm deletions using clearCache or keepCache. Default is TRUE

**useCloud**
Logical. If TRUE, then every object that is deleted locally will also be deleted in the cloudFolderID, if it is non-NULL

**cloudFolderID**
A googledrive id of a folder, e.g., using drive_mkdir(). If left as NULL, the function will create a cloud folder with a warning. The warning will have the cloudFolderID that should be used in subsequent calls. It will also be added to options("reproducible.cloudFolderID"), but this will not persist across sessions.

**drv**
an object that inherits from DBIDriver, or an existing DBIConnection object (in order to clone an existing connection).

**conn**
A DBIConnection object, as returned by dbConnect().

... Other arguments. Currently, regexp, a logical, can be provided. This must be TRUE if the use is passing a regular expression. Otherwise, userTags will need to be exact matches. Default is missing, which is the same as FALSE. If there are errors due to regular expression problem, try FALSE. For cc, it is passed to clearCache, e.g., ask, userTags

---

**Copy, simList-method**  
*Copy for simList class objects*

**Description**

Because a simList works with an environment to hold all objects, all objects within that slot are pass-by-reference. That means it is not possible to simply copy an object with an assignment operator: the two objects will share the same objects. As one simList object changes so will the other. When this is not the desired behaviour, use this function. NOTE: use capital C, to limit confusion with data.table::copy() See Copy.
Usage

```r
# S4 method for signature 'simList'
Copy(object, filebackedDir, objects, queues)
```

Arguments

- **object**: An R object (likely containing environments) or an environment.
- **filebackedDir**: A directory to copy any files that are backing R objects, currently only valid for `Raster` classes. Defaults to `tempdir()`, which is unlikely to be very useful. Can be `NULL`, which means that the file will not be copied and could therefore cause a collision as the pre-copied object and post-copied object would have the same file backing them.
- **objects**: Whether the objects contained within the `simList` environment should be copied. Default `TRUE`, which may be slow.
- **queues**: Logical. Should the events queues (`events, current, completed`) be deep copied via `data.table::copy`?

Details

`simList` objects can contain a lot of information, much of which could be in pass-by-reference objects (e.g., `data.table` class), and objects that are file-backed, such as some `Raster*-class` objects. For all the objects that are file-backed, it is likely very important to give unique file-backed directories. This should be passed here, which gets passed on to the many methods of `Copy` in reproducible.

Author(s)

Eliot McIntire

See Also

- `Copy`

**copyModule**

Create a copy of an existing module
Usage

```r
copyModule(from, to, path, ...)
```

```r
## S4 method for signature 'character,character,character'
copyModule(from, to, path, ...)
```

```r
## S4 method for signature 'character,character,missing'
copyModule(from, to, path, ...)
```

**Arguments**

- `from` The name of the module to copy.
- `to` The name of the copy.
- `path` The path to a local module directory. Defaults to the path set by the `spades.modulePath` option. See `setPaths`.
- `...` Additional arguments to `file.copy`, e.g., `overwrite = TRUE`.

**Value**

Invisible logical indicating success (`TRUE`) or failure (`FALSE`).

**Author(s)**

Alex Chubaty

**Examples**

```r
## Not run: copyModule(from, to)
```

---

`createsOutput` *Define an output object of a module*

**Description**

Used to specify an output object’s name, class, description and other specifications.

**Usage**

```r
createsOutput(objectName, objectClass, desc, ...)
```

```r
## S4 method for signature 'ANY,ANY,ANY'
createsOutput(objectName, objectClass, desc, ...)
```

```r
## S4 method for signature 'character,character,character'
createsOutput(objectName, objectClass, desc, ...)
```
defineModule

Arguments

- **objectName**: Character string to define the output object’s name.
- **objectClass**: Character string to specify the output object’s class.
- **desc**: Text string providing a brief description of the output object.
- **...**: Other specifications of the output object.

Value

A `data.frame` suitable to be passed to `outputObjects` in a module’s metadata.

Author(s)

Yong Luo

Examples

```r
outputObjects <- dplyr::bind_rows(
  createsOutput(objectName = "outputObject1", objectClass = "character",
                 desc = "this is for example"),
  createsOutput(objectName = "outputObject2", objectClass = "numeric",
                 desc = "this is for example",
                 otherInformation = "I am the second output object")
)
```

defineModule

*Define a new module.*

Description

Specify a new module’s metadata as well as object and package dependencies. Packages are loaded during this call. Any or all of these can be missing, with missing values set to defaults.

Usage

```r
defineModule(sim, x)
```

## S4 method for signature 'simList,list'
```r
defineModule(sim, x)
```

Arguments

- **sim**: A `simList` object from which to extract element(s) or in which to replace element(s).
- **x**: A list with a number of named elements, referred to as the metadata. See details.
**defineModule**

**Value**

Updated simList object.

**Required metadata elements**

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>name</td>
<td>Module name. Must match the filename (without the .R extension). This is currently not parsed by SpaDES; it is for human readers only.</td>
</tr>
<tr>
<td>description</td>
<td>Brief description of the module. This is currently not parsed by SpaDES; it is for human readers only.</td>
</tr>
<tr>
<td>keywords</td>
<td>Author-supplied keywords. This is currently not parsed by SpaDES; it is for human readers only.</td>
</tr>
<tr>
<td>childModules</td>
<td>If this contains any character vector, then it will be treated as a parent module. If this is a parent module, then module version number (will be coerced to numeric_version if a character or numeric are supplied). The Module version number (will be coerced to numeric_version if a character or numeric are supplied). The Module version number (will be coerced to numeric_version if a character or numeric are supplied). The Module version number (will be coerced to numeric_version if a character or numeric are supplied). The Module version number (will be coerced to numeric_version if a character or numeric are supplied). The Module version number (will be coerced to numeric_version if a character or numeric are supplied). The Module version number (will be coerced to numeric_version if a character or numeric are supplied). The Module version number (will be coerced to numeric_version if a character or numeric are supplied). The Module version number (will be coerced to numeric_version if a character or numeric are supplied).</td>
</tr>
<tr>
<td>authors</td>
<td>Module author information (as a vector of person objects. This is currently not parsed by SpaDES; it is for human readers only.</td>
</tr>
<tr>
<td>version</td>
<td>Module version number (will be coerced to numeric_version if a character or numeric are supplied). The Module version number (will be coerced to numeric_version if a character or numeric are supplied). The Module version number (will be coerced to numeric_version if a character or numeric are supplied). The Module version number (will be coerced to numeric_version if a character or numeric are supplied). The Module version number (will be coerced to numeric_version if a character or numeric are supplied). The Module version number (will be coerced to numeric_version if a character or numeric are supplied). The Module version number (will be coerced to numeric_version if a character or numeric are supplied). The Module version number (will be coerced to numeric_version if a character or numeric are supplied). The Module version number (will be coerced to numeric_version if a character or numeric are supplied).</td>
</tr>
<tr>
<td>spatialExtent</td>
<td>The spatial extent of the module supplied via raster::extent. This is currently unimplemented. Once implemented, this should define what spatial region this module is scientifically reasonable to be used in.</td>
</tr>
<tr>
<td>timeframe</td>
<td>Vector (length 2) of POSIXt dates specifying the temporal extent of the module. Currently unimplemented.</td>
</tr>
<tr>
<td>citation</td>
<td>List of character strings specifying module citation information. Alternatively, a list of filenames of .bib or .bib files.</td>
</tr>
<tr>
<td>documentation</td>
<td>List of filenames referring to module documentation sources. This is currently not parsed by SpaDES; it is for human readers only.</td>
</tr>
<tr>
<td>reqdPkgs</td>
<td>List of R package names required by the module. These packages will be loaded when simInit is called.</td>
</tr>
<tr>
<td>parameters</td>
<td>A data.frame specifying the parameters used in the module. Usually produced by rbind-ing the outputs of defineParameter.</td>
</tr>
<tr>
<td>inputObjects</td>
<td>A data.frame specifying the data objects expected as inputs to the module, with columns objectName (class character), objectClass (class character), sourceURL (character), downloadData (function), and downloadModule (function).</td>
</tr>
<tr>
<td>outputObjects</td>
<td>A data.frame specifying the data objects output by the module, with columns objectName (class character), objectClass (class character), sourceURL (character), downloadData (function), and downloadModule (function).</td>
</tr>
</tbody>
</table>

**Author(s)**

Alex Chubaty

**See Also**

moduleDefaults

**Examples**

```r
## Not run:
## a default version of the defineModule is created with a call to newModule
newModule("test", path = tempdir(), open = FALSE)

## view the resulting module file
if (interactive()) file.edit(file.path(tempdir(), "test", "test.R"))

## End(Not run)
```
defineParameter  Define a parameter used in a module

Description

Used to specify a parameter’s name, value, and set a default. The min and max arguments are ignored by simInit or spades; they are for human use only. To ensure that a user cannot set parameters outside of a range of values, the module developer should use assertions in their module code.

Usage

```r
defineParameter(name, class, default, min, max, desc)

## S4 method for signature 'character,character,ANY,ANY,ANY,character'
defineParameter(name, class, default, min, max, desc)

## S4 method for signature 'character,character,ANY,missing,missing,character'
defineParameter(name, class, default, desc)

## S4 method for signature 'missing,missing,missing,missing,missing,missing'
defineParameter()
```

Arguments

- **name**: Character string giving the parameter name.
- **class**: Character string giving the parameter class.
- **default**: The default value to use when none is specified by the user. Non-standard evaluation is used for the expression.
- **min**: With max, used to define a suitable range of values. Non-standard evaluation is used for the expression. These are not tested by simInit or spades. These are primarily for human use, i.e., to tell a module user what values the module expects.
- **max**: With min, used to define a suitable range of values. Non-standard evaluation is used for the expression. These are not tested by simInit or spades. These are primarily for human use, i.e., to tell a module user what values the module expects.
- **desc**: Text string providing a brief description of the parameter.

Value

- data.frame

Note

Be sure to use the correct NA type: logical (NA), integer (NA_integer_), real (NA_real_), complex (NA_complex_), or character (NA_character_). See `NA`.
Author(s)
Alex Chubaty

See Also
P, params for accessing these parameters in a module.

Examples
parameters = rbind(
  defineParameter("lambda", "numeric", 1.23, desc = "intrinsic rate of increase"),
  defineParameter("P", "numeric", 0.2, 0, 1, "probability of attack")
)

## Not run:
# Create a new module, then access parameters using \code{P}
tmpdir <- file.path(tempdir(), "test")
checkPath(tmpdir, create = TRUE)

# creates a new, "empty" module -- it has defaults for everything that is required
newModule("testModule", tmpdir, open = FALSE)

# Look at new module code -- see defineParameter
if (interactive()) file.edit(file.path(tmpdir, "testModule", "testModule.R"))

# initialize the simList
mySim <- simInit(modules = "testModule",
  paths = list(modulePath = tmpdir))

# Access one of the parameters -- because this line is not inside a module
# function, we must specify the module name. If used within a module,
# we can omit the module name
P(mySim, "testModule")$.useCache

## End(Not run)

--
depsEdgeList Build edge list for module dependency graph

Description
Build edge list for module dependency graph

Usage
depsEdgeList(sim, plot)

## S4 method for signature 'simList,logical'
depsEdgeList(sim, plot)

## S4 method for signature 'simList,missing'
depsEdgeList(sim, plot)

**Arguments**

- `sim`: A `simList` object.
- `plot`: Logical indicating whether the edgelist (and subsequent graph) will be used for plotting. If TRUE, duplicated rows (i.e., multiple object dependencies between modules) are removed so that only a single arrow is drawn connecting the modules. Default is FALSE.

**Value**

A `data.table` whose first two columns give a list of edges and remaining columns the attributes of the dependency objects (object name, class, etc.).

**Author(s)**

Alex Chubaty

---

**Description**

Build a module dependency graph

**Usage**

depsGraph(sim, plot)

## S4 method for signature 'simList,logical'
depsGraph(sim, plot)

## S4 method for signature 'simList,missing'
depsGraph(sim)

**Arguments**

- `sim`: A `simList` object.
- `plot`: Logical indicating whether the edgelist (and subsequent graph) will be used for plotting. If TRUE, duplicated rows (i.e., multiple object dependencies between modules) are removed so that only a single arrow is drawn connecting the modules. Default is FALSE.
Value

An `igraph` object.

Author(s)

Alex Chubaty

docevent.checkpoint

Simulation checkpoints.

Description

Save and reload the current state of the simulation, including the state of the random number generator, by scheduling checkpoint events.

Usage

docevent.checkpoint(sim, eventTime, eventType, debug = FALSE)

checkpointLoad(file, envir = parent.frame())

.checkpointSave(sim, file)

checkpointFile(sim)

## S4 method for signature 'simList'
checkpointFile(sim)

checkpointFile(sim) <- value

## S4 replacement method for signature 'simList'
checkpointFile(sim) <- value

checkpointInterval(sim)

## S4 method for signature 'simList'
checkpointInterval(sim)

checkpointInterval(sim) <- value

## S4 replacement method for signature 'simList'
checkpointInterval(sim) <- value
downloadData

Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sim</td>
<td>A simList simulation object.</td>
</tr>
<tr>
<td>eventTime</td>
<td>A numeric specifying the time of the next event.</td>
</tr>
<tr>
<td>eventType</td>
<td>A character string specifying the type of event:</td>
</tr>
<tr>
<td></td>
<td>one of either &quot;init&quot;, &quot;load&quot;, or &quot;save&quot;.</td>
</tr>
<tr>
<td>debug</td>
<td>Optional logical flag determines whether sim debug info will be printed (default debug = FALSE).</td>
</tr>
<tr>
<td>file</td>
<td>The checkpoint file.</td>
</tr>
<tr>
<td>envir</td>
<td>the environment where the data should be loaded.</td>
</tr>
<tr>
<td>value</td>
<td>The object to be stored at the slot.</td>
</tr>
</tbody>
</table>

Details

RNG save code adapted from: http://www.cookbook-r.com/Numbers/Saving_the_state_of_the_random_number_generator/ and https://stackoverflow.com/questions/13997444/

Value

Returns the modified simList object.

Author(s)

Alex Chubaty

See Also

.Random.seed.

Other functions to access elements of a 'simList' object: .addDepends(), envir(), events(), globals(), inputs(), modules(), objs(), packages(), params(), paths(), progressInterval(), times()

Description

Download external data for a module if not already present in the module directory, or if there is a checksum mismatch indicating that the file is not the correct one.
downloadData

Usage

downloadData(
  module,
  path,
  quiet,
  quickCheck = FALSE,
  overwrite = FALSE,
  files = NULL,
  checked = NULL,
  urls = NULL,
  children = NULL,
  ...
)

## S4 method for signature 'character,character,logical'
downloadData(
  module,
  path,
  quiet,
  quickCheck = FALSE,
  overwrite = FALSE,
  files = NULL,
  checked = NULL,
  urls = NULL,
  children = NULL,
  ...
)

## S4 method for signature 'character,missing,missing'
downloadData(module, quickCheck, overwrite, files, checked, urls, children)

## S4 method for signature 'character,missing,logical'
downloadData(
  module,
  quiet,
  quickCheck,
  overwrite,
  files,
  checked,
  urls,
  children
)

## S4 method for signature 'character,character,missing'
downloadData(
  module,
  path,
  quickCheck,
Arguments

- **module**: Character string giving the name of the module.
- **path**: Character string giving the path to the module directory.
- **quiet**: Logical. This is passed to `download.file`. Default is `FALSE`.
- **quickCheck**: Logical. If `TRUE`, then the check with local data will only use `file.size` instead of `digest::digest`. This is faster, but potentially much less robust.
- **overwrite**: Logical. Should local data files be overwritten in case they exist? Default is `FALSE`.
- **files**: A character vector of length 1 or more if only a subset of files should be checked in the ‘CHECKSUMS.txt’ file.
- **checked**: The result of a previous `checksums` call. This should only be used when there is no possibility that the file has changed, i.e., if `downloadData` is called from inside another function.
- **urls**: Character vector of urls from which to get the data. This is automatically found from module metadata when this function invoked with `SpaDES.core::downloadModule(...,data = TRUE)`. See also `prepInputs`.
- **children**: The character vector of child modules (without path) to also run `downloadData` on
- **...**: Passed to `preProcess`, e.g., `purge`

Details

downloadData requires a checksums file to work, as it will only download the files specified therein. Hence, module developers should make sure they have manually downloaded all the necessary data and ran `checksums` to build a checksums file.

There is an experimental attempt to use the `googledrive` package to download data from a shared (publicly or with individual users) file. To try this, put the Google Drive URL in `sourceURL` argument of `prepInputs` in the module metadata, and put the filename once downloaded in the `objectName` argument. If using RStudio Server, you may need to use "out of band" authentication by setting `options(httr_oob_default = TRUE)`. To avoid caching of Oauth credentials, set `options(httr_oauth_cache = TRUE)`.

There is also an experimental option for the user to make a new ‘CHECKSUMS.txt’ file if there is a `sourceURL` but no entry for that file. This is experimental and should be used with caution.

