# Distributed Places

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See also §20.4 "Distributed Places" in *The Racket Guide*.

```
(require racket/place/distributed)
```
package: distributed-places-lib

Distributed places support programs whose computation may span physical machines. The design relies on machine *nodes* that perform computation. The programmer configures a new distributed system using a declarative syntax and callbacks. A node begins life with one initial place: the *message router*. After a node has been configured, its message router is activated by calling the `message-router` function. The message router listens on a TCP port for incoming connections from other nodes in the distributed system. Places can be spawned within the node by sending place-spawn request messages to the node's message router.

The distributed places implementation relies on two assumptions:

- The user's `".ssh/config"` and `".ssh/authorized_keys"` files are configured correctly to allow passwordless connection to remote hosts via public key authentication.
- Distributed places does not support the specification of ssh usernames. If a non-default ssh username is required the `".ssh/config"` file should be used to specifiy the username.
- All machines run the same version of Racket. Futures versions of distributed places may use the zo binary data format for serialization.

The following example illustrates a configuration and use of distributed places that starts a new node on the current machine and passes it a `"Hello World"` string:

Example:

```
> (module hello-world-example racket/base
    (require racket/place/distributed
```

```
            racket/place)

    (provide hello-world)

    (define (hello-world)
      (place ch
        (printf "hello-world received: ~a\n" (place-channel-
get ch))
        (place-channel-put ch "Hello World\n")
        (printf "hello-world sent: Hello World\n")))


    (module+ main
      ; 1) spawns a node running at "localhost" and listenting on
port
      ; 6344 for incomming connections.
      ; 2) connects to the node running at localhost:6344 and cre-
ates a
      ; place on that node by calling the hello-world procedure
from
      ; the current module.
      ; 3) returns a remote-node% instance (node) and a
      ; remote-connection% instance (pl) for communicating with
the
      ; new node and place
      (define-values (node pl)
        (spawn-node-supervise-place-at "localhost"
                                       #:listen-port 6344
                                       #:thunk #t
                                       (quote-module-path "..")
                                       'hello-world))

      ; starts a message router which adds three event-
container<%>s to
      ; its list of events to handle: the node and two after-
seconds
      ; event containers . Two seconds after the launch of the
message-router, a
      ; message will be sent to the pl place.  After six seconds,
the
      ; program and all spawned nodes and places will terminate.
      (message-router
        node
        (after-seconds 2
          (*channel-put pl "Hello")
          (printf "message-router received: ~a\n" (*channel-
```

```
get pl)))

        (after-seconds 6
          (exit 0)))))
```

```
(message-router ec ...+) → void?
  ec : (is-a?/c event-container<%>)
```

Waits in an endless loop for one of many events to become ready. The `message-router` procedure constructs a `node%` instance to serve as the message router for the node. The `message-router` procedure then adds all the declared `event-container<%>`s to the `node%` and finally calls the never ending loop `sync-events` method, which handles events for the node.

```
(spawn-node-with-place-at
  hostname
  instance-module-path
  instance-place-function-name
 [#:listen-port port
  #:initial-message initial-message
  #:racket-path racket-path
  #:ssh-bin-path ssh-path
  #:distributed-launch-path launcher-path
  #:restart-on-exit restart-on-exit
  #:named place-name
  #:thunk thunk])
→ (is-a?/c remote-connection%)
 hostname : string?
 instance-module-path : module-path?
 instance-place-function-name : symbol?
 port : port-no? = DEFAULT-ROUTER-PORT
 initial-message : any = #f
 racket-path : string-path? = (racket-path)
 ssh-path : string-path? = (ssh-bin-path)
 launcher-path : string-path?
               = (path->string distributed-launch-path)
 restart-on-exit : any/c = #f
 place-name : (or/c #f symbol?) = #f
 thunk : (or/c #f #t) = #f
```

Spawns a new remote node at *hostname* with one instance place specified by the *instance-module-path* and *instance-place-function-name*.

When *thunk* is `#f`, the place is created as the result of the framework calling `(dynamic-place` *instance-module-path instance-place-function-name*`)`. in the new node.

When *thunk* is #t the *instance-place-function-name* function should use dynamic-place or place to create and return an initial place in the new node.

When the *place-name* symbol is present a named place is created. The *place-name* symbol is used to establish later connections to the named place.

The result is a remote-node% instance, not a remote-connection%. Use get-first-place on the result to obtain a remote-connection%.

