

# **Kernel Application (KERNEL)**

version 2.12

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# Kernel Reference Manual

## Short Summaries

- Application **kernel** [page 32] – The Kernel Application
- Erlang Module **application** [page 36] – Generic OTP application functions
- Erlang Module **auth** [page 45] – Erlang Network Authentication Server
- Erlang Module **code** [page 47] – Erlang Code Server
- Erlang Module **disk\_log** [page 56] – A disk based term logging facility
- Erlang Module **erl\_boot\_server** [page 70] – Boot Server for Other Erlang Machines
- Erlang Module **erl\_ddll** [page 72] – Dynamic Driver Loader and Linker
- Erlang Module **erl\_prim\_loader** [page 87] – Low Level Erlang Loader
- Erlang Module **erlang** [page 90] – The Erlang BIFs
- Erlang Module **error\_handler** [page 167] – Default System Error Handler
- Erlang Module **error\_logger** [page 169] – Erlang Error Logger
- Erlang Module **file** [page 176] – File Interface Module
- Erlang Module **gen\_sctp** [page 199] – The `gen_sctp` module provides functions for communicating with sockets using the SCTP protocol.
- Erlang Module **gen\_tcp** [page 213] – Interface to TCP/IP sockets
- Erlang Module **gen\_udp** [page 220] – Interface to UDP sockets
- Erlang Module **global** [page 223] – A Global Name Registration Facility
- Erlang Module **global\_group** [page 228] – Grouping Nodes to Global Name Registration Groups
- Erlang Module **heart** [page 232] – Heartbeat Monitoring of an Erlang Runtime System
- Erlang Module **inet** [page 234] – Access to TCP/IP Protocols
- Erlang Module **init** [page 246] – Coordination of System Startup
- Erlang Module **net\_adm** [page 251] – Various Erlang Net Administration Routines
- Erlang Module **net\_kernel** [page 254] – Erlang Networking Kernel
- Erlang Module **os** [page 258] – Operating System Specific Functions
- Erlang Module **packages** [page 261] – Packages in Erlang
- Erlang Module **pg2** [page 264] – Distributed Named Process Groups
- Erlang Module **rpc** [page 267] – Remote Procedure Call Services
- Erlang Module **seq\_trace** [page 274] – Sequential Tracing of Messages

- Erlang Module **user** [page 282] – Standard I/O Server
- Erlang Module **wrap\_log\_reader** [page 283] – A function to read internally formatted wrap disk logs
- Erlang Module **zlib** [page 285] – Zlib Compression interface.
- File **app** [page 294] – Application resource file.
- File **config** [page 297] – Configuration file.

## kernel

No functions are exported.

## application

The following functions are exported:

- `get_all_env()` -> `Env`  
[page 36] Get the configuration parameters for an application
- `get_all_env(Application)` -> `Env`  
[page 36] Get the configuration parameters for an application
- `get_all_key()` -> `{ok, Keys} | []`  
[page 36] Get the application specification keys
- `get_all_key(Application)` -> `{ok, Keys} | undefined`  
[page 36] Get the application specification keys
- `get_application()` -> `{ok, Application} | undefined`  
[page 37] Get the name of an application containing a certain process or module
- `get_application(Pid | Module)` -> `{ok, Application} | undefined`  
[page 37] Get the name of an application containing a certain process or module
- `get_env(Par)` -> `{ok, Val} | undefined`  
[page 37] Get the value of a configuration parameter
- `get_env(Application, Par)` -> `{ok, Val} | undefined`  
[page 37] Get the value of a configuration parameter
- `get_key(Key)` -> `{ok, Val} | undefined`  
[page 37] Get the value of an application specification key
- `get_key(Application, Key)` -> `{ok, Val} | undefined`  
[page 37] Get the value of an application specification key
- `load(AppDescr)` -> `ok | {error, Reason}`  
[page 37] Load an application
- `load(AppDescr, Distributed)` -> `ok | {error, Reason}`  
[page 37] Load an application
- `loaded_applications()` -> `[{Application, Description, Vsn}]`  
[page 38] Get the currently loaded applications
- `permit(Application, Bool)` -> `ok | {error, Reason}`  
[page 38] Change an application's permission to run on a node.
- `set_env(Application, Par, Val)` -> `ok`  
[page 39] Set the value of a configuration parameter

- `set_env(Application, Par, Val, Timeout) -> ok`  
[page 39] Set the value of a configuration parameter
- `start(Application) -> ok | {error, Reason}`  
[page 39] Load and start an application
- `start(Application, Type) -> ok | {error, Reason}`  
[page 39] Load and start an application
- `start_type() -> StartType | local | undefined`  
[page 40] Get the start type of an ongoing application startup.
- `stop(Application) -> ok | {error, Reason}`  
[page 40] Stop an application
- `takeover(Application, Type) -> ok | {error, Reason}`  
[page 41] Take over a distributed application
- `unload(Application) -> ok | {error, Reason}`  
[page 41] Unload an application
- `unset_env(Application, Par) -> ok`  
[page 41] Unset the value of a configuration parameter
- `unset_env(Application, Par, Timeout) -> ok`  
[page 41] Unset the value of a configuration parameter
- `which_applications() -> [{Application, Description, Vsn}]`  
[page 42] Get the currently running applications
- `which_applications(Timeout) -> [{Application, Description, Vsn}]`  
[page 42] Get the currently running applications
- `Module:start(StartType, StartArgs) -> {ok, Pid} | {ok, Pid, State} | {error, Reason}`  
[page 42] Start an application
- `Module:start_phase(Phase, StartType, PhaseArgs) -> ok | {error, Reason}`  
[page 43] Extended start of an application
- `Module:prep_stop(State) -> NewState`  
[page 43] Prepare an application for termination
- `Module:stop(State)`  
[page 44] Clean up after termination of an application
- `Module:config_change(Changed, New, Removed) -> ok`  
[page 44] Update the configuration parameters for an application.

## auth

The following functions are exported:

- `is_auth(Node) -> yes | no`  
[page 45] Status of communication authorization (deprecated)
- `cookie() -> Cookie`  
[page 45] Magic cookie for local node (deprecated)
- `cookie(TheCookie) -> true`  
[page 45] Set the magic for the local node (deprecated)
- `node_cookie([Node, Cookie]) -> yes | no`  
[page 45] Set the magic cookie for a node and verify authorization (deprecated)
- `node_cookie(Node, Cookie) -> yes | no`  
[page 45] Set the magic cookie for a node and verify authorization (deprecated)

## code

The following functions are exported:

- `set_path(Path) -> true | {error, What}`  
[page 49] Set the code server search path
- `get_path() -> Path`  
[page 49] Return the code server search path
- `add_path(Dir) -> true | {error, What}`  
[page 49] Add a directory to the end of the code path
- `add_pathz(Dir) -> true | {error, What}`  
[page 49] Add a directory to the end of the code path
- `add_patha(Dir) -> true | {error, What}`  
[page 49] Add a directory to the beginning of the code path
- `add_paths(Dirs) -> ok`  
[page 50] Add directories to the end of the code path
- `add_pathsz(Dirs) -> ok`  
[page 50] Add directories to the end of the code path
- `add_pathsa(Dirs) -> ok`  
[page 50] Add directories to the beginning of the code path
- `del_path(Name | Dir) -> true | false | {error, What}`  
[page 50] Delete a directory from the code path
- `replace_path(Name, Dir) -> true | {error, What}`  
[page 50] Replace a directory with another in the code path
- `load_file(Module) -> {module, Module} | {error, What}`  
[page 51] Load a module
- `load_abs(Filename) -> {module, Module} | {error, What}`  
[page 51] Load a module, residing in a given file
- `ensure_loaded(Module) -> {module, Module} | {error, What}`  
[page 51] Ensure that a module is loaded
- `load_binary(Module, Filename, Binary) -> {module, Module} | {error, What}`  
[page 51] Load object code for a module
- `delete(Module) -> true | false`  
[page 52] Removes current code for a module
- `purge(Module) -> true | false`  
[page 52] Removes old code for a module
- `soft_purge(Module) -> true | false`  
[page 52] Removes old code for a module, unless no process uses it
- `is_loaded(Module) -> {file, Loaded} | false`  
[page 52] Check if a module is loaded
- `all_loaded() -> [{Module, Loaded}]`  
[page 53] Get all loaded modules
- `which(Module) -> Which`  
[page 53] The object code file of a module
- `get_object_code(Module) -> {Module, Binary, Filename} | error`  
[page 53] Get the object code for a module



- `root_dir() -> string()`  
[page 53] Root directory of Erlang/OTP
- `lib_dir() -> string()`  
[page 53] Library directory of Erlang/OTP
- `lib_dir(Name) -> string() | {error, bad_name}`  
[page 54] Library directory for an application
- `compiler_dir() -> string()`  
[page 54] Library directory for the compiler
- `priv_dir(Name) -> string() | {error, bad_name}`  
[page 54] Priv directory for an application
- `objfile_extension() -> ".beam"`  
[page 54] Object code file extension
- `stick_dir(Dir) -> ok | error`  
[page 55] Mark a directory as sticky
- `unstick_dir(Dir) -> ok | error`  
[page 55] Remove a sticky directory mark
- `rehash() -> ok`  
[page 55] Rehash or create code path cache
- `where_is_file(Filename) -> Absname | non_existing`  
[page 55] Full name of a file located in the code path
- `clash() -> ok`  
[page 55] Search for modules with identical names.

## disk\_log

The following functions are exported:

- `accessible_logs() -> {[LocalLog], [DistributedLog]}`  
[page 58] Return the accessible disk logs on the current node.
- `alog(Log, Term)`  
[page 58] Asynchronously log an item onto a disk log.
- `balog(Log, Bytes) -> ok | {error, Reason}`  
[page 58] Asynchronously log an item onto a disk log.
- `alog_terms(Log, TermList)`  
[page 58] Asynchronously log several items onto a disk log.
- `balog_terms(Log, BytesList) -> ok | {error, Reason}`  
[page 58] Asynchronously log several items onto a disk log.
- `block(Log)`  
[page 59] Block a disk log.
- `block(Log, QueueLogRecords) -> ok | {error, Reason}`  
[page 59] Block a disk log.
- `change_header(Log, Header) -> ok | {error, Reason}`  
[page 59] Change the head or head\_func option for an owner of a disk log.
- `change_notify(Log, Owner, Notify) -> ok | {error, Reason}`  
[page 59] Change the notify option for an owner of a disk log.
- `change_size(Log, Size) -> ok | {error, Reason}`  
[page 60] Change the size of an open disk log.

- `chunk(Log, Continuation)`  
[page 60] Read a chunk of items written to a disk log.
- `chunk(Log, Continuation, N) -> {Continuation2, Terms} | {Continuation2, Terms, Badbytes} | eof | {error, Reason}`  
[page 60] Read a chunk of items written to a disk log.
- `bchunk(Log, Continuation)`  
[page 60] Read a chunk of items written to a disk log.
- `bchunk(Log, Continuation, N) -> {Continuation2, Binaries} | {Continuation2, Binaries, Badbytes} | eof | {error, Reason}`  
[page 60] Read a chunk of items written to a disk log.
- `chunk_info(Continuation) -> InfoList | {error, Reason}`  
[page 61] Return information about a chunk continuation of a disk log.
- `chunk_step(Log, Continuation, Step) -> {ok, Continuation2} | {error, Reason}`  
[page 61] Step forward or backward among the wrap log files of a disk log.
- `close(Log) -> ok | {error, Reason}`  
[page 62] Close a disk log.
- `format_error(Error) -> Chars`  
[page 62] Return an English description of a disk log error reply.
- `inc_wrap_file(Log) -> ok | {error, Reason}`  
[page 62] Change to the next wrap log file of a disk log.
- `info(Log) -> InfoList | {error, no_such_log}`  
[page 62] Return information about a disk log.
- `lclose(Log)`  
[page 64] Close a disk log on one node.
- `lclose(Log, Node) -> ok | {error, Reason}`  
[page 64] Close a disk log on one node.
- `log(Log, Term)`  
[page 64] Log an item onto a disk log.
- `blog(Log, Bytes) -> ok | {error, Reason}`  
[page 64] Log an item onto a disk log.
- `log_terms(Log, TermList)`  
[page 64] Log several items onto a disk log.
- `blog_terms(Log, BytesList) -> ok | {error, Reason}`  
[page 65] Log several items onto a disk log.
- `open(ArgL) -> OpenRet | DistOpenRet`  
[page 65] Open a disk log file.
- `pid2name(Pid) -> {ok, Log} | undefined`  
[page 68] Return the name of the disk log handled by a pid.
- `reopen(Log, File)`  
[page 68] Reopen a disk log and save the old log.
- `reopen(Log, File, Head)`  
[page 68] Reopen a disk log and save the old log.
- `breopen(Log, File, BHead) -> ok | {error, Reason}`  
[page 68] Reopen a disk log and save the old log.
- `sync(Log) -> ok | {error, Reason}`  
[page 69] Flush the contents of a disk log to the disk.

- `truncate(Log)`  
[page 69] Truncate a disk log.
- `truncate(Log, Head)`  
[page 69] Truncate a disk log.
- `btruncate(Log, BHead) -> ok | {error, Reason}`  
[page 69] Truncate a disk log.
- `unblock(Log) -> ok | {error, Reason}`  
[page 69] Unblock a disk log.

