

Package ‘supr3’

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Title Experimenting Parallel and Distributed Computation in R

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Description Support for parallel distributed computation, including multithreading, distributed file and memory management, and flexible cluster-wise iterative computing.

License GPL (>=2)

Imports stats, graphics

Suggests methods

NeedsCompilation yes

Depends R (>= 4.3.1)

R topics documented:

1. supr3-package	1
2. SupR	3
3. Cluster	9
4. DDS or DFS	21
5. Thread	29

Index	38
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1. supr3-package	<i>SupR: an experimental R package for parallel and distributed computing</i>
------------------	---

Description

Support for parallel and distributed computation, including multithreading, distributed file and memory management, and flexible cluster-wise iterative computing.

Details

SupR consists of three main components:

1. *Cluster*: a cluster that is based on a collection of stand-alone programs, namely, driver, master, worker, and taskrunner. These programs and those for DDS/DFS (dfs_name to run as a namenode, and dfs_data to run datanodes), are available in package's bin directory. The *context* function provides as a main user interface to start and stop components of a cluster. The package provides a set of functions for implementing SupR's method for cluster-wide iterative statistical computing on distributed data, including those known as map-and-reduce or map-and-combine.
2. *SDFS*: a distributed file system, or more generally, a distributed object system. The user interface functions to access DFS have their names starting with *DD*.
3. *Thread*: a set of functions for multithreading, reflecting a collection of experimental efforts to use multithreading in R without any change of the R system code.

Author(s)

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References

<http://www.stat.purdue.edu/~chuanhai>

See Also

cluster dfs thread

Examples

```
## Not run:

library(supr3)
context()
typeof(context())
unlist(context())$ths

# Turn on verbose mode, 0 <= verbose <= 3L. Large values of verbose
# increase the verbosity

supr.options(info=TRUE) # or supr.options(verbose=1L) [TODO]
supr.options(debug=TRUE) # or supr.options(verbose=3L) [TODO]

context(driver = context())$driver
context()$driver$connections

context(shutdown)

## End(Not run)
```

Description

SupR: an experimental R package for parallel and distributed computing.

A cluster is referred to as a system consisting of a master, a number of workers, and a driver. The master serves as a central server for workers and drivers. Workers are registered at the master and connect to driver once a driver is available. A worker manages a number of task-runners that are grouped under executors. The current implementation of worker has a single executor. Each task-runner is a R session as a child process of the worker, and works with a pthread of the worker to interact with other components of the cluster.

The driver provides a user interface to the cluster. Computation tasks are submitted to the cluster as jobs through the driver via the `cluster.eval` function. Details are described in the [cluster](#) section.

Usage

```
.SuprEnv
supr.version()
context(...)
supr.options(...)

suprenv(address)
masterenv()
driverenv()
workerenv(which)
nenv()
dnenv(which)

ping(address, timeout = 10)
netstat(port, args = NULL)

send(msg, to)
recv(timeout = 0)
messages()
```

Arguments

<code>address</code>	a character object representing the socket server a SupR component; See <i>Details</i> .
<code>which</code>	an integer object referring to the worker number registered at the master or the DFS datanode number at the DFS namenode; See <i>Details</i> .
<code>...</code>	a list of named arguments reserved for future development.

Details

The `.SuprEnv` variable is an environment object defined in `.GlobalEnv` in every `supr` component R session. It has `.GlobalEnv` as its parent environment, except `taskrunner`. It serves as the parent environment for cluster level evaluations.

The `supr.version` function returns a character object of the `supr` package version.

The `context` function provides a simple way of working with SupR cluster context. It allow the user to start and examine components of a cluster. The arguments of `context` takes the following character (or symbol) values:

Argument	Value	Action
<code>shutdown</code>		command to shutdown cluster by sending a shutdown message to master, driver, and dfs_name.
<code>info</code>	(integer) <code>port_number</code>	start an info socket server
<code>dfs</code>	(character) <code>socket_address</code>	start DFS
	NULL	shutdown the dfs server
<code>driver</code>	(integer) <code>port_number</code>	start driver and cluster
	NULL	shutdown the driver
<code>master</code>	(character) <code>socket_address</code>	start master and workers
	NULL	shutdown the master
<code>ths</code>	(list) <code>socket_addresses</code>	start thread servers
		return the context environment
		session: luster component name
<code>proc</code>		show all <code>supr3</code> processes
<code>killall</code>		kill all <code>supr3</code> processes
<code>config</code>	a list of arguments	generate <code>.supr/supr.conf</code>
	<code>nodes=</code>	a character object of hostnames
	<code>force=</code>	TRUE: replace <code>.supr/supr.conf</code>
		FALSE: replace <code>.supr/supr.conf</code> when safe
	<code>port=</code>	lower limit on socket ports to use
	<code>ncpu=</code>	number of cpu cores/taskrunners

The `supr.options` function has three logical options `info`, `verbose`, and `debug` and an integer option to control the system information details. It offers a `timeout` option that is used in establishing socket connections and reading from sockets. In addition, it has a `port` option, which is used as the lower limit of socket ports when a dynamic socket server port is allowed.

The `suprenv` function creates a socket connection to the server of the cluster component. The target component is specified by its socket server address of the `hostname:port` format. The `driverenv`, `masterenv`, `workerenv`, `nnenv`, and `dnenv` functions are intended to provide a convenient way of accessing cluster components.

The `ping` function sends an echo request to the socket server specified by the `address` argument.

The `netstat` function uses the OS command `netstat` to provide information on network connections on a given port of interest.

The `send` function sends an R object `msg` as a message to the recipient to.

The `recv` function reads one message, if there are messages available during the time period specified by the `timeout (sec.)` argument.

The `messages` function reads all the messages that have been received from the last read.

Value

The `suprenv` function returns an environment object as an interface to the `.SuprEnv` object of the component server.

Common objects that are available for all such environments include `.SuprThreads`, `connections`, `makeActiveBinding`, `pthreads`, `shm`, and `supr.options`.

`masterenv()` returns an environment for accessing master's `.SuprEnv`.

`driverenv()` returns an environment for accessing driver's `.SuprEnv`. In addition to the common objects listed above, this environment has the following driver-specific objects: `dfs`, `master`, `job`, and `jobs`.

`nnenv()` returns an environment for accessing DFS namenode's `.SuprEnv`.

`workerenv(which)` returns an environment for accessing `.SuprEnv` of the `which`-th worker registered at the master. The call `workerenv(which=0)` returns all the worker addresses.

`dnenv(which)` returns an environment for accessing `.SuprEnv` of the `which`-th datanode registered at the DFS namenode. The call `dnenv(which=0)` returns all the datanode addresses.

`ping(address, timeout)` returns a received integer object from the server before timeout is expired, and generates an error message otherwise.

`netstat(port)` returns a character object as the information on socket connections involved the given port.

`recv(timeout)` returns the next messages from the last read, if available before the timeout is expired, and `NULL` otherwise.

`messages()` returns a list of messages.