The restart-on-exit argument can be #t to instruct the remote-connection% instance to respawn the place on the remote node should it exit or terminate at any time. It can also be a procedure of zero arguments to implement the restart procedure, or it can be an object that support a restart method that takes a place argument.}

```
(spawn-node-supervise-place-at
 hostname
 instance-module-path
 instance-place-function-name
 [#:listen-port port
  #:initial-message initial-message
  #:racket-path racket-path
  #:ssh-bin-path ssh-path
  #:distributed-launch-path launcher-path
  #:restart-on-exit restart-on-exit
  #:named named
  #:thunk thunk])
→ (is-a?/c remote-node%)
  (is-a?/c remote-connection%)
 hostname : string?
 instance-module-path : module-path?
 instance-place-function-name : symbol?
 port : port-no? = DEFAULT-ROUTER-PORT
 initial-message : any = #f
 racket-path : string-path? = (racket-path)
 ssh-path : string-path? = (ssh-bin-path)
 launcher-path : string-path?
               = (path->string distributed-launch-path)
 restart-on-exit : any/c = #f
 named : (or/c #f string?) = #f
 thunk : (or/c #f #t) = #f
```

Like spawn-node-with-dynamic-place-at, but the result is two values: the new remote-node% and its remote-connection% instance.

```
(spawn-remote-racket-node
 hostname
 [#:listen-port port
  #:racket-path racket-path
  #:ssh-bin-path ssh-path
  #:distributed-launch-path launcher-path]
  #:use-current-ports use-current-ports)
→ (is-a?/c remote-node%)
 hostname : string?
 port : port-no? = DEFAULT-ROUTER-PORT
 racket-path : string-path? = (racket-path)
 ssh-path : string-path? = (ssh-bin-path)
 launcher-path : string-path?
               = (path->string distributed-launch-path)
 use-current-ports : #f
```

Spawns a new remote node at *hostname* and returns a `remote-node%` handle.

```
(create-place-node  hostname
                   [#:listen-port port
                    #:racket-path racket-path
                    #:ssh-bin-path ssh-path
                    #:distributed-launch-path launcher-path
                    #:use-current-ports use-current-ports])
→ (is-a?/c remote-node%)
 hostname : string?
 port : port-no? = DEFAULT-ROUTER-PORT
 racket-path : string-path? = (racket-path)
 ssh-path : string-path? = (ssh-bin-path)
 launcher-path : string-path?
               = (path->string distributed-launch-path)
 use-current-ports : boolean? = #t
```

Like `spawn-remote-racket-node`, but the `current-output-port` and `current-error-port` are used as the standard ports for the spawned process instead of new pipe ports.

```
(supervise-place-at  remote-node
                     instance-module-path
                     instance-place-function-name
                    [#:restart-on-exit restart-on-exit
                     #:named named
                     #:thunk thunk])
→ (is-a?/c remote-connection%)
 remote-node : (is-a?/c remote-node%)
 instance-module-path : module-path?
```

```
  instance-place-function-name : symbol?
  restart-on-exit : any/c = #f
  named : (or/c #f symbol?) = #f
  thunk : (or/c #f #t) = #f
```

When *thunk* is #f, creates a new place on *remote-node* by using dynamic-place to invoke *instance-place-function-name* from the module *instance-module-path*.

When *thunk* is #t, creates a new place at *remote-node* by executing the thunk exported as *instance-place-function-name* from the module *instance-module-path*. The function should use dynamic-place or place to create and return a place in the new node.

When the place-name symbol is present a named place is created. The place-name symbol is used to establish later connections to the named place.

```
(supervise-process-at  hostname
                       commandline-argument ...+
                      [#:listen-port port])
 → (is-a?/c remote-process%)
  hostname : string?
  commandline-argument : string?
  port : port-no? = DEFAULT-ROUTER-PORT
```

Spawns an attached external process at host *hostname*.

```
(supervise-thread-at  remote-node
                      instance-module-path
                      instance-thunk-function-name
                     [#:restart-on-exit restart-on-exit])
 → (is-a?/c remote-connection%)
  remote-node : (is-a?/c remote-node%)
  instance-module-path : module-path?
  instance-thunk-function-name : symbol?
  restart-on-exit : any/c = #f
```

Creates a new threadon the *remote-node* by using dynamic-require to invoke instance-place-function-name from the module *instance-module-path*.

```
(restart-every  seconds
                [#:retry retry
                 #:on-final-fail on-final-fail])
 → (is-a/c respawn-and-fire%)
  seconds : (number?)
  retry : (or/c number? #f) = #f
  on-final-fail : (or/c #f (-> any/c)) = #f
```

Returns a restarter% instance that should be supplied to a #:restart-on-exit argument.

```
(every-seconds seconds-expr body ....)
```

Returns a respawn-and-fire% instance that should be supplied to a message-router. The respawn-and-fire% instance executes bodys once every *N* seconds, where *N* is the result of seconds-expr.

```
(after-seconds seconds-expr body ....)
```

