

# Package ‘future’

April 8, 2018

**Version** 1.8.0

**Title** Unified Parallel and Distributed Processing in R for Everyone

**Imports** digest, globals (>= 0.11.0), listenv (>= 0.7.0), parallel,  
utils

**Suggests** R.rsp, markdown

**VignetteBuilder** R.rsp

**Description** The purpose of this package is to provide a lightweight and unified Future API for sequential and parallel processing of R expression via futures. The simplest way to evaluate an expression in parallel is to use ``x %<% { expression }`` with ``plan(multiprocess)``. This package implements sequential, multicore, multisession, and cluster futures. With these, R expressions can be evaluated on the local machine, in parallel a set of local machines, or distributed on a mix of local and remote machines. Extensions to this package implement additional backends for processing futures via compute cluster schedulers etc. Because of its unified API, there is no need to modify any code in order switch from sequential on the local machine to, say, distributed processing on a remote compute cluster. Another strength of this package is that global variables and functions are automatically identified and exported as needed, making it straightforward to tweak existing code to make use of futures.

**License** LGPL (>= 2.1)

**LazyLoad** TRUE

**URL** <https://github.com/HenrikBengtsson/future>

**BugReports** <https://github.com/HenrikBengtsson/future/issues>

**RoxygenNote** 6.0.1

**NeedsCompilation** no

**Author** Henrik Bengtsson [aut, cre, cph]

**Maintainer** Henrik Bengtsson <henrikb@braju.com>

**Repository** CRAN

**Date/Publication** 2018-04-08 11:08:01 UTC

**R topics documented:**

as.cluster	2
backtrace	3
cluster	4
find_references	6
fold	6
future	7
Future-class	12
FutureGlobals	13
futureOf	14
futures	15
makeClusterPSOCK	16
multicore	21
multiprocess	23
multisession	25
nrOfWorkers	27
nullcon	27
plan	28
remote	30
resolve	32
resolved	33
sequential	34
supportsMulticore	35
tweak	36
value.Future	36
values	37
%globals%	38
%label%	38
%lazy%	39
%plan%	39
%seed%	40
%tweak%	40
<b>Index</b>	<b>41</b>

---

as.cluster

*Coerce an object to a cluster object*


---

**Description**

Coerce an object to a cluster object

**Usage**

```

as.cluster(x, ...)

## S3 method for class 'cluster'
as.cluster(x, ...)

## S3 method for class 'list'
as.cluster(x, ...)

## S3 method for class 'SOCKnode'
as.cluster(x, ...)

## S3 method for class 'SOCK0node'
as.cluster(x, ...)

## S3 method for class 'cluster'
c(..., recursive = FALSE)

```

**Arguments**

x	An object to be coerced.
...	Additional arguments passed to the underlying coercion method. For <code>c(...)</code> , the clusters and cluster nodes to be combined.
recursive	Not used.

**Value**

An object of class `cluster`.

`c(...)` combine multiple clusters and / or cluster nodes into one cluster returned as an of class `cluster`.

---

backtrace	<i>Back trace the expression evaluated when a condition was caught</i>
-----------	--

---

**Description**

Back trace the expression evaluated when a condition was caught

**Usage**

```
backtrace(future, envir = parent.frame(), ...)
```

**Arguments**

future	A future with a caught condition.
envir	the environment where to locate the future.
...	Not used.

**Value**

A list with one call.

**Known limitations**

It is currently *not* possible to infer the full call stack prior to when an error occurred. It is only possible to get the call that produced the call. This is a limitation of `tryCatch()` used internally for evaluating the future expression.

---

cluster	<i>Create a cluster future whose value will be resolved asynchronously in a parallel process</i>
---------	--

---

**Description**

A cluster future is a future that uses cluster evaluation, which means that its *value is computed and resolved in parallel in another process*.

**Usage**

```
cluster(expr, envir = parent.frame(), substitute = TRUE, lazy = FALSE,
  seed = NULL, globals = TRUE, persistent = FALSE,
  workers = availableWorkers(), user = NULL, revtunnel = TRUE,
  homogeneous = TRUE, gc = FALSE, earlySignal = FALSE, label = NULL,
  ...)
```

**Arguments**

expr	An R <a href="#">expression</a> to be evaluated.
envir	The <a href="#">environment</a> from where global objects should be identified. Depending on the future strategy (the evaluator), it may also be the environment in which the expression is evaluated.
substitute	If TRUE, argument expr is <code>substitute():ed</code> , otherwise not.
lazy	Specifies whether a future should be resolved lazily or eagerly (default).
seed	(optional) A L'Ecuyer-CMRG RNG seed.
globals	(optional) A logical, a character vector, or a named list for controlling how globals are handled. For details, see below section.
persistent	If FALSE, the evaluation environment is cleared from objects prior to the evaluation of the future.
workers	A cluster object created by <code>makeCluster()</code> .
user	(optional) The user name to be used when communicating with another host.
revtunnel	If TRUE, reverse SSH tunneling is used for the PSOCK cluster nodes to connect back to the master R process. This avoids the hassle of firewalls, port forwarding and having to know the internal / public IP address of the master R session.

homogeneous	If TRUE, all cluster nodes is assumed to use the same path to ‘Rscript’ as the main R session. If FALSE, the it is assumed to be on the PATH for each node.
gc	If TRUE, the garbage collector run (in the process that evaluated the future) after the value of the future is collected.
earlySignal	Specified whether conditions should be signaled as soon as possible or not.
label	An optional character string label attached to the future.
...	Additional arguments passed to the "evaluator".

### Details

This function will block if all available R cluster nodes are occupied and will be unblocked as soon as one of the already running cluster futures is resolved.

The preferred way to create an cluster future is not to call this function directly, but to register it via [plan\(cluster\)](#) such that it becomes the default mechanism for all futures. After this [future\(\)](#) and `%<-%` will create *cluster futures*.

### Value

A [ClusterFuture](#).

### Examples

```
## Use cluster futures
cl <- parallel::makeCluster(2L)
plan(cluster, workers = cl)

## A global variable
a <- 0

## Create multicore future (explicitly)
f <- future({
  b <- 3
  c <- 2
  a * b * c
})

## A cluster future is evaluated in a separate process.
## Changing the value of a global variable will not
## affect the result of the future.
a <- 7
print(a)

v <- value(f)
print(v)
stopifnot(v == 0)

## CLEANUP
parallel::stopCluster(cl)
```

---

find_references	<i>Get first or all references of an R object</i>
-----------------	---

---

**Description**

Get first or all references of an R object

Assert that there are no references among the identified globals

**Usage**

```
find_references(x, first_only = FALSE)
```

```
assert_no_references(x, action = c("error", "warning", "message", "string"))
```

**Arguments**

x	The R object to be checked.
first_only	If 'TRUE', only the first reference is returned, otherwise all references.
action	Type of action to take if a reference is found.

**Value**

'find\_references()' returns a list of one or more references identified.

If a reference is detected, an informative error, warning, message, or a character string is produced, otherwise 'NULL' is returned invisibly.

---

fold	<i>Efficient fold / reduce / accumulate / combine of a vector</i>
------	---

---

**Description**

Efficient fold / reduce / accumulate / combine of a vector

**Usage**

```
fold(x, f, left = TRUE, unname = TRUE, threshold = 1000L)
```

**Arguments**

<code>x</code>	A vector.
<code>f</code>	A binary function, i.e. a function take takes two arguments.
<code>left</code>	If 'TRUE', vector is combined from the left (the first element), otherwise the right (the last element).
<code>unname</code>	If 'TRUE', function 'f' is called as 'f(unname(y), x[[ii]])', otherwise as 'f(y, x[[ii]])', which may introduce name ""y".
<code>threshold</code>	An integer ( $\geq 2$ ) specifying the length where the recursive divide'and'conquer call will stop and incremental building of the partial value is performed. Using 'threshold = +Inf' will disable recursive folding.