Note

The installation of the `supr` package should create the file named `.suprrc`, under user's home directory. This is to be run with the bash shell command `source` to define three system environment variables `R_HOME`, `SUPR_SYS_HOME`, and `SUPR_USR_HOME`. The value of `R_HOME` is the HOME directory of the R version that was used in the installation. The value of `SUPR_SYS_HOME` is the HOME directory of the installed `supr` package. It is used for remote invocations of the `supr` commands `dfs_name`, `dfs_data`, `master`, `worker`, and `threadserver`. The value of `SUPR_USR_HOME`, with the default `$HOME/.supr`, is the top-level parent directory of the running `supr` commands.

Configurations of socket connection ports and distributed file locations are specified in the configuration file: `$SUPR_USR_HOME/supr.conf`. Here is an example, where a port number `n` followed immediately with '+' specifies any port in the range from the port `n` is allowed.

```
Namenode //machine.1:7200?data={
  file://$HOME/.supr/dfs_name/machine.1
```

```

}

Datanode //machine.1:7201?data={
    file://$HOME/.supr/dfs_data/machine.1
    file://$HOME/SupR/dfs_data
}

Datanode //machine.2:7201data={
    file://$HOME/.supr/dfs_data/machine.2
}

Master //machine.1:7202

Driver //machine.1:7203

Worker //machine.1:7204
Worker //machine.2:7204

Infonode //machine.1:7205+

Filetransfer //machine.1:7206+

ThreadServers {
    machine.1:7208+
    machine.2:7208+
}

TrustedHosts {
    machine.1
    machine.2
}

```

Note that multiple files locations can be used for datanodes to store data. This is illustrated with the first datanode in the above example.

The components of `supr3` can also be started using machine operation system (OS) commands:

```

dfs_name [-port n] [--verbose] [--debug] [--info] [--help]
        [-info addr] [-notify addr]

dfs_data [-port n] [--verbose] [--debug] [--info] [--help]
        [-info addr] [-notify addr] [-nn addr]

master [-port n] [--verbose] [--debug] [--info] [--help]
        [-info addr] [-notify addr]

worker [-port n] [--verbose] [--debug] [--info] [--help]
        [-info addr] [-notify addr] [-master addr] [-ntrs k]

```

```
driver [-port n] [--verbose] [--debug] [--info] [--help]
      [-info addr] [-notify addr] [-shm name] [-master addr]
      [-dfs addr]
```

```
threadserver [-port n] [--verbose] [--debug] [--info] [--help]
      [-info addr] [-notify addr]
```

More information on these commands can be obtained by invoking them with the `--help` argument.

See Also

[Cluster](#), [Thread](#)

Examples

```
## start
## Not run:

#####
##### New functions, subject to more testing #####
#####

library(supr3)

context(proc)    # show SupR processes on all the nodes found in supr.conf
context(killall) # kill all SupR processes on all the nodes found in supr.conf

# The following function call

context(config=list(nodes="bell-fe[00-06]", force = TRUE, port=2022))

# generates ~/.supr/supr.conf with the given nodes argument and
# the same network domain as that of the host of the R session

# The next example shows how to use nodes obtained via
# an interactive Slurm job, sinteractive -N 10 -n 100 -A standby -t 1:0:0
# Slurm Reference: <https://slurm.schedmd.com/quickstart.html>

context(config= list(nodes = Sys.getenv("SLURM_JOB_NODELIST"),
                      force=TRUE, port = 2022, ncpu=10))

# The following function call, subject to feature refinements,

# workerenv(1)$supr.options(xterm = TRUE)
workerenv(1)$xterm(interactive=TRUE)

# starts a remote X Terminal (xterm) for stdout and stderr and
# an interactive pthread running R REPL (Read-Eval-Print Loop)
```

```

# on worker workerenv(1).

# Added Sys.info2

Sys.info2()

# which provides information on the number of cpu cores and the limits
# on the maximum file descriptor number that can be opened by
# current process

#####
#####          End of New functions          #####
#####

library(supr3)
supr.options()
supr.options(info = TRUE, verbose = TRUE)

# Show the initial state of the context
context()

# Start a cluster
context(driver = context()$driver)
cluster <- context()$driver
cluster$connections

masterenv()$connections
masterenv()$pthreads
workerenv(0)
workerenv(1)$connections
workerenv(1)$pthreads

nnenv()$connections
nnenv()$pthreads
dnenv(0) # datanode server addresses
dnenv(1)$connections
dnenv(1)$pthreads

# Shutdown the cluster
context(shutdown)

## End(Not run)

```


Description

Functions to interface with the SupR cluster system.

Usage

```
.GlobalEnv$.SuprEnv$.LastValue
.job.id
.tr.id
JobEnv

clusterenv()
clusterenv()$jobs()
clusterenv()$job(job_id)

cluster.eval(expr, data, envir = list(), error.handler = NULL,
  env = parent.frame(), wait = TRUE, combine = job.combine.default,
  ...)
cluster.combine(x, combine, bykey = FALSE, env = parent.frame())
cluster.get(uri, name, remove = FALSE)
collect(x, remove = FALSE)

nextSubset(env = parent.frame())
info(text, conn = NULL)
# CHANGE IT TO cluster.combine

sync(monitor, expr, language.only = FALSE, env = parent.frame())
wait(monitor, timeout = 0, env = parent.frame())
notify(monitor, all = FALSE, env = parent.frame())

broadcast(..., addr = NULL)
broadcasted(new = FALSE, timeout = 0)
```

Arguments

<code>expr</code>	a meaningful expression executable by Taskrunners .
<code>data</code>	either a list object of subsets or a distributed data in SDFS.
<code>envir</code>	an environment objection used by Taskrunners to to evaluate <code>expr</code> for subsets. See Details .
<code>env</code>	an environment object.
<code>error.handler</code>	the error handler at the cluster level (not implemented yet)
<code>wait</code>	a logical object.

<code>combine</code>	a function used <code>cluster.eval</code> to combine results from taskrunners or a function that is to be used in <code>cluster.combine</code> to combine.
<code>uri</code>	a URI object. See Details .
<code>name</code>	a character string used as a name.
<code>job_id</code>	an integer used as job id.
<code>timeout</code>	an amount of time to wait for the job to finish.
<code>remove</code>	a logical object.
<code>bykey</code>	a logical object.
<code>x</code>	a named list or environment object.
<code>...</code>	optional arguments.

For `cluster.eval`, they are job-specific variables defined at the cluster level, i.e., at the driver site. For broadcast, they are variables to be sent to taskrunners.

Details

The object `JobEnv` acts as a `UserDatabase` linked to a cluster environment object at the driver session. The variables `job`, `task`, `address`, `firstSubset`, and `.__NAMESPACE__` are handled locally. The variable `job` is an integer object of a job id. When the value of `job` is -1, `JobEnv` is referred to as a `UserDatabase` to access global environment for job variables located at the driver site.

...

Value

`cluster.eval` returns the evaluated value for `wait = TRUE`, otherwise, it returns an object of the `Future` class. The returned result is a list of `TaskrunnerValue` objects from individual [taskrunners](#). A `tr.val` (`Taskrunner Value`) object is a list consisting of a *value* component, a *warnings* component, and *taskrunner* name. IN case of any error, the *value* is replaced by an *error* component. See [Examples](#).