Value

Invisibly, a list of downloaded files.
downloadModule

Author(s)
Alex Chubaty & Eliot McIntire

See Also
prepInputs, checksums, and downloadModule for downloading modules and building a checksums file.

Examples
## Not run:
# For a Google Drive example
# In metadata:
expectInputs("theFilename.zip", "NA", "NA",
sourceURL = "https://drive.google.com/open?id=1Ngb-jIRCSs1G6zcuaaCEFWlWoldkI_K8Ez")
# create the checksums file
checksums("thisModule", "there", write = TRUE)
downloadData("thisModule", "there", files = "theFilename.zip")

## End(Not run)

downloadModule

Download a module from a SpaDES module GitHub repository

Description
Download a .zip file of the module and extract (unzip) it to a user-specified location.

Usage
downloadModule(
  name,  
  path,  
  version, 
  repo, 
  data, 
  quiet, 
  quickCheck = FALSE, 
  overwrite = FALSE 
)

## S4 method for signature
## 'character,character,character,character,logical,logical,ANY,logical'
downloadModule(
  name, 
  path, 
  version, 

## S4 method for signature
## 'character,character,character,character,logical,logical,ANY,logical'
downloadModule(
  name, 
  path, 
  version, 

## S4 method for signature
## 'character,missing,missing,missing,missing,missing,ANY,ANY'
downloadModule(name, quickCheck, overwrite)

## S4 method for signature 'character,ANY,ANY,ANY,ANY,ANY,ANY,ANY'
downloadModule(
    name,
    path,
    version,
    repo,
    data,
    quiet,
    quickCheck = FALSE,
    overwrite = FALSE
)

### Arguments

- **name**: Character string giving the module name.
- **path**: Character string giving the location in which to save the downloaded module.
- **version**: The module version to download. (If not specified, or NA, the most recent version will be retrieved.)
- **repo**: GitHub repository name, specified as "username/repo". Default is "PredictiveEcology/SpaDES-modules" which is specified by the global option spades.moduleRepo. Only master branches can be used at this point.
- **data**: Logical. If TRUE, then the data that is identified in the module metadata will be downloaded, if possible. Default FALSE.
- **quiet**: Logical. This is passed to download.file (default FALSE).
- **quickCheck**: Logical. If TRUE, then the check with local data will only use file.size instead of digest::digest. This is faster, but potentially much less robust.
- **overwrite**: Logical. Should local module files be overwritten in case they exist? Default FALSE.

### Details

Currently only works with GitHub repositories where modules are located in a modules directory in the root tree on the master branch. Module .zip files' names should contain the version number and be inside their respective module folders (see zipModule for zip compression of modules).
**Value**

A list of length 2. The first element is a character vector containing a character vector of extracted files for the module. The second element is a tbl with details about the data that is relevant for the function, including whether it was downloaded or not, and whether it was renamed (because there was a local copy that had the wrong file name).

**Note**

downloadModule uses the GITHUB_PAT environment variable if a value is set. This alleviates 403 errors caused by too-frequent downloads. Generate a GitHub personal access token with no additional permissions at https://github.com/settings/tokens, and add this key to `.Renviron` as GITHUB_PAT=<your-github-pat-here>. The default is to overwrite any existing files in the case of a conflict.

**Author(s)**

Alex Chubaty

**See Also**

`zipModule` for creating module .zip folders.

---

### dyears `SpaDES time units`

**Description**

SpaDES modules commonly use approximate durations that divide with no remainder among themselves. For example, models that simulate based on a "week" timestep, will likely want to fall in lock step with a second module that is a "year" timestep. Since, weeks, months, years don’t really have this behaviour because of: leap years, leap seconds, not quite 52 weeks in a year, months that are of different duration, etc. We have generated a set of units that work well together that are based on the astronomical or "Julian" year. In an astronomical year, leap years are added within each year with an extra 1/4 day, (i.e., 1 year == 365.25 days); months are defined as year/12, and weeks as year/52.

**Usage**

```r
  dyears(x)
```

## S4 method for signature 'numeric'

dyears(x)

```r
dmonths(x)
```

## S4 method for signature 'numeric'
dmonths(x)
Arguments

x numeric. Number of the desired units

Details

When these units are not correct, a module developer can create their own time unit using, and create a function to calculate the number of seconds in that unit using the "d" prefix (for duration), following the lubridate package standard: dfortnight <- function(x) lubridate::duration(dday(14)). Then the module developer can use "fortnight" as the module’s time unit.

Value

Number of seconds within each unit

Author(s)

Eliot McIntire
Description

Accessor functions for the .xData slot, which is the default virtual slot for an S4 class object that inherits from an S3 object (specifically, the simList inherits from environment) in a simList object. These are included for advanced users.

Usage

envir(sim)

## S4 method for signature 'simList'
envir(sim)

envir(sim) <- value

## S4 replacement method for signature 'simList'
envir(sim) <- value

Arguments

- **sim** A simList object from which to extract element(s) or in which to replace element(s).
- **value** The object to be stored at the slot.

Details

Currently, only get and set methods are defined. Subset methods are not.

Value

Returns or sets the value of the slot from the simList object.

Author(s)

Alex Chubaty

See Also

SpaDES.core-package, specifically the section 1.2.8 on simList environment.

Other functions to access elements of a 'simList' object: .addDepends(), doEvent.checkpoint(), events(), globals(), inputs(), modules(),objs(), packages(), params(), paths(), progressInterval(), times()
Description

Create a Gantt Chart representing the events in a completed simulation. This event diagram is constructed using the completed event list. To change the number of events shown, provide an n argument.

Usage

```
eventDiagram(sim, n, startDate, ...)  
```

## S4 method for signature 'simList,numeric,character'
```
eventDiagram(sim, n, startDate, ...)  
```

## S4 method for signature 'simList,missing,character'
```
eventDiagram(sim, n, startDate, ...)  
```

## S4 method for signature 'simList,missing,missing'
```
eventDiagram(sim, n, startDate, ...)  
```

Arguments

- `sim`: A `simList` object (typically corresponding to a completed simulation).
- `n`: The number of most recently completed events to plot.
- `startDate`: A character representation of date in YYYY-MM-DD format.
- `...`: Additional arguments passed to `mermaid`. Useful for specifying height and width.

Details

Simulation time is presented on the x-axis, starting at date 'startDate'. Each module appears in a color-coded row, within which each event for that module is displayed corresponding to the sequence of events for that module. Note that only the start time of the event is meaningful in these figures: the width of the bar associated with a particular module’s event DOES NOT correspond to an event’s "duration".

Based on this StackOverflow answer: [http://stackoverflow.com/a/29999300/1380598](http://stackoverflow.com/a/29999300/1380598).

Value

Plots an event diagram as Gantt Chart, invisibly returning a `mermaid` object.

Note

A red vertical line corresponding to the current date may appear on the figure. This is useful for Gantt Charts generally but can be considered a 'bug' here.
events

Author(s)
Alex Chubaty

See Also
DiagrammeR::mermaid.

Simulation event lists

Description
Accessor functions for the events and completed slots of a simList object. These path functions will extract the values that were provided to the simInit function in the path argument.

Usage
events(sim, unit)

## S4 method for signature 'simList,character'
events(sim, unit)

## S4 method for signature 'simList,missing'
events(sim, unit)

events(sim) <- value

## S4 replacement method for signature 'simList'
events(sim) <- value

conditionalEvents(sim, unit)

## S4 method for signature 'simList,character'
conditionalEvents(sim, unit)

## S4 method for signature 'simList,missing'
conditionalEvents(sim, unit)

current(sim, unit)

## S4 method for signature 'simList,character'
current(sim, unit)

## S4 method for signature 'simList,missing'
current(sim, unit)

current(sim) <- value
## S4 replacement method for signature 'simList'
`current(sim) <- value`

completed(sim, unit, times = TRUE)

## S4 method for signature 'simList,character'
completed(sim, unit, times = TRUE)

## S4 method for signature 'simList,missing'
completed(sim, unit, times = TRUE)

completed(sim) <- value

## S4 replacement method for signature 'simList'
completed(sim) <- value

### Arguments

- **sim**: A `simList` object from which to extract element(s) or in which to replace element(s).
- **unit**: Character. One of the time units used in SpaDES.
- **value**: The object to be stored at the slot.
- **times**: Logical. Should this function report the clockTime?

### Details

By default, the event lists are shown when the `simList` object is printed, thus most users will not require direct use of these methods.

- **events**: Scheduled simulation events (the event queue).
- **completed**: Completed simulation events.

Currently, only get and set methods are defined. Subset methods are not.

### Value

Returns or sets the value of the slot from the `simList` object.

### Note

Each event is represented by a `data.table` row consisting of:

- **eventTime**: The time the event is to occur.
- **moduleName**: The module from which the event is taken.
- **eventType**: A character string for the programmer-defined event type.
expectsInput

Define an input object that the module expects.

Description

Used to specify an input object’s name, class, description, source url and other specifications.

Usage

expectsInput(objectName, objectClass, desc, sourceURL, ...)

## S4 method for signature 'ANY,ANY,ANY,ANY'
expectsInput(objectName, objectClass, desc, sourceURL, ...)

## S4 method for signature 'character,character,character,character'
expectsInput(objectName, objectClass, desc, sourceURL, ...)

## S4 method for signature 'character,character,character,missing'
expectsInput(objectName, objectClass, desc, sourceURL, ...)

Arguments

objectName Character string to define the input object’s name.
objectClass Character string to specify the input object’s class.
desc Text string providing a brief description of the input object.
sourceURL Character string to specify an URL to reach the input object, default is NA.
... Other specifications of the input object.

Value

A data.frame suitable to be passed to inputObjects in a module’s metadata.

Author(s)

Yong Luo
Examples

```r
dplyr::bind_rows(
  expectsInput(objectName = "inputObject1", objectClass = "character",
               desc = "this is for example", sourceURL = "not available"),
  expectsInput(objectName = "inputObject2", objectClass = "numeric",
               desc = "this is for example", sourceURL = "not available",
               otherInformation = "I am the second input object")
)
```

---

**extractURL**

*Extract a url from module metadata*

**Description**

This will get the `sourceURL` for the object named.

**Usage**

```r
extractURL(objectName, sim, module)
```

## S4 method for signature 'character,missing'
```
extractURL(objectName, sim, module)
```

## S4 method for signature 'character,simList'
```
extractURL(objectName, sim, module)
```

**Description**

These functions have been moved to SpaDES.experiment package.

**Usage**

```r
experiment(...)
```

```r
experiment2(...)
```

```r
POM(...)
```

```r
simInitAndExperiment(...)
```

**Arguments**

... Unused.
**fileName**

**Arguments**

- **objectName**: A character string of the object name in the metadata.
- **sim**: A simList object from which to extract the `sourceURL`.
- **module**: An optional character string of the module name whose metadata is to be used. If omitted, the function will use the `currentModule(sim)`, if defined.

**Value**

The `url`.

**Author(s)**

Eliot McIntire

---

**fileName**  
*Extract filename (without extension) of a file*

**Description**

Extract filename (without extension) of a file

**Usage**

`fileName(x)`

**Arguments**

- **x**: List or character vector

**Value**

A character vector.

**Author(s)**

Eliot McIntire
getModuleVersion

Find the latest module version from a SpaDES module repository

Description


Usage

getModuleVersion(name, repo)

## S4 method for signature 'character,character'
getModuleVersion(name, repo)

## S4 method for signature 'character,missing'
getModuleVersion(name)

Arguments

name Character string giving the module name.
repo GitHub repository name, specified as "username/repo". Default is "PredictiveEcology/SpaDES-modules", which is specified by the global option spades.moduleRepo. Only master branches can be used at this point.

Details

getModuleVersion extracts a module's most recent version by looking at the module `.zip` files contained in the module directory. It takes the most recent version, based on the name of the zip file.

See the modules vignette for details of module directory structure (http://spades-core.predictiveecology.org/articles/ii-modules.html#module-directory-structure-modulename), and see our SpaDES-modules repo for details of module repository structure (https://github.com/PredictiveEcology/SpaDES-modules).

Author(s)

Alex Chubaty

See Also

zipModule for creating module `.zip` folders.
### Description

globals, and the alias G, accesses or sets the "globals" in the simList. This currently is not an explicit slot in the simList, but it is a .globals element in the params slot of the simList.

### Usage

globals(sim)

```r
# S4 method for signature 'simList'
globals(sim)

globals(sim) <- value

# S4 replacement method for signature 'simList'
globals(sim) <- value
```

G(sim)

```r
# S4 method for signature 'simList'
G(sim)

G(sim) <- value

# S4 replacement method for signature 'simList'
G(sim) <- value
```

### Arguments

- **sim**: A simList object from which to extract element(s) or in which to replace element(s).
- **value**: The object to be stored at the slot.

### See Also

[SpaDES.core-package](https://example.com), specifically the section 1.2.1 on Simulation Parameters.

Other functions to access elements of a 'simList' object: `addDepends()`, `doEvent.checkpoint()`, `envir()`, `events()`, `inputs()`, `modules()`, `objs()`, `packages()`, `params()`, `paths()`, `progressInterval()`, `times()`
### initialize, simList-method

*Generate a simList object*

**Description**

Given the name or the definition of a class, plus optionally data to be included in the object, `new` returns an object from that class.

**Usage**

```r
## S4 method for signature 'simList'
initialize(.Object, ...)
```

```r
## S4 method for signature 'simList_'
initialize(.Object, ...)
```

**Arguments**

`.Object` A simList object.

`...` Optional Values passed to any or all slot

### inputObjects

*Metadata accessors*

**Description**

These accessors extract the metadata for a module (if specified) or all modules in a simList if not specified.

**Usage**

```r
inputObjects(sim, module)
```

```r
## S4 method for signature 'simList'
inputObjects(sim, module)
```

```r
outputObjects(sim, module)
```

```r
## S4 method for signature 'simList'
outputObjects(sim, module)
```

```r
outputObjectNames(sim, module)
```
## S4 method for signature 'simList'
outputObjectNames(sim, module)

reqdPkgs(sim, module)

## S4 method for signature 'simList'
reqdPkgs(sim, module)

documentation(sim, module)

## S4 method for signature 'simList'
documentation(sim, module)

citation(package, lib.loc = NULL, auto = NULL, module = character())

## S4 method for signature 'simList'
citation(package, lib.loc = NULL, auto = NULL, module = character())

## S4 method for signature 'character'
citation(package, lib.loc = NULL, auto = NULL, module = character())

### Arguments

- **sim**
  A simList object from which to extract element(s) or in which to replace element(s).

- **module**
  Optional character string indicating which module params should come from.

- **package**
  For compatibility with citation. This can be a simList or a character string for a package name.

- **lib.loc**
  a character vector with path names of R libraries, or the directory containing the source for package, or NULL. The default value of NULL corresponds to all libraries currently known. If the default is used, the loaded packages are searched before the libraries.

- **auto**
  a logical indicating whether the default citation auto-generated from the package 'DESCRIPTION' metadata should be used or not, or NULL (default), indicating that a 'CITATION' file is used if it exists, or an object of class "packageDescription" with package metadata (see below).

### Description

Accessor functions for the inputs slots in a simList object.
inputs

Usage

inputs(sim)

## S4 method for signature 'simList'
inputs(sim)

inputs(sim) <- value

## S4 replacement method for signature 'simList'
inputs(sim) <- value

inputArgs(sim)

## S4 method for signature 'simList'
inputArgs(sim)

inputArgs(sim) <- value

## S4 replacement method for signature 'simList'
inputArgs(sim) <- value

Arguments

sim 
A simList object from which to extract element(s) or in which to replace element(s).

value 
The object to be stored at the slot. See Details.

Details

These functions are one of three mechanisms to add the information about which input files to load in a spades call.

1. As arguments to a simInit call. Specifically, inputs or outputs. See ?simInit.
2. With the outputs(simList) function call.
3. By adding a function called .inputObjects inside a module, which will be executed during the simInit call. This last way is the most "modular" way to create default data sets for your model.

See below for more details.

Value

Returns or sets the value(s) of the input or output slots in the simList object.

inputs function or argument in simInit

inputs accepts a data.frame, with up to 7 columns. Columns are:

column required, a character string indicating the file path. There is no default.
inputs

optional, character string indicating the name of the object that the loaded file will be assigned to in the simList.

fun

optional, a character string indicating the function to use to load that file. Defaults to the known extensions in SpaDES.

package

optional character string indicating the package in which to find the fun (e.g., raster);

loadTime

optional numeric, indicating when in simulation time the file should be loaded. The default is the highest priority at start(sim), i.e., at the very start.

interval

optional numeric, indicating at what interval should this same exact file be reloaded from disk, e.g., 10 would mean every 10 time units. The default is NA or no interval, i.e, load the file only once as described in loadTime

arguments

is a list of lists of named arguments, one list for each fun. For example, if fun="raster", arguments = list(native = TRUE)

Currently, only file is required. All others will be filled with defaults if not specified.

See the modules vignette for more details (browseVignettes("SpaDES.core")).