Returns a after-seconds% instance that should be supplied to a message-router. The after-seconds% instance executes the bodys after a delay of *N* seconds from the start of the event loop, where *N* is the result of seconds-expr.

```
(connect-to-named-place node name)
 → (is-a?/c remote-connection%)
  node : (is-a?/c remote-node%)
  name : symbol?
```

Connects to a named place on the node named name and returns a remote-connection% object.

```
(log-message severity msg) → void?
  severity : (or/c 'fatal 'error 'warning 'info 'debug)
  msg : string?
```

Logs a message at the root node.

```
event-container<%> : interface?
```

All objects that are supplied to the message-router must implement the event-container<%> interface. The message-router calls the register method on each supplied event-container<%> to obtain a list of events on which the event loop should wait.

```
(send an-event-container register events) → (listof events?)
  events : (listof events?)
```

Returns the list of events inside the event-container<%> that should be waited on by the message-router.

The following classes all implement event-container<%> and can be supplied to a message-router: spawned-process%, place-socket-bridge%, node%, remote-node%, remote-connection%, place% connection%, respawn-and-fire%, and after-seconds%.

```
spawned-process% : class?
  superclass: object%
  extends: event-container<%>
```

```
(send a-spawned-process get-pid) → exact-positive-integer?
```

```
 (new spawned-process%
     [cmdline-list cmdline-list]
    [[parent parent]])
 → (is-a?/c spawned-process%)
  cmdline-list : (listof (or/c string? path?))
  parent : (is-a?/c remote-node%) = #f
```

The *cmdline-list* is a list of command line arguments of type `string` and/or `path`.

The *parent* argument is a `remote-node%` instance that will be notified when the process dies via a `(send parent process-died this)` call.

```
place-socket-bridge% : class?
  superclass: object%
  extends: event-container<%>
```

```
(send a-place-socket-bridge get-sc-id)
 → exact-positive-integer?
```

```
 (new place-socket-bridge%
    [pch pch]
    [sch sch]
    [id id])
 → (is-a?/c place-socket-bridge%)
  pch : place-channel?
  sch : (is-a?/c socket-connection%)
  id : exact-positive-integer?
```

The *pch* argument is a `place-channel`. Messages received on *pch* are forwarded to the socket-connection% *sch* via a `dcgm` message. e.g. `(sconn-write-flush sch (dcgm DCGM-TYPE-INTER-DCHANNEL id id msg))` The *id* is a `exact-positive-integer` that identifies the socket-connection subchannel for this inter-node place connection.

```
socket-connection% : class?
  superclass: object%
  extends: event-container<%>
```

```
(new socket-connection%
   [[host host]
    [port port]
    [retry-times retry-times]
    [delay delay]
    [background-connect? background-connect?]
    [in in]
    [out out]
    [remote-node remote-node]])
→ (is-a?/c socket-connection%)
 host : (or/c string? #f) = #f
 port : (or/c port-no? #f) = #f
 retry-times : exact-nonnegative-integer? = 30
 delay : number? = 1
 background-connect? : any/c = #f
 in : (or/c input-port? #f) = #f
 out : (or/c output-port #f) = #f
 remote-node : (or/c (is-a?/c remote-node%) #f) = #f
```

When a *host* and *port* are supplied a new tcp connection is established. If a input-port? and output-port? are supplied as *in* and *out*, the ports are used as a connection to the remote host. The *retry-times* argument specifies how many times to retry the connection attempt should it fail to connect and defaults to 30 retry attempts. Often a remote node is still booting up when a connection is attempted and the connection needs to be retried several times. The *delay* argument specifies how many seconds to wait between retry attempts. The *background-connect?* argument defaults to #t and specifies that the constructor should retry immediately and that connecion establishment should occur in the background. Finally, the *remote-node* argument specifies the remote-node% instance that should be notified should the connection fail.

```
node% : class?
  superclass: object%
  extends: event-container<%>
```

The node% instance controls a distributed places node. It launches places and routes inter-node place messages in the distributed system. The message-router form constructs a node% instance under the hood. Newly spawned nodes also have a node% instance in their initial place that serves as the node's message router.

```
(new node% [[listen-port listen-port]]) → (is-a?/c node%)
  listen-port : listen-port-number? = #f
```

Constructs a node% that will listen on *listen-port* for inter-node connections.

```
(send a-node sync-events) → void?
```

Starts the never ending event loop for this distributed places node.

```
remote-node% : class?
  superclass: object%
  extends: event-container<%>
```

Like node%, but for the remote API to a distributed places node. Instances of remote-node% are returned by create-place-node, spawn-remote-racket-node, and spawn-node-supervise-place-at.