**Details**

In order for recursive folding to give the same results as non-recursive folding, binary function 'f' must be `_associative_` with itself, i.e. 'f(f(x[[1]], x[[2]]), x[[3]])' equals 'f(x[[1]], f(x[[2]], x[[3]])'.

This function is a more efficient (memory and speed) of [`base::Reduce(f, x, right = !left, accumulate = FALSE)`][`base::Reduce`], especially when 'x' is long.

**Value**

A vector.

---

future	<i>Create a future</i>
--------	------------------------

---

**Description**

Creates a future that evaluates an R expression or a future that calls an R function with a set of arguments. How, when, and where these futures are evaluated can be configured using `plan()` such that it is evaluated in parallel on, for instance, the current machine, on a remote machine, or via a job queue on a compute cluster. Importantly, any R code using futures remains the same regardless on these settings and there is no need to modify the code when switching from, say, sequential to parallel processing.

**Usage**

```
future(expr, envir = parent.frame(), substitute = TRUE, globals = TRUE,
  packages = NULL, lazy = FALSE, seed = NULL, evaluator = plan("next"),
  ...)
```

```
futureAssign(x, value, envir = parent.frame(), substitute = TRUE,
  lazy = FALSE, seed = NULL, globals = TRUE, ..., assign.env = envir)
```

```
x %<-% value
```

```
futureCall(FUN, args = NULL, envir = parent.frame(), lazy = FALSE,
  seed = NULL, globals = TRUE, packages = NULL,
  evaluator = plan("next"), ...)
```

### Arguments

expr, value	An R <a href="#">expression</a> to be evaluated.
envir	The <a href="#">environment</a> from where global objects should be identified. Depending on the future strategy (the evaluator), it may also be the environment in which the expression is evaluated.
substitute	If TRUE, argument expr is <a href="#">substitute()</a> :ed, otherwise not.
globals	(optional) A logical, a character vector, or a named list for controlling how globals are handled. For details, see below section.
packages	(optional) a character vector specifying packages to be attached in the R environment evaluating the future.
lazy	Specifies whether a future should be resolved lazily or eagerly (default).
seed	(optional) A L'Ecuyer-CMRG RNG seed.
evaluator	The actual function that evaluates the future expression and returns a <a href="#">Future</a> . The evaluator function should accept all of the same arguments as the ones listed here (except evaluator, FUN and args). The default evaluator function is the one that the user has specified via <a href="#">plan()</a> .
...	Additional arguments passed to the "evaluator".
x	the name of a future variable, which will hold the value of the future expression (as a promise).
assign.env	The <a href="#">environment</a> to which the variable should be assigned.
FUN	A <a href="#">function</a> to be evaluated.
args	A <a href="#">list</a> of arguments passed to function FUN.

### Details

The state of a future is either unresolved or resolved. The value of a future can be retrieved using `v <- value(f)`. Querying the value of a non-resolved future will *block* the call until the future is resolved. It is possible to check whether a future is resolved or not without blocking by using [resolved\(f\)](#).

For a future created via a future assignment (`x %<-% value` or `futureAssign("x", value)`), the value is bound to a promise, which when queried will internally call [value\(\)](#) on the future and which will then be resolved into a regular variable bound to that value. For example, with future assignment `x %<-% value`, the first time variable `x` is queried the call blocks if (and only if) the future is not yet resolved. As soon as it is resolved, and any succeeding queries, querying `x` will immediately give the value.

The future assignment construct `x %<-% value` is not a formal assignment per se, but a binary infix operator on objects `x` and expression `value`. However, by using non-standard evaluation, this constructs can emulate an assignment operator similar to `x <- value`. Due to R's precedence rules of operators, future expressions often needs to be explicitly bracketed, e.g. `x %<-% { a + b }`.

**Value**

`f <- future(expr)` creates a **Future** `f` that evaluates expression `expr`, the value of the future is retrieved using `v <- value(f)`.

`x %<-% value` (a future assignment) and `futureAssign("x", value)` create a **Future** that evaluates expression `expr` and binds its value (as a **promise**) to a variable `x`. The value of the future is automatically retrieved when the assigned variable (promise) is queried. The future itself is returned invisibly, e.g. `f <- futureAssign("x", expr)` and `f <- (x %<-% expr)`. Alternatively, the future of a future variable `x` can be retrieved without blocking using `f <- futureOf(x)`. Both the future and the variable (promise) are assigned to environment `assign.env` where the name of the future is `.future_<name>`.

`f <- futureCall(FUN, args)` creates a **Future** `f` that calls function `FUN` with arguments `args`, where the value of the future is retrieved using `x <- value(f)`.

**Eager or lazy evaluation**

By default, a future is resolved using *eager* evaluation (`lazy = FALSE`). This means that the expression starts to be evaluated as soon as the future is created.

As an alternative, the future can be resolved using *lazy* evaluation (`lazy = TRUE`). This means that the expression will only be evaluated when the value of the future is requested. *Note that this means that the expression may not be evaluated at all - it is guaranteed to be evaluated if the value is requested.*

For future assignments, lazy evaluation can be controlled via the `%lazy%` operator, e.g. `x %<-% { expr } %lazy% TRUE`.

**Globals used by future expressions**

Global objects (short *globals*) are objects (e.g. variables and functions) that are needed in order for the future expression to be evaluated while not being local objects that are defined by the future expression. For example, in

```
a <- 42
f <- future({ b <- 2; a * b })
```

variable `a` is a global of future assignment `f` whereas `b` is a local variable. In order for the future to be resolved successfully (and correctly), all globals need to be gathered when the future is created such that they are available whenever and wherever the future is resolved.

The default behavior (`globals = TRUE`) of all evaluator functions, is that globals are automatically identified and gathered. More precisely, globals are identified via code inspection of the future expression `expr` and their values are retrieved with environment `envir` as the starting point (basically via `get(global, envir = envir, inherits = TRUE)`). *In most cases, such automatic collection of globals is sufficient and less tedious and error prone than if they are manually specified.*

However, for full control, it is also possible to explicitly specify exactly which the globals are by providing their names as a character vector. In the above example, we could use

```
a <- 42
f <- future({ b <- 2; a * b }, globals = "a")
```

Yet another alternative is to explicitly specify also their values using a named list as in

```
a <- 42
f <- future({ b <- 2; a * b }, globals = list(a = a))
```

or

```
f <- future({ b <- 2; a * b }, globals = list(a = 42))
```

Specifying globals explicitly avoids the overhead added from automatically identifying the globals and gathering their values. Furthermore, if we know that the future expression does not make use of any global variables, we can disable the automatic search for globals by using

```
f <- future({ a <- 42; b <- 2; a * b }, globals = FALSE)
```

Future expressions often make use of functions from one or more packages. As long as these functions are part of the set of globals, the future package will make sure that those packages are attached when the future is resolved. Because there is no need for such globals to be frozen or exported, the future package will not export them, which reduces the amount of transferred objects. For example, in

```
x <- rnorm(1000)
f <- future({ median(x) })
```

variable `x` and `median()` are globals, but only `x` is exported whereas `median()`, which is part of the **stats** package, is not exported. Instead it is made sure that the **stats** package is on the search path when the future expression is evaluated. Effectively, the above becomes

```
x <- rnorm(1000)
f <- future({
  library("stats")
  median(x)
})
```

To manually specify this, one can either do

```
x <- rnorm(1000)
f <- future({
  median(x)
}, globals = list(x = x, median = stats::median)
```

or

```
x <- rnorm(1000)
f <- future({
  library("stats")
  median(x)
}, globals = list(x = x))
```

Both are effectively the same.