.inputObjects function placed inside module

Any code placed inside a function called .inputObjects will be run during simInit() for the purpose of creating any objects required by this module, i.e., objects identified in the inputObjects element of defineModule. This is useful if there is something required before simulation to produce the module object dependencies, including such things as downloading default datasets, e.g., downloadData('LCC2005',modulePath(sim)). Nothing should be created here that does not create a named object in inputObjects. Any other initiation procedures should be put in the "init" eventType of the doEvent function. Note: the module developer can use 'sim$.userSuppliedObjNames' inside the function to selectively skip unnecessary steps because the user has provided those inputObjects in the simInit call. e.g., the following code would look to see if the user had passed defaultColor into during simInit. If the user had done this, then this function would not override that value with 'red'. If the user has not passed in a value for defaultColor, then the module will get it here:

    if (!('defaultColor' %in% sim$.userSuppliedObjNames)) { sim$defaultColor <- 'red' }

See Also

SpaDES.core-package, specifically the section 1.2.2 on loading and saving.

Other functions to access elements of a 'simList' object: .addDepends(), doEvent.checkpoint(), envir(), events(), globals(), modules(), objs(), packages(), params(), paths(), progressInterval(), times()

Examples

#' inputs

# Start with a basic empty simList
sim <- simInit()

test <- 1:10
library(igraph) # for %>%
library(reproducible) # for checkPath
tmpdir <- file.path(tempdir(), "inputs") %>% checkPath(create = TRUE)
tmpFile <- file.path(tmpdir, "test.rds")
saveRDS(test, file = tmpFile)
inputs(sim) <- data.frame(file = tmpFile) # using only required column, "file"
inputs(sim) # see that it is not yet loaded, but when it is scheduled to be loaded
simOut <- spades(sim)
inputs(simOut) # confirm it was loaded
simOut$test

# can put data.frame for inputs directly inside simInit call
allTifs <- dir(system.file("maps", package = "quickPlot"),
               full.names = TRUE, pattern = "tif")

# next: .objectNames are taken from the filenames (without the extension)
# This will load all 5 tifs in the SpaDES sample directory, using
# the raster function in the raster package, all at time = 0
if (require("rgdal", quietly = TRUE)) {
  sim <- simInit(
    inputs = data.frame(
      files = allTifs,
      functions = "raster",
      package = "raster",
      loadTime = 0,
      stringsAsFactors = FALSE)
  )
}

################################
#A fully described inputs object, including arguments:
files <- dir(system.file("maps", package = "quickPlot"),
             full.names = TRUE, pattern = "tif")
# arguments must be a list of lists. This may require I() to keep it as a list
# once it gets coerced into the data.frame.
arguments = I(rep(list(native = TRUE), length(files)))
filelist = data.frame(
  objectName = paste0("Maps", 1:5),
  files = files,
  functions = "raster::raster",
  arguments = arguments,
  loadTime = 0,
  intervals = c(rep(NA, length(files) - 1), 10)
)
inputs(sim) <- filelist
spades(sim)
}

# Example showing loading multiple objects from global environment onto the
# same object in the simList, but at different load times
a1 <- 1
a2 <- 2
# Note arguments must be a list of NROW(inputs), with each element itself being a list,
# which is passed to do.call(fun[x], arguments[[x]]), where x is row number, one at a time
args <- lapply(1:2, function(x) {
  list(x = paste0("a", x),
       envir = environment()) # may be necessary to specify in which envir a1, a2
# are located, if not in an interactive sessiono
})


```r
inputs <- data.frame(objectName = "a", loadTime = 1:2, fun = "base::get", arguments = I(args))
a <- simInit(inputs = inputs, times = list(start = 0, end = 1))
a <- spades(a)
identical(a1, a$a)

end(a) <- 3
a <- spades(a) # different object (a2) loaded onto a$a
identical(a2, a$a)

# Clean up after
unlink(tmpdir, recursive = TRUE)
```

### inSeconds

#### Convert time units

**Description**

In addition to using the `lubridate` package, some additional functions to work with times are provided.

This function takes a numeric with a "unit" attribute and converts it to another numeric with a different time attribute. If the units passed to argument `units` are the same as `attr(time,"unit")`, then it simply returns input time.

**Usage**

```r
inSeconds(unit, envir, skipChecks = FALSE)
convertTimeunit(time, unit, envir, skipChecks = FALSE)
```

**Arguments**

- **unit**: Character. One of the time units used in SpaDES or user defined time unit, given as the unit name only. See details.

- **envir**: An environment. This is where to look up the function definition for the time unit. See details.
skipChecks: For speed, the internal checks for classes and missingness can be skipped. Default FALSE.

time: Numeric. With a unit attribute, indicating the time unit of the input numeric. See Details.

Format
An object of class character of length 12.

Details
Current pre-defined units are found within the \texttt{spadesTimes()} function. The user can define a new unit. The unit name can be anything, but the function definition must be of the form "\texttt{dunitName}". e.g., \texttt{dyear} or \texttt{dfortnight}. The unit name is the part without the \texttt{d} and the function name definition includes the \texttt{d}. This new function, e.g., \texttt{dfortnight <- function(x) lubridate::duration(dday(14))} can be placed anywhere in the search path or in a module.

Because of R scoping, if \texttt{envir} is a \texttt{simList} environment, then this function will search there first, then up the current \texttt{search()} path. Thus, it will find a user defined or module defined unit before a SpaDES unit. This means that a user can override the \texttt{dyear} given in SpaDES, for example, which is 365.25 days, with \texttt{dyear <- function(x) lubridate::duration(dday(365))}.

If time has no unit attribute, then it is assumed to be seconds.

Value
A numeric vector of length 1, with unit attribute set to "seconds".

Author(s)
Alex Chubaty & Eliot McIntire
Eliot McIntire

---

### loadPackages

**Load packages.**

**Description**
Load and optionally install additional packages.

**Usage**

```r
loadPackages(packageList, install = FALSE, quiet = TRUE)
```

```r
## S4 method for signature 'character'
loadPackages(packageList, install = FALSE, quiet = TRUE)
```

```r
## S4 method for signature 'list'
loadPackages(packageList, install = FALSE, quiet = TRUE)
```
makeMemoisable.simList

## S4 method for signature 'NULL'
loadPackages(packageList, install = FALSE, quiet = TRUE)

### Arguments
- **packageList**: A list of character strings specifying the names of packages to be loaded.
- **install**: Logical flag. If required packages are not already installed, should they be installed?
- **quiet**: Logical flag. Should the final "packages loaded" message be suppressed?

### Value
Specified packages are loaded and attached using `require()`, invisibly returning a logical vector of successes.

### Author(s)
Alex Chubaty

### See Also
- `require`

### Examples
```
## Not run:
pkgs <- list("raster", "lme4")
loadPackages(pkgs) # loads packages if installed
loadPackages(pkgs, install = TRUE) # loads packages after installation (if needed)
## End(Not run)
```

---

**makeMemoisable.simList**

*Make simList correctly work with memoise*

### Description
Because of the environment slot, `simList` objects don’t correctly memoise a `simList`. This method for `simList` converts the object to a `simList_` first.

### Usage
```
## S3 method for class 'simList'
makeMemoisable(x)

## S3 method for class 'simList_'
unmakeMemoisable(x)
```
Arguments

x An object to make memoisable. See individual methods in other packages.

Value

A simList_ object or a simList, in the case of unmakeMemoisable.

See Also

makeMemoisable

maxTimeunit

Determine the largest timestep unit in a simulation

Description

Determine the largest timestep unit in a simulation

Usage

maxTimeunit(sim)

## S4 method for signature 'simList'
maxTimeunit(sim)

Arguments

sim A simList simulation object.

Value

The timeunit as a character string. This defaults to NA if none of the modules has explicit units.

Author(s)

Eliot McIntire and Alex Chubaty
memoryUseThisSession  

Estimate memory used with system("ps")

Description

This will give a slightly different estimate than pryr::mem_used, which uses gc() internally. The purpose of this function is to allow continuous monitoring, external to the R session. Normally, this is run in a different session.

This will only work if the user has specified before running the spades call, set the interval, in seconds, that ps is run with options("spades.memoryUseInterval" = 0.5), will assess memory use every 0.5 seconds. The default is 0, meaning no interval, "off".

Usage

memoryUseThisSession(thisPid)

memoryUse(sim, max = TRUE)

Arguments

- **thisPid**: Numeric or integer, the PID of the process. If omitted, it will be found with Sys.getpid()
- **sim**: A completed simList
- **max**: Logical. If TRUE, then it the return value will be summarized by module/event, showing the maximum memory used. If FALSE, then the raw memory used during each event will be shown.

See Also

The vignette("iv-modules")

minTimeunit  

Determine the smallest timeunit in a simulation

Description

When modules have different timeunit, SpaDES automatically takes the smallest (e.g., "second") as the unit for a simulation.
Usage

minTimeunit(sim)

```r
## S4 method for signature 'simList'
minTimeunit(sim)
```

```r
## S4 method for signature 'list'
minTimeunit(sim)
```

Arguments

sim A simList simulation object.

Value

The timeunit as a character string. This defaults to "second" if none of the modules has explicit units.

Author(s)

Eliot McIntire

---

moduleCoverage Calculate module coverage of unit tests

Description

Calculate the test coverage by unit tests for the module and its functions.

Usage

moduleCoverage(name, path)

```r
## S4 method for signature 'character,character'
moduleCoverage(name, path)
```

```r
## S4 method for signature 'character,missing'
moduleCoverage(name)
```

Arguments

name Character string. The module’s name.

path Character string. The path to the module directory (default is the current working directory).
Value

Return a list of two coverage objects and two data.table objects. The two coverage objects are named ‘moduleCoverage’ and ‘functionCoverage’. The ‘moduleCoverage’ object contains the percent value of unit test coverage for the module. The ‘functionCoverage’ object contains percentage values for unit test coverage for each function defined in the module. Please use \texttt{report} to view the coverage information. Two data.tables give the information of all the tested and untested functions in the module.

Note

When running this function, the test files must be strictly placed in the ‘tests/testthat/’ directory under module path. To automatically generate this folder, please set \texttt{unitTests = TRUE} when creating a new module using \texttt{newModule}. To accurately test your module, the test filename must follow the format test-functionName.R.

Author(s)

Yong Luo

See Also

\texttt{newModule}.

Examples

```r
## Not run:
library(igraph) # for %>
library(SpaDES.core)
tmpdir <- file.path(tempdir(), "coverage")
modulePath <- file.path(tmpdir, "Modules") %>% checkPath(create = TRUE)
moduleName <- "forestAge" # sample module to test
downloadModule(name = moduleName, path = modulePath) # download sample module
testResults <- moduleCoverage(name = moduleName, path = modulePath)
report(testResults$moduleCoverage)
report(testResults$functionCoverage)
unlink(tmpdir, recursive = TRUE)
## End(Not run)
```

\textit{moduleDefaults}

\textit{Defaults values used in defineModule}

Description

Where individual elements are missing in defineModule, these defaults will be used.

Usage

\texttt{moduleDefaults}
Format

An object of class list of length 12.

Description

Create a network diagram illustrating the simplified module dependencies of a simulation. Offers a less detailed view of specific objects than does plotting the depsEdgeList directly with objectDiagram.

Usage

moduleDiagram(sim, type, showParents, ...)

## S4 method for signature 'simList,character,logical'
moduleDiagram(sim, type, showParents, ...)

## S4 method for signature 'simList,missing,ANY'
moduleDiagram(sim, type, showParents, ...)

Arguments

sim A simList object (typically corresponding to a completed simulation).
type Character string, either "rgl" for igraph::rglplot or "tk" for igraph::tkplot. Default missing, which uses regular plot.
showParents Logical. If TRUE, then any children that are grouped into parent modules will be grouped together by colored blobs. Internally, this is calling moduleGraph. Default FALSE.

... Additional arguments passed to plotting function specified by type.

Value

Plots module dependency diagram.

Author(s)

Alex Chubaty

See Also

igraph, moduleGraph for a version that accounts for parent and children module structure.
moduleGraph

Build a module dependency graph

Description

This is still experimental, but this will show the hierarchical structure of parent and children modules and return a list with an igraph object and an igraph communities object, showing the groups. Currently only tested with relatively simple structures.

Usage

moduleGraph(sim, plot, ...)

## S4 method for signature 'simList,logical'
moduleGraph(sim, plot, ...)

## S4 method for signature 'simList,missing'
moduleGraph(sim, plot, ...)

Arguments

sim A simList object.
plot Logical indicating whether the edgelist (and subsequent graph) will be used for plotting. If TRUE, duplicated rows (i.e., multiple object dependencies between modules) are removed so that only a single arrow is drawn connecting the modules. Default is FALSE.
...
Arguments passed to Plot

Value

A list with 2 elements, an igraph object and an igraph communities object.

Author(s)

Eliot McIntire

See Also

moduleDiagram
moduleMetadata  

Parse and extract module metadata

Description

Parse and extract module metadata

Usage

moduleMetadata(sim, module, path)

## S4 method for signature 'missing,character,character'
moduleMetadata(module, path)

## S4 method for signature 'missing,character,missing'
moduleMetadata(module)

## S4 method for signature 'ANY,ANY,ANY'
moduleMetadata(sim, module, path)

Arguments

sim A simList simulation object, generally produced by simInit.
module Character string. Your module’s name.
path Character string specifying the file path to modules directory. Default is to use the spades.modulePath option.

Value

A list of module metadata, matching the structure in defineModule.

Author(s)

Alex Chubaty

See Also

defineModule

Examples

path <- system.file("sampleModules", package = "SpaDES.core")
sampleModules <- dir(path)
# turn off code checking -- don't need it here
opts <- options("spades.moduleCodeChecks" = FALSE,
                  "spades.useRequire" = FALSE)
x <- moduleMetadata(sampleModules[3], path = path)
# using simList
mySim <- simInit(
  times = list(start = 2000.0, end = 2001.0, timeunit = "year"),
  params = list(
    .globals = list(stackName = "landscape"
  ),
  modules = list("caribouMovement"),
  paths = list(modulePath = system.file("sampleModules", package = "SpaDES.core"))
)
moduleMetadata(sim = mySim)

# turn code checking back on -- don't need it here
options(opts)

---

modules

Simulation modules and dependencies

Description

Accessor functions for the depends and modules slots in a simList object. These are included for advanced users.

- `depends`: List of simulation module dependencies. (advanced)
- `modules`: List of simulation modules to be loaded. (advanced)
- `inputs`: List of loaded objects used in simulation. (advanced)

Usage

```r
modules(sim, hidden = FALSE)
## S4 method for signature 'simList'
modules(sim, hidden = FALSE)
modules(sim) <- value
## S4 replacement method for signature 'simList'
modules(sim) <- value
depends(sim)
## S4 method for signature 'simList'
depends(sim)
depends(sim) <- value
## S4 replacement method for signature 'simList'
```


depends(sim) <- value

Arguments

- **sim**: A simList object from which to extract element(s) or in which to replace element(s).
- **hidden**: Logical. If TRUE, show the default core modules.
- **value**: The object to be stored at the slot.

Details

Currently, only get and set methods are defined. Subset methods are not.

Value

Returns or sets the value of the slot from the simList object.

Author(s)

Alex Chubaty

See Also

SpaDES.core-package, specifically the section 1.2.7 on Modules and dependencies.

Other functions to access elements of a 'simList' object: \texttt{addDepends()}, \texttt{doEvent.checkpoint()}, \texttt{envir()}, \texttt{events()}, \texttt{globals()}, \texttt{inputs()}, \texttt{objs()}, \texttt{packages()}, \texttt{params()}, \texttt{paths()}, \texttt{progressInterval()}, \texttt{times()}

\begin{verbatim}
moduleVersion moduleVersion Parse and extract a module's version
\end{verbatim}

Description

Parse and extract a module’s version

Usage

\begin{verbatim}
moduleVersion(module, path, sim, envir = NULL)

## S4 method for signature 'character,character,missing'
moduleVersion(module, path, envir)

## S4 method for signature 'character,missing,missing'
moduleVersion(module, envir)

## S4 method for signature 'character,missing,simList'
moduleVersion(module, sim, envir)
\end{verbatim}
Arguments

- **module**: Character string. Your module’s name.
- **path**: Character string specifying the file path to modules directory. Default is to use the `spades.modulePath` option.
- **sim**: A `simList` simulation object, generally produced by `simInit`.
- **envir**: Optional environment in which to store parsed code. This may be useful if the same file is being parsed multiple times. This function will check in that `envir` for the parsed file before parsing again. If the `envir` is transient, then this will have no effect.

Value

numeric_version indicating the module’s version.

Author(s)

Alex Chubaty

See Also

`moduleMetadata`

Examples

```r
path <- system.file("sampleModules", package = "SpaDES.core")

# using filepath
moduleVersion("caribouMovement", path)

# using simList
mySim <- simInit(
  times = list(start = 2000.0, end = 2002.0, timeunit = "year"),
  params = list(
    .globals = list(stackName = "landscape", burnStats = "nPixelsBurned")
  ),
  modules = list("caribouMovement"),
  paths = list(modulePath = path)
)
moduleVersion("caribouMovement", sim = mySim)
```

**newModule**

Create new module from template

Description

Autogenerate a skeleton for a new SpaDES module, a template for a documentation file, a citation file, a license file, a ‘README.txt’ file, and a folder that contains unit tests information. The `newModuleDocumentation` will not generate the module file, but will create the other files.
Usage

newModule(name, path, ...)