A job state notification is sent to user as a message (see `send`, `recv`, and `messages`) by the driver. The message is an object of the `JobStatus` class. Objects of the `JobStatus` class have three named objects, namely, `job`, `state`, and `ntrs`. The `job` element is an integer as the job id. The `ntrs` element is the number of task runners that are still involved in finishing the job. The `state` element takes one of the three values as follows:

Job State	Notification Value	Comments
<code>TASKS_ASSIGNED</code>	"assigned"	all the subsets have been taken
<code>CANCELLED</code>	"cancelled"	by user or due to errors
<code>FINISHED</code>	"finished"	

With `wait = TRUE`, `cluster.eval` returns an environment object, having a S3 class name "Future". The class "Future" has the following objects to operate on the submitted job.

```

class "Future" {
  cancel(): cancel the submitted job.
  get(timeout = 0): get the result if available within next \code{timeout}
                    seconds.
  is.cancelled(): returns TRUE if the job is cancelled and FALSE otherwise.
  is.done(): return TRUE if the job is finished and FALSE otherwise.
  job.id: an integer object used as the job id.
  .value: the list of returned values from the taskrunners.
  combine: combine the list of taskrunner results, \code{.value}.
  .done: a logical object used internally by the \code{is.done} function.
  envir: the environment object of the \code{env} argument in calling
         \code{cluster()}$eval}.
}

```

When a job submitted with `wait = TRUE` is user-interrupted by, for example, pressing Ctr-C on the keyboard, the job will continue as with `wait = FALSE`. The object of class "Future" for accessing this job can be obtained from the current value of `.GlobalEnv$.SuprEnv$.LastValue`.

The three objects named `.job.id`, `.tr.id`, `.tr.name` are defined in the environment, `.GlobalEnv$.SuprEnv`, of taskrunners. The value of `.job.id` object is the integer value of the ID of the job the taskrunner is running. The value of `.tr.id` object is the integer value of the job-specific taskrunner ID assigned to the taskrunner running the job. The value of `.tr.name` object is the character of length one to uniquely identify the taskrunner process. Its value has the form of `hostname:pid` and equals `paste(Sys.info()["nodename"], Sys.getpid(), sep=":")`.

Note

...

See Also

`dfs`, `thread`

Examples

```

## Not run:

library(supr3)
cluster <- clusterenv()
supr.options(level = 1)

ls(cluster)
ls(cluster$.LocalEnv)
cluster$connections
cluster$pthreads
cluster$supr.options()
cluster$supr.options(level=1)

## End(Not run)

# An echo example of different kinds

```

```

## Not run:

## a plain version
expr.echo <- quote({
  subsets <- list()
  while(!is.null(x <- nextSubset()))
    subsets <- append(subsets, x)
  subsets
})
results <- cluster.eval(expr.echo, as.list(1:100), envir=list())
sort(unlist(results))
messages()

## a version making use of the send function
expr.echo <- quote({
  subsets <- list()
  while(!is.null(x <- nextSubset())){
    send(x, "user")
    subsets <- append(subsets, x)
  }
  subsets
})
results <- cluster.eval(expr.echo, as.list(1:100))
sort(unlist(results))
messages()

## a version making use of the send and recv functions
expr.echo <- quote({
  subsets <- list()
  while(!is.null(x <- nextSubset())){
    Sys.sleep(1)
    send(x, "user")
    subsets <- append(subsets, x)
  }
  subsets
})

eval({
  results <- cluster.eval(expr.echo, as.list(1:100), wait=FALSE)

  i <- 0
  y <- numeric(0)
  while(!is.null(x <- recv(timeout=60))){
    if(class(x) == "JobStatus"){
      print(x)
      if(x$state == "finished") break;
    } else {
      cat("[", i <- i + 1, "] x:", x, "\n")
      y[i] <- x
      plot(1:i, y)
    }
  }
})

```

```

    }

    sort(unlist(results$get()))
  })

## End(Not run)

## a version making use of JobEnv
## Not run:
library(supr3)
cluster <- clusterenv()
supr.options(level=1)

expr.echo <- quote({
  subsets <- list()
  while(!is.null(x <- nextSubset())){
    JobEnv$z <- x
    Sys.sleep(1)
    info(paste("JobEnv$i =", JobEnv$i));
    send(x, "user")
    subsets <- append(subsets, x)
  }
  subsets
})

eval({
  results <- cluster.eval(expr.echo, as.list(1:100), wait=FALSE)

  JobEnv$job <- results$job.id
  JobEnv$task <- -1
  i <- 0
  y <- numeric(0)
  z <- numeric(0)
  while(!is.null(x <- recv(timeout=60))){
    if(class(x) == "JobStatus"){
      print(x)
      if(x$state == "finished") break;
    } else {
      cat("[", i <- i + 1, "] x:", x, "\n")
      JobEnv$i <- i
      y[i] <- x
      z[i] <- JobEnv$z
      plot(1:i, y)
      lines(1:i, z)
    }
  }

  sort(unlist(results$get()))
})

cluster$jobs()

```

```

context(shutdown)

## End(Not run)

## Not run:
# The use of the parallel random number generator in the rlecuyer package
library(supr3)
cluster <- clusterenv()
supr.options(level=1)

expr.rgn <- quote({ # FIXME?
  library(rlecuyer)
  retval <- list()
  while(!is.null(x <- nextSubset())) {
    info(paste("x:", x, "pid:", Sys.getpid()))
    .lec.SetPackageSeed()
    .lec.StreamNames <- paste("lec.stream", 1:ntasks, sep=".")
    .lec.CreateStream(.lec.StreamNames)
    kind.old <- .lec.CurrentStream(.lec.StreamNames[.tr.id])

    val <- list(ntasks=ntasks, x=x, tr.id=.tr.id,
      u.1 = runif(1), u.2 = runif(1))

    .lec.CurrentStreamEnd(kind.old)
    .lec.DeleteStream(.lec.StreamNames)
    retval <- rbind(retval, val)
  }
  info(paste("x:", x, "pid:", Sys.getpid()))
  retval
})

results <- cluster.eval(expr.rgn, as.list(1:100L),
  envir=list2env(list(ntasks=100L)), wait=F)

## End(Not run)

# A cluster-level combine example
## Not run:

library(supr3)
cluster <- clusterenv()
supr.options(level=1)

expr.combine <- quote({
  my.combine <- function(x, y){x+y}
  x <- nextSubset()
  while(!is.null( y <- nextSubset() )){
    x <- my.combine(x, y)
    Sys.sleep(1)
  }
  cluster.combine(x, my.combine)
})

```

```

    })

    results <- cluster.eval(expr.combine, data=as.list(1:100))

    results
    unlist(results)

    cluster$jobs()
    context(shutdown)

## End(Not run)

# A cluster-level combine_by_key example

## Not run:

library(supr3)
cluster <- clusterenv()
supr.options(level=1)

data <- 1:100
data <- lapply(as.list(data), function(x) {
  names(x) <- LETTERS[(x-1) %% 26 + 1]
  x
})

expr.cbk <- quote({
  Sys.sleep(1)
  tr.combine <- function(x, y){
    keys <- unique(c(names(x), names(y)))
    z <- numeric(length(keys))
    names(z) <- keys
    for(key in keys)
z[key] <- sum(c(if(is.null(x)) x else x[names(x)==key],
if(is.null(y)) y else y[names(y)==key]))
    z
  }
  y <- NULL
  while(!is.null(x <- nextSubset()))
    y <- tr.combine(y, x)

  data <- as.environment(as.list(y))
  send(ls.str(data), "user")
  my.combine <- function(x, y) x+y
  cluster.combine(data, my.combine, bykey = TRUE)
})

results <- cluster.eval(expr.cbk, data=data)

messages()

r <- collect(results, TRUE)
r <- unlist(r)