A remote-node% is a place location in the sense of place-location?, which means that it can be supplied as the #:at argument to dynamic-place.

```
 (new remote-node%
    [[listen-port listen-port]
     [restart-on-exit restart-on-exit]])
 → (is-a?/c remote-node%)
  listen-port : listen-port-number? = #f
  restart-on-exit : any/c = #f
```

Constructs a node% that will listen on *listen-port* for inter-node connections.

When set to true the *restart-on-exit* parameter causes the specified node to be restarted when the ssh session spawning the node dies.

```
(send a-remote-node get-first-place)
 → (is-a?/c remote-connection%)
```

Returns the remote-connection% object instance for the first place spawned on this node.

```
(send a-remote-node get-first-place-channel) → place-
channel?
```

Returns the communication channel for the first place spawned on this node.

```
(send a-remote-node get-log-prefix) → string?
```

Returns `(format "PLACE ~a:~a" host-name listen-port)`

```
(send a-remote-node launch-place
 place-exec
 [#:restart-on-exit restart-on-exit
  #:one-sided-place? one-sided-place?])
→ (is-a?/c remote-connection%)
 place-exec : list?
 restart-on-exit : any/c = #f
 one-sided-place? : any/c = #f
```

Launches a place on the remote node represented by this `remote-node%` instance.

The *place-exec* argument describes how the remote place should be launched, and it should have one of the following shapes:

- `(list 'place place-module-path place-thunk)`
- `(list 'dynamic-place place-module-path place-func)`

The difference between these two launching methods is that the `'place` version of *place-exec* expects a thunk to be exported by the module `place-module-path`. Executing the thunk is expected to create a new place and return a place descriptor to the newly created place. The `'dynamic-place` version of *place-exec* expects place-func to be a function taking a single argument, the initial channel argument, and calls `dynamic-place` on behalf of the user and creates the new place from the `place-module-path` and `place-func`.

The *restart-on-exit* argument is treated in the same way as for `spawn-node-with-dynamic-place-at`.

The *one-sided-place?* argument is an internal use argument for launching remote places from within a place using the old design pattern.

```
(send a-remote-node remote-connect name) → remote-
connection%
  name : string?
```

Connects to a named place on the remote node represented by this `remote-node%` instance.

```
(send a-remote-node send-exit) → void?
```

Sends a message instructing the remote node represented by this `remote-node%` instance to exit immediately

```
(node-send-exit remote-node%) → void?
  remote-node% : node
```

Sends `node` a message telling it to exit immediately.

```
(node-get-first-place remote-node%)
 → (is-a?/c remote-connection%)
  remote-node% : node
```

Returns the `remote-connection%` instance of the first place spawned at this node

```
(distributed-place-wait remote-connection%) → void?
  remote-connection% : place
```

Waits for `place` to terminate.

```
remote-connection% : class?
  superclass: object%
  extends: event-container<%>
```

The `remote-connection%` instance provides a remote api to a place running on a remote distributed places node. It launches a places or connects to a named place and routes inter-node place messages to the remote place.

```
 (new remote-connection%
    [node node]
    [place-exec place-exec]
    [name name]
    [restart-on-exit restart-on-exit]
    [one-sided-place? one-sided-place?]
    [on-channel on-channel])
 → (is-a?/c remote-connection%)
  node : (is-a?/c remote-node%)
  place-exec : list?
  name : string?
  restart-on-exit : #f
  one-sided-place? : #f
  on-channel : #f
```

Constructs a `remote-connection%` instance.

The *place-exec* argument describes how the remote place should be launched in the same way as for `launch-place` in `remote-node%`.

The *restart-on-exit* argument is treated in the same way as for spawn-node-with-dynamic-place-at.

The *one-sided-place?* argument is an internal use argument for launching remote places from within a place using the old design pattern.

See set-on-channel! for description of *on-channel* argument.

```
(send a-remote-connection set-on-channel! callback) → void?
  callback : (-> channel msg void?)
```

Installs a handler function that handles messages from the remote place. The setup/distributed-docs module uses this callback to handle job completion messages.

```
place% : class?
  superclass: object%
  extends: event-container<%>
```

The place% instance represents a place launched on a distributed places node at that node. It launches a compute places and routes inter-node place messages to the place.

```
 (new place%
     [node node]
     [place-exec place-exec]
     [ch-id ch-id]
     [sc sc]
    [[on-place-dead on-place-dead]]) → (is-a?/c place%)
  node : (is-a?/c remote-connection%)
  place-exec : list?
  ch-id : exact-positive-integer?
  sc : (is-a?/c socket-connection%)
  on-place-dead : (-> event void?) = default-on-place-dead
```