## S4 method for signature 'character,character'
newModule(name, path, ...)

## S4 method for signature 'character,missing'
newModule(name, path, ...)

Arguments

name Character string specifying the name of the new module.
path Character string. Subdirectory in which to place the new module code file. The default is the current working directory.
... Additional arguments. Currently, only the following are supported:

open Logical. Should the new module file be opened after creation? Default TRUE.

unitTests Logical. Should the new module include unit test files? Default TRUE. Unit testing relies on the testthat package.

type Character string specifying one of "child" (default), or "parent".

children Required when type = "parent". A character vector specifying the names of child modules.

Details

All files will be created within a subdirectory named name within the path:

- path/
  - name/
    - R/ # contains additional module R scripts
    - data/ # directory for all included data
      * CHECKSUMS.txt # contains checksums for data files
    - tests/ # contains unit tests for module code
    - citation.bib # bibtext citation for the module
    - LICENSE.txt # describes module's legal usage
    - README.txt # provide overview of key aspects
    - name.R # module code file (incl. metadata)
    - name.Rmd # documentation, usage info, etc.
newModuleCode

Value

Nothing is returned. The new module file is created at ‘path/name.R’, as well as ancillary files for documentation, citation, ‘LICENSE’, ‘README’, and ‘tests’ directory.

Note

On Windows there is currently a bug in RStudio that prevents the editor from opening when file.edit is called. Similarly, in RStudio on macOS, there is an issue opening files where they are opened in an overlayed window rather than a new tab. file.edit does work if the user types it at the command prompt. A message with the correct lines to copy and paste is provided.

Author(s)

Alex Chubaty and Eliot McIntire

See Also

Other module creation helpers: newModuleCode(), newModuleDocumentation(), newModuleTests()

Examples

## Not run:
```r
## create a "myModule" module in the "modules" subdirectory.
newModule("myModule", "modules")

## create a new parent module in the "modules" subdirectory.
newModule("myParentModule", "modules", type = "parent", children = c("child1", "child2"))
```

## End(Not run)

---

`newModuleCode`  Create new module code file

Description

Create new module code file

Usage

`newModuleCode(name, path, open, type, children)`

## S4 method for signature 'character,character,logical,character,character'
`newModuleCode(name, path, open, type, children)`
**newModuleDocumentation**

**Arguments**

- **name**  
  Character string specifying the name of the new module.
- **path**  
  Character string. Subdirectory in which to place the new module code file. The default is the current working directory.
- **open**  
  Logical. Should the new module file be opened after creation? Default `TRUE` in an interactive session.
- **type**  
  Character string specifying one of "child" (default), or "parent".
- **children**  
  Required when `type = "parent"`. A character vector specifying the names of child modules.

**Author(s)**

Eliot McIntire and Alex Chubaty

**See Also**

Other module creation helpers: `newModuleDocumentation()`, `newModuleTests()`, `newModule()`

---

**Description**

Create new module documentation

**Usage**

```r
newModuleDocumentation(name, path, open, type, children)
```

## S4 method for signature 'character,character,logical,character,character'

```r
newModuleDocumentation(name, path, open, type, children)
```

## S4 method for signature 'character,missing,logical,ANY,ANY'

```r
newModuleDocumentation(name, open)
```

## S4 method for signature 'character,character,missing,ANY,ANY'

```r
newModuleDocumentation(name, path)
```

## S4 method for signature 'character,missing,missing,ANY,ANY'

```r
newModuleDocumentation(name)
```
newModuleTests

Arguments

name  Character string specifying the name of the new module.
path  Character string. Subdirectory in which to place the new module code file. The default is the current working directory.
open  Logical. Should the new module file be opened after creation? Default TRUE in an interactive session.
type  Character string specifying one of "child" (default), or "parent".
children  Required when type = "parent". A character vector specifying the names of child modules.

Author(s)

Eliot McIntire and Alex Chubaty

See Also

Other module creation helpers: newModuleCode(), newModuleTests(), newModule()
newProgressBar  Progress bar

Description

Shows a progress bar that is scaled to simulation end time.

Usage

newProgressBar(sim)
setProgressBar(sim)

Arguments

sim  A simList simulation object.

Details

The progress bar object is stored in a separate environment, #'.pkgEnv.'

Author(s)

Alex Chubaty and Eliot McIntire

newProject  Create new SpaDES project

Description

Initialize a project with subdirectories 'cache/', 'modules/', 'inputs/', 'outputs/', and setPaths accordingly.

Usage

newProject(name, path, open)

## S4 method for signature 'character,character,logical'
newProject(name, path, open)

## S4 method for signature 'character,character,missing'
newProject(name, path, open)
**newProjectCode**

**Arguments**

- **name**: project name (name of project directory)
- **path**: path to directory in which to create the project directory
- **open**: Logical. Should the new project file be opened after creation? Default TRUE in an interactive session.

**Examples**

```r
myProjDir <- newProject("myProject", tempdir())

dir.exists(file.path(myProjDir, "cache"))
dir.exists(file.path(myProjDir, "inputs"))
dir.exists(file.path(myProjDir, "modules"))
dir.exists(file.path(myProjDir, "outputs"))
unlink(myProjDir, recursive = TRUE) ## cleanup
```

---

**newProjectCode**

*Create new module code file*

**Description**

Create new module code file

**Usage**

```r
newProjectCode(name, path, open)
```

## S4 method for signature 'character,character,logical'

```r
newProjectCode(name, path, open = interactive())
```

**Arguments**

- **name**: project name (name of project directory)
- **path**: path to directory in which to create the project directory
- **open**: Logical. Should the new project file be opened after creation? Default TRUE in an interactive session.

**Author(s)**

Alex Chubaty
Simulation object dependency diagram

Description

Create a sequence diagram illustrating the data object dependencies of a simulation. Offers a more
detailed view of specific objects than does plotting the depsEdgeList directly with moduleDiagram.

Usage

objectDiagram(sim, ...)

## S4 method for signature 'simList'
objectDiagram(sim, ...)

Arguments

sim A simList object (typically corresponding to a completed simulation).
...
Additional arguments passed to DiagrammeR::mermaid. Useful for specifying
height and width.

Value

Plots a sequence diagram, invisibly returning a DiagrammeR::mermaid object.

Author(s)

Alex Chubaty

See Also

DiagrammeR::mermaid.

Identify synonyms in a simList

Description

This will create active bindings amongst the synonyms. To minimize copying, the first one that
exists in the character vector will become the "canonical" object. All others named in the character
vector will be activeBindings to that canonical one. This synonym list will be assigned to the
envir, as an object named objectSynonyms. That object will have an attribute called, bindings
indicating which one is the canonical one and which is/are the activeBindings. EXPERIMENTAL:
If the objects are removed during a spades call by, say, a module, then at the end of the event, the
spades call will replace the bindings. In other words, if a module deletes the object, it will "come
back". This may not always be desired.
Usage

objectSynonyms(envir, synonyms)

Arguments

envir An environment, which in the context of SpaDES.core is usually a simList to find and/or place the objectSynonyms object.
synonyms A list of synonym character vectors, such as list(c("age", "ageMap", "age2"), c("veg", "vegMap"))

Details

This is very experimental and only has minimal tests. Please report if this is not working, and under what circumstances (e.g., please submit a reproducible example to our issues tracker)

This function will append any new objectSynonym to any pre-existing objectSynonym in the envir. Similarly, this function assumes transitivity, i.e., if age and ageMap are synonyms, and ageMap and timeSinceFire are synonyms, then age and timeSinceFire must be synonyms.

Value

Active bindings in the envir so that all synonyms point to the same canonical object, e.g., they would be at envir[[synonym[[1]][1]]] and envir[[synonym[[1]][2]]], if a list of length one is passed into synonyms, with a character vector of length two. See examples.

Examples

sim <- simInit()
sim$age <- 1:10;
sim <- objectSynonyms(sim, list(c("age", "ageMap"))

identical(sim$ageMap, sim$age)
sim$age <- 4
identical(sim$ageMap, sim$age)
sim$ageMap <- 2:5
sim$ageMap[3] <- 11
identical(sim$ageMap, sim$age)

# Also works to pass it in as an object
objectSynonyms <- list(c("age", "ageMap"))
sim <- simInit(objects = list(objectSynonyms = objectSynonyms))
identical(sim$ageMap, sim$age) # they are NULL at this point
sim$age <- 1:10
identical(sim$ageMap, sim$age) # they are not NULL at this point

## More complicated, with 'updating' i.e., you can add new synonyms to previous
sim <- simInit()
os <- list(c("age", "ageMap"), c("vegMap", "veg"), c("studyArea", "studyArea2"))
os2 <- list(c("ageMap", "timeSinceFire", "tsf"),
            c("systime", "systime2"),
            c("vegMap", "veg"))
```r
sim <- objectSynonyms(sim, os)
sim <- objectSynonyms(sim, os2)

# check
sim$objectSynonyms
```

---

### objs

**Extract or replace an object from the simulation environment**

---

#### Description

The `[[` and `$` operators provide "shortcuts" for accessing objects in the simulation environment. I.e., instead of using `envir(sim)$object` or `envir(sim)["object"]`, one can simply use `sim$object` or `sim[["object"]].`

#### Usage

```r
objs(sim, ...)
```

#### Arguments

- `sim`: A `simList` object from which to extract element(s) or in which to replace element(s).
- `...`: passed to `ls`
- `value`: objects to assign to the `simList`

#### Details

`objs` can take `...` arguments passed to `ls`, allowing, e.g., `all.names=TRUE objs<-` requires takes a named list of values to be assigned in the simulation environment.

#### Value

Returns or sets a list of objects in the `simList` environment.
**objSize.simList**

**Description**

Recursively, runs `objSize` on the `simList` environment, so it estimates the correct size of functions stored there (e.g., with their enclosing environments) plus, it adds all other "normal" elements of the `simList`, e.g., `objSize(completed(sim))`.

**Usage**

```r
## S3 method for class 'simList'
objSize(
  x,
  quick = getOption("reproducible.quick", FALSE),
  enclosingEnvs = TRUE,
  .prevEnvirs = list(),
  ...
)
```

**Arguments**

- `x` 
  An object
- `quick` 
  Logical. Only some methods use this. e.g., Path class objects. In which case, `file.size` will be used instead of `object.size`.
- `enclosingEnvs` 
  Logical indicating whether to include enclosing environments. Default `TRUE`.
- `prevEnvirs` 
  For internal account keeping to identify and prevent duplicate counting
- `...` 
  Additional arguments (currently unused)

**Examples**

```r
a <- simInit(objects = list(d = 1:10, b = 2:20))
objSize(a)
utils::object.size(a)
```

**See Also**

- SpaDES.core-package, specifically the section 1.2.1 on Simulation Parameters.
- Other functions to access elements of a 'simList' object: `.addDepends()`, `doEvent.checkpoint()`, `envir()`, `events()`, `globals()`, `inputs()`, `modules()`, `packages()`, `params()`, `paths()`, `progressInterval()`, `times()`
openModules

Open all modules nested within a base directory

Description

This is just a convenience wrapper for opening several modules at once, recursively. A module is defined as any file that ends in `.R` or `.r` and has a directory name identical to its filename. Thus, this must be case sensitive.

Usage

openModules(name, path)

## S4 method for signature 'character,character'
openModules(name, path)

## S4 method for signature 'missing,missing'
openModules()

## S4 method for signature 'missing,character'
openModules(path)

## S4 method for signature 'character,missing'
openModules(name)

## S4 method for signature 'simList,missing'
openModules(name)

Arguments

name Character vector with names of modules to open. If missing, then all modules will be opened within the basedir.

path Character string of length 1. The base directory within which there are only module subdirectories.

Value

Nothing is returned. All file are open via file.edit.

Note

On Windows there is currently a bug in RStudio that prevents the editor from opening when file.edit is called. file.edit does work if the user types it at the command prompt. A message with the correct lines to copy and paste is provided.

Author(s)

Eliot McIntire
### Example

```r
## Not run: openModules("~/path/to/my/modules")
```

---

### Description

Accessor functions for the `outputs` slots in a `simList` object.

### Usage

```r
outputs(sim)  
## S4 method for signature 'simList'
outputs(sim)

outputs(sim) <- value
## S4 replacement method for signature 'simList'
outputs(sim) <- value

outputArgs(sim)  
## S4 method for signature 'simList'
outputArgs(sim)

outputArgs(sim) <- value
## S4 replacement method for signature 'simList'
outputArgs(sim) <- value
```

### Arguments

- `sim`: A `simList` object from which to extract element(s) or in which to replace element(s).
- `value`: The object to be stored at the slot. See Details.

### Details

These functions are one of three mechanisms to add information about which output files to save.

1. As arguments to a `simInit` call. Specifically, `inputs` or `outputs`. See ?`simInit`.
2. With the `outputs(simList)` function call.
3. By adding a function called .inputObjects inside a module, which will be executed during the simInit call. This last way is the most "modular" way to create default data sets for your model.

See below for more details.

outputs function or argument in simInit

outputs accepts a data.frame similar to the inputs data.frame, but with up to 6 columns.

- **objectName**  required, character string indicating the name of the object in the simList that will be saved to disk (without the sim$ prefix).
- **file**  optional, a character string indicating the file path to save to. The default is to concatenate objectName with the Simulation timeunit and saveTime, separated by underscore. So a default filename would be "Fires_year1.rds".
- **fun**  optional, a character string indicating the function to use to save that file. The default is saveRDS.
- **package**  optional character string indicating the package in which to find the fun).
- **saveTime**  optional numeric, indicating when in simulation time the file should be saved. The default is the lowest priority at end(sim).
- **arguments**  is a list of lists of named arguments, one list for each fun. For example, if fun = "write.csv", arguments = list(row.names = TRUE).

See the modules vignette for more details (browseVignettes("SpaDES.core")).

Note

The automatic file type handling only adds the correct extension from a given fun and package. It does not do the inverse, from a given extension find the correct fun and package.

Examples

```
# outputs
library(igraph) # for %>%
tmpdir <- file.path(tempdir(), "outputs") %>% checkPath(create = TRUE)
tmpFile <- file.path(tmpdir, "temp.rds")
tempObj <- 1:10

# Can add data.frame of outputs directly into simInit call
sim <- simInit(objects = c("tempObj"),
               outputs = data.frame(objectName = "tempObj"),
               paths = list(outputPath = tmpdir))
outputs(sim) # To see what will be saved, when, what filename
sim <- spades(sim)
outputs(sim) # To see that it was saved, when, what filename

# Also can add using assignment after a simList object has been made
sim <- simInit(objects = c("tempObj"),
               paths = list(outputPath = tmpdir))
outputs(sim) <- data.frame(objectName = "tempObj", saveTime = 1:10)
sim <- spades(sim)
outputs(sim) # To see that it was saved, when, what filename.

# can do highly variable saving
```
tempObj2 <- paste("val", 1:10)
df1 <- data.frame(col1 = tempObj, col2 = tempObj2)
sim <- simInit(objects = c("tempObj", "tempObj2", "df1"),
paths=list(outputPath = tmpdir))
outputs(sim) = data.frame(
  objectName = c(rep("tempObj", 2), rep("tempObj2", 3), "df1"),
  saveTime = c(c(1,4), c(2,6,7), end(sim)),
  fun = c(rep("saveRDS", 5), "write.csv"),
  package = c(rep("base", 5), "utils"),
  stringsAsFactors = FALSE)
# since write.csv has a default of adding a column, x, with rownames, must add additional
# argument for 6th row in data.frame (corresponding to the write.csv function)
outputArgs(sim)[[6]] <- list(row.names=FALSE)
sim <- spades(sim)
outputs(sim)

# read one back in just to test it all worked as planned
newObj <- read.csv(dir(tmpdir, pattern = "year10.csv", full.name = TRUE))
newObj

# using saving with SpaDES-aware methods
# To see current ones SpaDES can do
.saveFileExtensions()

library(raster)
if (require(rgdal)) {
  ras <- raster(ncol = 4, nrow = 5)
  ras[] <- 1:20

  sim <- simInit(objects = c("ras"), paths = list(outputPath = tmpdir))
  outputs(sim) = data.frame(
    file = "test",
    fun = "writeRaster",
    package = "raster",
    objectName = "ras",
    stringsAsFactors = FALSE)

  outputArgs(sim)[[1]] <- list(format = "GTiff") # see ?raster::writeFormats
  simOut <- spades(sim)
  outputs(simOut)
  newRas <- raster(dir(tmpdir, full.name = TRUE, pattern = ".tif"))
  all.equal(newRas, ras) # Should be TRUE
}
# Clean up after
unlink(tmpdir, recursive = TRUE)

packages

Get module or simulation package dependencies

Description

Get module or simulation package dependencies
paddedFloatToChar

Convert numeric to character with padding

Description

Convert numeric to character with padding

Usage

packages(sim, modules, paths, filenames, envir, clean = FALSE, ...)