```

```

# Checking
s <- sapply(LETTERS, function(x) {
  sum(unlist(lapply(data, function(y) y[names(y)==x])))
})
s <- s[sort(names(s))]

# Checking: is r[names(s)] - s a vector of 26 zeros?
print(r[names(s)] - s)

## End(Not run)

# A simple EM example using the standard synchronization method.
# For the DD object EM_data, see the DD example
## Not run:
options(verbose=TRUE)
options(debug=TRUE)

# options(info=TRUE) # info default is TRUE
library(supr3) # .Call("Pthread_sigmask", NULL)
context(driver = context())$driver
cluster <- context()$driver
cluster$connections

expr.em <- quote({ subsets <- list()
  while(!is.null(sub <- nextSubset())) { x <- sub$x[,1]
    subsets <- append(subsets, list(x)); Sys.sleep(0.1)
# if(runif(1)<0.01) stop("testing")
  }
  n.subsets = length(subsets)
  if(n.subsets==0){ stop("FIXME"); X <- numeric(0); mu <- 0 } else {
    X <- unlist(subsets); mu <- mean(X[!is.na(X)])
  }
  print(length(X)); print(head(X)); print(typeof(X)); print(class(X))

  mis <- is.na(X); n.com <- length(X)
  E.step <- function(mu){
    X[mis] <- mu
    list(sx = sum(X), n = n.com)
  }
  my.combine <- function(x, y){ list(sx = x$sx + y$sx, n = x$n + y$n) }
  M.step <- function(SS){ SS$sx/SS$n }

  n <- 0; max.n = 10; this.job <- paste0("JOB-", .job_id)
  while(n < max.n) { n <- n + 1
    SS <- E.step(mu) #my.result <- cluster.combine(SS, my.combine)
    my.result <- cluster.combine(SS, my.combine)
    if (is.null(my.result)) {
      mu <- sync(std_EM, {timeout <- wait(std_EM, timeout=timeout())

```



```

    if(timeout < 0) notify(std_EM, all=TRUE)
    JobEnv$mu })
  #if(runif(1)<0.01) stop("testing") else if(runif(1)<0.01) q("no")
  } else {
    mu <- M.step(my.result) #broadcast(mu=mu, test="OKAY?")
  }
JobEnv$mu <- mu
  sync(std_EM, { timeout <- wait(std_EM, timeout=timeout())
  if(timeout < 0) notify(std_EM, all=TRUE)
  s <- if(timeout < 0) "*" else " "
  #send(paste(s, "job.id =", .job_id, "iter =", n, "mu =", mu), "user")
  info(paste(s, "job.id =", .job_id, "tr.id =", .tr_id, "iter =", n, "mu =", mu))
})
}
}
list(mu=mu, Sx=SS$sx, n = n, n.mis=sum(mis), n.subsets=n.subsets)
})
print(proc.time())
result <- cluster.eval(expr.em, data=structure("EM_data", class="DD"))
print(proc.time())

for(i in 1:5000){print(i); result <- cluster.eval(expr.em, data=structure("EM_data", class="DD"), wait=TRUE) }

for(i in 1:10){print(i); result <- cluster.eval(expr.em, data=structure("EM_data", class="DD"), wait=FALSE) }

# CHECKING job_id > 60?
options(info=TRUE)
library(supr3)
context(driver = context()$driver)
cluster <- context()$driver
cluster$connections

## Use broadcast for sync
expr.em <- quote({ subsets <- list()
  while(!is.null(sub <- nextSubset())) { x <- sub$x[,1]
    subsets <- append(subsets, list(x)); Sys.sleep(0.1)
  }
  n.subsets = length(subsets)
  if(n.subsets==0){ stop("FIXME"); X <- numeric(0); mu <- 0 } else {
    X <- unlist(subsets); mu <- mean(X[!is.na(X)])
  }
  print(length(X)); print(head(X)); print(typeof(X)); print(class(X))

  mis <- is.na(X); n.com <- length(X)
  E.step <- function(mu){
    X[mis] <- mu
    list(sx = sum(X), n = n.com)
  }
  my.combine <- function(x, y){ list(sx = x$sx + y$sx, n = x$n + y$n) }
  M.step <- function(SS){ SS$sx/SS$n }

  n <- 0; max.n = 50; this.job <- paste0("JOB-", .job_id)

```

```

while(n < max.n) { n <- n + 1
  SS <- E.step(mu) #my.result <- cluster.combine(SS, my.combine)
  my.result <- cluster.combine(SS, my.combine)
  if (!is.null(my.result)) {
    mu <- M.step(my.result)
  }
broadcast(mu=mu, iter = n)
  info(paste("pid =", Sys.getpid(), "job.id =", .job_id,
    "tr.id =", .tr_id, "iter =", n, "mu =", mu))
# info(as.character(rc))
}
# if(runif(1)<0.01) stop("testing")
mu <- broadcasted(new = TRUE)$mu
}
list(mu=mu, Sx=SS$sx, n = n, n.mis=sum(mis), n.subsets=n.subsets)
})

print(proc.time())
result <- cluster.eval(expr.em, data=structure("EM_data", class="DD"))
print(proc.time())

i <- 0; while(TRUE){i <- i+1; print(i); result <- cluster.eval(expr.em, data=structure("EM_data", class="DD"))

library(supr3)
cluster <- clusterenv()
supr.options(level=1)

## Use broadcast for sync
expr.em <- quote({ subsets <- list()
  while(!is.null(sub <- nextSubset())) { x <- sub$x[,1]
    subsets <- append(subsets, list(x)); Sys.sleep(0.1)
  }
  n.subsets = length(subsets)
  if(n.subsets==0){ stop("FIXME"); X <- numeric(0); mu <- 0 } else {
    X <- unlist(subsets); mu <- mean(X[!is.na(X)])
  }
  print(length(X)); print(head(X)); print(typeof(X)); print(class(X))

  mis <- is.na(X); n.com <- length(X)
  E.step <- function(mu){
    X[mis] <- mu
    list(sx = sum(X), n = n.com)
  }
  my.combine <- function(x, y){ list(sx = x$sx + y$sx, n = x$n + y$n) }
  M.step <- function(SS){ SS$sx/SS$n }

  n <- 0; this.job <- paste0("JOB-", .job_id)
  while(n < max.n) { n <- n + 1
    SS <- E.step(mu) #my.result <- cluster.combine(SS, my.combine)
    my.result <- cluster.combine(SS, my.combine)
    if (!is.null(my.result)) {
      mu <- M.step(my.result)
    }
  }
}