When using future assignments, globals can be specified analogously using the `%globals%` operator, e.g.

```
x <- rnorm(1000)
y %<-% { median(x) } %globals% list(x = x, median = stats::median)
```

**See Also**

How, when and where futures are resolved is given by the *future strategy*, which can be set by the end user using the `plan()` function. The future strategy must not be set by the developer, e.g. it must not be called within a package.

**Examples**

```
## Evaluate futures in parallel
plan(multiprocess)

## Data
x <- rnorm(100)
y <- 2 * x + 0.2 + rnorm(100)
w <- 1 + x ^ 2

## (1) Regular assignments (evaluated sequentially)
fitA <- lm(y ~ x, weights = w)      ## with offset
fitB <- lm(y ~ x - 1, weights = w) ## without offset
fitC <- {
  w <- 1 + abs(x) ## Different weights
  lm(y ~ x, weights = w)
}
print(fitA)
print(fitB)
print(fitC)

## (2) Future assignments (evaluated in parallel)
fitA %<-% lm(y ~ x, weights = w)     ## with offset
fitB %<-% lm(y ~ x - 1, weights = w) ## without offset
fitC %<-% {
  w <- 1 + abs(x)
  lm(y ~ x, weights = w)
}
print(fitA)
print(fitB)
print(fitC)

## (3) Explicitly create futures (evaluated in parallel)
## and retrieve their values
fA <- future( lm(y ~ x, weights = w) )
fB <- future( lm(y ~ x - 1, weights = w) )
fC <- future({
  w <- 1 + abs(x)
  lm(y ~ x, weights = w)
})
fitA <- value(fA)
fitB <- value(fB)
```

```

fitC <- value(fC)
print(fitA)
print(fitB)
print(fitC)

## (4) Explit future assignments (evaluated in parallel)
futureAssign("fitA", lm(y ~ x, weights = w))
futureAssign("fitB", lm(y ~ x - 1, weights = w))
futureAssign("fitC", {
  w <- 1 + abs(x)
  lm(y ~ x, weights = w)
})
print(fitA)
print(fitB)
print(fitC)

```

---

Future-class	<i>A future represents a value that will be available at some point in the future</i>
--------------	---

---

## Description

A *future* is an abstraction for a *value* that may available at some point in the future. A future can either be unresolved or resolved, a state which can be checked with `resolved()`. As long as it is *unresolved*, the value is not available. As soon as it is *resolved*, the value is available via `value()`.

## Usage

```

Future(expr = NULL, envir = parent.frame(), substitute = FALSE,
       globals = NULL, packages = NULL, seed = NULL, lazy = FALSE,
       local = TRUE, gc = FALSE, earlySignal = FALSE, label = NULL, ...)

```

## Arguments

<code>expr</code>	An R <a href="#">expression</a> .
<code>envir</code>	The <a href="#">environment</a> in which the evaluation is done (or inherits from if <code>local</code> is <code>TRUE</code> ).
<code>substitute</code>	If <code>TRUE</code> , argument <code>expr</code> is <code>substitute()</code> :ed, otherwise not.
<code>globals</code>	(optional) a named list of global objects needed in order for the future to be resolved correctly.
<code>packages</code>	(optional) a character vector specifying packages to be attached in the R environment evaluating the future.
<code>seed</code>	(optional) A L'Ecuyer-CMRG RNG seed.
<code>lazy</code>	If <code>FALSE</code> (default), the future is resolved eagerly (starting immediately), otherwise not.

local	If TRUE, the expression is evaluated such that all assignments are done to local temporary environment, otherwise the assignments are done to the global environment of the R process evaluating the future.
gc	If TRUE, the garbage collector run (in the process that evaluated the future) after the value of the future is collected. <i>Some types of futures ignore this argument.</i>
earlySignal	Specified whether conditions should be signaled as soon as possible or not.
label	An optional character string label attached to the future.
...	Additional named elements of the future.

**Details**

A Future object is itself an [environment](#).

**Value**

An object of class Future.

**See Also**

One function that creates a Future is [future\(\)](#). It returns a Future that evaluates an R expression in the future. An alternative approach is to use the `%<-%` infix assignment operator, which creates a future from the right-hand-side (RHS) R expression and assigns its future value to a variable as a [promise](#).

---

FutureGlobals	<i>A representation of a set of globals used with futures</i>
---------------	---

---

**Description**

A representation of a set of globals used with futures

**Usage**

```
FutureGlobals(object = list(), resolved = FALSE, total_size = NA_real_,
  ...)
```

**Arguments**

object	A named list.
resolved	A logical indicating whether these globals have been scanned for and resolved futures or not.
total_size	The total size of all globals, if known.
...	Not used.

**Details**

This class extends the [Globals](#) class by add attribute resolved.

**Value**

An object of class FutureGlobals.

---

futureOf	<i>Get the future of a future variable</i>
----------	--

---

**Description**

Get the future of a future variable that has been created directly or indirectly via [future\(\)](#).

**Usage**

```
futureOf(var = NULL, envir = parent.frame(), mustExist = TRUE,
         default = NA, drop = FALSE)
```

**Arguments**

var	the variable. If NULL, all futures in the environment are returned.
envir	the environment where to search from.
mustExist	If TRUE and the variable does not exists, then an informative error is thrown, otherwise NA is returned.
default	the default value if future was not found.
drop	if TRUE and var is NULL, then returned list only contains futures, otherwise also default values.

**Value**

A [Future](#) (or default). If var is NULL, then a named list of Future:s are returned.

**Examples**

```
a %<-% { 1 }

f <- futureOf(a)
print(f)

b %<-% { 2 }

f <- futureOf(b)
print(f)

## All futures
fs <- futureOf()
```

```
print(fs)

## Futures part of environment
env <- new.env()
env$c %<-% { 3 }

f <- futureOf(env$c)
print(f)

f2 <- futureOf(c, envir = env)
print(f2)

f3 <- futureOf("c", envir = env)
print(f3)

fs <- futureOf(envir = env)
print(fs)
```

---

futures

*Gets all futures in an object*

---

### Description

Gets all futures in an environment, a list, or a list environment and returns an object of the same class (and dimensions). Non-future elements are returned as is.

### Usage

```
futures(x, ...)
```

### Arguments

x	An environment, a list, or a list environment.
...	Not used.

### Details

This function is useful for retrieve futures that were created via future assignments (%<-%) and therefore stored as promises. This function turns such promises into standard Future objects.

### Value

An object of same type as x and with the same names and/or dimensions, if set.

---

makeClusterPSOCK      *Create a cluster of R workers for parallel processing*

---

## Description

The `makeClusterPSOCK()` function creates a cluster of R workers for parallel processing. These R workers may be background R sessions on the current machine, R sessions on external machines (local or remote), or a mix of such. For external workers, the default is to use SSH to connect to those external machines. This function works similarly to `makePSOCKcluster` of the **parallel** package, but provides additional and more flexibility options for controlling the setup of the system calls that launch the background R workers, and how to connect to external machines.