## S4 method for signature 'ANY'
packages(sim, modules, paths, filenames, envir, clean = FALSE, ...)

Arguments

* sim A simList object.
* modules Character vector, specifying the name or vector of names of module(s)
* paths Character vector, specifying the name or vector of names of paths(s) for those modules. If path not specified, it will be taken fromgetOption("spades.modulePath"), which is set with setPaths)
* filenames Character vector specifying filenames of modules (i.e. combined path & module. If this is specified, then modules and path are ignored.
* envir Optional environment in which to store parsed code. This may be useful if the same file is being parsed multiple times. This function will check in that envir for the parsed file before parsing again. If the envir is transient, then this will have no effect.
* clean Optional logical. If TRUE, it will scrub any references to github repositories, e.g., "PredictiveEcology/reproducible" will be returned as "reproducible"
* ... All simInit parameters.

Value

A sorted character vector of package names.

Author(s)

Alex Chubaty & Eliot McIntire

See Also

Other functions to access elements of a 'simList' object: .addDepends(), doEvent.checkpoint(), envir(), events(), globals(), inputs(), modules(), objs(), params(), paths(), progressInterval(), times()
Usage

```r
paddedFloatToChar(x, padL = ceiling(log10(x + 1)), padR = 3, pad = "0")
```

Arguments

- **x**: numeric. Number to be converted to character with padding
- **padL**: numeric. Desired number of digits on left side of decimal. If not enough, pad will be used to pad.
- **padR**: numeric. Desired number of digits on right side of decimal. If not enough, pad will be used to pad.
- **pad**: character to use as padding (`nchar(pad) == 1` must be TRUE). Passed to `stri_pad`

Value

Character string representing the filename.

Author(s)

Eliot McIntire and Alex Chubaty

Examples

```r
paddedFloatToChar(1.25)
paddedFloatToChar(1.25, padL = 3, padR = 5)
```

---

**params**

*Get and set simulation parameters*

Description

`params` and `P` access the parameter slot in the `simList`. `params` has a replace method, so can be used to update a parameter value.

Usage

```r
params(sim)
```

## S4 method for signature 'simList'

```r
params(sim)
```

```r
params(sim) <- value
```

## S4 replacement method for signature 'simList'

```r
params(sim) <- value
```

```r
P(sim, module, param)
```
parameters(sim, asDF = FALSE)

## S4 method for signature 'simList'
parameters(sim, asDF = FALSE)

### Arguments

- **sim**: A simList object from which to extract element(s) or in which to replace element(s).
- **value**: The object to be stored at the slot.
- **module**: Optional character string indicating which module params should come from.
- **param**: Optional character string indicating which parameter to choose.
- **asDF**: Logical. For parameters, if TRUE, this will produce a single data.frame of all model parameters. If FALSE, then it will return a data.frame with 1 row for each parameter within nested lists, with the same structure as params.

### Details

parameters will extract only the metadata with the metadata defaults, NOT the current values that may be overwritten by a user. See examples.

### Value

Returns or sets the value of the slot from the simList object.

### Note

The differences between P, params and being explicit with passing arguments are mostly a question of speed and code compactness. The computationally fastest way to get a parameter is to specify moduleName and parameter name, as in: P(sim,"moduleName","paramName") (replacing moduleName and paramName with your specific module and parameter names), but it is more verbose than P(sim)$paramName. Note: the important part for speed (e.g., 2-4x faster) is specifying the moduleName. Specifying the parameter name is <5

### See Also

- SpaDES.core-package, specifically the section 1.2.1 on Simulation parameters.
- Other functions to access elements of a 'simList' object: .addDepends(), doEvent.checkpoint(), envir(), events(), globals(), inputs(), modules(), objs(), packages(), paths(), progressInterval(), times()

### Examples

```r
modules <- list("randomLandscapes")
paths <- list(modulePath = system.file("sampleModules", package = "SpaDES.core"))
mySim <- simInit(modules = modules, paths = paths,
                 params = list(.globals = list(stackName = "landscape")))
```
# update some parameters using assignment -- currently only params will work
params(mySim)$randomLandscapes$nx <- 200
params(mySim)$randomLandscapes$ny <- 200

parameters(mySim) # Does not contain these user overridden values

# These next 2 are same here because they are not within a module
P(mySim) # Does contain the user overridden values
params(mySim) # Does contain the user overridden values

# NOTE -- deleting a parameter will affect params and P, not parameters
params(mySim)$randomLandscapes$nx <- NULL
params(mySim)$randomLandscapes$ny <- NULL

parameters(mySim) # Shows nx and ny

# These next 2 are same here because they are not within a module
P(mySim) # nx and ny are Gone
params(mySim) # nx and ny are Gone

---

**paths**

*Specify paths for modules, inputs, outputs, and temporary rasters*

---

**Description**

Accessor functions for the paths slot in a simList object.

dataPath will return file.path(modulePath(sim),currentModule(sim),"data"). dataPath, like currentModule, is namespaced. This means that when it is used inside a module, then it will return that model-specific information. For instance, if used inside a module called "movingAgent", then currentModule(sim) will return "movingAgent", and dataPath(sim) will return file.path(modulePath(sim),"movingAgent","data").

**Usage**

paths(sim)

## S4 method for signature 'simList'
paths(sim)

paths(sim) <- value

## S4 replacement method for signature 'simList'
paths(sim) <- value

cachePath(sim)

## S4 method for signature 'simList'
cachePath(sim)
cachePath(sim) <- value

## S4 replacement method for signature 'simList'
cachePath(sim) <- value

inputPath(sim)

## S4 method for signature 'simList'
inputPath(sim)

inputPath(sim) <- value

## S4 replacement method for signature 'simList'
inputPath(sim) <- value

outputPath(sim)

## S4 method for signature 'simList'
outputPath(sim)

outputPath(sim) <- value

## S4 replacement method for signature 'simList'
outputPath(sim) <- value

modulePath(sim, module)

## S4 method for signature 'simList'
modulePath(sim, module)

modulePath(sim) <- value

## S4 replacement method for signature 'simList'
modulePath(sim) <- value

rasterPath(sim)

## S4 method for signature 'simList'
rasterPath(sim)

rasterPath(sim) <- value

## S4 replacement method for signature 'simList'
rasterPath(sim) <- value

dataPath(sim)

## S4 method for signature 'simList'
dataPath(sim)

Arguments

sim  A simList object from which to extract element(s) or in which to replace element(s).
value The object to be stored at the slot.
module The optional character string of the module(s) whose paths are desired. If omitted, will return all modulePaths, if more than one exist.

Details

These are ways to add or access the file paths used by spades. There are five file paths: cachePath, modulePath, inputPath, outputPath, and rasterPath. Each has a function to get or set the value in a simList object. If no paths are specified, the defaults are as follows:

- cachePath:getOption("reproducible.cachePath");
- inputPath:getOption("spades.modulePath");
- modulePath:getOption("spades,inputPath");
- outputPath:getOption("spades.outputPath");
- rasterPath:raster::tmpDir()

Value

Returns or sets the value of the slot from the simList object.

See Also

SpaDES.core-package, specifically the section 1.2.4 on Simulation Paths.

Other functions to access elements of a 'simList' object: .addDepends(), doEvent.checkpoint(), envir(), events(), globals(), inputs(), modules(), objs(), packages(), params(), progressInterval(), times()
## S4 method for signature 'simList'

```r
Plot(
  ..., 
  new = FALSE, 
  addTo = NULL, 
  gp = gpar(), 
  gpText = gpar(), 
  gpAxis = gpar(), 
  axes = FALSE, 
  speedup = 1, 
  size = 5, 
  cols = NULL, 
  col = NULL, 
  zoomExtent = NULL, 
  visualSqueeze = NULL, 
  legend = TRUE, 
  legendRange = NULL, 
  legendText = NULL, 
  pch = 19, 
  title = NULL, 
  na.color = "#FFFFFF00", 
  zero.color = NULL, 
  length = NULL, 
  arr = NULL, 
  plotFn = "plot"
)
```

### Arguments

- `...`: A combination of `spatialObjects` or non-spatial objects. For many object classes, there are specific `Plot` methods. Where there are no specific ones, the base plotting will be used internally. This means that for objects with no specific `Plot` methods, many arguments, such as `addTo`, will not work. See details.

- `new`: Logical. If `TRUE`, then the previous named plot area is wiped and a new one made; if `FALSE`, then the ... plots will be added to the current device, adding or rearranging the plot layout as necessary. Default is `FALSE`. This currently works best if there is only one object being plotted in a given `Plot` call. However, it is possible to pass a list of logics to this, matching the length of the ... objects. Use `clearPlot` to clear the whole plotting device.

- `addTo`: Character vector, with same length as ... This is for overplotting, when the overplot is not to occur on the plot with the same name, such as plotting a `SpatialPoints*` object on a `RasterLayer`.

- `gp`: A `gpar` object, created by `gpar` function, to change plotting parameters (see `grid` package).

- `gpText`: A `gpar` object for the title text. Default `gpar(col = "black")`.

- `gpAxis`: A `gpar` object for the axes. Default `gpar(col = "black")`. 
### Plot, simList-method

**axes**
Logical or "L", representing the left and bottom axes, over all plots.

**speedup**
Numeric. The factor by which the number of pixels is divided by to plot rasters. See Details.

**size**
Numeric. The size, in points, for SpatialPoints symbols, if using a scalable symbol.

**cols**
(also col) Character vector or list of character vectors of colours. See details.

**col**
(also cols) Alternative to cols to be consistent with plot. cols takes precedence, if both are provided.

**zoomExtent**
An Extent object. Supplying a single extent that is smaller than the rasters will call a crop statement before plotting. Defaults to NULL. This occurs after any downsampling of rasters, so it may produce very pixelated maps.

**visualSqueeze**
Numeric. The proportion of the white space to be used for plots. Default is 0.75.

**legend**
Logical indicating whether a legend should be drawn. Default is TRUE.

**legendRange**
Numeric vector giving values that, representing the lower and upper bounds of a legend (i.e., 1:10 or c(1,10) will give same result) that will override the data bounds contained within the grobToPlot.

**legendText**
Character vector of legend value labels. Defaults to NULL, which results in a pretty numeric representation. If Raster\* has a Raster Attribute Table (rat; see raster package), this will be used by default. Currently, only a single vector is accepted. The length of this must match the length of the legend, so this is mostly useful for discrete-valued rasters.

**pch**
see ?par.

**title**
Logical or character string. If logical, it indicates whether to print the object name as the title above the plot. If a character string, it will print this above the plot. NOTE: the object name is used with addTo, not the title. Default NULL, which means print the object name as title, if no other already exists on the plot, in which case, keep the previous title.

**na.color**
Character string indicating the color for NA values. Default transparent.

**zero.color**
Character string indicating the color for zero values, when zero is the minimum value, otherwise, zero is treated as any other color. Default transparent.

**length**
Numeric. Optional length, in inches, of the arrow head.

**arr**
A vector of length 2 indicating a desired arrangement of plot areas indicating number of rows, number of columns. Default NULL, meaning let Plot function do it automatically.

**plotFn**
An optional function name to do the plotting internally, e.g., "barplot" to get a barplot() call. Default "plot".

## Details

Plot for simList class objects

See Plot. This method strips out stuff from a simList class object that would make it otherwise not reproducibly digestible between sessions, operating systems, or machines. This will likely still not allow identical digest results across R versions.
See Also

Plot

<table>
<thead>
<tr>
<th>priority</th>
<th>Event priority</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Description

Preset event priorities: 1 = first (highest); 5 = normal; 10 = last (lowest).

Usage

.first()
.highest()
.last()
.lowest()
.normal()

Value

A numeric.

Author(s)

Alex Chubaty

progressInterval

Get and set simulation progress bar details

Description

The progress bar can be set in two ways in SpaDES. First, by setting values in the .progress list element in the params list element passed to `simInit`. Second, at the `spades` call itself, which can be simpler. See examples.
Usage

progressInterval(sim)

## S4 method for signature 'simList'

progressInterval(sim)

progressInterval(sim) <- value

## S4 replacement method for signature 'simList'

progressInterval(sim) <- value

progressType(sim)

## S4 method for signature 'simList'

progressType(sim)

progressType(sim) <- value

## S4 replacement method for signature 'simList'

progressType(sim) <- value

Arguments

sim A simList object from which to extract element(s) or in which to replace element(s).

value The object to be stored at the slot.

Details

Progress Bar: Progress type can be one of "text", "graphical", or "shiny". Progress interval can be a numeric. These both can get set by passing a .progress = list(type = "graphical", interval = 1) into the simInit call. See examples.

See Also

Other functions to access elements of a 'simList' object: .addDepends(), doEvent.checkpoint(), envir(), events(), globals(), inputs(), modules(), objs(), packages(), params(), paths(), times()

Examples

## Not run:

mySim <- simInit(
  times = list(start=0.0, end=100.0),
  params = list(.globals = list(stackName = "landscape"),
    .progress = list(type = "text", interval = 10),
    .checkpoint = list(interval = 10, file = "chkpnt.RData")),
  modules = list("randomLandscapes"),
  paths = list(modulePath = system.file("sampleModules", package = "SpaDES.core")))
# progress bar
progressType(mySim) # "text"
progressInterval(mySim) # 10

# parameters
params(mySim) # returns all parameters in all modules
    # including .global, .progress, .checkpoint
globals(mySim) # returns only global parameters

# checkpoint
checkpointFile(mySim) # returns the name of the checkpoint file
    # In this example, "chkpnt.RData"
cHECKpointInterval(mySim) # 10

## End(Not run)

---

### rasterToMemory

**Read raster to memory**

#### Description
Wrapper to the `raster` function, that creates the raster object in memory, even if it was read in from file.

#### Usage

```r
rasterToMemory(x, ...)
```

#### Arguments

- `x` An object passed directly to the function `raster` (e.g., character string of a file-name).
- `...` Additional arguments to `raster`.

#### Value

A raster object whose values are stored in memory.

#### Author(s)

Eliot McIntire and Alex Chubaty

#### See Also

- `raster`
**remoteFileSize**

*Determine the size of a remotely hosted file*

**Description**

Query a remote web server to determine the size of a remote file.

**Usage**

remoteFileSize(url)

**Arguments**

- **url**
  - The url of the remote file.

**Value**

A numeric indicating the size of the remote file in bytes.

**Author(s)**

Eliot McIntire and Alex Chubaty

**Examples**

```r
    "http://example.com/doesntexist.csv")
try(remoteFileSize(urls)) ## 5429, 3997384, 0
```

---

**restartR**

*Restart R programmatically*

**Description**

This will attempt to restart the R session, reloading all packages, and saving and reloading the simList. Currently, this is not intended for general use: it has many specialized pieces for using inside a spades call. The main purpose for doing this is to clear memory leaks (possibly deep in R [https://github.com/r-lib/fastmap](https://github.com/r-lib/fastmap)) that are not fully diagnosed. *This is still very experimental.* This should only be used if there are RAM limitations being hit with long running simulations. It has been tested to work Linux within Rstudio and at a terminal R session. The way to initiate restarting of R is simply setting the spades.restartRInterval or setting the equivalent parameter in the restartR core module via: simInit(...,params = list(.restartR = list(.restartRInterval = 1)),...) greater than 0, which is the default, e.g., options("spades.restartRInterval" = 100). This is only intended to restart a simulation in exactly the same place as it was (i.e., cannot
change machines), and because of the restart, the assignment of the spades call will be either to sim or the user must make such an assignment manually, e.g., `sim <- SpaDES.core:::.pkgEnv$.sim`. This is stated in a message.

Usage

```r
restartR(
  sim,
  reloadPkgs = TRUE,
  .First = NULL,
  .RDataFile = getOption("spades.restartR.RDataFilename"),
  restartDir = getOption("spades.restartR.restartDir", NULL)
)
```

Arguments

- `sim` Required. A simList to be retained through the restart
- `reloadPkgs` Logical. If TRUE, it will attempt to reload all the packages as they were in previous session, in the same order. If FALSE, it will load no packages beyond normal R startup. Default TRUE
- `.First` A function to save to `~/.RData` which will be loaded at restart from `~/.RData` and run. Default is NULL, meaning it will use the non-exported SpaDES.core:::.First. If a user wants to make a custom `First` file, it should built off that one.
- `.RDataFile` A filename for saving the simList. Defaults to `getOption("spades.restartR.RDataFilename")`, and the directory will be in `restartDir`. The simulation time will be appended to this name, as in: `basename(.RDataFile),_time`, `paddedFloatToChar(time(sim),padL = nchar(as.character(end(sim)))))`
- `restartDir` A character string indicating root directory to save simList and other ancillary files during restart. Defaults to `getOption("spades.restartR.restartDir",NULL)`. If NULL, then it will try, in order, `outputPath(sim)`, `modulePath(sim)`, `inputPath(sim)`, `cachePath(sim)`, taking the first one that is not inside the `tempdir()`, which will disappear during restart of R. The actual directory for a given spades call that is restarting will be: `file.path(restartDir,"restartR",paste0(sim$_startClockTime,"_",rndString))`. The random string is to prevent parallel processes that started at the same clock time from colliding.