```

```

broadcast(mu=mu, iter = n)
  send(list(mu=mu, n=n), "user")
}
mu <- broadcasted(new = TRUE)$mu
}
list(mu=mu, Sx=SS$sx, n = n, n.mis=sum(mis), n.subsets=n.subsets)
})

messages()
res <- eval({
  result <- cluster.eval(expr.em, data=structure("EM_data", class="DD"),
    wait = FALSE, envir=list(max.n = 50), my.par=1:10)
  i <- 0; mu <- n <- numeric(0)
  while(!is.null(x <- recv(timeout=5))){
    if(class(x) == "JobStatus"){
      print(x)
      if(x$state == "finished") break;
    } else {
      i <- i+1
      mu[i] <- x$mu
      n[i] <- x$n
      s <- ceiling(length(n)/2):length(n)
      plot(n[s], mu[s])
    }
  }
  result$get()
})

messages()

## End(Not run)

## An asynchronous distributed EM
## Not run:
library(supr3)
cluster <- clusterenv()
supr.options(level=1)

expr.em <- quote({ subsets <- list()
  while(!is.null(sub <- nextSubset())) { x <- sub$x[,1]
    subsets <- append(subsets, list(x)); Sys.sleep(0.1)
  }
  n.subsets = length(subsets)
  if(n.subsets==0){ stop("FIXME"); X <- numeric(0); mu <- 0 } else {
    X <- unlist(subsets); mu <- mean(X[!is.na(X)])
  }
  print(length(X)); print(head(X)); print(typeof(X)); print(class(X))

  mis <- is.na(X); n.com <- length(X)
  E.step <- function(mu){
    X[mis] <- mu

```

```

    list(sx = sum(X), n = n.com)
  }
my.combine <- function(x, y){ list(sx = x$sx + y$sx, n = x$n + y$n) }

n <- 0; this.job <- paste0("JOB-", .job_id)
while(n < max.n) { n <- n + 1
  SS <- E.step(mu)
  send(list(SS=SS, tr = .tr_id), "user")
  mu <- broadcasted(new = TRUE)$mu
  info(paste("mu:", mu))
}
list(mu=mu, Sx=SS$sx, n = n, n.mis=sum(mis), n.subsets=n.subsets)
})

messages()
res <- eval({

  M.step <- function(SS){
    sum(unlist(lapply(SS, "[", "sx")))/
    sum(unlist(lapply(SS, "[", "n")))
  }
  result <- cluster.eval(expr.em, data=structure("EM_data", class="DD"),
    wait = FALSE, envir=list(max.n = 50), my.par=1:10)

  JobEnv$job <- result$job.id; JobEnv$task <- -1
  ##ntrs <- 0; SS <- list(); R <- logical(0)

  n <- 0; mu.seq <- n.seq <- numeric(0)
  while(!is.null(x <- recv(timeout=5))){
    if(class(x) == "JobStatus"){
print(x)
      if(x$state == "finished") break;
      if(x$state == "assigned") {
        ntrs <- x$ntrs
SS <- lapply(as.list(1:ntrs), function(x) list(sx=0, n=0))
R <- logical(ntrs)
count <- logical(ntrs)
      }
    } else {
      k <- x$tr+1
      SS[[k]] <- x$SS
R[k] <- TRUE
if(sum(R) >= 0.75*ntrs || runif(1) < 0.01){
  cat("sum(R):", sum(R), "\n")
  mu <- M.step(SS)
  n <- n + 1
  broadcast(mu=mu, iter = n)
R[] <- FALSE
  mu.seq[n] <- mu
  n.seq[n] <- n
  s <- ceiling(length(n.seq)/2):length(n.seq)
  plot(n.seq[s], mu.seq[s])
}

```

```
    }  
  }  
  if(is.null(x)) stop("unexpected NULL msg ...")  
  # result$get()  
})  
  
# result$cancel()  
  
## End(Not run)
```

Description

These functions represent an interface for accessing the SupR distributed data system (DDS). They include

the common set of functions, namely, `assign` or ``$<-``, `exists`, `get` or ``$``, `ls`, and `rm`, as an interface for environments and `userDefinedDatabase` objects.

Usage

```
DD(name)
DD.close(name, save = TRUE)
DD.exists(name, ...)
DD.get(name, subset.names, ..., env = parent.frame())
DD.list(name = ".")
DD.mv(src, dest)
DD.open(name, create = TRUE)
DD.options(...)
DD.persist(name, level = c("file", "tmp", "shm", "mem", "null"))
DD.put(dd.name, subsets, subset.names)
DD.replicate(name)
DD.rm(name, recursive = FALSE)

DDEnv(name=".", addr = context()$dfs)
open.DDEnv(ddenv, name, save = TRUE)
close.DDEnv(ddenv, name, save = TRUE)
is.DDEnv(x)
print.DDEnv(x, ...)
replicate.DDEnv(x)
mv(src, dest)

`[.DDEnv`(x, i, j, combine, ..., env = list())
```

Arguments

<code>create</code>	a logical object.
<code>name</code> , <code>dd.name</code>	a DD name, a character string representing a Unix file path.
<code>subset.names</code>	a character vector of Unix simple file names.
<code>env</code>	an environment for evaluations of arguments.
<code>src</code> , <code>dest</code>	DD names.
<code>level</code>	one of the values given in its default.
<code>subsets</code>	a list of objects representing subsets.
<code>subset.names</code>	a character vector specifying the subset names.
<code>...</code>	optional arguments.

Details

The `DD()` function makes an DD object, regardless the existence of the named DD.

The `DD.exists()` function tests for the existence of the distributed data.

The `DD.get()` function gets the named data subsets of the DD name from DFS.

The `DD.list()` function returns simple information on the DD name or a file directory at DFS.

The `DD.mv()` function rename `src` to `dest`.

The `DD.open()` function opens the data data named `name` if it exists. Otherwise, it creates and opens the data if `create = TRUE`, and generates an error if `create = FALSE`.

The `DD.options()` invokes the `options()` function at DFS*.

The `DD.persist()` changes the storage type of the named DD.

The `DD.put()` function adds data subsets, a list of objects, with subset names `subset.names` to the distributed data named `name`.

The `DD.replicate()` increases the (minimum) number of subset replications by one.

The `DD.rm()` removes the named DD.

Value

The `DD()` function returns an DD object, regardless the existence of the named DD.

The `DD.close()` function returns an integer as the return code* The `DD.exists()` function returns `TRUE` if the named DD exists, and `FALSE` otherwise. The `DD.get()` function returns a list of objects. The `DD.list()` function returns a data frame object of subset name, size, timestamp, locations, and number of replications. The `DD.mv()` function returns an integer as the return code* The `DD.open()` function returns a DD object.

The `DD.options()` function returns the value of the `options()` function call at DFS*.

The `DD.persist()` function returns an integer as the return code*

The `DD.put()` function returns the number of subsets.

The `DD.replicate()` function returns the number of replications of the updated DD object.

The `DD.rm()` function returns an integer as the return code*

The `DDEnv` function returns a `DDEnv` object as an alternative representation of a DD object, in term of an `userDefinedDatabase` and `environment` object. The other functions following `DDEnv` on above usage list of functions are intended to provide operations to act on DD objects in the same way as on `environment` objects, as demonstrated below in the examples.

The ``[, DDEnv`` function provides a simple way to operate on `DDEnv` objects as `distributed data.frame` or `data.table`. The general form of `DDEnv` syntax is `DDEnv[i, j, combine, ..., env = list()]`. The `i` argument is an expression. When evaluated remotely, its value is either a logical or integer object, which is to be use as to select rows of `DDEnv`. The `j` argument is an expression to be evaluated remotely. The logical, integer, and character values are used to select columns according to column variable positions and names. When its value is a list, a new `data.frame` or `data.table` type of object is created with the list of objects, when its components are objects of logical, integer, numeric, and character and have the same length.