## Usage

```
makeClusterPSOCK(workers, makeNode = makeNodePSOCK, port = c("auto",
  "random"), ..., verbose = getOption("future.debug", FALSE))

makeNodePSOCK(worker = "localhost", master = NULL, port,
  connectTimeout = getOption("future.makeNodePSOCK.connectTimeout", 2 * 60),
  timeout = getOption("future.makeNodePSOCK.timeout", 30 * 24 * 60 * 60),
  rscript = NULL, homogeneous = NULL, rscript_args = NULL,
  methods = TRUE, useXDR = TRUE, outfile = "/dev/null",
  renice = NA_integer_, rshcmd = getOption("future.makeNodePSOCK.rshcmd",
  NULL), user = NULL, revtunnel = TRUE,
  rshopts = getOption("future.makeNodePSOCK.rshopts", NULL), rank = 1L,
  manual = FALSE, dryrun = FALSE, verbose = FALSE)
```

## Arguments

<code>workers</code>	The hostnames of workers (as a character vector) or the number of localhost workers (as a positive integer).
<code>makeNode</code>	A function that creates a "SOCKnode" or "SOCK0node" object, which represents a connection to a worker.
<code>port</code>	The port number of the master used to for communicating with all the workers (via socket connections). If an integer vector of ports, then a random one among those is chosen. If "random", then a random port in 11000:11999 is chosen. If "auto" (default), then the default is taken from environment variable <code>R_PARALLEL_PORT</code> , otherwise "random" is used.
<code>...</code>	Optional arguments passed to <code>makeNode(workers[i], ..., rank = i)</code> where <code>i = seq_along(workers)</code> .
<code>verbose</code>	If TRUE, informative messages are outputted.
<code>worker</code>	The hostname or IP number of the machine where the worker should run.
<code>master</code>	The hostname or IP number of the master / calling machine, as known to the workers. If NULL (default), then the default is <code>Sys.info()[["nodename"]]</code> unless <code>worker</code> is <code>localhost</code> or <code>revtunnel = TRUE</code> in case it is "localhost".

connectTimeout	The maximum time (in seconds) allowed for each socket connection between the master and a worker to be established (defaults to 2 minutes). <i>See note below on current lack of support on Linux and macOS systems.</i>
timeout	The maximum time (in seconds) allowed to pass without the master and a worker communicate with each other (defaults to 30 days).
rscript, homogeneous	The system command for launching Rscript on the worker and whether it is installed in the same path as the calling machine or not. For more details, see below.
rscript_args	Additional arguments to Rscript (as a character vector).
methods	If TRUE, then the <b>methods</b> package is also loaded.
useXDR	If TRUE, the communication between master and workers, which is binary, will use big-endian (XDR).
outfile	Where to direct the <code>stdout</code> and <code>stderr</code> connection output from the workers.
renice	A numerical 'niceness' (priority) to set for the worker processes.
rshcmd, rshopts	The command (character vector) to be run on the master to launch a process on another host and any additional arguments (character vector). These arguments are only applied if machine is not <i>localhost</i> . For more details, see below.
user	(optional) The user name to be used when communicating with another host.
revtunnel	If TRUE, a reverse SSH tunnel is set up for each worker such that the worker R process sets up a socket connection to its local port ( <code>port - rank + 1</code> ) which then reaches the master on port <code>port</code> . If FALSE, then the worker will try to connect directly to port <code>port</code> on master. For more details, see below.
rank	A unique one-based index for each worker (automatically set).
manual	If TRUE the workers will need to be run manually. The command to run will be displayed.
dryrun	If TRUE, nothing is set up, but a message suggesting how to launch the worker from the terminal is outputted. This is useful for troubleshooting.

## Value

An object of class `c("SOCKcluster", "cluster")` consisting of a list of "SOCKnode" or "SOCK0node" workers.

`makeNodePSOCK()` returns a "SOCKnode" or "SOCK0node" object representing an established connection to a worker.

## Definition of *localhost*

A hostname is considered to be *localhost* if it equals:

- "localhost",
- "127.0.0.1", or
- `Sys.info()[["nodename"]]`.

It is also considered *localhost* if it appears on the same line as the value of `Sys.info()[["nodename"]]` in file `'/etc/hosts'`.

**Default values of arguments `rshcmd` and `rshopts`**

Arguments `rshcmd` and `rshopts` are only used when connecting to an external host.

The default method for connecting to an external host is via SSH and the system executable for this is given by argument `rshcmd`. The default is given by option `future.makeNodePSOCK.rshcmd` and if that is not set the default is either of `ssh` and `plink -ssh`. Most Unix-like systems, including macOS, have `ssh` preinstalled on the PATH. It is less common to find this command on Windows system, which are more likely to have the PuTTY software and its SSH client `plink` installed. Furthermore, when running R from RStudio on Windows, the `ssh` client that is distributed with RStudio will be used as a fallback if neither of the above two commands are available on the PATH. Note that on Windows 10, there is a beta version of OpenSSH that can be enabled in the Windows Settings, cf. <https://www.thomasmaurer.ch/2017/11/install-ssh-on-windows-10-as-optional-feature/>. If no SSH-client is found, an informative error message is produced. It is also possible to specify the absolute path to the SSH client. To do this for PuTTY, specify the absolute path in the first element and option `-ssh` in the second as in `rshcmd = c("C:/Path/PuTTY/plink.exe", "-ssh")`. This is because all elements of `rshcmd` are individually "shell" quoted and element `rshcmd[1]` must be on the system PATH.

Additional SSH options may be specified via argument `rshopts`, which defaults to option `future.makeNodePSOCK.rshopts`. For instance, a private SSH key can be provided as `rshopts = c("-i", "~/ .ssh/my_private_key")`. PuTTY users should specify a PuTTY PPK file, e.g. `rshopts = c("-i", "C:/Users/joe/.ssh/my_keys.ppk")`. Contrary to `rshcmd`, elements of `rshopts` are not quoted.

**Reverse SSH tunneling**

The default is to use reverse SSH tunneling (`revtunnel = TRUE`) for workers running on other machines. This avoids the complication of otherwise having to configure port forwarding in firewalls, which often requires static IP address as well as privileges to edit the firewall, something most users don't have. It also has the advantage of not having to know the internal and / or the public IP address / hostname of the master. Yet another advantage is that there will be no need for a DNS lookup by the worker machines to the master, which may not be configured or is disabled on some systems, e.g. compute clusters.

**Default value of argument `rscript`**

If `homogeneous` is `FALSE`, the `rscript` defaults to `"Rscript"`, i.e. it is assumed that the `Rscript` executable is available on the PATH of the worker. If `homogeneous` is `TRUE`, the `rscript` defaults to `file.path(R.home("bin"), "Rscript")`, i.e. it is basically assumed that the worker and the caller share the same file system and R installation.

**Default value of argument `homogeneous`**

The default value of `homogeneous` is `TRUE` if and only if either of the following is fulfilled:

- worker is `localhost`
- `revtunnel` is `FALSE` and master is `localhost`
- worker is neither an IP number nor a fully qualified domain name (FQDN). A hostname is considered to be a FQDN if it contains one or more periods

### Connection time out

Argument `connectTimeout` does *not* work properly on Unix and macOS due to limitation in R itself. For more details on this, please see R-devel thread 'BUG?: On Linux setTimeLimit() fails to propagate timeout error when it occurs (works on Windows)' on 2016-10-26 (<https://stat.ethz.ch/pipermail/r-devel/2016-October/073309.html>). When used, the timeout will eventually trigger an error, but it won't happen until the socket connection timeout itself happens.

### Communication time out

If there is no communication between the master and a worker within the timeout limit, then the corresponding socket connection will be closed automatically. This will eventually result in an error in code trying to access the connection.