## erl\_boot\_server

The following functions are exported:

- `start(Slaves) -> {ok, Pid} | {error, What}`  
[page 70] Start the boot server
- `start_link(Slaves) -> {ok, Pid} | {error, What}`  
[page 70] Start the boot server and links the caller
- `add_slave(Slave) -> ok | {error, What}`  
[page 70] Add a slave to the list of allowed slaves
- `delete_slave(Slave) -> ok | {error, What}`  
[page 70] Delete a slave from the list of allowed slaves
- `which_slaves() -> Slaves`  
[page 71] Return the current list of allowed slave hosts

## erl\_ddll

The following functions are exported:

- `demonitor(MonitorRef) -> ok`  
[page 74] Remove a monitor for a driver
- `info() -> AllInfoList`  
[page 74] Retrieve information about all drivers
- `info(Name) -> InfoList`  
[page 74] Retrieve information about one driver
- `info(Name, Tag) -> Value`  
[page 75] Retrieve specific information about one driver
- `load(Path, Name) -> ok | {error, ErrorDesc}`  
[page 75] Load a driver
- `load_driver(Path, Name) -> ok | {error, ErrorDesc}`  
[page 76] Load a driver
- `monitor(Tag, Item) -> MonitorRef`  
[page 77] Create a monitor for a driver
- `reload(Path, Name) -> ok | {error, ErrorDesc}`  
[page 78] Replace a driver
- `reload_driver(Path, Name) -> ok | {error, ErrorDesc}`  
[page 79] Replace a driver

- `try_load(Path, Name, OptionList) -> {ok,Status} | {ok, PendingStatus, Ref} | {error, ErrorDesc}`  
[page 80] Load a driver
- `try_unload(Name, OptionList) -> {ok,Status} | {ok, PendingStatus, Ref} | {error, ErrorAtom}`  
[page 83] Unload a driver
- `unload(Name) -> ok | {error, ErrorDesc}`  
[page 85] Unload a driver
- `unload_driver(Name) -> ok | {error, ErrorDesc}`  
[page 85] Unload a driver
- `loaded_drivers() -> {ok, Drivers}`  
[page 86] List loaded drivers
- `format_error(ErrorDesc) -> string()`  
[page 86] Format an error descriptor

## erl\_prim\_loader

The following functions are exported:

- `start(Id, Loader, Hosts) -> {ok, Pid} | {error, What}`  
[page 87] Start the Erlang low level loader
- `get_file(File) -> {ok, Bin, FullName} | error`  
[page 87] Get a file
- `get_path() -> {ok, Path}`  
[page 88] Get the path set in the loader
- `set_path(Path) -> ok`  
[page 88] Set the path of the loader

## erlang

The following functions are exported:

- `abs(Number) -> int() | float()`  
[page 90] Arithmetical absolute value
- `adler32(Data) -> int()`  
[page 90] Compute adler32 checksum
- `adler32(OldAdler, Data) -> int()`  
[page 91] Compute adler32 checksum
- `adler32_combine(FirstAdler, SecondAdler, SecondSize) -> int()`  
[page 91] Combine two adler32 checksums
- `erlang:append_element(Tuple1, Term) -> Tuple2`  
[page 91] Append an extra element to a tuple
- `apply(Fun, Args) -> term() | empty()`  
[page 91] Apply a function to an argument list
- `apply(Module, Function, Args) -> term() | empty()`  
[page 92] Apply a function to an argument list
- `atom_to_list(Atom) -> string()`  
[page 92] Text representation of an atom

- `binary_to_list(Binary) -> [char()]`  
[page 92] Convert a binary to a list
- `binary_to_list(Binary, Start, Stop) -> [char()]`  
[page 93] Convert part of a binary to a list
- `bitstring_to_list(Bitstring) -> [char()|bitstring()]`  
[page 93] Convert a bitstring to a list
- `binary_to_term(Binary) -> term()`  
[page 93] Decode an Erlang external term format binary
- `bit_size(Bitstring) -> int()`  
[page 93] Return the size of a bitstring
- `erlang:bump_reductions(Reductions) -> void()`  
[page 93] Increment the reduction counter
- `byte_size(Bitstring) -> int()`  
[page 94] Return the size of a bitstring (or binary)
- `erlang:cancel_timer(TimerRef) -> Time | false`  
[page 94] Cancel a timer
- `check_process_code(Pid, Module) -> bool()`  
[page 94] Check if a process is executing old code for a module
- `concat_binary(ListOfBinaries)`  
[page 95] Concatenate a list of binaries (deprecated)
- `crc32(Data) -> int()`  
[page 95] Compute crc32 (IEEE 802.3) checksum
- `crc32(OldCrc, Data) -> int()`  
[page 95] Compute crc32 (IEEE 802.3) checksum
- `crc32_combine(FirstCrc, SecondCrc, SecondSize) -> int()`  
[page 95] Combine two crc32 (IEEE 802.3) checksums
- `date() -> {Year, Month, Day}`  
[page 95] Current date
- `decode_packet(Type,Bin,Options) -> {ok,Packet,Rest} | {more,Length}  
| {error,Reason}`  
[page 96] Extracts a protocol packet from a binary
- `delete_module(Module) -> true | undefined`  
[page 97] Make the current code for a module old
- `erlang:demonitor(MonitorRef) -> true`  
[page 98] Stop monitoring
- `erlang:demonitor(MonitorRef, OptionList) -> true`  
[page 98] Stop monitoring
- `disconnect_node(Node) -> bool() | ignored`  
[page 99] Force the disconnection of a node
- `erlang:display(Term) -> true`  
[page 99] Print a term on standard output
- `element(N, Tuple) -> term()`  
[page 99] Get Nth element of a tuple
- `erase() -> [{Key, Val}]`  
[page 100] Return and delete the process dictionary
- `erase(Key) -> Val | undefined`  
[page 100] Return and delete a value from the process dictionary

- `erlang:error(Reason)`  
[page 100] Stop execution with a given reason
- `erlang:error(Reason, Args)`  
[page 100] Stop execution with a given reason
- `exit(Reason)`  
[page 101] Stop execution with a given reason
- `exit(Pid, Reason) -> true`  
[page 101] Send an exit signal to a process
- `erlang:fault(Reason)`  
[page 101] Stop execution with a given reason
- `erlang:fault(Reason, Args)`  
[page 101] Stop execution with a given reason
- `float(Number) -> float()`  
[page 102] Convert a number to a float
- `float_to_list(Float) -> string()`  
[page 102] Text representation of a float
- `erlang:fun_info(Fun) -> [{Item, Info}]`  
[page 102] Information about a fun
- `erlang:fun_info(Fun, Item) -> {Item, Info}`  
[page 103] Information about a fun
- `erlang:fun_to_list(Fun) -> string()`  
[page 103] Text representation of a fun
- `erlang:function_exported(Module, Function, Arity) -> bool()`  
[page 104] Check if a function is exported and loaded
- `garbage_collect() -> true`  
[page 104] Force an immediate garbage collection of the calling process
- `garbage_collect(Pid) -> bool()`  
[page 104] Force an immediate garbage collection of a process
- `get() -> [{Key, Val}]`  
[page 104] Return the process dictionary
- `get(Key) -> Val | undefined`  
[page 104] Return a value from the process dictionary
- `erlang:get_cookie() -> Cookie | nocookie`  
[page 105] Get the magic cookie of the local node
- `get_keys(Val) -> [Key]`  
[page 105] Return a list of keys from the process dictionary
- `erlang:get_stacktrace() -> [{Module, Function, Arity | Args}]`  
[page 105] Get the call stack back-trace of the last exception
- `group_leader() -> GroupLeader`  
[page 105] Get the group leader for the calling process
- `group_leader(GroupLeader, Pid) -> true`  
[page 105] Set the group leader for a process
- `halt()`  
[page 106] Halt the Erlang runtime system and indicate normal exit to the calling environment
- `halt(Status)`  
[page 106] Halt the Erlang runtime system

- `erlang:hash(Term, Range) -> Hash`  
[page 106] Hash function (deprecated)
- `hd(List) -> term()`  
[page 106] Head of a list
- `erlang:hibernate(Module, Function, Args)`  
[page 107] Hibernate a process until a message is sent to it
- `integer_to_list(Integer) -> string()`  
[page 107] Text representation of an integer
- `erlang:integer_to_list(Integer, Base) -> string()`  
[page 107] Text representation of an integer
- `iolist_to_binary(IoListOrBinary) -> binary()`  
[page 107] Convert an iolist to a binary
- `iolist_size(Item) -> int()`  
[page 108] Size of an iolist
- `is_alive() -> bool()`  
[page 108] Check whether the local node is alive
- `is_atom(Term) -> bool()`  
[page 108] Check whether a term is an atom
- `is_binary(Term) -> bool()`  
[page 108] Check whether a term is a binary
- `is_bitstring(Term) -> bool()`  
[page 108] Check whether a term is a bitstring
- `is_boolean(Term) -> bool()`  
[page 108] Check whether a term is a boolean
- `erlang:is_builtin(Module, Function, Arity) -> bool()`  
[page 109] Check if a function is a BIF implemented in C
- `is_float(Term) -> bool()`  
[page 109] Check whether a term is a float
- `is_function(Term) -> bool()`  
[page 109] Check whether a term is a fun
- `is_function(Term, Arity) -> bool()`  
[page 109] Check whether a term is a fun with a given arity
- `is_integer(Term) -> bool()`  
[page 109] Check whether a term is an integer
- `is_list(Term) -> bool()`  
[page 110] Check whether a term is a list
- `is_number(Term) -> bool()`  
[page 110] Check whether a term is a number
- `is_pid(Term) -> bool()`  
[page 110] Check whether a term is a pid
- `is_port(Term) -> bool()`  
[page 110] Check whether a term is a port
- `is_process_alive(Pid) -> bool()`  
[page 110] Check whether a process is alive
- `is_record(Term, RecordTag) -> bool()`  
[page 110] Check whether a term appears to be a record

- `is_record(Term, RecordTag, Size) -> bool()`  
[page 111] Check whether a term appears to be a record
- `is_reference(Term) -> bool()`  
[page 111] Check whether a term is a reference
- `is_tuple(Term) -> bool()`  
[page 111] Check whether a term is a tuple
- `length(List) -> int()`  
[page 111] Length of a list
- `link(Pid) -> true`  
[page 112] Create a link to another process (or port)
- `list_to_atom(String) -> atom()`  
[page 112] Convert from text representation to an atom
- `list_to_binary( IoList) -> binary()`  
[page 112] Convert a list to a binary
- `list_to_bitstring(BitstringList) -> bitstring()`  
[page 112] Convert a list to a bitstring
- `list_to_existing_atom(String) -> atom()`  
[page 113] Convert from text representation to an atom
- `list_to_float(String) -> float()`  
[page 113] Convert from text representation to a float
- `list_to_integer(String) -> int()`  
[page 113] Convert from text representation to an integer
- `erlang:list_to_integer(String, Base) -> int()`  
[page 113] Convert from text representation to an integer
- `list_to_pid(String) -> pid()`  
[page 113] Convert from text representation to a pid
- `list_to_tuple(List) -> tuple()`  
[page 114] Convert a list to a tuple
- `load_module(Module, Binary) -> {module, Module} | {error, Reason}`  
[page 114] Load object code for a module
- `erlang:loaded() -> [Module]`  
[page 114] List of all loaded modules
- `erlang:localtime() -> {Date, Time}`  
[page 115] Current local date and time
- `erlang:localtime_to_universaltime({Date1, Time1}) -> {Date2, Time2}`  
[page 115] Convert from local to Universal Time Coordinated (UTC) date and time
- `erlang:localtime_to_universaltime({Date1, Time1}, IsDst) -> {Date2, Time2}`  
[page 115] Convert from local to Universal Time Coordinated (UTC) date and time
- `make_ref() -> ref()`  
[page 116] Return an almost unique reference
- `erlang:make_tuple(Arity, InitialValue) -> tuple()`  
[page 116] Create a new tuple of a given arity
- `erlang:md5(Data) -> Digest`  
[page 116] Compute an MD5 message digest



- `erlang:md5_final(Context) -> Digest`  
[page 116] Finish the update of an MD5 context and return the computed MD5 message digest
- `erlang:md5_init() -> Context`  
[page 116] Create an MD5 context
- `erlang:md5_update(Context, Data) -> NewContext`  
[page 117] Update an MD5 context with data, and return a new context
- `erlang:memory() -> [{Type, Size}]`  
[page 117] Information about dynamically allocated memory
- `erlang:memory(Type | [Type]) -> Size | [{Type, Size}]`  
[page 118] Information about dynamically allocated memory
- `module_loaded(Module) -> bool()`  
[page 119] Check if a module is loaded
- `erlang:monitor(Type, Item) -> MonitorRef`  
[page 119] Start monitoring
- `monitor_node(Node, Flag) -> true`  
[page 121] Monitor the status of a node
- `erlang:monitor_node(Node, Flag, Options) -> true`  
[page 121] Monitor the status of a node
- `node() -> Node`  
[page 122] Name of the local node
- `node(Arg) -> Node`  
[page 122] At which node is a pid, port or reference located
- `nodes() -> Nodes`  
[page 122] All visible nodes in the system
- `nodes(Arg | [Arg]) -> Nodes`  
[page 122] All nodes of a certain type in the system
- `now() -> {MegaSecs, Secs, MicroSecs}`  
[page 122] Elapsed time since 00:00 GMT
- `open_port(PortName, PortSettings) -> port()`  
[page 123] Open a port
- `erlang:phash(Term, Range) -> Hash`  
[page 125] Portable hash function
- `erlang:phash2(Term [, Range]) -> Hash`  
[page 125] Portable hash function
- `pid_to_list(Pid) -> string()`  
[page 125] Text representation of a pid
- `port_close(Port) -> true`  
[page 126] Close an open port
- `port_command(Port, Data) -> true`  
[page 126] Send data to a port
- `port_connect(Port, Pid) -> true`  
[page 126] Set the owner of a port
- `port_control(Port, Operation, Data) -> Res`  
[page 127] Perform a synchronous control operation on a port
- `erlang:port_call(Port, Operation, Data) -> term()`  
[page 127] Synchronous call to a port with term data

- `erlang:port_info(Port) -> [{Item, Info}] | undefined`  
[page 128] Information about a port
- `erlang:port_info(Port, Item) -> {Item, Info} | undefined | []`  
[page 128] Information about a port
- `erlang:port_to_list(Port) -> string()`  
[page 128] Text representation of a port identifier
- `erlang:ports() -> [port()]`  
[page 129] All open ports
- `pre_loaded() -> [Module]`  
[page 129] List of all pre-loaded modules
- `erlang:process_display(Pid, Type) -> void()`  
[page 129] Write information about a local process on standard error
- `process_flag(Flag, Value) -> OldValue`  
[page 129] Set process flags for the calling process
- `process_flag(Pid, Flag, Value) -> OldValue`  
[page 131] Set process flags for a process
- `process_info(Pid) -> InfoResult`  
[page 131] Information about a process
- `process_info(Pid, ItemSpec) -> InfoResult`  
[page 132] Information about a process
- `processes() -> [pid()]`  
[page 134] All processes
- `purge_module(Module) -> void()`  
[page 134] Remove old code for a module
- `put(Key, Val) -> OldVal | undefined`  
[page 135] Add a new value to the process dictionary
- `erlang:raise(Class, Reason, Stacktrace)`  
[page 135] Stop execution with an exception of given class, reason and call stack  
backtrace
- `erlang:read_timer(TimerRef) -> int() | false`  
[page 136] Number of milliseconds remaining for a timer
- `erlang:ref_to_list(Ref) -> string()`  
[page 136] Text representation of a reference
- `register(RegName, Pid | Port) -> true`  
[page 136] Register a name for a pid (or port)
- `registered() -> [RegName]`  
[page 136] All registered names
- `erlang:resume_process(Suspendee) -> true`  
[page 137] Resume a suspended process
- `round(Number) -> int()`  
[page 137] Return an integer by rounding a number
- `self() -> pid()`  
[page 137] Pid of the calling process
- `erlang:send(Dest, Msg) -> Msg`  
[page 137] Send a message
- `erlang:send(Dest, Msg, [Option]) -> Res`  
[page 138] Send a message conditionally