Note

...

See Also[Cluster](#), [Supr](#), [Thread](#).**Examples**

```

# Create a distributed data, named "EM_data", consisting of
# simulated subsets, and upload it into DFS
## Not run:
options(info=TRUE)
library(supr3)

context(dfs=context())$dfs

{
  data.name = "EM_data"
  DD.open(data.name)
  DD.list(data.name)
  tmp <- DD.get(data.name, NULL)
  length(tmp)
  table(is.na(tmp[[1]]$x))

  DD.close(data.name)

  supr.options(verbose=TRUE)

  x <- ddenv("EM_data")
  x[][]
}

## distribute subsets of R objects saved in files
data.name = "EM_data"

if(DD.exists(data.name)) DD.rm(data.name, TRUE)

DD.open(data.name)

N <- 100L # number of subsets
K <- 1000L # subset size
mis.prob <- 0.5 # fraction of missing values

if(!dir.exists(data.name))
  dir.create(data.name)

files <- paste0(data.name, "/part_", 1:N, ".rdata")
for(i in 1:length(files)){
  x <- rnorm(K)
  mis <- runif(K) < mis.prob

```



```

    x[mis] <- NA
    x <- data.frame(x=x)
    save(N, x, file=files[i])
  }

  DD.put(data.name, files, NULL)
  DD.list(data.name)

  #unlink(data.name, recursive = TRUE, force = TRUE)

## End(Not run)

## distribute R objects via R serialization
## Not run:
options(info=TRUE)
library(supr3)
context(dfs=context())$dfs

dn <- dnenv(1)
dn$supr.options(level=1)
dn <- dnenv(2)
dn$supr.options(level=1)

dfs <- context()$dfs
nn <- nnenv()
nn$supr.options(level=1)

data.name = "data_frame"

if(DD.exists(data.name)) DD.rm(data.name, TRUE)
DD.open(data.name)
N <- 10L # number of subsets
K <- 1000L # subset size
P <- 10L # number of variables
var.names <- paste("X", 1:P, sep=".")
for(i in 1:N){
  X <- matrix(runif(K*P), nrow=K, dimnames=list(NULL, var.names))
  X <- as.data.frame(X)
  DD.put(data.name, list(X), paste0("part_", i))
  # added suffix ".sro" internally
}

DD.list(data.name)
DD.persist(data.name)

DD.get(data.name, "part_2.sro")

A <- dfs$open(data.name)
A[1:2, 2:4]
```

```

## End(Not run)

## Create one more replicate of the data in DFS
## Not run: DD.replicate(data.name)
DD.list(data.name)

## End(Not run)

# Persist the data to disk
## Not run: DD.persist(data.name, "file")
DD.close(data.name)

## End(Not run)

# Read data subsets, all subsets in this example
## Not run: tmp <- DD.get(data.name, NULL)
length(tmp)
table(is.na(tmp[[1]]$x))
DD.close(data.name)

## End(Not run)

# Stop the SupR context
## Not run: context(shutdown)

# Double check
## Not run: context()

Supr(verbose = TRUE)
data.name = "EM_data"
DD.open(data.name)
tmp <- DD.get(data.name, NULL)
length(tmp)
table(is.na(tmp[[1]]$x))

DD.close(data.name)

context(shutdown)

## End(Not run)

## Not run:
# library(supr3)
# context(dfs=context())$dfs

options(debug=TRUE)

options(info=TRUE)
library(supr3)
context(dfs = context())$dfs
dfs <- context()$dfs

```

```

dfs <- ddenv()

{
  a <- dfsenv()
  a$connections
  a$pthreads
}

{
  em.data <- dfs$open("EMData")
}

context(dfs = NULL)

em.data <- open(DDEnv("EMData"))

assign("x", 1:10, envir = em.data)
assign("y", 1:100, envir = em.data)
ls(em.data)
get("x", envir=em.data)
get("y", envir=em.data)
get("z", envir=em.data)
em.data$x
em.data$y
em.data$z
em.data$z <- 1:20
em.data$z

exists("EMData", envir=em.data) # check subsets... or no?

rm(EMData, envir = em.data) # check subsets... or no?

# mv(em.data, as.character(when))
persist(em.data, level)
replicate(em.data)

if(FALSE){

#####
## some limited experiments on `[.DDEnv`      ##
## a tada.table framework; See the data.table R package  ##
#####

options(info=TRUE)
library(supr3)
context(dfs = context())$dfs)
#supr.options(level=1)

dn <- dnenv(1)
dn$supr.options(level=1)

```

```

dn <- dnenv(2)
dn$supr.options(level=1)

dfs <- context()$dfs
nn <- nnenv()
nn$supr.options(level=1)

# em.data <- dfs$open("EMData")
em.data <- dfs$open("EM_data")

b <- (a <- em.data[, list(x=x, y=x^2, z = foo(x), key = x > 0), , foo= sin])

(a <- em.data[, list(x=x, y=x^2, z = foo(x), key = x > 0), test,
  test= function(x) {
    v <- x$value
    x <- x$x
    if (is.null(x)) {
      return(v)
    }
    else if (class(x) == "DD.frame") { # dn
      n <- length(x)
      append(v, as.list(n))
    } else { # nn
      append(v, x)
    }
  }, foo= sin][,dim])

(a <- em.data[, list(x=x, y=x^2, z = foo(x), key = x > 0), test, test= function(x) {
  c(x$value, runif(10))
}, foo= sin])

(a <- em.data[, list(x=x, y=x^2, z = foo(x), key = x > 0), dim , foo= sin])

(a <- em.data[, list(x=x, y=x^2, z = foo(x), key = x > 0), , foo= sin][, 2:3, dim, j2=4])

(a <- em.data[, list(x=x, y=x^2, z = foo(x), key = x > 0), , foo= sin][, 2:3, , j2=4][,dim()])

(a <- em.data[, list(x=x, y=x^2, z = foo(x), key = x > 0), , foo= sin][, 2:3, , j2=4][, , ][,dim()])

(a <- em.data[, list(x=x, y=x^2, z = foo(x), key = x > 0), function(x) {
  if(runif(1)<0.1) stop("testing")
  c(x$value, search())
}, foo= sin])

(a <- em.data[, list(x=x, y=x^2, z = foo(x), key = x > 0), function(x){if(runif(1) < 0.01) stop("TESTING"); 100}])

(a <- em.data[!is.na(x), list(x=x, y=x^2, z = foo(x), key = x > 0), dim, foo= sin][, 1:3, , j2=4][, 1:2, group=foo])

(a <- em.data[, list(x=x, y=x^2, z = foo(x), key = x > 0), .n, foo= sin][, 3, , j2=4][, , group=function(){} ][1,
)
```

```
    a
}

# close(em.data)
{
  dfs$close(attr(em.data, "name"))
  em.data$close()
}

context(shutdown)

## End(Not run)
```

Description

SupR Multithreading with thread functions, implemented using both (Linux) processes and pthreads.
To see the exported functions, run the code `grep("[Tt]hread", ls("package:supr3"), value=TRUE)`.