Constructs a remote-connection% instance. The *place-exec* argument describes how the remote place should be launched in the same way as for launch-place in remote-node%. The *ch-id* and *sc* arguments are internally used to establish routing between the remote node spawning this place and the place itself. The *on-place-dead* callback handles the event when the newly spawned place terminates.

```
(send a-place wait-for-die) → void?
```

Blocks and waits for the subprocess representing the remote-node% to exit.

```
connection% : class?
  superclass: object%
  extends: event-container<%>
```

The connection% instance represents a connection to a named-place instance running on the current node. It routes inter-node place messages to the named place.

```
(new connection%
   [node node]
   [name name]
   [ch-id ch-id]
   [sc sc])       → (is-a?/c connection%)
 node : (is-a?/c remote-node%)
 name : string?
 ch-id : exact-positive-integer?
 sc : (is-a?/c socket-connection%)
```

Constructs a remote-connection% instance. The place-exec argument describes how the remote place should be launched in the same way as for launch-place in remote-node%. The *ch-id* and *sc* arguments are internally used to establish routing between the remote node and this named-place.

```
respawn-and-fire% : class?
  superclass: object%
  extends: event-container<%>
```

The respawn-and-fire% instance represents a thunk that should execute every n seconds.

```
(new respawn-and-fire%
   [seconds seconds]
   [thunk thunk])
→ (is-a?/c respawn-and-fire%)
 seconds : (and/c real? (not/c negative?))
 thunk : (-> void?)
```

Constructs a respawn-and-fire% instance that when placed inside a message-router construct causes the supplied thunk to execute every n seconds.

```
after-seconds% : class?
```

```
  superclass: object%
  extends: event-container<%>
```

The `after-seconds%` instance represents a thunk that should execute after `n` seconds.

```
(new after-seconds%
   [seconds seconds]
   [thunk thunk])
→ (is-a?/c after-seconds%)
 seconds : (and/c real? (not/c negative?))
 thunk : (-> void?)
```

Constructs an `after-seconds%` instance that when placed inside a `message-router` construct causes the supplied thunk to execute after `n` seconds.

```
restarter% : class?
  superclass: after-seconds%
  extends: event-container<%>
```

The `restarter%` instance represents a restart strategy.

```
(new restarter%
    [seconds seconds]
   [[retry retry]
    [on-final-fail on-final-fail]])
→ (is-a?/c restarter%)
 seconds : number?
 retry : (or/c number? #f) = #f
 on-final-fail : (or/c #f (-> any/c)) = #f
```

Constructs an `restarter%` instance that when supplied to a `#:restart-on-exit` argument, attempts to restart the process every *`seconds`*. The *`retry`* argument specifies how many time to attempt to restart the process before giving up. If the process stays alive for `(* 2 seconds)` the attempted retries count is reset to `0`. The *`on-final-fail`* thunk is called when the number of retries is exceeded

```
distributed-launch-path : path?
```

Contains the local path to the distributed places launcher. The distributed places launcher is the bootsrap file that launches the message router on a new node.

```
(ssh-bin-path) → string?
```

Returns the path to the ssh binary on the local system in string form.

Example:

```
> (ssh-bin-path)
#<path:/usr/bin/ssh>
```

```
(racket-path) → path?
```

Returns the path to the currently executing Racket binary on the local system.

```
(build-distributed-launch-path collects-path) → string?
  collects-path : path-string?
```

Returns the path to the distributed places launch file. The function can take an optional argument specifying the path to the collects directory.

```
(spawn-node-at  hostname
                [#:listen-port port
                 #:racket-path racket-path
                 #:ssh-bin-path ssh-path
                 #:distributed-launch-path launcher-path])
 → channel?
  hostname : string?
  port : port-no? = DEFAULT-ROUTER-PORT
  racket-path : string-path? = (racket-path)
  ssh-path : string-path? = (ssh-bin-path)
  launcher-path :  string-path?
                 = (path->string distributed-launch-path)
```

Spawns a node in the background using a Racket thread and returns a channel that becomes ready with a `remote-node%` once the node has spawned successfully

```
(spawn-nodes/join nodes-descs) → void?
  nodes-descs : list?
```

Spawns a list of nodes by calling `(lambda (x) (apply keyword-apply spawn-node-at x))` for each node description in *nodes-descs* and then waits for each node to spawn.

```
(*channel-put ch msg) → void?
  ch : (or/c place-channel? async-bi-channel?
             channel? (is-a?/c remote-connection%))
  msg : any
```

Sends *msg* over *ch* channel.

```
(*channel-get ch) → any
  ch : (or/c place-channel? async-bi-channel?
             channel? (is-a?/c remote-connection%))
```