- `erlang:send_after(Time, Dest, Msg) -> TimerRef`  
[page 138] Start a timer
- `erlang:send_nosuspend(Dest, Msg) -> bool()`  
[page 139] Try to send a message without ever blocking
- `erlang:send_nosuspend(Dest, Msg, Options) -> bool()`  
[page 140] Try to send a message without ever blocking
- `erlang:set_cookie(Node, Cookie) -> true`  
[page 140] Set the magic cookie of a node
- `setelement(Index, Tuple1, Value) -> Tuple2`  
[page 140] Set Nth element of a tuple
- `size(Item) -> int()`  
[page 141] Size of a tuple or binary
- `spawn(Fun) -> pid()`  
[page 141] Create a new process with a fun as entry point
- `spawn(Node, Fun) -> pid()`  
[page 141] Create a new process with a fun as entry point on a given node
- `spawn(Module, Function, Args) -> pid()`  
[page 141] Create a new process with a function as entry point
- `spawn(Node, Module, Function, ArgumentList) -> pid()`  
[page 141] Create a new process with a function as entry point on a given node
- `spawn_link(Fun) -> pid()`  
[page 142] Create and link to a new process with a fun as entry point
- `spawn_link(Node, Fun) ->`  
[page 142] Create and link to a new process with a fun as entry point on a specified node
- `spawn_link(Module, Function, Args) -> pid()`  
[page 142] Create and link to a new process with a function as entry point
- `spawn_link(Node, Module, Function, Args) -> pid()`  
[page 142] Create and link to a new process with a function as entry point on a given node
- `spawn_monitor(Fun) -> {pid(),reference()}`  
[page 142] Create and monitor a new process with a fun as entry point
- `spawn_monitor(Module, Function, Args) -> {pid(),reference()}`  
[page 143] Create and monitor a new process with a function as entry point
- `spawn_opt(Fun, [Option]) -> pid() | {pid(),reference()}`  
[page 143] Create a new process with a fun as entry point
- `spawn_opt(Node, Fun, [Option]) -> pid()`  
[page 143] Create a new process with a fun as entry point on a given node
- `spawn_opt(Module, Function, Args, [Option]) -> pid() | {pid(),reference()}`  
[page 143] Create a new process with a function as entry point
- `spawn_opt(Node, Module, Function, Args, [Option]) -> pid()`  
[page 144] Create a new process with a function as entry point on a given node
- `split_binary(Bin, Pos) -> {Bin1, Bin2}`  
[page 145] Split a binary into two
- `erlang:start_timer(Time, Dest, Msg) -> TimerRef`  
[page 145] Start a timer

- `statistics(Type) -> Res`  
[page 146] Information about the system
- `erlang:suspend_process(Suspendee, OptList) -> true | false`  
[page 146] Suspend a process
- `erlang:suspend_process(Suspendee) -> true`  
[page 148] Suspend a process
- `erlang:system_flag(Flag, Value) -> OldValue`  
[page 148] Set system flags
- `erlang:system_info(Type) -> Res`  
[page 149] Information about the system
- `erlang:system_monitor() -> MonSettings`  
[page 153] Current system performance monitoring settings
- `erlang:system_monitor(undefined | {MonitorPid, Options}) -> MonSettings`  
[page 154] Set or clear system performance monitoring options
- `erlang:system_monitor(MonitorPid, [Option]) -> MonSettings`  
[page 154] Set system performance monitoring options
- `erlang:system_profile() -> ProfilerSettings`  
[page 155] Current system profiling settings
- `erlang:system_profile(ProfilerPid, Options) -> ProfilerSettings`  
[page 155] Current system profiling settings
- `term_to_binary(Term) -> ext_binary()`  
[page 156] Encode a term to an Erlang external term format binary
- `term_to_binary(Term, [Option]) -> ext_binary()`  
[page 156] Encode a term to an Erlang external term format binary
- `throw(Any)`  
[page 157] Throw an exception
- `time() -> {Hour, Minute, Second}`  
[page 157] Current time
- `tl(List1) -> List2`  
[page 157] Tail of a list
- `erlang:trace(PidSpec, How, FlagList) -> int()`  
[page 157] Set trace flags for a process or processes
- `erlang:trace_delivered(Tracee) -> Ref`  
[page 160] Notification when trace has been delivered
- `erlang:trace_info(PidOrFunc, Item) -> Res`  
[page 161] Trace information about a process or function
- `erlang:trace_pattern(MFA, MatchSpec) -> int()`  
[page 162] Set trace patterns for global call tracing
- `erlang:trace_pattern(MFA, MatchSpec, FlagList) -> int()`  
[page 162] Set trace patterns for tracing of function calls
- `trunc(Number) -> int()`  
[page 164] Return an integer by truncating a number
- `tuple_size(Tuple) -> int()`  
[page 164] Return the size of a tuple
- `tuple_to_list(Tuple) -> [term()]`  
[page 164] Convert a tuple to a list

- `erlang:universaltime() -> {Date, Time}`  
[page 164] Current date and time according to Universal Time Coordinated (UTC)
- `erlang:universaltime_to_localtime({Date1, Time1}) -> {Date2, Time2}`  
[page 165] Convert from Universal Time Coordinated (UTC) to local date and time
- `unlink(Id) -> true`  
[page 165] Remove a link, if there is one, to another process or port
- `unregister(RegName) -> true`  
[page 166] Remove the registered name for a process (or port)
- `whereis(RegName) -> pid() | port() | undefined`  
[page 166] Get the pid (or port) with a given registered name
- `erlang:yield() -> true`  
[page 166] Let other processes get a chance to execute

## error\_handler

The following functions are exported:

- `undefined_function(Module, Function, Args) -> term()`  
[page 167] Called when an undefined function is encountered
- `undefined_lambda(Module, Fun, Args) -> term()`  
[page 167] Called when an undefined lambda (fun) is encountered

## error\_logger

The following functions are exported:

- `error_msg(Format) -> ok`  
[page 169] Send a standard error event to the error logger
- `error_msg(Format, Data) -> ok`  
[page 169] Send a standard error event to the error logger
- `format(Format, Data) -> ok`  
[page 169] Send a standard error event to the error logger
- `error_report(Report) -> ok`  
[page 170] Send a standard error report event to the error logger
- `error_report(Type, Report) -> ok`  
[page 170] Send a user defined error report event to the error logger
- `warning_map() -> Tag`  
[page 170] Return the current mapping for warning events
- `warning_msg(Format) -> ok`  
[page 171] Send a standard warning event to the error logger
- `warning_msg(Format, Data) -> ok`  
[page 171] Send a standard warning event to the error logger
- `warning_report(Report) -> ok`  
[page 171] Send a standard warning report event to the error logger
- `warning_report(Type, Report) -> ok`  
[page 172] Send a user defined warning report event to the error logger

- `info_msg(Format) -> ok`  
[page 172] Send a standard information event to the error logger
- `info_msg(Format, Data) -> ok`  
[page 172] Send a standard information event to the error logger
- `info_report(Report) -> ok`  
[page 172] Send a standard information report event to the error logger
- `info_report(Type, Report) -> ok`  
[page 173] Send a user defined information report event to the error logger
- `add_report_handler(Handler) -> Result`  
[page 173] Add an event handler to the error logger
- `add_report_handler(Handler, Args) -> Result`  
[page 173] Add an event handler to the error logger
- `delete_report_handler(Handler) -> Result`  
[page 173] Delete an event handler from the error logger
- `tty(Flag) -> ok`  
[page 173] Enable or disable printouts to the tty
- `logfile(Request) -> ok | Filename | {error, What}`  
[page 174] Enable or disable error printouts to a file

## file

The following functions are exported:

- `change_group(Filename, Gid) -> ok | {error, Reason}`  
[page 176] Change group of a file
- `change_owner(Filename, Uid) -> ok | {error, Reason}`  
[page 176] Change owner of a file
- `change_owner(Filename, Uid, Gid) -> ok | {error, Reason}`  
[page 177] Change owner and group of a file
- `change_time(Filename, Mtime) -> ok | {error, Reason}`  
[page 177] Change the modification time of a file
- `change_time(Filename, Mtime, Atime) -> ok | {error, Reason}`  
[page 177] Change the modification and last access time of a file
- `close(IODevice) -> ok | {error, Reason}`  
[page 177] Close a file
- `consult(Filename) -> {ok, Terms} | {error, Reason}`  
[page 177] Read Erlang terms from a file
- `copy(Source, Destination) ->`  
[page 178] Copy file contents
- `copy(Source, Destination, ByteCount) -> {ok, BytesCopied} | {error, Reason}`  
[page 178] Copy file contents
- `del_dir(Dir) -> ok | {error, Reason}`  
[page 178] Delete a directory
- `delete(Filename) -> ok | {error, Reason}`  
[page 179] Delete a file

- `eval(Filename) -> ok | {error, Reason}`  
[page 179] Evaluate Erlang expressions in a file
- `eval(Filename, Bindings) -> ok | {error, Reason}`  
[page 180] Evaluate Erlang expressions in a file
- `file_info(Filename) -> {ok, FileInfo} | {error, Reason}`  
[page 180] Get information about a file (deprecated)
- `format_error(Reason) -> Chars`  
[page 180] Return a descriptive string for an error reason
- `get_cwd() -> {ok, Dir} | {error, Reason}`  
[page 180] Get the current working directory
- `get_cwd(Drive) -> {ok, Dir} | {error, Reason}`  
[page 180] Get the current working directory for the drive specified
- `list_dir(Dir) -> {ok, Filenames} | {error, Reason}`  
[page 181] List files in a directory
- `make_dir(Dir) -> ok | {error, Reason}`  
[page 181] Make a directory
- `make_link(Existing, New) -> ok | {error, Reason}`  
[page 181] Make a hard link to a file
- `make_symlink(Name1, Name2) -> ok | {error, Reason}`  
[page 182] Make a symbolic link to a file or directory
- `open(Filename, Modes) -> {ok, IoDevice} | {error, Reason}`  
[page 182] Open a file
- `path_consult(Path, Filename) -> {ok, Terms, FullName} | {error, Reason}`  
[page 184] Read Erlang terms from a file
- `path_eval(Path, Filename) -> {ok, FullName} | {error, Reason}`  
[page 184] Evaluate Erlang expressions in a file
- `path_open(Path, Filename, Modes) -> {ok, IoDevice, FullName} | {error, Reason}`  
[page 185] Open a file
- `path_script(Path, Filename) -> {ok, Value, FullName} | {error, Reason}`  
[page 185] Evaluate and return the value of Erlang expressions in a file
- `path_script(Path, Filename, Bindings) -> {ok, Value, FullName} | {error, Reason}`  
[page 186] Evaluate and return the value of Erlang expressions in a file
- `pid2name(Pid) -> string() | undefined`  
[page 186] Return the name of the file handled by a pid
- `position(IoDevice, Location) -> {ok, NewPosition} | {error, Reason}`  
[page 186] Set position in a file
- `pread(IoDevice, LocNums) -> {ok, DataL} | eof | {error, Reason}`  
[page 187] Read from a file at certain positions
- `pread(IoDevice, Location, Number) -> {ok, Data} | eof | {error, Reason}`  
[page 187] Read from a file at a certain position
- `pwrite(IoDevice, LocBytes) -> ok | {error, {N, Reason}}`  
[page 188] Write to a file at certain positions

- `pwrite(IoDevice, Location, Bytes) -> ok | {error, Reason}`  
[page 188] Write to a file at a certain position
- `read(IoDevice, Number) -> {ok, Data} | eof | {error, Reason}`  
[page 188] Read from a file
- `read_file(Filename) -> {ok, Binary} | {error, Reason}`  
[page 188] Read a file
- `read_file_info(Filename) -> {ok, FileInfo} | {error, Reason}`  
[page 189] Get information about a file
- `read_link(Name) -> {ok, Filename} | {error, Reason}`  
[page 190] See what a link is pointing to
- `read_link_info(Name) -> {ok, FileInfo} | {error, Reason}`  
[page 190] Get information about a link or file
- `rename(Source, Destination) -> ok | {error, Reason}`  
[page 191] Rename a file
- `script(Filename) -> {ok, Value} | {error, Reason}`  
[page 191] Evaluate and return the value of Erlang expressions in a file
- `script(Filename, Bindings) -> {ok, Value} | {error, Reason}`  
[page 192] Evaluate and return the value of Erlang expressions in a file
- `set_cwd(Dir) -> ok | {error, Reason}`  
[page 192] Set the current working directory
- `sync(IoDevice) -> ok | {error, Reason}`  
[page 192] Synchronizes the in-memory state of a file with that on the physical medium
- `truncate(IoDevice) -> ok | {error, Reason}`  
[page 192] Truncate a file
- `write(IoDevice, Bytes) -> ok | {error, Reason}`  
[page 193] Write to a file
- `write_file(Filename, Bytes) -> ok | {error, Reason}`  
[page 193] Write a file
- `write_file(Filename, Bytes, Modes) -> ok | {error, Reason}`  
[page 193] Write a file
- `write_file_info(Filename, FileInfo) -> ok | {error, Reason}`  
[page 194] Change information about a file

## gen\_sctp

The following functions are exported:

- `abort(sctp_socket(), Assoc) -> ok | {error, posix()}`  
[page 200] Abnormally terminate the association given by Assoc, without flushing of unsent data
- `close(sctp_socket()) -> ok | {error, posix()}`  
[page 200] Completely close the socket and all associations on it
- `connect(Socket, Addr, Port, Opts) -> {ok, Assoc} | {error, posix()}`  
[page 200] Same as `connect(Socket, Addr, Port, infinity)`.