Details

The process responds to several options. Though under most cases, the default behaviour should suffice. These are of 3 types: `restartRInterval` the arguments to `restartR` and the arguments to `saveSimList`, these latter two using a dot to separate the function name and its argument. The defaults for two key options are: options("spades.restartR.restartDir" = NULL, meaning use `file.path(restartDir,"restartR",paste0(sim$_startClockTime,"_",rndString))`) and options("spades.saveSimList.fileBackend" = 0), which means don’t do anything with raster-backed files. See specific functions for defaults and argument meanings. The only difference from the default function values is with `saveSimList` argument `fileBackend = FALSE` during `restartR` by default, because it is assumed that the file backends will still be intact after a restart, so no need to move them all to memory.
Note

Because of the restarting, the object name of the original assignment of the spades call can not be preserved. The spades call will be assigned to sim in the .GlobalEnv.

Because this function is focused on restarting during a spades call, it will remove all objects in the .GlobalEnv, emulating q("no"). If the user wants to keep those objects, then they should be saved to disk immediately before the spades call. This can then be recovered immediately after the return from the spades call.

To keep the saved simList, use options("spades.restartR.clearFiles" = TRUE). The default is to treat these files as temporary files and so will be removed.

restartSpades

Restart an interrupted simulation

Description

This is very experimental and has not been thoroughly tested. Use with caution. This function will reparse a single module (currently) into the simList where its source code should reside, and then optionally restart a simulation that stopped on an error, presumably after the developer has modified the source code of the module that caused the break. This will restart the simulation at the next event in the event queue (i.e., returned by events(sim)). Because of this, this function will not do anything if the event queue is empty.

Usage

restartSpades(sim = NULL, module = NULL, numEvents = Inf, restart = TRUE, ...)

Arguments

sim
A simList. If not supplied (the default), this will take the sim from SpaDES.core:::.pkgEnv$.sim, i.e., the one that was interrupted

module
A character string length one naming the module that caused the error and whose source code was fixed. This module will be reparsed and placed into the simList

numEvents
Numeric. Default is Inf (i.e., all available). In the simList, if options('spades.recoveryMode') is set to TRUE or a numeric, then there will be a list in the simList called .recoverableObjs. These will be replayed backwards in time to reproduce the initial state of the simList before the event that is numEvents back from the first event in events(sim).

restart
Logical. If TRUE, then the call to spades will be made, i.e., restarting the simulation. If FALSE, then it will return a new simList with the module code parsed into the simList

... Passed to spades, e.g., debug, .plotInitialTime
Details
This will only parse the source code from the named module. It will not affect any objects that are
in the mod or sim.

The random number seed will be reset to the state it was at the start of the earliest event recovered,
thereby returning to the exact stochastic simulation trajectory.

Value
A simList as if spades had been called on a simList.

Note
This will only work reliably if the simList was not modified yet during the event which caused the
error. The simList will be in the state it was at the time of the error.

Examples
## Not run:
# options("spades.recoveryMode" = 1) # now the default
s <- simInit()
# this this is interrupted or fails
s <- spades(s)
# don't need to put simList
s <- restartSpades()

## End(Not run)

---

**rndstr**

*Generate random strings*

**Description**
Generate a vector of random alphanumeric strings each of an arbitrary length.

**Usage**

```r
rndstr(n, len, characterFirst)
```

## S4 method for signature 'numeric,numeric,logical'
rndstr(n, len, characterFirst)

## S4 method for signature 'numeric,numeric,missing'
rndstr(n, len)

## S4 method for signature 'numeric,missing,logical'
rndstr(n, characterFirst)

## S4 method for signature 'missing,numeric,logical'
rndstr(len, characterFirst)

## S4 method for signature 'numeric,missing,missing'
rndstr(n)

## S4 method for signature 'missing,numeric,missing'
rndstr(len)

## S4 method for signature 'missing,missing,logical'
rndstr(characterFirst)

## S4 method for signature 'missing,missing,missing'
rndstr(n, len, characterFirst)

### Arguments

- **n**  
  Number of strings to generate (default 1). Will attempt to coerce to integer value.

- **len**  
  Length of strings to generate (default 8). Will attempt to coerce to integer value.

- **characterFirst**  
  Logical, if TRUE, then a letter will be the first character of the string (useful if being used for object names).

### Value

Character vector of random strings.

### Author(s)

Alex Chubaty and Eliot McIntire

### Examples

```r
set.seed(11)
rndstr()
rndstr(len = 10)
rndstr(characterFirst = FALSE)
rndstr(n = 5, len = 10)
rndstr(n = 5)
rndstr(n = 5, characterFirst = TRUE)
rndstr(len = 10, characterFirst = TRUE)
rndstr(n = 5, len = 10, characterFirst = TRUE)
```
saveFiles

Description

In the simInit call, a parameter called .saveObjects can be provided in each module. This must be a character string vector of all object names to save. These objects will then be saved whenever a call to saveFiles is made.

Usage

saveFiles(sim)

Arguments

sim            A simList simulation object.

Details

The file names will be equal to the object name plus time(sim) is appended at the end. The files are saved as .rds files, meaning, only one object gets saved per file.

For objects saved using this function, the module developer must create save events that schedule a call to saveFiles.

If this function is used outside of a module, it will save all files in the outputs(sim) that are scheduled to be saved at the current time in the simList.

There are 3 ways to save objects using SpaDES.

1. Model-level saving

Using the outputs slot in the simInit call. See example in simInit. This can be convenient because it gives overall control of many modules at a time, and it gets automatically scheduled during the simInit call.

2. Module-level saving

Using the saveFiles function inside a module. This must be accompanied by a .saveObjects list element in the params slot in the simList. Usually a module developer will create this method for future users of their module.

3. Custom saving

A module developer can save any object at any time inside their module, using standard R functions for saving R objects (e.g., save or saveRDS). This is the least modular approach, as it will happen whether a module user wants it or not.

Note

It is not possible to schedule separate saving events for each object that is listed in the .saveObjects.
Author(s)
Eliot McIntire
Alex Chubaty

Examples

## Not run:

# This will save the "caribou" object at the save interval of 1 unit of time
# in the outputPath location
outputPath <- file.path(tempdir(), "test_save")
times <- list(start = 0, end = 6, "month")
parameters <- list(
  .globals = list(stackName = "landscape"),
  caribouMovement = list(
    .saveObjects = "caribou",
    .saveInitialTime = 1, .saveInterval = 1
  ),
  randomLandscapes = list(.plotInitialTime = NA, nx = 20, ny = 20)
)
modules <- list("randomLandscapes", "caribouMovement")
paths <- list(
  modulePath = system.file("sampleModules", package = "SpaDES.core"),
  outputPath = savePath
)
mySim <- simInit(times = times, params = parameters, modules = modules,
  paths = paths)

# The caribou module has a saveFiles(sim) call, so it will save caribou
spades(mySim)
dir(outputPath)

# remove the files
file.remove(dir(savePath, full.names = TRUE))

## End(Not run)

saveSimList

Save a whole simList object to disk

Description

Because of the environment slot, this is not quite as straightforward as just saving the object. This also has option for file-backed Rasters.

Usage

saveSimList(sim, filename, fileBackend = 0, filebackedDir = NULL, envir, ...)
scheduleConditionalEvent

Arguments

- **sim**: Either a simList or a character string of the name of a simList that can be found in envir. Using a character string will assign that object name to the saved simList, so when it is recovered it will be given that name.

- **filename**: Character string with the path for saving simList

- **fileBackend**: Numeric. 0 means don’t do anything with file backed rasters. Leave their file intact as is, in its place. 1 means save a copy of the file backed rasters in fileBackedDir. 2 means move all data in file-backed rasters to memory. This means that the objects will be part of the main RData file of the simList. Default is 0.

- **filebackedDir**: Only used if fileBackend is 1. NULL, the default, or Character string. If NULL, then the files will be copied to the directory: file.path(dirname(filename),"rasters"). A character string will be interpreted as a path to copy all rasters to.

- **envir**: If sim is a character string, then this must be provided. It is the environment where the object named sim can be found.

- **...**: Passed to save, e.g., compression

Value

A saved .RData file in filename location.

See Also

- zipSimList

scheduleConditionalEvent

Schedule a conditional simulation event

Description

Adds a new event to the simulation’s conditional event queue, updating the simulation object by creating or appending to sim$._conditionalEvents. This is very experimental. Use with caution.

Usage

scheduleConditionalEvent(
  sim,
  condition, moduleName, eventType,
  eventPriority = .pkgEnv$.normalVal,
  minEventTime = start(sim),
  maxEventTime = end(sim)
)
scheduleConditionalEvent

Arguments

sim
A simList simulation object.

condition
A string, call or expression that will be assessed for TRUE after each event in the regular event queue. It can access objects in the simList by using functions of sim, e.g., "sim$age > 1"

moduleName
A character string specifying the module from which to call the event. If missing, it will use currentModule(sim)

eventType
A character string specifying the type of event from within the module.

eventType
A numeric specifying the priority of the event. Lower number means higher priority. As a best practice, it is recommended that decimal values are conceptual grouped by their integer values (e.g., 4.0, 4.25, 4.5 are conceptually similar). See priority.

minEventTime
A numeric specifying the time before which the event should not occur, even if the condition is met. Defaults to start(sim)

maxEventTime
A numeric specifying the time after which the event should not occur, even if the condition is met. Defaults to end(sim)

Value

Returns the modified simList object, i.e., sim$._conditionalEvents.

This conditional event queue will be assessed at every single event in the normal event queue. If there are no conditional events, then spades will proceed as normal. As conditional event conditions are found to be true, then it will trigger a call to scheduleEvent(...) with the current time passed to eventTime and it will remove the conditional event from the conditional queue. If the user would like the triggered conditional event to occur as the very next event, then a possible strategy would be to set eventPriority of the conditional event to very low or even negative to ensure it gets inserted at the top of the event queue.

Author(s)

Eliot McIntire

References


See Also

scheduleEvent, conditionalEvents

Examples

```r
sim <- simInit(times = list(start = 0, end = 2))
condition <- "sim$age > 1" # provide as string
condition <- quote(sim$age > 1) # provide as a call
condition <- expression(sim$age > 1) # provide as an expression
```
`scheduleEvent`  

**Schedule a simulation event**

**Description**

Adds a new event to the simulation’s event queue, updating the simulation object.

**Usage**

```r
scheduleEvent(
  sim,  
  eventTime,  
  moduleName,  
  eventType,  
  eventPriority = .pkgEnv$.normalVal,  
  .skipChecks = FALSE  
)
```

**Arguments**

- `sim`: A `simList` simulation object.
- `eventTime`: A numeric specifying the time of the next event.
- `moduleName`: A character string specifying the module from which to call the event. If missing, it will use `currentModule(sim)`
- `eventType`: A character string specifying the type of event from within the module.
- `eventPriority`: A numeric specifying the priority of the event. Lower number means higher priority. As a best practice, it is recommended that decimal values are conceptual grouped by their integer values (e.g., 4.0, 4.25, 4.5 are conceptually similar). See `priority`.
- `.skipChecks`: Logical. If TRUE, then internal checks that arguments match expected types are skipped. Should only be used if speed is critical.

**Details**

Here, we implement a simulation in a more modular fashion so it’s easier to add submodules to the simulation. We use S4 classes and methods, and use `data.table` instead of `data.frame` to implement the event queue (because it is much faster).
Value

Returns the modified simList object.

Author(s)

Alex Chubaty

References


See Also

priority, scheduleConditionalEvent

Examples

## Not run:
scheduleEvent(x, time(sim) + 1.0, "firemodule", "burn") # default priority
scheduleEvent(x, time(sim) + 1.0, "firemodule", "burn", .normal()) # default priority
scheduleEvent(x, time(sim) + 1.0, "firemodule", "burn", .normal()-1) # higher priority
scheduleEvent(x, time(sim) + 1.0, "firemodule", "burn", .normal()+1) # lower priority
scheduleEvent(x, time(sim) + 1.0, "firemodule", "burn", .highest()) # highest priority
scheduleEvent(x, time(sim) + 1.0, "firemodule", "burn", .lowest()) # lowest priority

## End(Not run)
Initialize a new simulation

Description
Create a new simulation object, the "sim" object. This object is implemented using an environment where all objects and functions are placed. Since environments in R are pass by reference, "putting" objects in the sim object does no actual copy. The simList also stores all parameters, and other important simulation information, such as times, paths, modules, and module load order. See more details below.

Usage

```r
simInit(
  times,
  params,
  modules,
  objects,
  paths,
  inputs,
  outputs,
  loadOrder,
  notOlderThan = NULL
)
```

## S4 method for signature
## 'list, list, list, list, list, data.frame, data.frame, character'

```r
simInit(
  times,
  params,
  modules,
  objects,
  paths,
  inputs,
  outputs,
  loadOrder,
  notOlderThan = NULL
)
```

## S4 method for signature 'ANY, ANY, ANY, character, ANY, ANY, ANY, ANY'

```r
simInit(
  times,
  params,
  modules,
  objects,
  paths,
  inputs,
```
simInit

```r
simInit(
  times,  
  params,  
  modules,  
  objects,  
  paths,  
  inputs,  
  outputs,  
  loadOrder,  
  notOlderThan = NULL
)
```

## S4 method for signature 'ANY,ANY,character,ANY,ANY,ANY,ANY,ANY'

```r
simInit(
  times,  
  params,  
  modules,  
  objects,  
  paths,  
  inputs,  
  outputs,  
  loadOrder,  
  notOlderThan = NULL
)
```

Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>times</code></td>
<td>A named list of numeric simulation start and end times (e.g., <code>times = list(start = 0.0, end = 10.0)</code>).</td>
</tr>
<tr>
<td><code>params</code></td>
<td>A list of lists of the form <code>list(moduleName=list(param1=value,param2=value))</code>. See details.</td>
</tr>
<tr>
<td><code>modules</code></td>
<td>A named list of character strings specifying the names of modules to be loaded for the simulation. Note: the module name should correspond to the R source file from which the module is loaded. Example: a module named &quot;caribou&quot; will be sourced form the file 'caribou.R', located at the specified modulePath(simList) (see below).</td>
</tr>
<tr>
<td><code>objects</code></td>
<td>(optional) A vector of object names (naming objects that are in the calling environment of the <code>simInit</code>, which is often the <code>.GlobalEnv</code> unless used programmatically – NOTE: this mechanism will fail if object name is in a package dependency), or a named list of data objects to be passed into the simList (more reliable). These objects will be accessible from the simList as a normal list, e.g., <code>mySim$obj</code>.</td>
</tr>
</tbody>
</table>
paths

An optional named list with up to 4 named elements, `modulePath`, `inputPath`, `outputPath`, and `cachePath`. See details. NOTE: Experimental feature now allows for multiple `modulePath` to be specified in a character vector. The modules will be searched for sequentially in the first `modulePath`, then if it doesn’t find it, in the second etc.

inputs

A `data.frame`. Can specify from 1 to 6 columns with following column names: `objectName` (character, required), `file` (character), `fun` (character), `package` (character), `interval` (numeric), `loadTime` (numeric). See `inputs` and vignette("ii-modules") section about inputs.

outputs

A `data.frame`. Can specify from 1 to 5 columns with following column names: `objectName` (character, required), `file` (character), `fun` (character), `package` (character), `saveTime` (numeric) and `eventPriority` (numeric). If `eventPriority` is not set, it defaults to `.last()`. If `eventPriority` is set to a low value, e.g., 0, 1, 2 and `saveTime` is `start(sim)`, it should give "initial conditions". See `outputs` and vignette("ii-modules") section about outputs.

loadOrder

An optional list of module names specifying the order in which to load the modules. If not specified, the module load order will be determined automatically.

not OlderThan

A time, as in from `Sys.time()`. This is passed into the Cache function that wraps `.inputObjects`. If the module uses the `.useCache` parameter and it is set to `TRUE` or ".inputObjects", then the `.inputObjects` will be cached. Setting `notOlderThan = Sys.time()` will cause the cached versions of `.inputObjects` to be refreshed, i.e., rerun.