### Examples

```
## Setup of three R workers on two remote machines are set up
workers <- c("n1.remote.org", "n2.remote.org", "n1.remote.org")
cl <- makeClusterPSOCK(workers, dryrun = TRUE)

## Same setup when the two machines are on the local network and
## have identical software setups
cl <- makeClusterPSOCK(
  workers,
  revtunnel = FALSE, homogeneous = TRUE,
  dryrun = TRUE
)

## Setup of remote worker with more detailed control on
## authentication and reverse SSH tunnelling
cl <- makeClusterPSOCK(
  "remote.server.org", user = "johnny",
  ## Manual configuration of reverse SSH tunnelling
  revtunnel = FALSE,
  rshopts = c("-v", "-R 11000:gateway:11942"),
  master = "gateway", port = 11942,
  ## Run Rscript nicely and skip any startup scripts
  rscript = c("nice", "/path/to/Rscript"),
  rscript_args = c("--vanilla"),
  dryrun = TRUE
)

## Setup of 2 Docker workers running rocker/r-base
## (requires installation of future package)
cl <- makeClusterPSOCK(
  rep("localhost", times = 2L),
  ## Launch Rscript inside Docker container
  rscript = c(
    "docker", "run", "--net=host", "rocker/r-base",
    "Rscript"
  ),
)
```

```

## Install future package
rscript_args = c(
  "-e", shQuote("install.packages('future')")
),
dryrun = TRUE
)

## Setup of a single udocker.py worker running rocker/r-base
## (requires installation of future package and extra quoting)
cl <- makeClusterPSOCK(
  "localhost",
  ## Launch Rscript inside Docker container (using udocker)
  rscript = c(
    "udocker.py", "run", "rocker/r-base",
    "Rscript"
  ),
  ## Install future package and manually launch parallel workers
  ## (need double shQuote():s because udocker.py drops one level)
  rscript_args = c(
    "-e", shQuote(shQuote("install.packages('future')")),
    "-e", shQuote(shQuote("parallel:::slaveRSOCK()"))
  ),
  dryrun = TRUE
)

## Launching worker on Amazon AWS EC2 running one of the
## Amazon Machine Images (AMI) provided by RStudio
## (http://www.louisaslett.com/RStudio\_AMI/)
public_ip <- "1.2.3.4"
ssh_private_key_file <- "~/ssh/my-private-aws-key.pem"
cl <- makeClusterPSOCK(
  ## Public IP number of EC2 instance
  public_ip,
  ## User name (always 'ubuntu')
  user = "ubuntu",
  ## Use private SSH key registered with AWS
  rshopts = c(
    "-o", "StrictHostKeyChecking=no",
    "-o", "IdentitiesOnly=yes",
    "-i", ssh_private_key_file
  ),
  ## Set up .libPaths() for the 'ubuntu' user and
  ## install future package
  rscript_args = c(
    "-e", shQuote("local({
      p <- Sys.getenv('R_LIBS_USER')
      dir.create(p, recursive = TRUE, showWarnings = FALSE)
      .libPaths(p)
    })"),
    "-e", shQuote("install.packages('future')")
  ),
)

```

```

    dryrun = TRUE
  )

  ## Launching worker on Google Cloud Engine (GCE) running a
  ## container based VM (with a #cloud-config specification)
  public_ip <- "1.2.3.4"
  user <- "johnny"
  ssh_private_key_file <- "~/ssh/google_compute_engine"
  cl <- makeClusterPSOCK(
    ## Public IP number of GCE instance
    public_ip,
    ## User name (== SSH key label (sic!))
    user = user,
    ## Use private SSH key registered with GCE
    rshopts = c(
      "-o", "StrictHostKeyChecking=no",
      "-o", "IdentitiesOnly=yes",
      "-i", ssh_private_key_file
    ),
    ## Launch Rscript inside Docker container
    rscript = c(
      "docker", "run", "--net=host", "rocker/r-base",
      "Rscript"
    ),
    ## Install future package
    rscript_args = c(
      "-e", shQuote("install.packages('future')")
    ),
    dryrun = TRUE
  )

  ## Connect to remote Unix machine 'remote.server.org' on port 2200
  ## as user 'bob' from a Windows machine with PuTTY installed
  cl <- makeClusterPSOCK(
    "remote.server.org", user = "bob",
    rshopts = c("-P", 2200, "-i", "C:/Users/bobby/.ssh/putty.ppk"),
    dryrun = TRUE
  )

```

---

multicore

*Create a multicore future whose value will be resolved asynchronously in a forked parallel process*

---

### Description

A multicore future is a future that uses multicore evaluation, which means that its *value is computed and resolved in parallel in another process*.

**Usage**

```
multicore(expr, envir = parent.frame(), substitute = TRUE, lazy = FALSE,
  seed = NULL, globals = TRUE, workers = availableCores(constraints =
  "multicore"), earlySignal = FALSE, label = NULL, ...)
```

**Arguments**

expr	An R <a href="#">expression</a> to be evaluated.
envir	The <a href="#">environment</a> from where global objects should be identified. Depending on the future strategy (the evaluator), it may also be the environment in which the expression is evaluated.
substitute	If TRUE, argument expr is <a href="#">substitute()</a> :ed, otherwise not.
lazy	Specifies whether a future should be resolved lazily or eagerly (default).
seed	(optional) A L'Ecuyer-CMRG RNG seed.
globals	(optional) A logical, a character vector, or a named list for controlling how globals are handled. For details, see below section.
workers	The maximum number of multicore futures that can be active at the same time before blocking.
earlySignal	Specified whether conditions should be signaled as soon as possible or not.
label	An optional character string label attached to the future.
...	Additional arguments passed to the "evaluator".

**Details**

This function will block if all cores are occupied and will be unblocked as soon as one of the already running multicore futures is resolved. For the total number of cores available including the current/main R process, see [availableCores\(\)](#).

Not all systems support multicore futures. For instance, it is not supported on Microsoft Windows. Trying to create multicore futures on non-supported systems will silently fall back to using [sequential](#) futures, which effectively corresponds to a multicore future that can handle one parallel process (the current one) before blocking.

The preferred way to create an multicore future is not to call this function directly, but to register it via [plan\(multicore\)](#) such that it becomes the default mechanism for all futures. After this [future\(\)](#) and [%<-%](#) will create *multicore futures*.

**Value**

A [MulticoreFuture](#) If `workers == 1`, then all processing using done in the current/main R session and we therefore fall back to using an sequential future. This is also the case whenever multicore processing is not supported, e.g. on Windows.

## See Also

For processing in multiple background R sessions, see [multisession](#) futures. For multicore processing with fallback to multisession where the former is not supported, see [multiprocess](#) futures.

Use [availableCores\(\)](#) to see the total number of cores that are available for the current R session. Use [availableCores\("multicore"\) > 1L](#) to check whether multicore futures are supported or not on the current system.

## Examples

```
## Use multicore futures
plan(multicore)

## A global variable
a <- 0

## Create multicore future (explicitly)
f <- future({
  b <- 3
  c <- 2
  a * b * c
})

## A multicore future is evaluated in a separate forked
## process. Changing the value of a global variable
## will not affect the result of the future.
a <- 7
print(a)

v <- value(f)
print(v)
stopifnot(v == 0)
```

---

`multiprocess`

*Create a multiprocess future whose value will be resolved asynchronously using multicore or a multisession evaluation*

---

## Description

A multiprocess future is a future that uses [multicore](#) evaluation if supported, otherwise it uses [multisession](#) evaluation. Regardless, its *value is computed and resolved in parallel in another process*.