- `connect(Socket, Addr, Port, [Opt], Timeout) -> {ok, Assoc} | {error, posix()}`  
[page 200] Establish a new association for the socket `Socket`, with a peer (SCTP server socket)
- `controlling_process(sctp_socket(), pid()) -> ok`  
[page 201] Assign a new controlling process `pid` to the socket
- `eof(Socket, Assoc) -> ok | {error, Reason}`  
[page 201] Gracefully terminate the association given by `Assoc`, with flushing of all unsent data
- `listen(Socket, IsServer) -> ok | {error, Reason}`  
[page 201] Set up a socket to listen.
- `open() -> {ok, Socket} | {error, posix()}`  
[page 202] Create an SCTP socket and bind it to local addresses
- `open(Port) -> {ok, Socket} | {error, posix()}`  
[page 202] Create an SCTP socket and bind it to local addresses
- `open([Opt]) -> {ok, Socket} | {error, posix()}`  
[page 202] Create an SCTP socket and bind it to local addresses
- `open(Port, [Opt]) -> {ok, Socket} | {error, posix()}`  
[page 202] Create an SCTP socket and bind it to local addresses
- `recv(sctp_socket()) -> {ok, {FromIP, FromPort, AncData, BinMsg}} | {error, Reason}`  
[page 202] Receive a message from a socket
- `recv(sctp_socket(), timeout()) -> {ok, {FromIP, FromPort, AncData, Data}} | {error, Reason}`  
[page 202] Receive a message from a socket
- `send(Socket, SndRcvInfo, Data) -> ok | {error, Reason}`  
[page 204] Send a message using an `#sctp_sndrcvinfo` record
- `send(Socket, Assoc, Stream, Data) -> ok | {error, Reason}`  
[page 204] Send a message over an existing association and given stream
- `error_string(integer()) -> ok | string() | undefined`  
[page 204] Translate an SCTP error number into a string

## gen\_tcp

The following functions are exported:

- `connect(Address, Port, Options) -> {ok, Socket} | {error, Reason}`  
[page 214] Connect to a TCP port
- `connect(Address, Port, Options, Timeout) -> {ok, Socket} | {error, Reason}`  
[page 214] Connect to a TCP port
- `listen(Port, Options) -> {ok, ListenSocket} | {error, Reason}`  
[page 215] Set up a socket to listen on a port
- `accept(ListenSocket) -> {ok, Socket} | {error, Reason}`  
[page 215] Accept an incoming connection request on a listen socket
- `accept(ListenSocket, Timeout) -> {ok, Socket} | {error, Reason}`  
[page 215] Accept an incoming connection request on a listen socket

- `send(Socket, Packet) -> ok | {error, Reason}`  
[page 216] Send a packet
- `recv(Socket, Length) -> {ok, Packet} | {error, Reason}`  
[page 216] Receive a packet from a passive socket
- `recv(Socket, Length, Timeout) -> {ok, Packet} | {error, Reason}`  
[page 216] Receive a packet from a passive socket
- `controlling_process(Socket, Pid) -> ok | {error, Reason}`  
[page 217] Change controlling process of a socket
- `close(Socket) -> ok | {error, Reason}`  
[page 217] Close a TCP socket
- `shutdown(Socket, How) -> ok | {error, Reason}`  
[page 217] Immediately close a socket

## gen\_udp

The following functions are exported:

- `open(Port) -> {ok, Socket} | {error, Reason}`  
[page 220] Associate a UDP port number with the process calling it
- `open(Port, Options) -> {ok, Socket} | {error, Reason}`  
[page 220] Associate a UDP port number with the process calling it
- `send(Socket, Address, Port, Packet) -> ok | {error, Reason}`  
[page 221] Send a packet
- `recv(Socket, Length) -> {ok, {Address, Port, Packet}} | {error, Reason}`  
[page 221] Receive a packet from a passive socket
- `recv(Socket, Length, Timeout) -> {ok, {Address, Port, Packet}} | {error, Reason}`  
[page 221] Receive a packet from a passive socket
- `controlling_process(Socket, Pid) -> ok`  
[page 221] Change controlling process of a socket
- `close(Socket) -> ok | {error, Reason}`  
[page 222] Close a UDP socket

## global

The following functions are exported:

- `del_lock(Id)`  
[page 224] Delete a lock
- `del_lock(Id, Nodes) -> void()`  
[page 224] Delete a lock
- `notify_all_name(Name, Pid1, Pid2) -> none`  
[page 224] Name resolving function that notifies both pids
- `random_exit_name(Name, Pid1, Pid2) -> Pid1 | Pid2`  
[page 224] Name resolving function that kills one pid
- `random_notify_name(Name, Pid1, Pid2) -> Pid1 | Pid2`  
[page 224] Name resolving function that notifies one pid

- `register_name(Name, Pid)`  
[page 225] Globally register a name for a pid
- `register_name(Name, Pid, Resolve) -> yes | no`  
[page 225] Globally register a name for a pid
- `registered_names() -> [Name]`  
[page 225] All globally registered names
- `re_register_name(Name, Pid)`  
[page 225] Atomically re-register a name
- `re_register_name(Name, Pid, Resolve) -> void()`  
[page 225] Atomically re-register a name
- `send(Name, Msg) -> Pid`  
[page 226] Send a message to a globally registered pid
- `set_lock(Id)`  
[page 226] Set a lock on the specified nodes
- `set_lock(Id, Nodes)`  
[page 226] Set a lock on the specified nodes
- `set_lock(Id, Nodes, Retries) -> boolean()`  
[page 226] Set a lock on the specified nodes
- `sync() -> void()`  
[page 227] Synchronize the global name server
- `trans(Id, Fun)`  
[page 227] Micro transaction facility
- `trans(Id, Fun, Nodes)`  
[page 227] Micro transaction facility
- `trans(Id, Fun, Nodes, Retries) -> Res | aborted`  
[page 227] Micro transaction facility
- `unregister_name(Name) -> void()`  
[page 227] Remove a globally registered name for a pid
- `whereis_name(Name) -> pid() | undefined`  
[page 227] Get the pid with a given globally registered name

## global\_group

The following functions are exported:

- `global_groups() -> {GroupName, GroupNames} | undefined`  
[page 229] Return the global group names
- `info() -> [{Item, Info}]`  
[page 229] Information about global groups
- `monitor_nodes(Flag) -> ok`  
[page 229] Subscribe to node status changes
- `own_nodes() -> Nodes`  
[page 229] Return the group nodes
- `registered_names(Where) -> Names`  
[page 230] Return globally registered names
- `send(Name, Msg) -> pid() | {badarg, {Name, Msg}}`  
[page 230] Send a message to a globally registered pid

- `send(Where, Name, Msg) -> pid() | {badarg, {Name, Msg}}`  
[page 230] Send a message to a globally registered pid
- `sync() -> ok`  
[page 230] Synchronize the group nodes
- `whereis_name(Name) -> pid() | undefined`  
[page 230] Get the pid with a given globally registered name
- `whereis_name(Where, Name) -> pid() | undefined`  
[page 230] Get the pid with a given globally registered name

## heart

The following functions are exported:

- `set_cmd(Cmd) -> ok | {error, {bad_cmd, Cmd}}`  
[page 233] Set a temporary reboot command
- `clear_cmd() -> ok`  
[page 233] Clear the temporary boot command
- `get_cmd() -> {ok, Cmd}`  
[page 233] Get the temporary reboot command

## inet

The following functions are exported:

- `close(Socket) -> ok`  
[page 235] Close a socket of any type
- `get_rc() -> [{Par, Val}]`  
[page 235] Return a list of IP configuration parameters
- `format_error(Posix) -> string()`  
[page 235] Return a descriptive string for an error reason
- `getaddr(Host, Family) -> {ok, Address} | {error, posix()}`  
[page 236] Return the IP-address for a host
- `getaddrs(Host, Family) -> {ok, Addresses} | {error, posix()}`  
[page 236] Return the IP-addresses for a host
- `gethostbyaddr(Address) -> {ok, Hostent} | {error, posix()}`  
[page 236] Return a hostent record for the host with the given address
- `gethostbyname(Name) -> {ok, Hostent} | {error, posix()}`  
[page 236] Return a hostent record for the host with the given name
- `gethostbyname(Name, Family) -> {ok, Hostent} | {error, posix()}`  
[page 236] Return a hostent record for the host with the given name
- `gethostname() -> {ok, Hostname}`  
[page 236] Return the local hostname
- `getopts(Socket, Options) -> OptionValues | {error, posix()}`  
[page 237] Get one or more options for a socket
- `peername(Socket) -> {ok, {Address, Port}} | {error, posix()}`  
[page 238] Return the address and port for the other end of a connection
- `port(Socket) -> {ok, Port}`  
[page 238] Return the local port number for a socket

- `sockname(Socket) -> {ok, {Address, Port}} | {error, posix()}`  
[page 238] Return the local address and port number for a socket
- `setopts(Socket, Options) -> ok | {error, posix()}`  
[page 238] Set one or more options for a socket

## init

The following functions are exported:

- `boot(BootArgs) -> void()`  
[page 246] Start the Erlang runtime system
- `get_args() -> [Arg]`  
[page 246] Get all non-flag command line arguments
- `get_argument(Flag) -> {ok, Arg} | error`  
[page 246] Get the values associated with a command line user flag
- `get_arguments() -> Flags`  
[page 247] Get all command line user flags
- `get_plain_arguments() -> [Arg]`  
[page 247] Get all non-flag command line arguments
- `get_status() -> {InternalStatus, ProvidedStatus}`  
[page 247] Get system status information
- `reboot() -> void()`  
[page 247] Take down and restart an Erlang node smoothly
- `restart() -> void()`  
[page 248] Restart the running Erlang node
- `script_id() -> Id`  
[page 248] Get the identity of the used boot script
- `stop() -> void()`  
[page 248] Take down an Erlang node smoothly
- `stop(Status) -> void()`  
[page 248] Take down an Erlang node smoothly

## net\_adm

The following functions are exported:

- `dns_hostname(Host) -> {ok, Name} | {error, Host}`  
[page 251] Official name of a host
- `host_file() -> Hosts | {error, Reason}`  
[page 251] Read the `.hosts.erlangfile`
- `localhost() -> Name`  
[page 251] Name of the local host
- `names() -> {ok, [{Name, Port}]} | {error, Reason}`  
[page 251] Names of Erlang nodes at a host
- `names(Host) -> {ok, [{Name, Port}]} | {error, Reason}`  
[page 251] Names of Erlang nodes at a host
- `ping(Node) -> pong | pang`  
[page 252] Set up a connection to a node

- `world()` -> `[node()]`  
[page 252] Lookup and connect to all nodes at all hosts in `.hosts.erlang`
- `world(Arg)` -> `[node()]`  
[page 252] Lookup and connect to all nodes at all hosts in `.hosts.erlang`
- `world_list(Hosts)` -> `[node()]`  
[page 252] Lookup and connect to all nodes at specified hosts
- `world_list(Hosts, Arg)` -> `[node()]`  
[page 252] Lookup and connect to all nodes at specified hosts

## net\_kernel

The following functions are exported:

- `allow(Nodes)` -> `ok | error`  
[page 254] Limit access to a specified set of nodes
- `connect_node(Node)` -> `true | false | ignored`  
[page 254] Establish a connection to a node
- `monitor_nodes(Flag)` -> `ok | Error`  
[page 255] Subscribe to node status change messages
- `monitor_nodes(Flag, Options)` -> `ok | Error`  
[page 255] Subscribe to node status change messages
- `get_net_ticktime()` -> `Res`  
[page 256] Get `net_ticktime`
- `set_net_ticktime(NetTicktime)` -> `Res`  
[page 256] Set `net_ticktime`
- `set_net_ticktime(NetTicktime, TransitionPeriod)` -> `Res`  
[page 256] Set `net_ticktime`
- `start([Name])` -> `{ok, pid()} | {error, Reason}`  
[page 257] Turn an Erlang runtime system into a distributed node
- `start([Name, NameType])` -> `{ok, pid()} | {error, Reason}`  
[page 257] Turn an Erlang runtime system into a distributed node
- `start([Name, NameType, Ticktime])` -> `{ok, pid()} | {error, Reason}`  
[page 257] Turn an Erlang runtime system into a distributed node
- `stop()` -> `ok | {error, not_allowed | not_found}`  
[page 257] Turn a node into a non-distributed Erlang runtime system

## OS

The following functions are exported:

- `cmd(Command)` -> `string()`  
[page 258] Execute a command in a shell of the target OS
- `find_executable(Name)` -> `Filename | false`  
[page 258] Absolute filename of a program
- `find_executable(Name, Path)` -> `Filename | false`  
[page 258] Absolute filename of a program
- `getenv()` -> `[string()]`  
[page 258] List all environment variables

- `getenv(VarName) -> Value | false`  
[page 259] Get the value of an environment variable
- `getpid() -> Value`  
[page 259] Return the process identifier of the emulator process
- `putenv(VarName, Value) -> true`  
[page 259] Set a new value for an environment variable
- `type() -> {Osfamily, Osname} | Osfamily`  
[page 259] Return the OS family and, in some cases, OS name of the current operating system
- `version() -> {Major, Minor, Release} | VersionString`  
[page 259] Return the Operating System version

## packages

The following functions are exported:

- no functions exported  
[page 263] x

## pg2

The following functions are exported:

- `create(Name) -> void()`  
[page 264] Create a new, empty process group
- `delete(Name) -> void()`  
[page 264] Delete a process group
- `get_closest_pid(Name) -> Pid | {error, Reason}`  
[page 264] Common dispatch function
- `get_members(Name) -> [Pid] | {error, Reason}`  
[page 265] Return all processes in a group
- `get_local_members(Name) -> [Pid] | {error, Reason}`  
[page 265] Return all local processes in a group
- `join(Name, Pid) -> ok | {error, Reason}`  
[page 265] Join a process to a group
- `leave(Name, Pid) -> ok | {error, Reason}`  
[page 265] Make a process leave a group
- `which_groups() -> [Name]`  
[page 265] Return a list of all known groups
- `start()`  
[page 265] Start the pg2 server
- `start_link() -> {ok, Pid} | {error, Reason}`  
[page 265] Start the pg2 server

## rpc

The following functions are exported:

- `call(Node, Module, Function, Args) -> Res | {badrpc, Reason}`  
[page 267] Evaluate a function call on a node
- `call(Node, Module, Function, Args, Timeout) -> Res | {badrpc, Reason}`  
[page 267] Evaluate a function call on a node
- `block_call(Node, Module, Function, Args) -> Res | {badrpc, Reason}`  
[page 267] Evaluate a function call on a node in the RPC server's context
- `block_call(Node, Module, Function, Args, Timeout) -> Res | {badrpc, Reason}`  
[page 268] Evaluate a function call on a node in the RPC server's context
- `async_call(Node, Module, Function, Args) -> Key`  
[page 268] Evaluate a function call on a node, asynchronous version
- `yield(Key) -> Res | {badrpc, Reason}`  
[page 268] Deliver the result of evaluating a function call on a node (blocking)
- `nb_yield(Key) -> {value, Val} | timeout`  
[page 268] Deliver the result of evaluating a function call on a node (non-blocking)
- `nb_yield(Key, Timeout) -> {value, Val} | timeout`  
[page 269] Deliver the result of evaluating a function call on a node (non-blocking)
- `multicall(Module, Function, Args) -> {ResL, BadNodes}`  
[page 269] Evaluate a function call on a number of nodes
- `multicall(Nodes, Module, Function, Args) -> {ResL, BadNodes}`  
[page 269] Evaluate a function call on a number of nodes
- `multicall(Module, Function, Args, Timeout) -> {ResL, BadNodes}`  
[page 269] Evaluate a function call on a number of nodes
- `multicall(Nodes, Module, Function, Args, Timeout) -> {ResL, BadNodes}`  
[page 269] Evaluate a function call on a number of nodes
- `cast(Node, Module, Function, Args) -> void()`  
[page 270] Run a function on a node ignoring the result
- `eval_everywhere(Module, Funtion, Args) -> void()`  
[page 270] Run a function on all nodes, ignoring the result
- `eval_everywhere(Nodes, Module, Function, Args) -> void()`  
[page 270] Run a function on specific nodes, ignoring the result
- `abcast(Name, Msg) -> void()`  
[page 271] Broadcast a message asynchronously to a registered process on all nodes
- `abcast(Nodes, Name, Msg) -> void()`  
[page 271] Broadcast a message asynchronously to a registered process on specific nodes
- `sbcast(Name, Msg) -> {GoodNodes, BadNodes}`  
[page 271] Broadcast a message synchronously to a registered process on all nodes
- `sbcast(Nodes, Name, Msg) -> {GoodNodes, BadNodes}`  
[page 271] Broadcast a message synchronously to a registered process on specific nodes



- `server_call(Node, Name, ReplyWrapper, Msg) -> Reply | {error, Reason}`  
[page 271] Interact with a server on a node
- `multi_server_call(Name, Msg) -> {Replies, BadNodes}`  
[page 272] Interact with the servers on a number of nodes
- `multi_server_call(Nodes, Name, Msg) -> {Replies, BadNodes}`  
[page 272] Interact with the servers on a number of nodes
- `safe_multi_server_call(Name, Msg) -> {Replies, BadNodes}`  
[page 272] Interact with the servers on a number of nodes (deprecated)
- `safe_multi_server_call(Nodes, Name, Msg) -> {Replies, BadNodes}`  
[page 272] Interact with the servers on a number of nodes (deprecated)
- `parallel_eval(FuncCalls) -> ResL`  
[page 273] Evaluate several function calls on all nodes in parallel
- `pmap({Module, Function}, ExtraArgs, List2) -> List1`  
[page 273] Parallel evaluation of mapping a function over a list
- `pinfo(Pid) -> [{Item, Info}] | undefined`  
[page 273] Information about a process
- `pinfo(Pid, Item) -> {Item, Info} | undefined | []`  
[page 273] Information about a process

## seq\_trace

The following functions are exported:

- `set_token(Token) -> PreviousToken`  
[page 274] Set the trace token
- `set_token(Component, Val) -> {Component, OldVal}`  
[page 274] Set a component of the trace token
- `get_token() -> TraceToken`  
[page 275] Return the value of the trace token
- `get_token(Component) -> {Component, Val}`  
[page 275] Return the value of a trace token component
- `print(TraceInfo) -> void()`  
[page 275] Put the Erlang term `TraceInfo` into the sequential trace output
- `print(Label, TraceInfo) -> void()`  
[page 275] Put the Erlang term `TraceInfo` into the sequential trace output
- `reset_trace() -> void()`  
[page 276] Stop all sequential tracing on the local node
- `set_system_tracer(Tracer) -> OldTracer`  
[page 276] Set the system tracer
- `get_system_tracer() -> Tracer`  
[page 276] Return the `pid()` or `port()` of the current system tracer.

## user

No functions are exported.

## wrap\_log\_reader

The following functions are exported:

- `chunk(Continuation)`  
[page 283] Read a chunk of objects written to a wrap log.
- `chunk(Continuation, N) -> {Continuation2, Terms} | {Continuation2, Terms, Badbytes} | {Continuation2, eof} | {error, Reason}`  
[page 283] Read a chunk of objects written to a wrap log.
- `close(Continuation) -> ok`  
[page 284] Close a log
- `open(Filename) -> OpenRet`  
[page 284] Open a log file
- `open(Filename, N) -> OpenRet`  
[page 284] Open a log file

## zlib

The following functions are exported:

- `open() -> Z`  
[page 286] Open a stream and return a stream reference
- `close(Z) -> ok`  
[page 286] Close a stream
- `deflateInit(Z) -> ok`  
[page 286] Initialize a session for compression
- `deflateInit(Z, Level) -> ok`  
[page 286] Initialize a session for compression
- `deflateInit(Z, Level, Method, WindowBits, MemLevel, Strategy) -> ok`  
[page 286] Initialize a session for compression
- `deflate(Z, Data) -> Compressed`  
[page 287] Compress data
- `deflate(Z, Data, Flush) ->`  
[page 287] Compress data
- `deflateSetDictionary(Z, Dictionary) -> Adler32`  
[page 288] Initialize the compression dictionary
- `deflateReset(Z) -> ok`  
[page 288] Reset the deflate session
- `deflateParams(Z, Level, Strategy) -> ok`  
[page 288] Dynamicly update deflate parameters
- `deflateEnd(Z) -> ok`  
[page 289] End deflate session
- `inflateInit(Z) -> ok`  
[page 289] Initialize a session for decompression
- `inflateInit(Z, WindowBits) -> ok`  
[page 289] Initialize a session for decompression
- `inflate(Z, Data) -> DeCompressed`  
[page 289] Decompress data

- `inflateSetDictionary(Z, Dictionary) -> ok`  
[page 289] Initialize the decompression dictionary
- `inflateReset(Z) -> ok`  
[page 290] >Reset the inflate session
- `inflateEnd(Z) -> ok`  
[page 290] End inflate session
- `setBufSize(Z, Size) -> ok`  
[page 290] Set buffer size
- `getBufSize(Z) -> Size`  
[page 290] Get buffer size
- `crc32(Z) -> CRC`  
[page 290] Get current CRC
- `crc32(Z, Binary) -> CRC`  
[page 290] Calculate CRC
- `crc32(Z, PrevCRC, Binary) -> CRC`  
[page 291] Calculate CRC
- `crc32_combine(Z, CRC1, CRC2, Size2) -> CRC`  
[page 291] Combine two CRC's
- `adler32(Z, Binary) -> Checksum`  
[page 291] Calculate the adler checksum
- `adler32(Z, PrevAdler, Binary) -> Checksum`  
[page 291] Calculate the adler checksum
- `adler32_combine(Z, Adler1, Adler2, Size2) -> Adler`  
[page 292] Combine two Adler-32 checksums
- `compress(Binary) -> Compressed`  
[page 292] Compress a binary with standard zlib functionality
- `uncompress(Binary) -> Decompressed`  
[page 292] Uncompress a binary with standard zlib functionality
- `zip(Binary) -> Compressed`  
[page 292] Compress a binary without the zlib headers
- `unzip(Binary) -> Decompressed`  
[page 292] Uncompress a binary without the zlib headers
- `gzip(Data) -> Compressed`  
[page 292] Compress a binary with gz header
- `gunzip(Bin) -> Decompressed`  
[page 292] Uncompress a binary with gz header

## app

No functions are exported.

## config

No functions are exported.

# kernel

## Application

The Kernel application is the first application started. It is mandatory in the sense that the minimal system based on Erlang/OTP consists of Kernel and STDLIB. The Kernel application contains the following services:

- application controller, see `application(3)`
- code
- disk\_log
- dist\_ac, distributed application controller
- erl\_boot\_server
- erl\_ddll
- error\_logger
- file
- global
- global\_group
- heart
- inet
- net\_kernel
- os
- pg2
- rpc
- seq\_trace
- user

## Error Logger Event Handlers

Two standard error logger event handlers are defined in the Kernel application. These are described in `error_logger(3)` [page 169].

## Configuration

The following configuration parameters are defined for the Kernel application. See `app(3)` for more information about configuration parameters.

`browser_cmd = string() | {M,F,A}` When pressing the Help button in a tool such as Debugger or TV, the help text (an HTML file `File`) is by default displayed in a Netscape browser which is required to be up and running. This parameter can be used to change the command for how to display the help text if another browser than Netscape is preferred, or another platform than Unix or Windows is used. If set to a string `Command`, the command "`Command File`" will be evaluated using `os:cmd/1`.

If set to a module-function-args tuple `{M,F,A}`, the call `apply(M,F, [File|A])` will be evaluated.

`distributed = [Distrib]` Specifies which applications are distributed and on which nodes they may execute. In this parameter:

- `Distrib = {App,Nodes} | {App,Time,Nodes}`
- `App = atom()`
- `Time = integer(>0)`
- `Nodes = [node() | {node(),...,node()}]`

The parameter is described in `application(3)`, function `load/2`.

`dist_auto_connect = Value` Specifies when nodes will be automatically connected. If this parameter is not specified, a node is always automatically connected, e.g when a message is to be sent to that node. Value is one of:

`never` Connections are never automatically connected, they must be explicitly connected. See `net_kernel(3)`.

`once` Connections will be established automatically, but only once per node. If a node goes down, it must thereafter be explicitly connected. See `net_kernel(3)`.

`permissions = [Perm]` Specifies the default permission for applications when they are started. In this parameter:

- `Perm = {App1Name,Bool}`
- `App1Name = atom()`
- `Bool = boolean()`

Permissions are described in `application(3)`, function `permit/2`.

`error_logger = Value` Value is one of:

`tty` Installs the standard event handler which prints error reports to `stdio`. This is the default option.

`{file, FileName}` Installs the standard event handler which prints error reports to the file `FileName`, where `FileName` is a string.

`false` No standard event handler is installed, but the initial, primitive event handler is kept, printing raw event messages to `tty`.

`silent` Error logging is turned off.

`global_groups = [GroupTuple]` Defines global groups, see `global_group(3)`.

- `GroupTuple = {GroupName, [Node]} | {GroupName, PublishType, [Node]}`
- `GroupName = atom()`

- PublishType = normal | hidden
  - Node = node()
- `inet_default_connect_options` = [{Opt, Val}] Specifies default options for connect sockets, see `inet(3)`.
- `inet_default_listen_options` = [{Opt, Val}] Specifies default options for listen (and accept) sockets, see `inet(3)`.
- {`inet_dist_use_interface`, `ip_address()`} If the host of an Erlang node has several network interfaces, this parameter specifies which one to listen on. See `inet(3)` for the type definition of `ip_address()`.
- {`inet_dist_listen_min`, First} See below.
- {`inet_dist_listen_max`, Last} Define the First..Last port range for the listener socket of a distributed Erlang node.
- `inet_parse_error_log` = silent If this configuration parameter is set, no `error_logger` messages are generated when erroneous lines are found and skipped in the various Inet configuration files.
- `inetrc` = Filename The name (string) of an Inet user configuration file. See ERTS User's Guide, Inet configuration.
- `net_setup_time` = SetupTime SetupTime must be a positive integer or floating point number, and will be interpreted as the maximally allowed time for each network operation during connection setup to another Erlang node. The maximum allowed value is 120; if higher values are given, 120 will be used. The default value if the variable is not given, or if the value is incorrect (e.g. not a number), is 7 seconds. Note that this value does not limit the total connection setup time, but rather each individual network operation during the connection setup and handshake.
- `net_ticktime` = TickTime Specifies the `net_kernel` tick time. TickTime is given in seconds. Once every TickTime/4 second, all connected nodes are ticked (if anything else has been written to a node) and if nothing has been received from another node within the last four (4) tick times that node is considered to be down. This ensures that nodes which are not responding, for reasons such as hardware errors, are considered to be down.
- The time T, in which a node that is not responding is detected, is calculated as:  $\text{MinT} < T < \text{MaxT}$  where:
- $$\text{MinT} = \text{TickTime} - \text{TickTime} / 4$$
- $$\text{MaxT} = \text{TickTime} + \text{TickTime} / 4$$
- TickTime is by default 60 (seconds). Thus,  $45 < T < 75$  seconds.
- Note:* All communicating nodes should have the same TickTime value specified.
- Note:* Normally, a terminating node is detected immediately.
- `sync_nodes_mandatory` = [NodeName] Specifies which other nodes *must* be alive in order for this node to start properly. If some node in the list does not start within the specified time, this node will not start either. If this parameter is undefined, it defaults to [].
- `sync_nodes_optional` = [NodeName] Specifies which other nodes *can* be alive in order for this node to start properly. If some node in this list does not start within the specified time, this node starts anyway. If this parameter is undefined, it defaults to the empty list.
- `sync_nodes_timeout` = integer() | infinity Specifies the amount of time (in milliseconds) this node will wait for the mandatory and optional nodes to start. If this parameter is undefined, no node synchronization is performed. This option also makes sure that `global` is synchronized.

`start_dist_ac = true | false` Starts the `dist_ac` server if the parameter is true. This parameter should be set to true for systems that use distributed applications. The default value is false. If this parameter is undefined, the server is started if the parameter `distributed` is set.

`start_boot_server = true | false` Starts the `boot_server` if the parameter is true (see `erl_boot_server(3)`). This parameter should be set to true in an embedded system which uses this service. The default value is false.

`boot_server_slaves = [SlaveIP]` If the `start_boot_server` configuration parameter is true, this parameter can be used to initialize `boot_server` with a list of slave IP addresses. `SlaveIP = string() | atom | {integer(), integer(), integer(), integer()}` where  $0 \leq \text{integer()} \leq 255$ . Examples of `SlaveIP` in atom, string and tuple form are: `'150.236.16.70'`, `"150,236,16,70"`, `{150,236,16,70}`. The default value is `[]`.