Details

**Calling this simInit function does the following::**

<table>
<thead>
<tr>
<th>What</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>fills simList slots</td>
<td>places the arguments <code>times</code>, <code>params</code>, <code>modules</code>, <code>paths</code> into equivalently named simList slots</td>
</tr>
<tr>
<td>sources all module files</td>
<td>places all function definitions in the simList, specifically, into a sub-environment of the module</td>
</tr>
<tr>
<td>copies objects</td>
<td>from the global environment to the simList environment</td>
</tr>
<tr>
<td>loads objects</td>
<td>from disk into the simList</td>
</tr>
<tr>
<td>schedule object loading/copying</td>
<td>Objects can be loaded into the simList at any time during a simulation</td>
</tr>
<tr>
<td>schedule object saving</td>
<td>Objects can be saved to disk at any arbitrary time during the simulation. If specified here, the objects will be saved to disk using the write method of the module.</td>
</tr>
<tr>
<td>schedules &quot;init&quot; events</td>
<td>via the inputs and outputs identified in their metadata. This gives the order of the <code>.inputObjects</code> events.</td>
</tr>
<tr>
<td>assesses module dependencies</td>
<td>takes time units of modules and how they fit together</td>
</tr>
<tr>
<td>determines time unit</td>
<td>from every module in the module order as determined above</td>
</tr>
<tr>
<td>runs <code>.inputObjects</code> functions</td>
<td></td>
</tr>
</tbody>
</table>

`params` can only contain updates to any parameters that are defined in the metadata of modules. Take the example of a module named, `Fire`, which has a parameter named `.plotInitialTime`. In the metadata of that module, it says `TRUE`. Here we can override that default with: `list(Fire=list(.plotInitialTime=NA))`, effectively turning off plotting. Since this is a list of lists, one can override the module defaults for multiple parameters from multiple modules all at once, with say: `list(Fire = list(.plotInitialTime = NA,.plotInterval = 2), caribouModule = list(N = 1000))`. We implement a discrete event simulation in a more modular fashion so it is easier to add modules
to the simulation. We use S4 classes and methods, and fast lists to manage the event queue.

paths specifies the location of the module source files, the data input files, and the saving output files. If no paths are specified the defaults are as follows:

- cachePath: `getOption("reproducible.cachePath")`
- inputPath: `getOption("spades.modulePath")`
- modulePath: `getOption("spades.inputPath")`
- inputPath: `getOption("spades.outputPath")`.

Value

A simList simulation object, pre-initialized from values specified in the arguments supplied.

Parsing and Checking Code

The `simInit` function will attempt to find usage of `sim$xxx` or `sim[['xxx']]` on either side of the assignment "<-" operator. It will compare these to the module metadata, specifically `inputObjects` for cases where objects or "gotten" from the simList and `outputObjects` for cases where objects are assigned to the simList.

It will also attempt to find potential, common function name conflicts with things like scale and stack (both in base and raster), and Plot (in quickPlot and some modules).

*This code checking is young and may get false positives and false negatives – i.e., miss things.* It also takes computational time, which may be undesirable in operational code. To turn off checking (i.e., if there are too many false positives and negatives), set the option `spades.moduleCodeChecks` to FALSE, e.g., `options(spades.moduleCodeChecks = FALSE)`

Caching

Using caching with SpaDES is vital when building re-usable and reproducible content. Please see the vignette dedicated to this topic.

Note

Since the objects in the simList are passed-by-reference, it is useful to create a copy of the initialized simList object prior to running the simulation (e.g., `mySimOut <- spades(Copy(mySim))`). This ensures you retain access to the original objects, which would otherwise be overwritten/modified during the simulation.

The user can opt to run a simpler simInit call without inputs, outputs, and times. These can be added later with the accessor methods (See example). These are not required for initializing the simulation via simInit. All of modules, paths, params, and objects are needed for successful initialization.

Author(s)

Alex Chubaty and Eliot McIntire
References


See Also

spades, times, params, objs, paths, modules, inputs, outputs

Examples

```r
## Not run:
mySim <- simInit(
  times = list(start = 0.0, end = 2.0, timeunit = "year"),
  params = list(
    .globals = list(stackName = "landscape", burnStats = "nPixelsBurned")
  ),
  modules = list("randomLandscapes", "fireSpread", "caribouMovement"),
  paths = list(modulePath = system.file("sampleModules", package = "SpaDES.core"))
)
spades(mySim) # shows plotting

# Change more parameters, removing plotting
mySim <- simInit(
  times = list(start = 0.0, end = 2.0, timeunit = "year"),
  params = list(
    .globals = list(stackName = "landscape", burnStats = "nPixelsBurned"),
    fireSpread = list(.plotInitialTime = NA)
  ),
  modules = list("randomLandscapes", "fireSpread", "caribouMovement"),
  paths = list(modulePath = system.file("sampleModules", package = "SpaDES.core"))
)
outSim <- spades(mySim)

# A little more complicated with inputs and outputs
if (require(rgdal)) {
  mapPath <- system.file("maps", package = "quickPlot")
  mySim <- simInit(
    times = list(start = 0.0, end = 2.0, timeunit = "year"),
    params = list(
      .globals = list(stackName = "landscape", burnStats = "nPixelsBurned")
    ),
    modules = list("randomLandscapes", "fireSpread", "caribouMovement"),
    paths = list(modulePath = system.file("sampleModules", package = "SpaDES.core"),
                 outputPath = tempdir()),
    inputs = data.frame(
      files = dir(file.path(mapPath), full.names = TRUE, pattern = "tif"[1:2],
                  functions = "raster",
                  package = "raster",
                  loadTime = 1,
                  stringsAsFactors = FALSE),
    outputs = data.frame(
      expand.grid(objectName = c("caribou","landscape"))
  )
)```
saveTime = 1:2,
stringsAsFactors = FALSE))
)

# Use accessors for inputs, outputs
mySim2 <- simInit(
  times = list(current = 0, start = 0.0, end = 2.0, timeunit = "year"),
  modules = list("randomLandscapes", "fireSpread", "caribouMovement"),
  params = list(.globals = list(stackName = "landscape", burnStats = "nPixelsBurned")),
  paths = list(  
    modulePath = system.file("sampleModules", package = "SpaDES.core"),
    outputPath = tempdir()
  )
)

# add by accessor is equivalent
inputs(mySim2) <- data.frame(  
  files = dir(file.path(mapPath), full.names = TRUE, pattern = "tif")[1:2],
  functions = "raster",
  package = "raster",
  loadTime = 1,
  stringsAsFactors = FALSE)
outputs(mySim2) <- data.frame(  
  expand.grid(objectName = c("caribou", "landscape"),
    saveTime = 1:2,
    stringsAsFactors = FALSE)
)

all.equal(mySim, mySim2) # TRUE

# Use accessors for times -- does not work as desired because times are  
# adjusted to the input timeunit during simInit
mySim2 <- simInit(  
  params = list(  
    .globals = list(stackName = "landscape", burnStats = "nPixelsBurned")
  ),
  modules = list("randomLandscapes", "fireSpread", "caribouMovement"),
  paths = list(modulePath = system.file("sampleModules", package = "SpaDES.core"),
    outputPath = tempdir()),
  inputs = data.frame(  
    files = dir(file.path(mapPath), full.names = TRUE, pattern = "tif")[1:2],
    functions = "raster",
    package = "raster",
    loadTime = 1,
    stringsAsFactors = FALSE),
  outputs = data.frame(  
    expand.grid(objectName = c("caribou", "landscape"),
      saveTime = 1:2,
      eventPriority = c(0,10), # eventPriority 0 may give "initial" conditions
      stringsAsFactors = FALSE)
  )
)

# add times by accessor fails all.equal test because "year" was not  
# declared during module loading, so month became the default

times(mySim2) <- list(current = 0, start = 0.0, end = 2.0, timeunit = "year")
all.equal(mySim, mySim2) # fails because time units are all different, so # several parameters that have time units in # "months" because they were loaded that way
params(mySim)$fireSpread$.plotInitialTime
params(mySim2)$fireSpread$.plotInitialTime
events(mySim) # load event is at time 1 year
events(mySim2) # load event is at time 1 month, reported in years because of # update to times above

## End(Not run)

---

**simInitAndSpades**

*Call simInit and spades together*

**Description**

These functions are convenience wrappers that may allow for more efficient Caching. Passes all arguments to simInit, then passes the created simList to spades.

**Usage**

```r
simInitAndSpades(
  times,
  params,
  modules,
  objects,
  paths,
  inputs,
  outputs,
  loadOrder,
  notOlderThan,
  debug,
  progress,
  cache,
  .plotInitialTime,
  .saveInitialTime,
  ...
)
```

**Arguments**

- **times**: A named list of numeric simulation start and end times (e.g., `times = list(start = 0.0, end = 10.0)`).
- **params**: A list of lists of the form `list(moduleName=list(param1=value,param2=value))`. See details.
modules
A named list of character strings specifying the names of modules to be loaded for the simulation. Note: the module name should correspond to the R source file from which the module is loaded. Example: a module named "caribou" will be sourced form the file 'caribou.R', located at the specified modulePath(simList) (see below).

objects
(optional) A vector of object names (naming objects that are in the calling environment of the simInit, which is often the .GlobalEnv unless used programmatically – NOTE: this mechanism will fail if object name is in a package dependency), or a named list of data objects to be passed into the simList (more reliable). These objects will be accessible from the simList as a normal list, e.g., mySim$obj.

paths
An optional named list with up to 4 named elements, modulePath, inputPath, outputPath, and cachePath. See details. NOTE: Experimental feature now allows for multiple modulePaths to be specified in a character vector. The modules will be searched for sequentially in the first modulePath, then if it doesn’t find it, in the second etc.

inputs
A data.frame. Can specify from 1 to 6 columns with following column names: objectName (character, required), file (character), fun (character), package (character), interval (numeric), loadTime (numeric). See inputs and vignette("i-modules") section about inputs.

outputs
A data.frame. Can specify from 1 to 5 columns with following column names: objectName (character, required), file (character), fun (character), package (character), saveTime (numeric) and eventPriority (numeric). If eventPriority is not set, it defaults to .last(). If eventPriority is set to a low value, e.g., 0, 1, 2 and saveTime is start(sim), it should give "initial conditions". See outputs and vignette("i-modules") section about outputs.

loadOrder
An optional list of module names specifying the order in which to load the modules. If not specified, the module load order will be determined automatically.

notOlderThan
A time, as in from Sys.time(). This is passed into the Cache function that wraps .inputObjects. If the module uses the .useCache parameter and it is set to TRUE or " .inputObjects", then the .inputObjects will be cached. Setting notOlderThan = Sys.time() will cause the cached versions of .inputObjects to be refreshed, i.e., rerun.

debug
Optional tools for invoking debugging. Supplying a list will invoke the more powerful logging package. See details. Default is to use the value in getOption("spades.debug").

progress
Logical (TRUE or FALSE show a graphical progress bar), character ("graphical", "text") or numeric indicating the number of update intervals to show in a graphical progress bar.

cache
Logical. If TRUE, then the spades call will be cached. This means that if the call is made again with the same simList, then ‘spades” will return the return value from the previous run of that exact same simList. Default FALSE. See Details. See also the vignette on caching for examples.

.plotInitialTime
Numeric. Temporarily override the .plotInitialTime parameter for all modules. See Details.
.saveInitialTime
Numeric. Temporarily override the .plotInitialTime parameter for all modules. See Details.

... Arguments passed to simInit and spades

Value

Same as spades (a simList) or

See Also

simInit, spades

---

**simList-class**

*The simList class*

**Description**

Contains the minimum components of a SpaDES simulation. Various slot accessor methods (i.e., get and set functions) are provided (see 'Accessor Methods' below).

**Details**

Based on code from chapter 7.8.3 of Matloff (2011): "Discrete event simulation". Here, we implement a discrete event simulation in a more modular fashion so it's easier to add simulation components (i.e., "simulation modules"). We use S4 classes and methods, and use data.table instead of data.frame to implement the event queue (because it is much more efficient).

**Slots**

- `modules` List of character names specifying which modules to load.
- `params` Named list of potentially other lists specifying simulation parameters.
- `events` The list of scheduled events (i.e., event queue), which can be converted to a sorted data.table with events(sim). See 'Event Lists' for more information.
- `current` The current event, as a data.table. See 'Event Lists' for more information.
- `completed` An environment consisting of completed events, with each object named a character representation of the order of events. This was converted from a previous version which was a list. This was changed because the list became slow as number of events increased. See 'Event Lists' for more information. It is kept as an environment of individual events for speed. The completed method converts it to a sorted data.table.
- `depends` A .simDeps list of .moduleDeps objects containing module object dependency information.
- `sintimes` List of numerical values describing the simulation start and end times; as well as the current simulation time.
- `inputs` a data.frame or data.table of files and metadata
outputs a data.frame or data.table of files and metadata

paths Named list of modulePath, inputPath, and outputPath paths. Partial matching is performed.

.xData Environment referencing the objects used in the simulation. Several "shortcuts" to accessing objects referenced by this environment are provided, and can be used on the simList object directly instead of specifying the .xData slot: $, [[, ls, ls.str, objs. See examples.

.envir Deprecated. Please do not use any more.

Accessor Methods

Several slot (and sub-slot) accessor methods are provided for use, and categorized into separate help pages:

- simList-accessors-envir Simulation environment.
- simList-accessors-events Scheduled and completed events.
- simList-accessors-inout Passing data in to / out of simulations.
- simList-accessors-modules Modules loaded and used; module dependencies.
- simList-accessors-objects Accessing objects used in the simulation.
- simList-accessors-params Global and module-specific parameters.
- simList-accessors-paths File paths for modules, inputs, and outputs.
- simList-accessors-times Simulation times.

Event Lists

The main event list is a sorted data.table (keyed) on eventTime, and eventPriority. The completed event list is an ordered list in the exact order that the events were executed. Each event is represented by a data.table row consisting of:

- eventTime The time the event is to occur.
- moduleName The module from which the event is taken.
- eventType A character string for the programmer-defined event type.
- eventPriority The priority given to the event.

Note

The simList class extends the environment, by adding several slots that provide information about the metadata for a discrete event simulation. The environment slot, if accessed directly is .xData and this is where input and output objects from modules are placed. The simList class is similar, but it extends the list class. All other slots are the same. Thus, simList is identical to simList_, except that the former uses an environment for objects and the latter uses a list. The class simList_ is only used internally when saving/loading, because saving/loading a list behaves more reliably than saving/loading an environment.

Author(s)

Alex Chubaty and Eliot McIntire
Run a spatial discrete event simulation

Description

Here, we implement a simulation in a more modular fashion so it's easier to add submodules to the simulation. We use S4 classes and methods, and use `data.table` instead of `data.frame` to implement the event queue (because it is much faster).

Usage

```r
spades(
  sim,
  debug =getOption("spades.debug"),
  progress = NA,
  cache,
  .plotInitialTime = NULL,
  .saveInitialTime = NULL,
  notOlderThan = NULL,
  ...
)
```

```r
## S4 method for signature 'simList,ANY,ANY,missing'
spades(
  sim,
  debug =getOption("spades.debug"),
  progress = NA,
  cache,
  .plotInitialTime = NULL,
  .saveInitialTime = NULL,
  notOlderThan = NULL,
  ...
)
```