## Usage

```
multiprocess(expr, envir = parent.frame(), substitute = TRUE,
  lazy = FALSE, seed = NULL, globals = TRUE, workers = availableCores(),
  gc = FALSE, earlySignal = FALSE, label = NULL, ...)
```

**Arguments**

<code>expr</code>	An R <a href="#">expression</a> to be evaluated.
<code>envir</code>	The <a href="#">environment</a> from where global objects should be identified. Depending on the future strategy (the evaluator), it may also be the environment in which the expression is evaluated.
<code>substitute</code>	If TRUE, argument <code>expr</code> is <a href="#">substitute()</a> :ed, otherwise not.
<code>lazy</code>	If FALSE (default), the future is resolved eagerly (immediately), otherwise not.
<code>seed</code>	(optional) A L'Ecuyer-CMRG RNG seed.
<code>globals</code>	(optional) a logical, a character vector, or a named list for controlling how globals are handled. For details, see section 'Globals used by future expressions' in the help for <a href="#">future()</a> .
<code>workers</code>	The maximum number of multiprocess futures that can be active at the same time before blocking.
<code>gc</code>	If TRUE, the garbage collector run (in the process that evaluated the future) after the value of the future is collected.
<code>earlySignal</code>	Specified whether conditions should be signaled as soon as possible or not.
<code>label</code>	An optional character string label attached to the future.
<code>...</code>	Not used.

**Value**

A [MultiprocessFuture](#) implemented as either a [MulticoreFuture](#) or a [MultisessionFuture](#).

**See Also**

Internally [multicore\(\)](#) and [multisession\(\)](#) are used.

**Examples**

```
## Use multiprocess futures
plan(multiprocess)

## A global variable
a <- 0

## Create multicore future (explicitly)
f <- future({
  b <- 3
  c <- 2
  a * b * c
})

## A multiprocess future is evaluated in a separate R process.
## Changing the value of a global variable will not affect
## the result of the future.
```

```

a <- 7
print(a)

v <- value(f)
print(v)
stopifnot(v == 0)

```

---

multisession	<i>Create a multisession future whose value will be resolved asynchronously in a parallel R session</i>
--------------	---

---

### Description

A multisession future is a future that uses multisession evaluation, which means that its *value is computed and resolved in parallel in another R session*.

### Usage

```

multisession(expr, envir = parent.frame(), substitute = TRUE,
  lazy = FALSE, seed = NULL, globals = TRUE, persistent = FALSE,
  workers = availableCores(), gc = FALSE, earlySignal = FALSE,
  label = NULL, ...)

```

### Arguments

expr	An R <a href="#">expression</a> to be evaluated.
envir	The <a href="#">environment</a> from where global objects should be identified. Depending on the future strategy (the evaluator), it may also be the environment in which the expression is evaluated.
substitute	If TRUE, argument expr is <a href="#">substitute()</a> ed, otherwise not.
lazy	Specifies whether a future should be resolved lazily or eagerly (default).
seed	(optional) A L'Ecuyer-CMRG RNG seed.
globals	(optional) A logical, a character vector, or a named list for controlling how globals are handled. For details, see below section.
persistent	If FALSE, the evaluation environment is cleared from objects prior to the evaluation of the future.
workers	The maximum number of multisession futures that can be active at the same time before blocking.
gc	If TRUE, the garbage collector run (in the process that evaluated the future) after the value of the future is collected.
earlySignal	Specified whether conditions should be signaled as soon as possible or not.
label	An optional character string label attached to the future.
...	Additional arguments passed to the "evaluator".

## Details

This function will block if all available R sessions are occupied and will be unblocked as soon as one of the already running multisession futures is resolved. For the total number of R sessions available including the current/main R process, see `availableCores()`.

A multisession future is a special type of cluster future.

The preferred way to create an multisession future is not to call this function directly, but to register it via `plan(multisession)` such that it becomes the default mechanism for all futures. After this `future()` and `%<-%` will create *multisession futures*.

## Value

A `MultisessionFuture`. If `workers == 1`, then all processing is done in the current/main R session and we therefore fall back to using a lazy future.

## Known issues

In the current implementation, *all* background R sessions are allocated and launched in the background *as soon as the first multisession future is created*. This means that more R sessions may be running than what will ever be used. The reason for this is that background sessions are currently created using `makeCluster()`, which requires that all R sessions are created at once.

## See Also

For processing in multiple forked R sessions, see `multicore` futures. For multicore processing with fallback to multisession where the former is not supported, see `multiprocess` futures.

Use `availableCores()` to see the total number of cores that are available for the current R session.

## Examples

```
## Use multisession futures
plan(multisession)

## A global variable
a <- 0

## Create multicore future (explicitly)
f <- future({
  b <- 3
  c <- 2
  a * b * c
})

## A multisession future is evaluated in a separate R session.
## Changing the value of a global variable will not affect
## the result of the future.
a <- 7
print(a)
```

```
v <- value(f)
print(v)
stopifnot(v == 0)
```

---

nbrOfWorkers	<i>Gets the number of workers available</i>
--------------	---

---

**Description**

Gets the number of workers available

**Usage**

```
nbrOfWorkers(evaluator = NULL)
```

**Arguments**

evaluator      A future evaluator function. If NULL (default), the current evaluator as returned by `plan()` is used.

**Value**

A number in [1, Inf].

**Examples**

```
plan(multiprocess)
nbrOfWorkers() ## == availableCores()

plan(multiprocess, workers = 2)
nbrOfWorkers() ## == 2

plan(sequential)
nbrOfWorkers() ## == 1
```

---

nullcon	<i>Creates a connection to the system null device</i>
---------	---

---

**Description**

Creates a connection to the system null device

**Usage**

```
nullcon()
```

**Value**

Returns a open, binary [base::connection()].

---

plan

*Plan how to resolve a future*

---

**Description**

This function allows *the user* to plan the future, more specifically, it specifies how `future():s` are resolved, e.g. sequentially or in parallel.

**Usage**

```
plan(strategy = NULL, ..., substitute = TRUE, .call = TRUE,
      .cleanup = TRUE, .init = TRUE)
```

**Arguments**

strategy	The evaluation function (or name of it) to use for resolving a future. If <code>NULL</code> , then the current strategy is returned.
...	Additional arguments overriding the default arguments of the evaluation function. Which additional arguments are supported depends on what evaluation function is used, e.g. several support argument workers but not all. For details, see the individual functions of which some are linked to below.
substitute	If <code>TRUE</code> , the strategy expression is <code>substitute():d</code> , otherwise not.
.call	(internal) Used for recording the call to this function.
.cleanup	(internal) Used to stop implicitly started clusters.
.init	(internal) Used to initiate workers.

**Details**

The default strategy is `sequential`, but the default can be configured by option ‘`future.plan`’ and, if that is not set, system environment variable `R_FUTURE_PLAN`. To reset the strategy back to the default, use `plan("default")`.

**Value**

If a new strategy is chosen, then the previous one is returned (invisible), otherwise the current one is returned (visibly).

### Implemented evaluation strategies

- **sequential**: Resolves futures sequentially in the current R process.
- **transparent**: Resolves futures sequentially in the current R process and assignments will be done to the calling environment. Early stopping is enabled by default.
- **multisession**: Resolves futures asynchronously (in parallel) in separate R sessions running in the background on the same machine.
- **multicore**: Resolves futures asynchronously (in parallel) in separate *forked* R processes running in the background on the same machine. Not supported on Windows.
- **multiprocess**: If multicore evaluation is supported, that will be used, otherwise multisession evaluation will be used.
- **cluster**: Resolves futures asynchronously (in parallel) in separate R sessions running typically on one or more machines.
- **remote**: Resolves futures asynchronously in a separate R session running on a separate machine, typically on a different network.

Other package may provide additional evaluation strategies. Notably, the **future.batchtools** package implements a type of futures that will be resolved via job schedulers that are typically available on high-performance compute (HPC) clusters, e.g. LSF, Slurm, TORQUE/PBS, Sun Grid Engine, and OpenLava.