Usage

```
ThreadServer.cancel(host, port, address = paste(host, port, sep = ":"))
ThreadServer.connect(host, port, address = paste(host, port, sep = ":"))
connect(host, port, address = paste(host, port, sep = ":"))
ThreadServer.start(port)

Thread.interrupt(thread)
interrupt(thread)
Thread.join(thread, useProxy = TRUE)
join(thread, useProxy = TRUE)
Thread.new(expr, ..., env = parent.frame(), error.handler = NULL,
           server = local.thread.server, start = FALSE)
ThreadServer.connect(...)$new(expr, ..., env = parent.frame(), error.handler = NULL,
                              server = local.thread.server, start = FALSE)
start(thread)
state(thread)

Sync.eval(monitor, expr, language.only = FALSE, env = parent.frame())
Sync.notify(monitor, all = FALSE, env = parent.frame())
Sync.wait(monitor, timeout = 0, env = parent.frame())
sync(monitor, expr, language.only = FALSE, env = parent.frame())
notify(monitor, all = FALSE, env = parent.frame())
wait(monitor, timeout = 0, env = parent.frame())
```

Arguments

<code>env</code>	the parent of the environment where the <code>expr</code> is to be evaluated.
<code>error.handler</code>	a function to be called when errors occur. See Details .
<code>expr</code>	an object to be evaluated by the thread. See Details .
<code>host</code>	a character representing the hostname of the thread server.
<code>port</code>	an integer representing the socket port of the thread server.
<code>monitor</code>	an expression of the form <code>connection\$name</code> specifying a monitor named <code>name</code> at the ThreadServer <code>connection</code> .
<code>thread</code>	a Thread object created by <code>Thread.new</code> .
<code>start</code>	a logical object specifying that thread should start to run right after it was created.
<code>...</code>	named objects. For <code>Thread.new</code> , they are passed on to the thread environment.

Details

`ThreadServer.start` is used to start a thread server in the current R session.

`ThreadServer.connect` or `connect` is used to connect to the thread server specified by the arguments hostname `host` and socket port number `port`.

`ThreadServer.cancel` cancels the thread server specified by the arguments hostname `host` and port number `port`.

`Thread.new` creates a new thread in the thread server session. Non-name `expr` objects are to be evaluated by the thread. Name `expr` objects are looked up in the current scope and their bindings are to be treated as non-name `expr` objects.

`Thread.start(thread)` starts the thread identified by the thread object.

`Thread.join(thread)` or `join(thread)` obtains the result of the thread. This should be always called because the system resources allocated for the thread can only be released via this function call, which invokes the C library function `waitpid` etc.

`Thread.interrupt(thread)` or `interrupt(thread)` terminates the running of the thread.

`Thread.state(thread)` or `state(thread)` gets the last reported running state of the thread.

`Sync.eval` obtains the monitor and evaluates the expression `expr` while holding the monitor.

`Sync.wait` or `wait` releases the monitor and waits to be notified or for a time period specified by the argument `timeout` in seconds. The special value `timeout = 0` means that no time limit is provided. `timeout` can take an expression to be evaluated by the synchronization manager such as thread servers and driver in cluster evaluation. In this case, the value of the expression must be numeric and is used to determine the required time period (in seconds).

`Sync.notify` or `notify` wakes up threads waiting on the same monitor one at a time if `all = FALSE` and all with a single call with `all = TRUE`.

Value

`ThreadServer.start` returns a `ThreadServer` object, containing its hostname and port number for service connections.

`ThreadServer.connect` or `connect` returns a `ThreadServer` connection object. This object is to be used for the service of `SupR-threading`. It serves also as an `environment` object for accessing shared objects at the thread server session.

`ThreadServer.cancel` returns 0 if successful and -1 otherwise.

`Thread.new` return a thread identification number with the thread server attached as an attribute named `server`.

`Thread.start(thread)` returns an `integer` object 0 if successful and -1 otherwise.

`Thread.join(thread)` or `join(thread)` returns the value of thread evaluation along with the outputs to `stdout` and `stderr` if the task was performed normally. When errors occur, the returned object has no value. In such a case, the error message, if available, is attached as an attribute named `error`.

`Thread.interrupt(thread)` or `interrupt(thread)` returns 0 if successful and -1 otherwise.

`Thread.state(thread)` or `state(thread)` returns an `integer` value as the state of the thread as follows: 0 — created, 1 — started, 2 — evaluated, 3 — finished.

`Sync.eval` returns the value of the expression `expr`.

`Sync.wait` or `wait` returns 0 if successful and -1 otherwise.

`Sync.notify` or `notify` returns 0 if successful and -1 otherwise.

Note

The threading model here follows that of the JAVA language. Each thread is implemented with a Linux process. The process ID is used as the thread ID.

The shared objects at thread servers can be accessed via functions accessing objects in environments. A standard set of such functions consists of `ls`, `$`, `$<-`, `exists`, and `rm`.

See Also

[SupR](#) for some utility functions; [Distributed File System](#) for an alternative way of storing and accessing on SupR clusters; and [Cluster](#) for cluster such as map-and-reduce type of computing.

Examples

```
### NEW ###
library(supr3)

# Generate supr.conf based on SLURM_JOB_NODELIST
# where the syntax of (the value of) SLURM_JOB_NODELIST is
# ...
# context(config= list(nodes = Sys.getenv("SLURM_JOB_NODELIST"),
#   force=TRUE, port = 2022), ncpu=5)

## Not run:
supr.options(info=TRUE, xterm = TRUE)
context(killall)

# Start thread servers

context(th=context())$ths
ths <- context()$ths
ls(ths[[1]], all = TRUE)
ls(ths[[1]]$.LocalEnv, all = TRUE)
ths[[1]]$new

# Local info on thread servers
context(th=list())

# Stop thread servers
context(th=NULL) # or context(shutdown)

## End(Not run)

### END_NEW ###

## Load the supr3 package in a R session:
```



```

library(supr3)

## Create a thread server in this the current session with a port number in an
## appropriate range. Keep a record of this server address, consisting of the
## hostname and socket port number for connections from this and other R
## sessions on the same machine or different machines. At most one thread
## server can be running in a single R session. However, multiple thread
## servers can run simultaneously on different R sessions and on different
## machines.

## Not run:
server <- ThreadServer.start(port=2021L)
print(server)

context(th=context())$ths
ths <- context()$ths

## End(Not run)

## Connect thread servers (only one server in the following example) from
## the same or different R session:

## Not run:
servers <- attr(server, "address")

connections <- as.list(1:length(servers))
for(i in 1:length(servers))
  connections[[i]] <- connect(address = servers[i])

connections <- append(connections, ths)

## End(Not run)

## For a simple example, take one from these connections at random:

## Not run:
conn <- connections[[sample(1:length(connections), size=1)]]
print(conn)

## End(Not run)

## Use the above connection conn as a shared network environment for R objects:

## Not run:
ls(conn)
conn$x <- 1:10
ls(conn)
conn$x
exists("x", envir = conn)