`start_disk_log = true | false` Starts the `disk_log_server` if the parameter is true (see `disk_log(3)`). This parameter should be set to true in an embedded system which uses this service. The default value is false.

`start_pg2 = true | false` Starts the `pg2` server (see `pg2(3)`) if the parameter is true. This parameter should be set to true in an embedded system which uses this service. The default value is false.

`start_timer = true | false` Starts the `timer_server` if the parameter is true (see `timer(3)`). This parameter should be set to true in an embedded system which uses this service. The default value is false.

`shutdown_func = {Mod, Func}` Where:

- `Mod = atom()`
- `Func = atom()`

Sets a function that `application_controller` calls when it starts to terminate. The function is called as: `Mod:Func(Reason)`, where `Reason` is the terminate reason for `application_controller`, and it must return as soon as possible for `application_controller` to terminate properly.

## See Also

`app(4)` [page 294], `application(3)` [page 36], `code(3)` [page 47], `disk_log(3)` [page 56], `erl_boot_server(3)` [page 70], `erl_ddll(3)` [page 72], `error_logger(3)` [page 169], `file(3)` [page 176], `global(3)` [page 223], `global_group(3)` [page 228], `heart(3)` [page 232], `inet(3)` [page 234], `net_kernel(3)` [page 254], `os(3)` [page 258], `pg2(3)` [page 264], `rpc(3)` [page 267], `seq_trace(3)` [page 274], `user(3)` [page 282]

# application

Erlang Module

In OTP, *application* denotes a component implementing some specific functionality, that can be started and stopped as a unit, and which can be re-used in other systems as well. This module interfaces the *application controller*, a process started at every Erlang runtime system, and contains functions for controlling applications (for example starting and stopping applications), and functions to access information about applications (for example configuration parameters).

An application is defined by an *application specification*. The specification is normally located in an *application resource file* called `Application.app`, where `Application` is the name of the application. Refer to `app(4)` [page 294] for more information about the application specification.

This module can also be viewed as a behaviour for an application implemented according to the OTP design principles as a supervision tree. The definition of how to start and stop the tree should be located in an *application callback module* exporting a pre-defined set of functions.

Refer to [OTP Design Principles] for more information about applications and behaviours.

## Exports

```
get_all_env() -> Env
```

```
get_all_env(Application) -> Env
```

Types:

- `Application = atom()`
- `Env = [{Par,Val}]`
- `Par = atom()`
- `Val = term()`

Returns the configuration parameters and their values for `Application`. If the argument is omitted, it defaults to the application of the calling process.

If the specified application is not loaded, or if the process executing the call does not belong to any application, the function returns `[]`.

```
get_all_key() -> {ok, Keys} | []
```

```
get_all_key(Application) -> {ok, Keys} | undefined
```

Types:

- `Application = atom()`
- `Keys = [{Key,Val}]`



- Key = atom()
- Val = term()

Returns the application specification keys and their values for `Application`. If the argument is omitted, it defaults to the application of the calling process.

If the specified application is not loaded, the function returns `undefined`. If the process executing the call does not belong to any application, the function returns `[]`.

```
get_application() -> {ok, Application} | undefined
```

```
get_application(Pid | Module) -> {ok, Application} | undefined
```

Types:

- Pid = pid()
- Module = atom()
- Application = atom()

Returns the name of the application to which the process `Pid` or the module `Module` belongs. Providing no argument is the same as calling `get_application(self())`.

If the specified process does not belong to any application, or if the specified process or module does not exist, the function returns `undefined`.

```
get_env(Par) -> {ok, Val} | undefined
```

```
get_env(Application, Par) -> {ok, Val} | undefined
```

Types:

- Application = atom()
- Par = atom()
- Val = term()

Returns the value of the configuration parameter `Par` for `Application`. If the application argument is omitted, it defaults to the application of the calling process.

If the specified application is not loaded, or the configuration parameter does not exist, or if the process executing the call does not belong to any application, the function returns `undefined`.

```
get_key(Key) -> {ok, Val} | undefined
```

```
get_key(Application, Key) -> {ok, Val} | undefined
```

Types:

- Application = atom()
- Key = atom()
- Val = term()

Returns the value of the application specification key `Key` for `Application`. If the application argument is omitted, it defaults to the application of the calling process.

If the specified application is not loaded, or the specification key does not exist, or if the process executing the call does not belong to any application, the function returns `undefined`.

```
load(AppDescr) -> ok | {error, Reason}
```

```
load(AppDescr, Distributed) -> ok | {error, Reason}
```

Types:

- AppDescr = Application | AppSpec
- Application = atom()
- AppSpec = {application,Application,AppSpecKeys}
- AppSpec = [{Key,Val}]
- Key = atom()
- Val = term()
- Distributed = {Application,Nodes} | {Application,Time,Nodes} | default
- Nodes = [node() | {node(),...,node()}]
- Time = integer() > 0
- Reason = term()

Loads the application specification for an application into the application controller. It will also load the application specifications for any included applications. Note that the function does not load the actual Erlang object code.

The application can be given by its name `Application`. In this case the application controller will search the code path for the application resource file `Application.app` and load the specification it contains.

The application specification can also be given directly as a tuple `AppSpec`. This tuple should have the format and contents as described in `app(4)`.

If `Distributed == {Application, [Time,]Nodes}`, the application will be distributed. The argument overrides the value for the application in the Kernel configuration parameter `distributed`. `Application` must be the name of the application (same as in the first argument). If a node crashes and `Time` has been specified, then the application controller will wait for `Time` milliseconds before attempting to restart the application on another node. If `Time` is not specified, it will default to 0 and the application will be restarted immediately.

`Nodes` is a list of node names where the application may run, in priority from left to right. Node names can be grouped using tuples to indicate that they have the same priority. Example:

```
Nodes = [cp1@cave, {cp2@cave, cp3@cave}]
```

This means that the application should preferably be started at `cp1@cave`. If `cp1@cave` is down, the application should be started at either `cp2@cave` or `cp3@cave`.

If `Distributed == default`, the value for the application in the Kernel configuration parameter `distributed` will be used.

```
loaded_applications() -> [{Application, Description, Vsn}]
```

Types:

- Application = atom()
- Description = string()
- Vsn = string()

Returns a list with information about the applications which have been loaded using `load/1,2`, also included applications. `Application` is the application name. `Description` and `Vsn` are the values of its `description` and `vsn` application specification keys, respectively.

```
permit(Application, Bool) -> ok | {error, Reason}
```

Types:

- Application = atom()
- Bool = bool()
- Reason = term()

Changes the permission for Application to run at the current node. The application must have been loaded using `load/1,2` for the function to have effect.

If the permission of a loaded, but not started, application is set to `false`, `start` will return `ok` but the application will not be started until the permission is set to `true`.

If the permission of a running application is set to `false`, the application will be stopped. If the permission later is set to `true`, it will be restarted.

If the application is distributed, setting the permission to `false` means that the application will be started at, or moved to, another node according to how its distribution is configured (see `load/2` above).

The function does not return until the application is started, stopped or successfully moved to another node. However, in some cases where permission is set to `true` the function may return `ok` even though the application itself has not started. This is true when an application cannot start because it has dependencies to other applications which have not yet been started. When they have been started, Application will be started as well.

By default, all applications are loaded with permission `true` on all nodes. The permission is configurable by using the Kernel configuration parameter `permissions`.

```
set_env(Application, Par, Val) -> ok
set_env(Application, Par, Val, Timeout) -> ok
```

Types:

- Application = atom()
- Par = atom()
- Val = term()
- Timeout = int() | infinity

Sets the value of the configuration parameter Par for Application.

`set_env/3` uses the standard `gen_server` timeout value (5000 ms). A `Timeout` argument can be provided if another timeout value is useful, for example, in situations where the application controller is heavily loaded.

### Warning:

Use this function only if you know what you are doing, that is, on your own applications. It is very application and configuration parameter dependent when and how often the value is read by the application, and careless use of this function may put the application in a weird, inconsistent, and malfunctioning state.

```
start(Application) -> ok | {error, Reason}
start(Application, Type) -> ok | {error, Reason}
```

Types:

- Application = atom()
- Type = permanent | transient | temporary

- Reason = term()

Starts `Application`. If it is not loaded, the application controller will first load it using `load/1`. It will make sure any included applications are loaded, but will not start them. That is assumed to be taken care of in the code for `Application`.

The application controller checks the value of the application specification key `applications`, to ensure that all applications that should be started before this application are running. If not, `{error, {not_started, App}}` is returned, where `App` is the name of the missing application.

The application controller then creates an *application master* for the application. The application master is the group leader of all the processes in the application. The application master starts the application by calling the application callback function `Module:start/2` as defined by the application specification key `mod`.

The `Type` argument specifies the type of the application. If omitted, it defaults to `temporary`.

- If a permanent application terminates, all other applications and the entire Erlang node are also terminated.
- If a transient application terminates with `Reason == normal`, this is reported but no other applications are terminated. If a transient application terminates abnormally, all other applications and the entire Erlang node are also terminated.
- If a temporary application terminates, this is reported but no other applications are terminated.

Note that it is always possible to stop an application explicitly by calling `stop/1`. Regardless of the type of the application, no other applications will be affected.

Note also that the transient type is of little practical use, since when a supervision tree terminates, the reason is set to `shutdown`, not `normal`.

```
start_type() -> StartType | local | undefined
```

Types:

- StartType = normal | {takeover,Node} | {failover,Node}
- Node = node()

This function is intended to be called by a process belonging to an application, when the application is being started, to determine the start type which is either `StartType` or `local`.

See `Module:start/2` for a description of `StartType`.

`local` is returned if only parts of the application is being restarted (by a supervisor), or if the function is called outside a startup.

If the process executing the call does not belong to any application, the function returns `undefined`.

```
stop(Application) -> ok | {error, Reason}
```

Types:

- Application = atom()
- Reason = term()

Stops `Application`. The application master calls `Module:prep_stop/1`, if such a function is defined, and then tells the top supervisor of the application to shutdown (see `supervisor(3)`). This means that the entire supervision tree, including included applications, is terminated in reversed start order. After the shutdown, the application master calls `Module:stop/1`. `Module` is the callback module as defined by the application specification key `mod`.

Last, the application master itself terminates. Note that all processes with the application master as group leader, i.e. processes spawned from a process belonging to the application, thus are terminated as well.

When stopped, the application is still loaded.

In order to stop a distributed application, `stop/1` has to be called on all nodes where it can execute (that is, on all nodes where it has been started). The call to `stop/1` on the node where the application currently executes will stop its execution. The application will not be moved between nodes due to `stop/1` being called on the node where the application currently executes before `stop/1` is called on the other nodes.

```
takeover(Application, Type) -> ok | {error, Reason}
```

Types:

- `Application = atom()`
- `Type = permanent | transient | temporary`
- `Reason = term()`

Performs a takeover of the distributed application `Application`, which executes at another node `Node`. At the current node, the application is restarted by calling `Module:start({takeover, Node}, StartArgs)`. `Module` and `StartArgs` are retrieved from the loaded application specification. The application at the other node is not stopped until the startup is completed, i.e. when `Module:start/2` and any calls to `Module:start_phase/3` have returned.

Thus two instances of the application will run simultaneously during the takeover, which makes it possible to transfer data from the old to the new instance. If this is not acceptable behavior, parts of the old instance may be shut down when the new instance is started. Note that the application may not be stopped entirely however, at least the top supervisor must remain alive.

See `start/1, 2` for a description of `Type`.

```
unload(Application) -> ok | {error, Reason}
```

Types:

- `Application = atom()`
- `Reason = term()`

Unloads the application specification for `Application` from the application controller. It will also unload the application specifications for any included applications. Note that the function does not purge the actual Erlang object code.

```
unset_env(Application, Par) -> ok
```

```
unset_env(Application, Par, Timeout) -> ok
```

Types:

- `Application = atom()`
- `Par = atom()`

- Timeout = int() | infinity

Removes the configuration parameter `Par` and its value for `Application`.

`unset_env/2` uses the standard `gen_server` timeout value (5000 ms). A `Timeout` argument can be provided if another timeout value is useful, for example, in situations where the application controller is heavily loaded.

### Warning:

Use this function only if you know what you are doing, that is, on your own applications. It is very application and configuration parameter dependent when and how often the value is read by the application, and careless use of this function may put the application in a weird, inconsistent, and malfunctioning state.

```
which_applications() -> [{Application, Description, Vsn}]
```

```
which_applications(Timeout) -> [{Application, Description, Vsn}]
```

Types:

- Application = atom()
- Description = string()
- Vsn = string()
- Timeout = int() | infinity

Returns a list with information about the applications which are currently running. `Application` is the application name. `Description` and `Vsn` are the values of its description and `vsn` application specification keys, respectively.

`which_applications/0` uses the standard `gen_server` timeout value (5000 ms). A `Timeout` argument can be provided if another timeout value is useful, for example, in situations where the application controller is heavily loaded.

## CALLBACK MODULE

The following functions should be exported from an `application` callback module.

### Exports

```
Module:start(StartType, StartArgs) -> {ok, Pid} | {ok, Pid, State} | {error, Reason}
```

Types:

- StartType = normal | {takeover,Node} | {failover,Node}
- Node = node()
- StartArgs = term()
- Pid = pid()
- State = term()

This function is called whenever an application is started using `application:start/1,2`, and should start the processes of the application. If the application is structured according to the OTP design principles as a supervision tree, this means starting the top supervisor of the tree.

`StartType` defines the type of `start`:

- `normal` if its a normal startup.
- `normal` also if the application is distributed and started at the current node due to a failover from another node, and the application specification key `start_phases == undefined`.
- `{takeover,Node}` if the application is distributed and started at the current node due to a takeover from `Node`, either because `application:takeover/2` has been called or because the current node has higher priority than `Node`.
- `{failover,Node}` if the application is distributed and started at the current node due to a failover from `Node`, and the application specification key `start_phases /= undefined`.

`StartArgs` is the `StartArgs` argument defined by the application specification key `mod`.

The function should return `{ok,Pid}` or `{ok,Pid,State}` where `Pid` is the pid of the top supervisor and `State` is any term. If omitted, `State` defaults to `[]`. If later the application is stopped, `State` is passed to `Module:prep_stop/1`.

```
Module:start_phase(Phase, StartType, PhaseArgs) -> ok | {error, Reason}
```

Types:

- `Phase = atom()`
- `StartType = normal | {takeover,Node} | {failover,Node}`
- `Node = node()`
- `PhaseArgs = term()`
- `Pid = pid()`
- `State = state()`

This function is used to start an application with included applications, when there is a need for synchronization between processes in the different applications during startup.