### For package developers

Please refrain from modifying the future strategy inside your packages / functions, i.e. do not call `plan()` in your code. Instead, leave the control on what backend to use to the end user. This idea is part of the core philosophy of the future framework - as a developer you can never know what future backends the user have access to. Moreover, by not making any assumptions about what backends are available, your code will also work automatically will any new backends developed after you wrote your code.

If you think it is necessary to modify the future strategy within a function, then make sure to undo the changes when exiting the function. This can be done using:

```
oplan <- plan()
on.exit(plan(oplan), add = TRUE)
[...]
```

### Examples

```
a <- b <- c <- NA_real_

# An sequential future
plan(sequential)
f <- future({
  a <- 7
  b <- 3
  c <- 2
  a * b * c
})
y <- value(f)
```

```
print(y)
str(list(a = a, b = b, c = c)) ## All NAs

# A sequential future with lazy evaluation
plan(sequential)
f <- future({
  a <- 7
  b <- 3
  c <- 2
  a * b * c
}) %lazy% TRUE
y <- value(f)
print(y)
str(list(a = a, b = b, c = c)) ## All NAs

# A multicore future (specified as a string)
plan("multicore")
f <- future({
  a <- 7
  b <- 3
  c <- 2
  a * b * c
})
y <- value(f)
print(y)
str(list(a = a, b = b, c = c)) ## All NAs

## Multisession futures gives an error on R CMD check on
## Windows (but not Linux or OS X) for unknown reasons.
## The same code works in package tests.

# A multisession future (specified via a string variable)
strategy <- "future::multisession"
plan(strategy)
f <- future({
  a <- 7
  b <- 3
  c <- 2
  a * b * c
})
y <- value(f)
print(y)
str(list(a = a, b = b, c = c)) ## All NAs
```

---

remote *Create a remote future whose value will be resolved asynchronously in a remote process*

---

## Description

A remote future is a future that uses remote cluster evaluation, which means that its *value is computed and resolved remotely in another process*.

## Usage

```
remote(expr, envir = parent.frame(), substitute = TRUE, lazy = FALSE,
       seed = NULL, globals = TRUE, persistent = TRUE, workers = NULL,
       user = NULL, revtunnel = TRUE, gc = FALSE, earlySignal = FALSE,
       myip = NULL, label = NULL, ...)
```

## Arguments

expr	An R <a href="#">expression</a> to be evaluated.
envir	The <a href="#">environment</a> from where global objects should be identified. Depending on the future strategy (the evaluator), it may also be the environment in which the expression is evaluated.
substitute	If TRUE, argument expr is <a href="#">substitute()</a> :ed, otherwise not.
lazy	Specifies whether a future should be resolved lazily or eagerly (default).
seed	(optional) A L'Ecuyer-CMRG RNG seed.
globals	(optional) A logical, a character vector, or a named list for controlling how globals are handled. For details, see below section.
persistent	If FALSE, the evaluation environment is cleared from objects prior to the evaluation of the future.
workers	The maximum number of multiprocess futures that can be active at the same time before blocking.
user	(optional) The user name to be used when communicating with another host.
revtunnel	If TRUE, reverse SSH tunneling is used for the PSOCK cluster nodes to connect back to the master R process. This avoids the hassle of firewalls, port forwarding and having to know the internal / public IP address of the master R session.
gc	If TRUE, the garbage collector run (in the process that evaluated the future) after the value of the future is collected.
earlySignal	Specified whether conditions should be signaled as soon as possible or not.
myip	The external IP address of this machine. If NULL, then it is inferred using an online service (default).
label	An optional character string label attached to the future.
...	Additional arguments passed to the "evaluator".

**Details**

Note that remote futures use `persistent = TRUE` by default.

**Value**

A [ClusterFuture](#).

**Examples**

```
## Not run: \donttest{

## Use a remote machine
plan(remote, workers = "remote.server.org")

## Evaluate expression remotely
host %<-% { Sys.info()[["nodename"]] }
host
[1] "remote.server.org"

}
## End(Not run)
```

---

resolve

*Resolve one or more futures synchronously*

---

**Description**

This function provides an efficient mechanism for waiting for multiple futures in a container (e.g. list or environment) to be resolved while in the meanwhile retrieving values of already resolved futures.

**Usage**

```
resolve(x, idxs = NULL, value = FALSE, recursive = 0, sleep = 1,
        progress = getOption("future.progress", FALSE), ...)
```

**Arguments**

<code>x</code>	a list, an environment, or a list environment holding futures that should be resolved. May also be a single <a href="#">Future</a> .
<code>idxs</code>	(optional) integer or logical index specifying the subset of elements to check.
<code>value</code>	If TRUE, the values are retrieved, otherwise not.
<code>recursive</code>	A non-negative number specifying how deep of a recursion should be done. If TRUE, an infinite recursion is used. If FALSE or zero, no recursion is performed.
<code>sleep</code>	Number of seconds to wait before checking if futures have been resolved since last time.

progress	If TRUE textual progress summary is outputted. If a function, the it is called as <code>progress(done, total)</code> every time a future is resolved.
...	Not used

**Details**

This function is resolves synchronously, i.e. it blocks until `x` and any containing futures are resolved.

**Value**

Returns `x` (regardless of subsetting or not).

**See Also**

To resolve a future *variable*, first retrieve its [Future](#) object using `futureOf()`, e.g. `resolve(futureOf(x))`.

---

resolved	<i>Check whether a future is resolved or not</i>
----------	--

---

**Description**

Check whether a future is resolved or not

**Usage**

```
resolved(x, ...)
```

**Arguments**

<code>x</code>	A <a href="#">Future</a> , a list or an environment (which also includes <a href="#">list environment</a> ).
...	Not used

**Details**

This method needs to be implemented by the class that implement the Future API. The implementation must never throw an error, but only return either TRUE or FALSE. It should also be possible to use the method for polling the future until it is resolved (without having to wait infinitely long), e.g. `while (!resolved(future)) Sys.sleep(5)`.

**Value**

A logical of the same length and dimensions as `x`. Each element is TRUE unless the corresponding element is a non-resolved future in case it is FALSE.

---

 sequential

 Create a sequential future whose value will be in the current R session
 

---

### Description

A sequential future is a future that is evaluated sequentially in the current R session similarly to how R expressions are evaluated in R. The only difference to R itself is that globals are validated by default just as for all other types of futures in this package.

### Usage

```
sequential(expr, envir = parent.frame(), substitute = TRUE, lazy = FALSE,
  seed = NULL, globals = TRUE, local = TRUE, earlySignal = FALSE,
  label = NULL, ...)
```

```
transparent(expr, envir = parent.frame(), substitute = TRUE, lazy = FALSE,
  seed = NULL, globals = FALSE, local = FALSE, earlySignal = TRUE,
  label = NULL, ...)
```

### Arguments

expr	An R <a href="#">expression</a> to be evaluated.
envir	The <a href="#">environment</a> from where global objects should be identified. Depending on the future strategy (the evaluator), it may also be the environment in which the expression is evaluated.
substitute	If TRUE, argument expr is <a href="#">substitute()</a> :ed, otherwise not.
lazy	Specifies whether a future should be resolved lazily or eagerly (default).
seed	(optional) A L'Ecuyer-CMRG RNG seed.
globals	(optional) A logical, a character vector, or a named list for controlling how globals are handled. For details, see below section.
local	If TRUE, the expression is evaluated such that all assignments are done to local temporary environment, otherwise the assignments are done in the calling environment.
earlySignal	Specified whether conditions should be signaled as soon as possible or not.
label	An optional character string label attached to the future.
...	Additional arguments passed to the "evaluator".