```r
## S4 method for signature 'ANY,ANY,ANY,logical'
spades(
  sim,
  debug =getOption("spades.debug"),
  progress = NA,
  cache,
  .plotInitialTime = NULL,
  .saveInitialTime = NULL,
  ...
)
```
notOlderThan = NULL,
...
)

Arguments

sim A simList simulation object, generally produced by simInit.
debug Optional tools for invoking debugging. Supplying a list will invoke the more powerful logging package. See details. Default is to use the value in getOption("spades.debug").
progress Logical (TRUE or FALSE show a graphical progress bar), character ("graphical", "text") or numeric indicating the number of update intervals to show in a graphical progress bar.
cache Logical. If TRUE, then the spades call will be cached. This means that if the call is made again with the same simList, then 'spades' will return the return value from the previous run of that exact same simList. Default FALSE. See Details. See also the vignette on caching for examples.
.plotInitialTime Numeric. Temporarily override the .plotInitialTime parameter for all modules. See Details.
.saveInitialTime Numeric. Temporarily override the .plotInitialTime parameter for all modules. See Details.
notOlderThan Date or time. Passed to reproducible::Cache to update the cache. Default is NULL, meaning don’t update the cache. If Sys.time() is provided, then it will force a recache, i.e., remove old value and replace with new value. Ignored if cache is FALSE.
...
Any. Can be used to make a unique cache identity, such as "replicate = 1". This will be included in the Cache call, so will be unique and thus spades will not use a cached copy as long as anything passed in ... is unique, i.e., not cached previously.

Details

The is the workhorse function in the SpaDES package. It runs simulations by implementing the rules outlined in the simList.

This function gives simple access to two sets of module parameters: .plotInitialTime and with .plotInitialTime. The primary use of these arguments is to temporarily turn off plotting and saving. "Temporary" means that the simList is not changed, so it can be used again with the simList values reinstated. To turn off plotting and saving, use .plotInitialTime = NA or .saveInitialTime = NA. NOTE: if a module did not use .plotInitialTime or .saveInitialTime, then these arguments will not do anything.

If cache is TRUE, this allows for a seamless way to "save" results of a simulation. The user does not have to intentionally do any saving manually. Instead, upon a call to spades in which the simList is identical, the function will simply return the result that would have come if it had been rerun. Use this with caution, as it will return exactly the result from a previous run, even if there is stochasticity internally. Caching is only based on the input simList. See also the vignette on caching for examples.
Value

Invisibly returns the modified simList object.

debug

The most powerful way to use debug is to invoke the logging R package. To invoke this, debug must be a list with up to 3 named elements: console, file, and debug. Each of these list elements must be a list (including empty list() for defaults) with the sub-list elements here:

<table>
<thead>
<tr>
<th>console</th>
<th>level</th>
<th>The level, see below, of information shown</th>
</tr>
</thead>
<tbody>
<tr>
<td>file</td>
<td>append</td>
<td>Logical. If TRUE, the default, then log entries are appended to file, if it exists</td>
</tr>
<tr>
<td>file</td>
<td></td>
<td>A filename. Defaults to log.txt</td>
</tr>
<tr>
<td>level</td>
<td></td>
<td>The level, see below, of information shown</td>
</tr>
<tr>
<td>debug</td>
<td></td>
<td>See possible values below</td>
</tr>
</tbody>
</table>

level can be a number from 0 to 100 or a character string matching one of the values in logging::loglevels. These are hierarchical levels of information passed to the console. Set a lower number for more information and a higher number for less information. Errors in code will be shown if level is set to "ERROR" or 40 or above; warnings in code will be shown if level is set to "WARN" or 30 or above; normal messages in code will be shown if level is set to "INFO" or 20 or above. For consistency with base R messaging, if default level is used, then normal messaging via message will be shown; this means that suppressMessages will work to suppress messaging only when level is set to "INFO" or 20. Some functions in the SpaDES ecosystem may have information at the lower levels, but currently, there are few to none.

debug can be a logical, character vector or a numeric scalar (currently 1 or 2). If debug is specified and is not FALSE, 2 things could happen: 1) there can be messages sent to console, such as events as they pass by, and 2) if options("spades.browserOnError" = TRUE) (experimental still) if there is an error, it will attempt to open a browser in the event where the error occurred. You can edit, and then press c to continue or Q to quit, plus all other normal interactive browser tools. c will trigger a reparse and events will continue as scheduled, starting with the one just edited. There may be some unexpected consequences if the simList objects had already been changed before the error occurred.

If not specified in the function call, the package option spades.debug is used. The following options for debug are available:

- TRUE
  - function name (as character string)
  - moduleName (as character string)
  - eventName (as character string)
  - c(<moduleName>, <eventName>)
  - Any other R expression expressed as a character string
  - A numeric scalar, currently 1 or 2 (maybe others)
  - information that users may find useful

the event immediately following will be printed as it runs (equivalent to current(sim)).

If a function, then it will be run on the simList, e.g., "time" will run time(sim).

All calls to that module will be entered interactively.

All calls that have that event name (in any module) will be entered into.

Only the event in that specified module will be entered into.

Will be evaluated with access to the simList as 'sim'. If this is more than one expression, then all will be printed to the screen in their sequence.

This will print out alternative forms of event information that users may find useful.
Note

The debug option is primarily intended to facilitate building simulation models by the user. Will print additional outputs informing the user of updates to the values of various simList slot components. See https://github.com/PredictiveEcology/SpaDES/wiki/Debugging for details.

Author(s)

Alex Chubaty and Eliot McIntire

References


See Also

SpaDES.core-package, simInit, and the caching vignette (very important for reproducibility): https://CRAN.R-project.org/package=SpaDES.core/vignettes/iii-cache.html which uses Cache.

Examples

```r
## Not run:
mySim <- simInit(
  times = list(start = 0.0, end = 2.0, timeunit = "year"),
  params = list(
    .globals = list(stackName = "landscape", burnStats = "nPixelsBurned")
  ),
  modules = list("randomLandscapes", "fireSpread", "caribouMovement"),
  paths = list(modulePath = system.file("sampleModules", package = "SpaDES.core"))
)
spades(mySim)

# set default debug printing for the current session
# setOption(spades.debug = TRUE)

# Different debug options (overrides the package option 'spades.debug')
spades(mySim, debug = TRUE) # Fastest
spades(mySim, debug = "simList")
spades(mySim, debug = "print(table(sim$landscape$Fires[]))")

# Can turn off plotting, and inspect the output simList instead
out <- spades(mySim, .plotInitialTime = NA) # much faster
completed(out) # shows completed events

# use cache -- simInit should generally be rerun each time a spades call is made
# to guarantee that it is identical. Here, run spades call twice, first
# time to establish cache, second time to return cached result
for (i in 1:2) {
  mySim <- simInit(
    times = list(start = 0.0, end = 2.0, timeunit = "year"),
```
params = list(
  .globals = list(stackName = "landscape", burnStats = "nPixelsBurned"),
  modules = list("randomLandscapes", "fireSpread", "caribouMovement"),
  paths = list(modulePath = system.file("sampleModules", package = "SpaDES.core"))
)
print(system.time(out <- spades(mySim, cache = TRUE)))
}

## End(Not run)

---

**spadesClasses**

*Classes defined in SpaDES*

### Description

These S4 classes are defined within SpaDES. "dot" classes are not exported and are therefore intended for internal use only.

### Simulation classes

<table>
<thead>
<tr>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>simList</code></td>
<td>The 'simList' class</td>
</tr>
<tr>
<td><code>.moduleDeps</code></td>
<td>Descriptor object for specifying SpaDES module dependencies</td>
</tr>
<tr>
<td><code>.simDeps</code></td>
<td>Defines all simulation dependencies for all modules within a SpaDES simulation</td>
</tr>
</tbody>
</table>

### Author(s)

Eliot McIntire and Alex Chubaty

### See Also

`simInit`

---

**spadesOptions**

*SpaDES.core options*

### Description

These provide top-level, powerful settings for a comprehensive SpaDES workflow. To see defaults, run `spadesOptions()`. See Details below.
suppliedElsewhere

Usage

suppliedElsewhere()

Details

Below are options that can be set with `options("spades.xxx" = newValue)`, where `xxx` is one of the values below, and `newValue` is a new value to give the option. Sometimes these options can be placed in the user's `.Rprofile` file so they persist between sessions.

The following options are likely of interest to most users

<table>
<thead>
<tr>
<th>OPTION</th>
<th>DEFAULT VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>spades.browserOnError</td>
<td>FALSE</td>
</tr>
<tr>
<td>reproducible.cachePath</td>
<td>getOption('reproducible.cachePath')</td>
</tr>
<tr>
<td>spades.inputPath</td>
<td>Default is a temporary directory (typically <code>/tmp</code>).</td>
</tr>
<tr>
<td>spades.debug</td>
<td>TRUE</td>
</tr>
<tr>
<td>spades.lowMemory</td>
<td>FALSE</td>
</tr>
<tr>
<td>spades.moduleCodeChecks</td>
<td>list(suppressParamUnused = FALSE, suppressUndefined = TRUE, suppressPartialMatchArgs = FALSE, suppressNoLocalFun = TRUE, skipWith = TRUE)</td>
</tr>
<tr>
<td>spades.modulePath</td>
<td>file.path(tempdir(), &quot;SpaDES&quot;)</td>
</tr>
<tr>
<td>spades.moduleRepo</td>
<td>&quot;PredictiveEcology/SpaDES&quot;</td>
</tr>
<tr>
<td>spades.nCompleted</td>
<td>1000L</td>
</tr>
<tr>
<td>spades.outputPath</td>
<td>file.path(tempdir(), &quot;SpaDES&quot;)</td>
</tr>
<tr>
<td>spades.recoveryMode</td>
<td>1L</td>
</tr>
<tr>
<td>spades.switchPkgNamespaces</td>
<td>FALSE to keep computational over .Machine$double.eps'</td>
</tr>
<tr>
<td>spades.tolerance</td>
<td>&quot;<a href="http://github.com/PredictiveEcology/SpaDES">http://github.com/PredictiveEcology/SpaDES</a>&quot;</td>
</tr>
<tr>
<td>spades.useragent</td>
<td></td>
</tr>
</tbody>
</table>

suppliedElsewhere Assess whether an object has or will be supplied from elsewhere

Description

When loading objects into a `simList`, especially during the `simInit` call, and inside the `.inputObjects` functions of modules, it is often useful to know if an object in question will or has been by the user via the `inputs` or `objects` arguments, or by another module's `.inputObjects` while preparing its expected inputs (via `expectsInputs` in metadata), or if it will be supplied by another module during its "init" event. In all these cases, it may not be necessary for a given module to load any default value for its `expectsInputs`. This function can be used as a check to determine whether the module needs to proceed in getting and assigning its default value.

Usage

suppliedElsewhere(
  object,
  sim,
  where = c("sim", "user", "initEvent"),
)
returnWhere = FALSE

Arguments

object Character vector
sim A simList in which to evaluate whether the object is supplied elsewhere
where Character vector with one to three of "sim", "user", or "initEvent". Default is all three. Partial matching is used. See details.
returnWhere Logical, default FALSE, whether the vector of length 3 logical should be returned, or a logical of length one

Details

where indicates which of three places to search, either "sim" i.e., the simList, which would be equivalent to is.null(sim$objName), or "user" which would be supplied by the user in the simInit function call via outputs or inputs (equivalent to (!('defaultColor' %in% sim$.userSuppliedObjNames))), or "initEvent", which would test whether a module that gets loaded before the present one will create it as part of its outputs (i.e., as indicated by createsOutputs in that module’s metadata). There is a caveat to this test, however; if that other event also has the object as an expectsInput, then it would fail this test, as it also needs it as an input. This final one ("initEvent") does not explicitly test that the object will be created in the "init" event, only that it is in the outputs of that module, and that it is a module that is loaded prior to this one.

Examples

mySim <- simInit()
suppliedElsewhere("test", mySim) # FALSE

# supplied in the simList
mySim$test <- 1
suppliedElsewhere("test", mySim) # TRUE
test <- 1

# supplied from user at simInit time -- note, this object would eventually get into the simList
# but the user supplied values come *after* the module's .inputObjects, so
# a basic is.null(sim$test) would return TRUE even though the user supplied test
mySim <- simInit(objects = list("test" = test))
suppliedElsewhere("test", mySim) # TRUE

## Not run:
# Example with prepInputs
# Put chunks like this in your .inputObjects
if (!suppliedElsewhere("test", mySim))
  sim$test <- Cache(prepInputs, "raster.tif", "downloadedArchive.zip",
destinationPath = dataPath(sim), studyArea = sim$studyArea,
rasterToMatch = sim$otherRasterTemplate, overwrite = TRUE)

## End(Not run)
**Description**

Functions for the `simtimes` slot of a `simList` object and its elements. To maintain modularity, the behaviour of these functions depends on where they are used. In other words, different modules can have their own `timeunit`. SpaDES converts these to seconds when running a simulation, but shows the user time in the units of the model as shown with `timeunit(sim)`

**Usage**

```r
times(x, ...) 
## S4 method for signature 'simList'
times(x) 
times(x) <- value

## S4 replacement method for signature 'simList'
times(x) <- value

## S3 method for class 'simList'
time(x, unit, ...)
time(x) <- value

## S4 replacement method for signature 'simList'
time(x) <- value

end(x, ...)
## S3 method for class 'simList'
end(x, unit, ...)
end(x) <- value

## S4 replacement method for signature 'simList'
end(x) <- value

start(x, ...)
## S3 method for class 'simList'
start(x, unit = NULL, ...)
start(x) <- value
```
## S4 replacement method for signature 'simList'
start(x) <- value

timeunit(x)

## S4 method for signature 'simList'
timeunit(x)
timeunit(x) <- value

## S4 replacement method for signature 'simList'
timeunit(x) <- value
timeunits(x)

## S4 method for signature 'simList'
timeunits(x)

timeunits(x)

## S4 method for signature 'simList'
timeunits(x)

elapsedTime(x, ...)

## S3 method for class 'simList'
elapsedTime(x, byEvent = TRUE, ...)

### Arguments

- **x**  
  A `simList`

- **...**  
  Additional parameters.

- **value**  
  A time, given as a numeric, optionally with a unit attribute, but this will be deduced from the model time units or module time units (if used within a module).

- **unit**  
  Character. One of the time units used in SpaDES.

- **byEvent**  
  Logical. If TRUE, the elapsed time will be by module and event; FALSE will report only by module. Default is TRUE.

### Details

timeunit will extract the current units of the time used in a simulation (i.e., within a `spades` call). If it is set within a `simInit`, e.g., `times=list(start=0,end=52,timeunit = "week")`, it will set the units for that simulation. By default, a `simInit` call will use the smallest unit contained within the metadata for the modules being used. If there are parent modules, then the parent module timeunit will be used even if one of its children is a smaller timeunit. If all modules, including parents, are set to NA, `timeunit` defaults to seconds. If parents are set to NA, then the set of modules defined by that parent module will be given the smallest units of the children.

Currently, available units are "second", "hours", "day", "week", "month", and "year" can be used in the metadata of a module.

The user can also define a new unit. The unit name can be anything, but the function definition must be of the form `dunitName`, e.g., `dyear` or `dfortnight`. The unit name is the part without the `d` and...
the function name definition includes the d. This new function, e.g.,
dfortnight <- function(x)
lubridate::duration(dday(14)) can be placed anywhere in the search path or in a module.
timeunits will extract the current units of the time of all modules used in a simulation. This is
different from timeunit because it is not necessarily associated with a spades call.
In many cases, the "simpler" use of each of these functions may be slower computationally. For
instance, it is much faster to use time(sim,"year") than time(sim). So as a module developer, it
is advantageous to write out the longer one, minimizing the looking up that R must do.

Value

Returns or sets the value of the slot from the simList object.

Note

These have default behaviour that is based on the calling frame timeunit. When used inside a
module, then the time is in the units of the module. If used in an interactive mode, then the time
will be in the units of the simulation.

Additional methods are provided to access the current, start, and end times of the simulation:

time Current simulation time.
start Simulation start time.
end Simulation end time.
timeunit Simulation timeunit.
timeunits Module timeunits.
times List of all simulation times (current, start, end, timeunit).

Author(s)

Alex Chubaty and Eliot McIntire

See Also

SpaDES.core-package, specifically the section 1.2.5 on Simulation times.

Other functions to access elements of a 'simList' object: .addDepends(), doEvent.checkpoint(),
envir(), events(), globals(), inputs(), modules(), objs(), packages(), params(), paths(),
progressInterval()

updateList

Update elements of a named list with elements of a second named list

Description

Merge two named list based on their named entries. Where any element matches in both lists, the
value from the second list is used in the updated list. Subelements are not examined and are simply
replaced. If one list is empty, then it returns the other one, unchanged.
Usage

updateList(x, y)

## S4 method for signature 'list,list'
updateList(x, y)

## S4 method for signature '\(\text{\`NULL\}}\),list'
updateList(x, y)

## S4 method for signature 'list,\(\text{\`NULL\}}\)'
updateList(x, y)

## S4 method for signature '\(\text{\`NULL\}}\),\(\text{\`NULL\}}\)'
updateList(x, y)

Arguments

x a named list
y a named list

Value

A named list, with elements sorted by name. The values of matching elements in list y replace the values in list x.

Author(s)

Alex Chubaty

Examples

L1 <- list(a = "hst", b = NA_character_, c = 43)
L2 <- list(a = "gst", c = 42, d = list(letters))
updateList(L1, L2)

updateList(L1, NULL)
updateList(NULL, L2)
updateList(NULL, NULL) # should return empty list

zipModule

Create a zip archive of a module subdirectory

Description

The most common use of this would be from a "modules" directory, rather than inside a given module.
Usage

zipModule(name, path, version, data = FALSE, ...)

## S4 method for signature 'character,character,character'
zipModule(name, path, version, data = FALSE, ...)

## S4 method for signature 'character,missing,character'
zipModule(name, path, version, data = FALSE, ...)

## S4 method for signature 'character,missing,missing'
zipModule(name, path, version, data = FALSE, ...)

## S4 method for signature 'character,character,missing'
zipModule(name, path, version, data = FALSE, ...)

Arguments

name Character string giving the module name.
path A file path to a directory containing the module subdirectory.
version The module version.
data Logical. If TRUE, then the data subdirectory will be included in the zip. Default is FALSE.
... Additional arguments to zip: e.g., add "-q" using flags="-q -r9X" (the default flags are "-r9X").

Author(s)

Eliot McIntire and Alex Chubaty

Description

Currently, this will save the raster-backed files, outputs(sim), inputs(sim). It will add these to a temp file, using Copy, where appropriate to not affect the original simList. VERY experimental; unlikely to work perfectly at the moment.

Usage

zipSimList(sim, zipfile, ..., outputs = TRUE, inputs = TRUE, cache = FALSE)
Arguments

- **sim**: A simList at the core of the zipping.
- **zipfile**: A character string indicating the filename for the zip file. Passed to `zip`.
- **...**: Passed to `saveSimList`, including important ones such as `filename`.
- **outputs**: Logical. If `TRUE`, all files identified in `outputs(sim)` will be included in the zip.
- **inputs**: Logical. If `TRUE`, all files identified in `inputs(sim)` will be included in the zip.
- **cache**: Logical. If `TRUE`, all files in `cachePath(sim)` will be included in the zip archive. Defaults to `FALSE` as this could be large, and may include many out of date elements. See Details. Not yet implemented.

Details

If cache is used, it is likely that it should be trimmed before zipping, to include only cache elements that are relevant.
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