The start phases is defined by the application specification key `start_phases == [{Phase,PhaseArgs}]`. For included applications, the set of phases must be a subset of the set of phases defined for the including application.

The function is called for each start phase (as defined for the primary application) for the primary application and all included applications, for which the start phase is defined.

See `Module:start/2` for a description of `StartType`.

```
Module:prep_stop(State) -> NewState
```

Types:

- `State = NewState = term()`

This function is called when an application is about to be stopped, before shutting down the processes of the application.

`State` is the state returned from `Module:start/2`, or `[]` if no state was returned.

`NewState` is any term and will be passed to `Module:stop/1`.

The function is optional. If it is not defined, the processes will be terminated and then `Module:stop(State)` is called.

`Module:stop(State)`

Types:

- `State = term()`

This function is called whenever an application has stopped. It is intended to be the opposite of `Module:start/2` and should do any necessary cleaning up. The return value is ignored.

`State` is the return value of `Module:prep_stop/1`, if such a function exists. Otherwise `State` is taken from the return value of `Module:start/2`.

`Module:config_change(Changed, New, Removed) -> ok`

Types:

- `Changed = [{Par,Val}]`
- `New = [{Par,Val}]`
- `Removed = [Par]`
- `Par = atom()`
- `Val = term()`

This function is called by an application after a code replacement, if there are any changes to the configuration parameters.

`Changed` is a list of parameter-value tuples with all configuration parameters with changed values, `New` is a list of parameter-value tuples with all configuration parameters that have been added, and `Removed` is a list of all parameters that have been removed.

## SEE ALSO

[OTP Design Principles], `kernel(6)` [page 32], `app(4)` [page 294]



# auth

Erlang Module

This module is deprecated. For a description of the Magic Cookie system, refer to [Distributed Erlang] in the Erlang Reference Manual.

## Exports

`is_auth(Node) -> yes | no`

Types:

- `Node = node()`

Returns `yes` if communication with `Node` is authorized. Note that a connection to `Node` will be established in this case. Returns `no` if `Node` does not exist or communication is not authorized (it has another cookie than `auth` thinks it has).

Use `net_adm:ping(Node)` [page 252] instead.

`cookie() -> Cookie`

Types:

- `Cookie = atom()`

Use `erlang:get_cookie()` [page 105] instead.

`cookie(TheCookie) -> true`

Types:

- `TheCookie = Cookie | [Cookie]`  
The cookie may also be given as a list with a single atom element
- `Cookie = atom()`

Use `erlang:set_cookie(node(), Cookie)` [page 140] instead.

`node_cookie([Node, Cookie]) -> yes | no`

Types:

- `Node = node()`
- `Cookie = atom()`

Equivalent to `node_cookie(Node, Cookie)` [page 45].

`node_cookie(Node, Cookie) -> yes | no`

Types:

- `Node = node()`

- `Cookie = atom()`

Sets the magic cookie of `Node` to `Cookie`, and verifies the status of the authorization. Equivalent to calling `erlang:set_cookie(Node, Cookie)` [page 140], followed by `auth:is_auth(Node)` [page 45].

# code

Erlang Module

This module contains the interface to the Erlang *code server*, which deals with the loading of compiled code into a running Erlang runtime system.

The runtime system can be started in either *embedded* or *interactive* mode. Which one is decided by the command line flag `-mode`.

```
% erl -mode interactive
```

Default mode is *interactive*.

- In embedded mode, all code is loaded during system start-up according to the boot script. (Code can also be loaded later by explicitly ordering the code server to do so).
- In interactive mode, only some code is loaded during system startup-up, basically the modules needed by the runtime system itself. Other code is dynamically loaded when first referenced. When a call to a function in a certain module is made, and the module is not loaded, the code server searches for and tries to load the module.

To prevent accidentally reloading modules affecting the Erlang runtime system itself, the `kernel`, `stdlib` and `compiler` directories are considered *sticky*. This means that the system issues a warning and rejects the request if a user tries to reload a module residing in any of them. The feature can be disabled by using the command line flag `-nostick`.

## Code Path

In interactive mode, the code server maintains a search path – usually called the *code path* – consisting of a list of directories, which it searches sequentially when trying to load a module.

Initially, the code path consists of the current working directory and all Erlang object code directories under the library directory `$OTPROOT/lib`, where `$OTPROOT` is the installation directory of Erlang/OTP, `code:root_dir()`. Directories can be named `Name[-Vsn]` and the code server, by default, chooses the directory with the highest version number among those which have the same `Name`. The `-Vsn` suffix is optional. If an `ebin` directory exists under `Name[-Vsn]`, it is this directory which is added to the code path.

The environment variable `ERL_LIBS` (defined in the operating system) can be used to define additional library directories that will be handled in the same way as the standard OTP library directory described above, except that directories that do not have an `ebin` directory will be ignored.

All application directories found in the additional directories will appear before the standard OTP applications, except for the `Kernel` and `STDLIB` applications, which will be placed before any additional applications. In other words, modules found in any of

the additional library directories will override modules with the same name in OTP, except for modules in Kernel and STDLIB.

The environment variable `ERL_LIBS` (if defined) should contain a colon-separated (for Unix-like systems) or semicolon-separated (for Windows) list of additional libraries.

Example: On an Unix-like system, `ERL_LIBS` could be set to `/usr/local/junger1:/home/some_user/my_erlang_lib`. (On Windows, use semi-colon as separator.)

## Code Path Cache

The code server incorporates a code path cache. The cache functionality is disabled by default. To activate it, start the emulator with the command line flag `-code_path_cache` or call `code:rehash()`. When the cache is created (or updated), the code server searches for modules in the code path directories. This may take some time if the code path is long. After the cache creation, the time for loading modules in a large system (one with a large directory structure) is significantly reduced compared to having the cache disabled. The code server is able to look up the location of a module from the cache in constant time instead of having to search through the code path directories.

Application resource files (`.app` files) are also stored in the code path cache. This feature is used by the application controller (see `application(3)` [page 36]) to load applications efficiently in large systems.

Note that when the code path cache is created (or updated), any relative directory names in the code path are converted to absolute.

## Current and Old Code

The code of a module can exist in two variants in a system: *current code* and *old code*. When a module is loaded into the system for the first time, the code of the module becomes 'current' and the global *export table* is updated with references to all functions exported from the module.

If then a new instance of the module is loaded (perhaps because of the correction of an error), then the code of the previous instance becomes 'old', and all export entries referring to the previous instance are removed. After that the new instance is loaded as if it was loaded for the first time, as described above, and becomes 'current'.

Both old and current code for a module are valid, and may even be evaluated concurrently. The difference is that exported functions in old code are unavailable. Hence there is no way to make a global call to an exported function in old code, but old code may still be evaluated because of processes lingering in it.

If a third instance of the module is loaded, the code server will remove (purge) the old code and any processes lingering in it will be terminated. Then the third instance becomes 'current' and the previously current code becomes 'old'.

For more information about old and current code, and how to make a process switch from old to current code, refer to [Erlang Reference Manual].

## Argument Types and Invalid Arguments

Generally, module and application names are atoms, while file and directory names are strings. For backward compatibility reasons, some functions accept both strings and atoms, but a future release will probably only allow the arguments that are documented.

From the R12B release, functions in this module will generally fail with an exception if they are passed an incorrect type (for instance, an integer or a tuple where an atom was expected). An error tuple will be returned if type of argument was correct, but there was some other error (for instance, a non-existing directory given to `set_path/1`).

## Exports

`set_path(Path) -> true | {error, What}`

Types:

- Path = [Dir]
- Dir = string()
- What = bad\_directory | bad\_path

Sets the code path to the list of directories Path.

Returns true if successful, or {error, bad\_directory} if any Dir is not the name of a directory, or {error, bad\_path} if the argument is invalid.

`get_path() -> Path`

Types:

- Path = [Dir]
- Dir = string()

Returns the code path

`add_path(Dir) -> true | {error, What}`

`add_pathz(Dir) -> true | {error, What}`

Types:

- Dir = string()
- What = bad\_directory

Adds Dir to the code path. The directory is added as the last directory in the new path. If Dir already exists in the path, it is not added.

Returns true if successful, or {error, bad\_directory} if Dir is not the name of a directory.

`add_patha(Dir) -> true | {error, What}`

Types:

- Dir = string()
- What = bad\_directory

Adds `Dir` to the beginning of the code path. If `Dir` already exists, it is removed from the old position in the code path.

Returns `true` if successful, or `{error, bad_directory}` if `Dir` is not the name of a directory.

```
add_paths(Dirs) -> ok
```

```
add_pathsz(Dirs) -> ok
```

Types:

- `Dirs = [Dir]`
- `Dir = string()`

Adds the directories in `Dirs` to the end of the code path. If a `Dir` already exists, it is not added. This function always returns `ok`, regardless of the validity of each individual `Dir`.

```
add_pathsa(Dirs) -> ok
```

Types:

- `Dirs = [Dir]`
- `Dir = string()`

Adds the directories in `Dirs` to the beginning of the code path. If a `Dir` already exists, it is removed from the old position in the code path. This function always returns `ok`, regardless of the validity of each individual `Dir`.

```
del_path(Name | Dir) -> true | false | {error, What}
```

Types:

- `Name = atom()`
- `Dir = string()`
- `What = bad_name`

Deletes a directory from the code path. The argument can be an atom `Name`, in which case the directory with the name `.../Name[-Vsn] [/ebin]` is deleted from the code path. It is also possible to give the complete directory name `Dir` as argument.

Returns `true` if successful, or `false` if the directory is not found, or `{error, bad_name}` if the argument is invalid.

```
replace_path(Name, Dir) -> true | {error, What}
```

Types:

- `Name = atom()`
- `Dir = string()`
- `What = bad_name | bad_directory | {badarg, term()}`

This function replaces an old occurrence of a directory named `.../Name[-Vsn] [/ebin]`, in the code path, with `Dir`. If `Name` does not exist, it adds the new directory `Dir` last in the code path. The new directory must also be named `.../Name[-Vsn] [/ebin]`. This function should be used if a new version of the directory (library) is added to a running system.

Returns `true` if successful, or `{error, bad_name}` if `Name` is not found, or `{error, bad_directory}` if `Dir` does not exist, or `{error, {badarg, [Name, Dir]}}` if `Name` or `Dir` is invalid.

`load_file(Module) -> {module, Module} | {error, What}`

Types:

- `Module = atom()`
- `What = nofile | sticky_directory | badarg | term()`

Tries to load the Erlang module `Module`, using the code path. It looks for the object code file with an extension that corresponds to the Erlang machine used, for example `Module.beam`. The loading fails if the module name found in the object code differs from the name `Module`. `load_binary/3` [page 51] must be used to load object code with a module name that is different from the file name.

Returns `{module, Module}` if successful, or `{error, nofile}` if no object code is found, or `{error, sticky_directory}` if the object code resides in a sticky directory, or `{error, badarg}` if the argument is invalid. Also if the loading fails, an error tuple is returned. See `erlang:load_module/2` [page 114] for possible values of `What`.

`load_abs(Filename) -> {module, Module} | {error, What}`

Types:

- `Filename = string()`
- `Module = atom()`
- `What = nofile | sticky_directory | badarg | term()`

Does the same as `load_file(Module)`, but `Filename` is either an absolute file name, or a relative file name. The code path is not searched. It returns a value in the same way as `load_file/1` [page 51]. Note that `Filename` should not contain the extension (for example `".beam"`); `load_abs/1` adds the correct extension itself.

`ensure_loaded(Module) -> {module, Module} | {error, What}`

Types:

- `Module = atom()`
- `What = nofile | sticky_directory | embedded | badarg | term()`

Tries to to load a module in the same way as `load_file/1` [page 51], unless the module is already loaded. In embedded mode, however, it does not load a module which is not already loaded, but returns `{error, embedded}` instead.

`load_binary(Module, Filename, Binary) -> {module, Module} | {error, What}`

Types:

- `Module = atom()`
- `Filename = string()`
- `What = sticky_directory | badarg | term()`

This function can be used to load object code on remote Erlang nodes. It can also be used to load object code where the file name and module name differ. This, however, is a very unusual situation and not recommended. The parameter `Binary` must contain object code for `Module`. `Filename` is only used by the code server to keep a record of from which file the object code for `Module` comes. Accordingly, `Filename` is not opened and read by the code server.

Returns `{module, Module}` if successful, or `{error, sticky_directory}` if the object code resides in a sticky directory, or `{error, badarg}` if any argument is invalid. Also if the loading fails, an error tuple is returned. See `erlang:load_module/2` [page 114] for possible values of `What`.

`delete(Module) -> true | false`

Types:

- `Module = atom()`

Removes the current code for `Module`, that is, the current code for `Module` is made old. This means that processes can continue to execute the code in the module, but that no external function calls can be made to it.

Returns `true` if successful, or `false` if there is old code for `Module` which must be purged first, or if `Module` is not a (loaded) module.

`purge(Module) -> true | false`

Types:

- `Module = atom()`

Purges the code for `Module`, that is, removes code marked as old. If some processes still linger in the old code, these processes are killed before the code is removed.

Returns `true` if successful and any process needed to be killed, otherwise `false`.

`soft_purge(Module) -> true | false`

Types:

- `Module = atom()`

Purges the code for `Module`, that is, removes code marked as old, but only if no processes linger in it.

Returns `false` if the module could not be purged due to processes lingering in old code, otherwise `true`.

`is_loaded(Module) -> {file, Loaded} | false`

Types:

- `Module = atom()`
- `Loaded = Absname | preloaded | cover_compiled`
- `Absname = string()`

Checks if `Module` is loaded. If it is, `{file, Loaded}` is returned, otherwise `false`.

Normally, `Loaded` is the absolute file name `Absname` from which the code was obtained. If the module is preloaded (see [script(4)]), `Loaded==preloaded`. If the module is Cover compiled (see [cover(3)]), `Loaded==cover_compiled`.



`all_loaded()` -> [{Module, Loaded}]

Types:

- Module = atom()
- Loaded = Absname | preloaded | cover\_compiled
- Absname = string()

Returns a list of tuples {Module, Loaded} for all loaded modules. Loaded is normally the absolute file name, as described for `is_loaded/1` [page 52].