### Details

The preferred way to create a sequential future is not to call these functions directly, but to register them via [plan\(sequential\)](#) such that it becomes the default mechanism for all futures. After this [future\(\)](#) and [%<-%](#) will create *sequential futures*.

**Value**

A [SequentialFuture](#).

**transparent futures**

Transparent futures are sequential futures configured to emulate how R evaluates expressions as far as possible. For instance, errors and warnings are signaled immediately and assignments are done to the calling environment (without `local()` as default for all other types of futures). This makes transparent futures ideal for troubleshooting, especially when there are errors.

**Examples**

```
## Use sequential futures
plan(sequential)

## A global variable
a <- 0

## Create a sequential future
f <- future({
  b <- 3
  c <- 2
  a * b * c
})

## Since 'a' is a global variable in future 'f' which
## is eagerly resolved (default), this global has already
## been resolved / incorporated, and any changes to 'a'
## at this point will not affect the value of 'f'.
a <- 7
print(a)

v <- value(f)
print(v)
stopifnot(v == 0)
```

---

supportsMulticore

*Check whether multicore processing is supported or not*

---

**Description**

Multicore futures are only supported on systems supporting multicore processing. R supports this on most systems, except on Microsoft Windows.

**Usage**

```
supportsMulticore()
```

**Value**

TRUE if multicore processing is supported, otherwise FALSE.

**See Also**

To use multicore futures, use `plan(multicore)`.

---

tweak	<i>Tweaks a future function by adjusting its default arguments</i>
-------	--

---

**Description**

Tweaks a future function by adjusting its default arguments

**Usage**

```
tweak(strategy, ..., penvir = parent.frame())
```

**Arguments**

strategy	An existing future function or the name of one.
...	Named arguments to replace the defaults of existing arguments.
penvir	The environment used when searching for a future function by its name.

**Value**

a future function.

**See Also**

Use `plan()` to set a future to become the new default strategy.

---

value.Future	<i>The value of a future</i>
--------------	------------------------------

---

**Description**

Gets the value of a future. If the future is unresolved, then the evaluation blocks until the future is resolved.

**Usage**

```
## S3 method for class 'Future'
value(future, signal = TRUE, ...)
```

**Arguments**

future	A <a href="#">Future</a> .
signal	A logical specifying whether ( <a href="#">conditions</a> ) should signaled or be returned as values.
...	Not used.

**Details**

This method needs to be implemented by the class that implement the Future API.

**Value**

An R object of any data type.

---

values	<i>Gets all values in an object</i>
--------	-------------------------------------

---

**Description**

Gets all values in an environment, a list, or a list environment and returns an object of the same class (and dimensions). All future elements are replaced by their corresponding `value()` values. For all other elements, the existing object is kept.

**Usage**

```
values(x, ...)
```

**Arguments**

x	An environment, a list, or a list environment.
...	Additional arguments passed to <code>value()</code> of each future.

**Value**

An object of same type as x and with the same names and/or dimensions, if set.

---

 %globals%

*Specify globals and packages for a future assignment*


---

### Description

Specify globals and packages for a future assignment

### Usage

```
fassignment %globals% globals
fassignment %packages% packages
```

### Arguments

fassignment	The future assignment, e.g. <code>x %&lt;-% { expr }</code> .
globals	(optional) A logical, a character vector, or a named list for controlling how globals are handled. For details, see below section.
packages	(optional) a character vector specifying packages to be attached in the R environment evaluating the future.

---

 %label%

*Specify label for a future assignment*


---

### Description

Specify label for a future assignment

### Usage

```
fassignment %label% label
```

### Arguments

fassignment	The future assignment, e.g. <code>x %&lt;-% { expr }</code> .
label	An optional character string label attached to the future.

---

`%lazy%` *Control lazy / eager evaluation for a future assignment*

---

**Description**

Control lazy / eager evaluation for a future assignment

**Usage**

```
fassignment %lazy% lazy
```

**Arguments**

<code>fassignment</code>	The future assignment, e.g. <code>x %&lt;-% { expr }</code> .
<code>lazy</code>	If FALSE (default), the future is resolved eagerly (immediately), otherwise not.

---

`%plan%` *Use a specific plan for a future assignment*

---

**Description**

Use a specific plan for a future assignment

**Usage**

```
fassignment %plan% strategy
```

**Arguments**

<code>fassignment</code>	The future assignment, e.g. <code>x %&lt;-% { expr }</code> .
<code>strategy</code>	The mechanism for how the future should be resolved. See <a href="#">plan()</a> for further details.

**See Also**

The [plan\(\)](#) function sets the default plan for all futures.

---

`%seed%`                      *Set random seed for future assignment*

---

**Description**

Set random seed for future assignment

**Usage**

`fassignment %seed% seed`

**Arguments**

`fassignment`      The future assignment, e.g. `x %<-% { expr }`.  
`seed`                      (optional) A L'Ecuyer-CMRG RNG seed.

---

`%tweak%`                      *Temporarily tweaks the arguments of the current strategy*

---

**Description**

Temporarily tweaks the arguments of the current strategy

**Usage**

`fassignment %tweak% tweaks`

**Arguments**

`fassignment`      The future assignment, e.g. `x %<-% { expr }`.  
`tweaks`                      A named list (or vector) with arguments that should be changed relative to the current strategy.

# Index

[.FutureGlobals (FutureGlobals), 13  
%->% (future), 7  
%<-% (future), 7  
%packages% (%globals%), 38  
%globals%, 10, 38  
%label%, 38  
%lazy%, 39  
%plan%, 39  
%seed%, 40  
%tweak%, 40

as.cluster, 2  
as.FutureGlobals (FutureGlobals), 13  
assert\_no\_references (find\_references),  
6  
availableCores, 22, 23, 26

backtrace, 3

c.cluster (as.cluster), 2  
c.FutureGlobals (FutureGlobals), 13  
cluster, 4, 29  
ClusterFuture, 5, 32  
conditions, 37

environment, 4, 8, 12, 13, 22, 24, 25, 31, 34  
expression, 4, 8, 12, 22, 24, 25, 31, 34

find\_references, 6  
fold, 6  
function, 8  
Future, 8, 9, 14, 32, 33, 37  
Future (Future-class), 12  
future, 5, 7, 13, 14, 22, 24, 26, 28, 34  
Future-class, 12  
futureAssign (future), 7  
futureCall (future), 7  
FutureGlobals, 13  
futureOf, 9, 14, 33  
futures, 15

Globals, 14

list, 8  
list environment, 33

makeCluster, 4, 26  
makeClusterPSOCK, 16  
makeNodePSOCK (makeClusterPSOCK), 16  
makePSOCKcluster, 16  
multicore, 21, 23, 24, 26, 29, 36  
MulticoreFuture, 22, 24  
multiprocess, 23, 23, 26, 29  
MultiprocessFuture, 24  
multisession, 23, 24, 25, 29  
MultisessionFuture, 24, 26

nbrOfWorkers, 27  
nullcon, 27

plan, 5, 7, 8, 11, 22, 26, 27, 28, 34, 36, 39  
promise, 9, 13

remote, 29, 30  
resolve, 32  
resolved, 8, 12, 33

sequential, 22, 28, 29, 34  
SequentialFuture, 35  
stderr, 17  
stdout, 17  
substitute, 4, 8, 12, 22, 24, 25, 31, 34  
supportsMulticore, 35

transparent, 29  
transparent (sequential), 34  
tryCatch(), 4  
tweak, 36

uniprocess (sequential), 34  
unique.FutureGlobals (FutureGlobals), 13  
value, 8, 12

value (value.Future), [36](#)  
value.Future, [36](#)  
values, [37](#)