Returns a message received on *ch* channel.

```
(*channel? v) → boolean?
  v : any/c
```

Returns #t if *v* is one of place-channel?, async-bi-channel?, channel?, or (is-a?/c remote-connection%).

```
(send-new-place-channel-to-named-dest ch
                                      src-id
                                      dest-list)
 → place-channel?
  ch : *channel?
  src-id : any
  dest-list : (listof string? port-no? string?)
```

Creates and returns a new place channel connection to a named place at *dest-list*. The *dest-list* argument is a list of a remote-hostname remote-port and named-place name. The channel *ch* should be a connection to a message-router.

```
(mr-spawn-remote-node  mrch
                       host
                      [#:listen-port listen-port
                       #:solo solo])              → void?
  mrch : *channel?
  host : string?
  listen-port : port-no? = DEFAULT-ROUTER-PORT
  solo : boolean? = #f
```

Sends a message to a message router over *mrch* channel asking the message router to spawn a new node at *host* listening on port *listen-port*. If the #:solo keyword argument is supplied the new node is not folded into the complete network with other nodes in the distributed system.

```
(mr-supervise-named-dynamic-place-at mrch
                                     dest
                                     name
                                     path
                                     func) → void?
```

```
  mrch : *channel?
  dest : (listof string? port-no?)
  name : string?
  path : string?
  func : symbol?
```

Sends a message to a message router over *mrch* channel asking the message router to spawn a named place at *dest* named *name*. The place is spawned at the remote node by calling dynamic place with module-path *path* and function *func*. The *dest* parameter should be a list of remote-hostname and remote-port.

```
(mr-connect-to mrch dest name) → void?
  mrch : *channel?
  dest : (listof string? port-no?)
  name : string?
```

Sends a message to a message router over *mrch* channel asking the message router to create a new connection to the named place named *name* at *dest*. The *dest* parameter should be a list of remote-hostname and remote-port.

```
(start-message-router/thread [#:listen-port listen-port
                              #:nodes nodes])
 → thread? channel?
  listen-port : port-no? = DEFAULT-ROUTER-PORT
  nodes : list? = null
```

Starts a message router in a Racket thread connected to *nodes*, listening on port *listen-port*, and returns a channel? connection to the message router.

```
(port-no? no) → boolean?
  no : (and/c exact-nonnegative-integer?  (integer-in 0 65535))
```

Returns #t if *no* is a exact-nonnegative-integer? between 0 and 65535.

```
DEFAULT-ROUTER-PORT : port-no?
```

The default port for distributed places message router.

```
named-place-typed-channel% : class?
  superclass: object%
```

```
(new named-place-typed-channel% [ch ch])
```

```
→ (is-a?/c named-place-typed-channel%)
  ch : place-channel?
```

The *ch* argument is a `place-channel`.

```
(send a-named-place-typed-channel get type) → any
  type : symbol?
```

Returns the first message received on `ch` that has the type *type*. Messages are lists and their type is the first item of the list which should be a `symbol?`. Messages of other types that are received are queued for later `get` requests.

```
(tc-get type ch) → void?
  type : symbol?
  ch : place-channel?
```

Gets a message of type *type* from the `named-place-typed-channel%` *ch*.

```
(write-flush datum port) → void?
  datum : any
  port : port?
```

Writes *datum* to *port* and then flushes *port*.

```
(printf/f format args ...) → void?
  format : string?
  args : any
```

Calls `printf` followed by a call to `flush-output`.

```
(displayln/f item) → void?
  item : any
```

Calls `displayln` followed by a call to `flush-output`.

Example:

```
> (write-flush "Hello World" (current-output-port))
"Hello World"
```

# 1 Define Remote Server

```
(require racket/place/define-remote-server)
                package: distributed-places-lib
```

```
(define-remote-server [name identifier?] rpc-forms ...+)
(define-named-remote-server [name identifier?] rpc-forms ...+)
```

The `define-remote-server` and `define-named-remote-server` forms are nearly identical. The `define-remote-server` form should be used with `supervise-dynamic-place-at` to build a private rpc server, while the `define-named-remote-server` form should be used with `supervise-named-dynamic-place-at` to build a rpc server inside a named place.