```

```
exists("y", envir = conn)
rm("x", envir = conn)
objects(conn)

## End(Not run)

## Create a new thread to evaluate:
## Not run:
s <- conn$new({
  print(Sys.info()["nodename"])
  print(Sys.getpid())
  sin(1:10)
})

start(s)
state(s)
res<- join(s)
print(res)

## End(Not run)

## or, equivalently,
## Not run:
expr <- quote({
  print(Sys.info()["nodename"])
  print(Sys.getpid())
  sin(1:10)
})

s <- conn$new(expr)

start(s)
state(s)
res<- join(s)
print(res)

## End(Not run)

## Start the thread:
## Not run:
start(s)

## End(Not run)

## Check the running state of the thread:
## Not run:
state(s)
```

```

## End(Not run)

## Get the result and automatically release the resources:
## Not run:
res <- join(s)

## End(Not run)

## A simple EM example to demonstrate the use of SupR thread synchronization.
## Create an artificial incomplete data from the standard Gaussian
## distribution with a fractional number of values missing at random:
## Not run:
  n <- 1000; mis.frac <- 0.25
  X <- rnorm(n)
  X[runif(n) < mis.frac] <- NA

## End(Not run)

## Start default thread servers with addresses provided in .supr/supr.conf
## Not run:
  library(supr3)
  supr.options(info=TRUE)
  #or
  supr.options(info=TRUE, xterm=TRUE)

  context(killall)

  context(th=context())$th

  connections <- context()$th

## End(Not run)

## Start m threads (at random) by the thread servers and choose a single
## server for shared objects
## Not run:
m <- 10
shared <- connections[[sample(1:length(connections), size=1)]]
shared.addr <- attr(shared, "address")
# or
shared.addr <- shared$address

## End(Not run)

# Create an object named as 'SS' at the thread server 'shared' for storing
# the expected sufficient statistics, sum(X) and length(X):

```

```

## Not run:
shared$SS <- c(0,0)

## End(Not run)

## Partition the data into m subsets:
## Not run:
m <- 10 # the number of threads to be used
dim(X) <- c(m, n/m)

## End(Not run)

# Create m threads:
## Not run:
threads <- as.list(1:m)
for(i in 1:length(threads)){
  conn <- connections[[sample(1:length(connections), size=1)]]
  expr <- quote({
shared <- connect(address = shared.addr)
  info("Start EM ...")
  which.mis <- which(is.na(x))
  for(it in 1:50){
    #E-step
    x[which.mis] <- mu
    my.SS <- c(sum(x), length(x))
    sync(shared$EM, { ##### a 'Sync.eval' example
      SS <- shared$SS + my.SS
      cat("[",it, "] SS:",SS, "n:", n, "\n")
      if(SS[2] < n) {
        shared$SS <- SS
        wait(shared$EM) ##### a 'wait' example
        mu <- shared$mu
        cat("[",it, "] mu:",mu,"\n")
      } else {
        #M-step
        mu <- SS[1]/n
        info(paste("[",it, "] pid:",Sys.getpid(),
          "mu:",mu)) ##### send a text message
        shared$mu <- mu
        shared$SS <- c(0,0)
        notify(shared$EM, all=TRUE) ##### a 'notify' example
      }
    })
  }
  info(paste("\033[0;31m[",it, "] pid:",Sys.getpid(),"\033[0m"))
  shared$mu
})
threads[[i]] <- conn$new(expr, x=X[i,],n=n,mu=0,shared.addr=shared.addr)
}

```

```
## End(Not run)

## Start the m threads
## Not run:
for(i in 1:length(threads)){ start(threads[[i]]) }

for(i in 1:length(threads)){ cat("[", i, " ] ", state(threads[[i]]), "\n") }

## End(Not run)

## Join the m threads
## Not run:
results <- as.list(1:length(threads))
for(i in 1:length(threads)){ results[[i]] <- join(threads[[i]]) }

print(shared$mu)
print(mean(as.numeric(X), na.rm = TRUE))

## End(Not run)

## Cancel a thread server:
## Not run:
  ThreadServer.cancel(address = attr(server, "address"))

## End(Not run)
```

Index

- * **package**
 - 1. `supr3-package`, 1
- * **supr**
 - 2. `SupR`, 3
- * **thread, concurrency**
 - 5. `Thread`, 29
- * **thread**
 - 2. `SupR`, 3
 - 3. `Cluster`, 9
 - 4. `DDS` or `DFS`, 21
 - `.job.id` (3. `Cluster`), 9
 - `.tr.id` (3. `Cluster`), 9
 - `$`, 32
 - 1. `supr3-package`, 1
 - 2. `SupR`, 3
 - 3. `Cluster`, 9
 - 4. `DDS` or `DFS`, 21
 - 5. `Thread`, 29
- `character`, 30
- `Cluster`, 7, 24, 32
- `cluster`, 3
- `cluster` (3. `Cluster`), 9
- `collect` (3. `Cluster`), 9
- `combine` (3. `Cluster`), 9
- `connect` (5. `Thread`), 29
- `connection`, 30
- `connection$name`, 30
- `context` (2. `SupR`), 3
- `data.table` (4. `DDS` or `DFS`), 21
- `DD` (4. `DDS` or `DFS`), 21
- `DDEnv` (4. `DDS` or `DFS`), 21
- `DDT` (4. `DDS` or `DFS`), 21
- `Details`, 9, 10, 30
- `dfs` (4. `DDS` or `DFS`), 21
- `dnenv` (2. `SupR`), 3
- `environment`, 31
- `Examples`, 10
- `exists`, 32
- `expr`, 31
- `host`, 31
- `http://www.stat.purdue.edu/~chuanhai`, 2
- `integer`, 30, 31
- `interrupt` (5. `Thread`), 29
- `join` (5. `Thread`), 29
- `logical`, 30
- `ls`, 32
- `masterenv` (2. `SupR`), 3
- `messages` (2. `SupR`), 3
- `mv` (4. `DDS` or `DFS`), 21
- `name`, 30
- `nextSubset` (3. `Cluster`), 9
- `nnenv` (2. `SupR`), 3
- `notify` (3. `Cluster`), 9
- `notify` (5. `Thread`), 29
- `persist` (4. `DDS` or `DFS`), 21
- `ping` (2. `SupR`), 3
- `port`, 31
- `recv` (2. `SupR`), 3
- `replicate` (4. `DDS` or `DFS`), 21
- `rm`, 32
- `sdfs` (4. `DDS` or `DFS`), 21
- `send` (2. `SupR`), 3
- `server`, 31
- `state` (5. `Thread`), 29
- `SupR`, 32
- `Supr`, 24
- `supr` (2. `SupR`), 3
- `supr3` (1. `supr3-package`), 1

supr3-package (1. supr3-package), [1](#)
sync (3. Cluster), [9](#)
sync (5. Thread), [29](#)
Sync.eval (5. Thread), [29](#)
Sync.notify (5. Thread), [29](#)
Sync.wait (5. Thread), [29](#)

Taskrunners, [9](#)
taskrunners, [10](#)
Thread, [7](#), [24](#), [30](#)
Thread (5. Thread), [29](#)
thread (5. Thread), [29](#)
Thread.interrupt (5. Thread), [29](#)
Thread.join (5. Thread), [29](#)
Thread.new, [30](#)
Thread.new (5. Thread), [29](#)
Thread.start (5. Thread), [29](#)
Thread.state (5. Thread), [29](#)
ThreadServer (5. Thread), [29](#)

wait (3. Cluster), [9](#)
wait (5. Thread), [29](#)
workerenv (2. SupR), [3](#)