The `define-named-remote-server` form takes an identifier and a list of custom expressions as its arguments. From the identifier a function is created by prepending the `make-` prefix. This procedure takes a single argument a `place-channel`. In the example below, the `make-tuple-server` identifier is the `place-function-name` given to the `supervise-named-dynamic-place-at` form to spawn an rpc server. The server created by the `make-tuple-server` procedure sits in a loop waiting for rpc requests from the `define-rpc` functions documented below.

```
(define-state id value)
```

Expands to a `define`, which is closed over by the `define-rpc` functions to form local state.

```
(define-rpc (id args ...) body ...)
```

Expands to a client rpc function `name-id` which sends *id* and *args* ... to the rpc server `rpc-place` and waits for a response. `(define (name-id rpc-place args ...) body)`

```
(define-cast (id args ...) body ...)
```

Expands to a client rpc function `name-id` which sends *id* and *args* ... to the rpc server `rpc-place` but does not receive any response. A cast is a one-way communication technique. `(define (name-id rpc-place args ...) body)`

The `define-state` custom form translates into a simple `define` form, which is closed over by the `define-rpc` forms.

The `define-rpc` form is expanded into two parts. The first part is the client stubs that call the rpc functions. The client function name is formed by concatenating the `define-named-remote-server` identifier, `tuple-server`, with the RPC function name `set` to form `tuple-server-set`. The RPC client functions take a destination argument which

is a `remote-connection%` descriptor and then the RPC function arguments. The RPC client function sends the RPC function name, `set`, and the RPC arguments to the destination by calling an internal function `named-place-channel-put`. The RPC client then calls `named-place-channel-get` to wait for the RPC response.

The second expansion part of `define-rpc` is the server implementation of the RPC call. The server is implemented by a match expression inside the `make-tuple-server` function. The match clause for `tuple-server-set` matches on messages beginning with the `'set` symbol. The server executes the RPC call with the communicated arguments and sends the result back to the RPC client.

The `define-cast` form is similar to the `define-rpc` form except there is no reply message from the server to client

Example:

```
> (module tuple-server-example racket/base
    (require racket/match
             racket/place/define-remote-server)

    (define-named-remote-server tuple-server
      (define-state h (make-hash))
      (define-rpc (set k v)
        (hash-set! h k v)
        v)
      (define-rpc (get k)
        (hash-ref h k #f))
      (define-cast (hello)
        (printf "Hello from define-cast\n")
        (flush-output))))
```

Example:

```
> (module bank-server-example racket/base
    (require racket/match
             racket/place/define-remote-server)

    (define-remote-server bank
      (define-state accounts (make-hash))
      (define-rpc (new-account who)
         (match (hash-has-key? accounts who)
           [#t '(already-exists)]
           [else
             (hash-set! accounts who 0)
             (list 'created who)]))
      (define-rpc (remove who amount)
```

```
    (cond
      [(hash-ref accounts who (lambda () #f)) =>
         (lambda (balance)
           (cond [(<= amount balance)
                  (define new-balance (- balance amount))
                  (hash-set! accounts who new-balance)
                  (list 'ok new-balance)]
                 [else
                   (list 'insufficient-funds balance)]))]
      [else
        (list 'invalid-account who)]))
(define-rpc (add who amount)
  (cond
     [(hash-ref accounts who (lambda () #f)) =>
        (lambda (balance)
          (define new-balance (+ balance amount))
          (hash-set! accounts who new-balance)
          (list 'ok new-balance))]
     [else
       (list 'invalid-account who)])))
```

```
(log-to-parent msg [#:severity severity]) → void?
  msg : string?
  severity : symbol? = 'info
```

The log-to-parent procedure can be used inside a `define-remote-server` or `define-named-remote-server` form to send a logging message to the remote owner of the rpc server.

# 2 Async Bidirectional Channels

```
(require racket/place/private/async-bi-channel)
```
package: base

```
(make-async-bi-channel) → async-bi-channel?
```

Creates and returns an opaque structure, which is the async bidirectional channel.

```
(async-bi-channel? ch) → boolean?
  ch : any
```

A predicate that returns `#t` for async bidirectional channels.

```
(async-bi-channel-get ch) → any
  ch : async-bi-channel?
```

Returns the next available message from the async bidirectional channel *ch*.

```
(async-bi-channel-put ch msg) → void?
  ch : async-bi-channel?
  msg : any
```

Sends message *msg* to the remote end of the async bidirectional channel *ch*.

# 3 Distributed Places MPI

```
(require racket/place/distributed/rmpi)
            package: distributed-places-lib
```

```
(struct rmpi-comm (id cnt channels))
  id : exact-nonnegative-integer?
  cnt : exact-positive-integer?
  channels : vector?
```

The communicator struct rmpi-comm contains the rmpi process rank id, the quantity of processes in the communicator group, cnt, and a vector of place-channels, one for each process in the group.

```
(rmpi-id comm) → exact-nonnegative-integer?
  comm : rmpi-comm?
```

Takes a rmpi communicator structure, *comm*, and returns the node id of the RMPI process.

```
(rmpi-cnt comm) → exact-positive-integer?
  comm : rmpi-comm?
```

Takes a rmpi communicator structure, *comm*, and returns the count of the RMPI processes in the communicator group.

```
(rmpi-send comm dest val) → void?
  comm : rmpi-comm?
  dest : exact-nonnegative-integer?
  val : any
```

Sends *val* to destination rmpi process number *dest* using the RMPI communicator structure *comm*.

```
(rmpi-recv comm src) → any
  comm : rmpi-comm?
  src : exact-nonnegative-integer?
```

Receives a message from source rmpi process number *src* using the RMPI communicator structure *comm*.

```
(rmpi-init ch) → rmpi-comm?
                 (listof any)
                 (is-a?/c named-place-typed-channel%)
  ch : place-channel?
```

Creates the rmpi-comm structure instance using the named place's original place-channel *ch*. In addition to the communicator structure, rmpi-init returns a list of initial arguments and the original place-channel *ch* wrapped in a named-place-typed-channel%. The named-place-typed-channel% wrapper allows for the reception of list messages typed by an initial symbol.

```
(rmpi-broadcast comm src) → any
  comm : rmpi-comm?
  src : exact-nonnegative-integer?
(rmpi-broadcast comm src val) → any
  comm : rmpi-comm?
  src : exact-nonnegative-integer?
  val : any
```

Broadcasts *val* from *src* to all rmpi processes in the communication group using a hypercube algorithm. Receiving processes call (rmpi-broadcast *comm src*).

```
(rmpi-reduce comm dest op val) → any
  comm : rmpi-comm?
  dest : exact-nonnegative-integer?
  op : procedure?
  val : any
```

Reduces *val* using the *op* operator to *dest* rmpi node using a hypercube algorithm.

```
(rmpi-barrier comm) → void?
  comm : rmpi-comm?
```

Introduces a synchronization barrier for all rmpi processes in the communcication group *comm*.

```
(rmpi-allreduce comm op val) → any
  comm : rmpi-comm?
  op : procedure?
  val : any
```

Reduces *val* using the *op* operator to rmpi node 0 and then broadcasts the reduced value to all nodes in the communication group.

```
(rmpi-partition comm num) → exact-nonnegative-integer?
                            exact-nonnegative-integer?
  comm : rmpi-comm?
  num : exact-nonnegative-integer?
```

Partitions *num* into rmpi-cnt equal pieces and returns the offset and length for the rmpi-idth piece.

```
(rmpi-build-default-config
 #:racket-path racket-path
 #:distributed-launch-path distributed-launch-path
 #:mpi-module mpi-module
 #:mpi-func mpi-func
 #:mpi-args mpi-args)
→ hash?
 racket-path : string?
 distributed-launch-path : string?
 mpi-module : string?
 mpi-func : symbol?
 mpi-args : (listof any)
```

Builds a hash from keywords to keyword arguments for use with the `rmpi-launch function`.

```
(rmpi-launch default-node-config config) → void?
  default-node-config : hash?
  config : (listof (list/c string? port-no? symbol?
                           exact-nonnegative-integer?))
```

Launches distributed places nodes running `#:mpi-func` in `#:mpi-module` with `#:mpi-args`. The config is a list of node configs, where each node config consists of a hostname, port, named place symbol and rmpi id number, followed by and optional hash of keyword `#:racket-path`, `#:distributed-launch-path`, `#:mpi-module`, `#:mpi-func`, and `#:mpi-args` to keyword arguments. Missing optional keyword arguments will be taken from the *default-node-config* hash of keyword arguments.

```
(rmpi-finish comm tc) → void?
  comm : rmpi-comm?
  tc : (is-a?/c named-place-typed-channel%)
```

Rendezvous with the `rmpi-launch`, using the *tc* returned by `rmpi-launch`, to indicate that the RMPI module is done executing and that `rmpi-launch` can return control to its caller.

Example:

```
> (rmpi-launch
      (rmpi-build-default-config
        #:racket-path "/tmp/mplt/bin/racket"
        #:distributed-launch-path (build-distributed-launch-path
                                   "/tmp/mplt/collects")
        #:mpi-module "/tmp/mplt/kmeans.rkt"
        #:mpi-func   'kmeans-place
```

```
  #:mpi-args    (list "/tmp/mplt/color100.bin" #t 100
                      9 10 1e-7))

(list (list "nodea.example.com" 6340 'kmeans_0 0)
      (list "nodeb.example.com" 6340 'kmeans_1 1)
      (list "nodec.example.com" 6340 'kmeans_2 2)
      (list "noded.example.com" 6340 'kmeans_3 3)))
```