`which(Module)` -> Which

Types:

- Module = atom()
- Which = Filename | non\_existing | preloaded | cover\_compiled
- Filename = string()

If the module is not loaded, this function searches the code path for the first file which contains object code for Module and returns the absolute file name. If the module is loaded, it returns the name of the file which contained the loaded object code. If the module is pre-loaded, `preloaded` is returned. If the module is Cover compiled, `cover_compiled` is returned. `non_existing` is returned if the module cannot be found.

`get_object_code(Module)` -> {Module, Binary, Filename} | error

Types:

- Module = atom()
- Binary = binary()
- Filename = string()

Searches the code path for the object code of the module Module. It returns {Module, Binary, Filename} if successful, and error if not. Binary is a binary data object which contains the object code for the module. This can be useful if code is to be loaded on a remote node in a distributed system. For example, loading module Module on a node Node is done as follows:

```
...
{Module, Binary, Filename} = code:get_object_code(Module),
rpc:call(Node, code, load_binary, [Module, Filename, Binary]),
...
```

`root_dir()` -> string()

Returns the root directory of Erlang/OTP, which is the directory where it is installed.

```
> code:root_dir().
"/usr/local/otp"
```

`lib_dir()` -> string()

Returns the library directory, \$OTPROOT/lib, where \$OTPROOT is the root directory of Erlang/OTP.

```
> code:lib_dir().
"/usr/local/otp/lib"
```

```
lib_dir(Name) -> string() | {error, bad_name}
```

Types:

- Name = atom()

This function is mainly intended for finding out the path for the “library directory”, the top directory, for an application Name located under \$OTPROOT/lib.

If there is a directory called Name in the code path, optionally with a -Vsn suffix and/or an ebin subdirectory, the name of this directory is returned.

```
> code:lib_dir(mnesia).
"/usr/local/otp/lib/mnesia-4.2.2"
```

Returns {error, bad\_name} if Name is not the name of an application under \$OTPROOT/lib. Fails with an exception if Name has the wrong type.

### Warning:

For backward compatibility, Name is also allowed to be a string. That will probably change in a future release.

```
compiler_dir() -> string()
```

Returns the compiler library directory. Equivalent to code:lib\_dir(compiler).

```
priv_dir(Name) -> string() | {error, bad_name}
```

Types:

- Name = atom()

This function is mainly intended for finding out the path for the priv directory for an application Name located under \$OTPROOT/lib.

If there is a directory called Name in the code path, optionally with a -Vsn suffix and/or an ebin subdirectory, the function returns the name of this directory with priv appended. It is not checked if this directory really exists.

```
> code:priv_dir(mnesia).
"/usr/local/otp/lib/mnesia-4.2.2/priv"
```

Returns {error, bad\_name} if Name is not the name of an application under \$OTPROOT/lib. Fails with an exception if Name has the wrong type.

### Warning:

For backward compatibility, Name is also allowed to be a string. That will probably change in a future release.

```
objfile_extension() -> ".beam"
```

Returns the object code file extension that corresponds to the Erlang machine used, namely ".beam".

`stick_dir(Dir) -> ok | error`

Types:

- `Dir = string()`
- `What = term()`

This function marks `Dir` as sticky.

Returns `ok` if successful or `error` if not.

`unstick_dir(Dir) -> ok | error`

Types:

- `Dir = string()`
- `What = term()`

This function unsticks a directory which has been marked as sticky.

Returns `ok` if successful or `error` if not.

`rehash() -> ok`

This function creates or rehashes the code path cache.

`where_is_file(Filename) -> Absname | non_existing`

Types:

- `Filename = Absname = string()`

Searches the code path for `Filename`, a file of arbitrary type. If found, the full name is returned. `non_existing` is returned if the file cannot be found. The function can be useful, for example, to locate application resource files. If the code path cache is used, the code server will efficiently read the full name from the cache, provided that `Filename` is an object code file or an `.app` file.

`clash() -> ok`

Searches the entire code space for module names with identical names and writes a report to `stdout`.

# disk\_log

Erlang Module

`disk_log` is a disk based term logger which makes it possible to efficiently log items on files. Two types of logs are supported, *halt logs* and *wrap logs*. A halt log appends items to a single file, the size of which may or may not be limited by the disk log module, whereas a wrap log utilizes a sequence of wrap log files of limited size. As a wrap log file has been filled up, further items are logged onto to the next file in the sequence, starting all over with the first file when the last file has been filled up. For the sake of efficiency, items are always written to files as binaries.

Two formats of the log files are supported, the *internal format* and the *external format*. The internal format supports automatic repair of log files that have not been properly closed, and makes it possible to efficiently read logged items in *chunks* using a set of functions defined in this module. In fact, this is the only way to read internally formatted logs. The external format leaves it up to the user to read the logged deep byte lists. The disk log module cannot repair externally formatted logs. An item logged to an internally formatted log must not occupy more than 4 GB of disk space (the size must fit in 4 bytes).

For each open disk log there is one process that handles requests made to the disk log; the disk log process is created when `open/1` is called, provided there exists no process handling the disk log. A process that opens a disk log can either be an *owner* or an anonymous *user* of the disk log. Each owner is linked to the disk log process, and the disk log is closed by the owner should the owner terminate. Owners can subscribe to *notifications*, messages of the form `{disk_log, Node, Log, Info}` that are sent from the disk log process when certain events occur, see the commands below and in particular the `open/1` option `notify` [page 66]. There can be several owners of a log, but a process cannot own a log more than once. One and the same process may, however, open the log as a user more than once. For a disk log process to properly close its file and terminate, it must be closed by its owners and once by some non-owner process for each time the log was used anonymously; the users are counted, and there must not be any users left when the disk log process terminates.

Items can be logged *synchronously* by using the functions `log/2`, `blog/2`, `log_terms/2` and `blog_terms/2`. For each of these functions, the caller is put on hold until the items have been logged (but not necessarily written, use `sync/1` to ensure that). By adding an `a` to each of the mentioned function names we get functions that log items *asynchronously*. Asynchronous functions do not wait for the disk log process to actually write the items to the file, but return the control to the caller more or less immediately.

When using the internal format for logs, the functions `log/2`, `log_terms/2`, `alog/2`, and `alog_terms/2` should be used. These functions log one or more Erlang terms. By prefixing each of the functions with a `b` (for "binary") we get the corresponding `blog` functions for the external format. These functions log one or more deep lists of bytes or, alternatively, binaries of deep lists of bytes. For example, to log the string "hello" in ASCII format, we can use `disk_log:blog(Log, "hello")`, or `disk_log:blog(Log, list_to_binary("hello"))`. The two alternatives are equally efficient. The `blog`

functions can be used for internally formatted logs as well, but in this case they must be called with binaries constructed with calls to `term_to_binary/1`. There is no check to ensure this, it is entirely the responsibility of the caller. If these functions are called with binaries that do not correspond to Erlang terms, the `chunk/2,3` and automatic repair functions will fail. The corresponding terms (not the binaries) will be returned when `chunk/2,3` is called.

A collection of open disk logs with the same name running on different nodes is said to be a *distributed disk log* if requests made to any one of the logs are automatically made to the other logs as well. The members of such a collection will be called individual distributed disk logs, or just distributed disk logs if there is no risk of confusion. There is no order between the members of such a collection. For instance, logged terms are not necessarily written onto the node where the request was made before written onto the other nodes. One could note here that there are a few functions that do not make requests to all members of distributed disk logs, namely `info`, `chunk`, `bchunk`, `chunk_step` and `lclose`. An open disk log that is not a distributed disk log is said to be a *local disk log*. A local disk log is accessible only from the node where the disk log process runs, whereas a distributed disk log is accessible from all nodes in the Erlang system, with exception for those nodes where a local disk log with the same name as the distributed disk log exists. All processes on nodes that have access to a local or distributed disk log can log items or otherwise change, inspect or close the log.

It is not guaranteed that all log files of a distributed disk log contain the same log items; there is no attempt made to synchronize the contents of the files. However, as long as at least one of the involved nodes is alive at each time, all items will be logged. When logging items to a distributed log, or otherwise trying to change the log, the replies from individual logs are ignored. If all nodes are down, the disk log functions reply with a `nonode` error.

**Note:**

In some applications it may not be acceptable that replies from individual logs are ignored. An alternative in such situations is to use several local disk logs instead of one distributed disk log, and implement the distribution without use of the disk log module.

Errors are reported differently for asynchronous log attempts and other uses of the disk log module. When used synchronously the disk log module replies with an error message, but when called asynchronously, the disk log module does not know where to send the error message. Instead owners subscribing to notifications will receive an `error_status` message.

The disk log module itself does not report errors to the `error_logger` module; it is up to the caller to decide whether the error logger should be employed or not. The function `format_error/1` can be used to produce readable messages from error replies. Information events are however sent to the error logger in two situations, namely when a log is repaired, or when a file is missing while reading chunks.

The error message `no_such_log` means that the given disk log is not currently open. Nothing is said about whether the disk log files exist or not.

**Note:**

If an attempt to reopen or truncate a log fails (see `reopen` and `truncate`) the disk log process immediately terminates. Before the process terminates links to owners and blocking processes (see `block`) are removed. The effect is that the links work in one direction only; any process using a disk log has to check for the error message `no_such_log` if some other process might truncate or reopen the log simultaneously.

## Exports

```
accessible_logs() -> {[LocalLog], [DistributedLog]}
```

Types:

- LocalLog = DistributedLog = term()

The `accessible_logs/0` function returns the names of the disk logs accessible on the current node. The first list contains local disk logs, and the second list contains distributed disk logs.

```
alog(Log, Term)
```

```
balog(Log, Bytes) -> ok | {error, Reason}
```

Types:

- Log = term()
- Term = term()
- Bytes = binary() | [Byte]
- Byte = [Byte] | 0 =< integer() =< 255
- Reason = no\_such\_log

The `alog/2` and `balog/2` functions asynchronously append an item to a disk log. The function `alog/2` is used for internally formatted logs, and the function `balog/2` for externally formatted logs. `balog/2` can be used for internally formatted logs as well provided the binary was constructed with a call to `term_to_binary/1`.

The owners that subscribe to notifications will receive the message `read_only`, `blocked_log` or `format_external` in case the item cannot be written on the log, and possibly one of the messages `wrap`, `full` and `error_status` if an item was written on the log. The message `error_status` is sent if there is something wrong with the header function or a file error occurred.

```
alog_terms(Log, TermList)
```

```
balog_terms(Log, BytesList) -> ok | {error, Reason}
```

Types:

- Log = term()
- TermList = [term()]
- BytesList = [Bytes]
- Bytes = binary() | [Byte]
- Byte = [Byte] | 0 =< integer() =< 255
- Reason = no\_such\_log

The `alog_terms/2` and `balog_terms/2` functions asynchronously append a list of items to a disk log. The function `alog_terms/2` is used for internally formatted logs, and the function `balog_terms/2` for externally formatted logs. `balog_terms/2` can be used for internally formatted logs as well provided the binaries were constructed with calls to `term_to_binary/1`.

The owners that subscribe to notifications will receive the message `read_only`, `blocked_log` or `format_external` in case the items cannot be written on the log, and possibly one or more of the messages `wrap`, `full` and `error_status` if items were written on the log. The message `error_status` is sent if there is something wrong with the header function or a file error occurred.

`block(Log)`

`block(Log, QueueLogRecords) -> ok | {error, Reason}`

Types:

- `Log = term()`
- `QueueLogRecords = bool()`
- `Reason = no_such_log | nonode | {blocked_log, Log}`

With a call to `block/1, 2` a process can block a log. If the blocking process is not an owner of the log, a temporary link is created between the disk log process and the blocking process. The link is used to ensure that the disk log is unblocked should the blocking process terminate without first closing or unblocking the log.

Any process can probe a blocked log with `info/1` or close it with `close/1`. The blocking process can also use the functions `chunk/2, 3`, `bchunk/2, 3`, `chunk_step/3`, and `unblock/1` without being affected by the block. Any other attempt than those hitherto mentioned to update or read a blocked log suspends the calling process until the log is unblocked or returns an error message `{blocked_log, Log}`, depending on whether the value of `QueueLogRecords` is `true` or `false`. The default value of `QueueLogRecords` is `true`, which is used by `block/1`.

`change_header(Log, Header) -> ok | {error, Reason}`

Types:

- `Log = term()`
- `Header = {head, Head} | {head_func, {M,F,A}}`
- `Head = none | term() | binary() | [Byte]`
- `Byte = [Byte] | 0 =< integer() =< 255`
- `Reason = no_such_log | nonode | {read_only_mode, Log} | {blocked_log, Log} | {badarg, head}`

The `change_header/2` function changes the value of the `head` or `head_func` option of a disk log.

`change_notify(Log, Owner, Notify) -> ok | {error, Reason}`

Types:

- `Log = term()`
- `Owner = pid()`
- `Notify = bool()`
- `Reason = no_such_log | nonode | {blocked_log, Log} | {badarg, notify} | {not_owner, Owner}`

The `change_notify/3` function changes the value of the `notify` option for an owner of a disk log.

```
change_size(Log, Size) -> ok | {error, Reason}
```

Types:

- `Log = term()`
- `Size = integer() > 0 | infinity | {MaxNoBytes, MaxNoFiles}`
- `MaxNoBytes = integer() > 0`
- `MaxNoFiles = integer() > 0`
- `Reason = no_such_log | nonode | {read_only_mode, Log} | {blocked_log, Log} | {new_size_too_small, CurrentSize} | {badarg, size} | {file_error, FileName, FileError}`

The `change_size/2` function changes the size of an open log. For a halt log it is always possible to increase the size, but it is not possible to decrease the size to something less than the current size of the file.

For a wrap log it is always possible to increase both the size and number of files, as long as the number of files does not exceed 65000. If the maximum number of files is decreased, the change will not be valid until the current file is full and the log wraps to the next file. The redundant files will be removed next time the log wraps around, i.e. starts to log to file number 1.

As an example, assume that the old maximum number of files is 10 and that the new maximum number of files is 6. If the current file number is not greater than the new maximum number of files, the files 7 to 10 will be removed when file number 6 is full and the log starts to write to file number 1 again. Otherwise the files greater than the current file will be removed when the current file is full (e.g. if the current file is 8, the files 9 and 10); the files between new maximum number of files and the current file (i.e. files 7 and 8) will be removed next time file number 6 is full.

If the size of the files is decreased the change will immediately affect the current log. It will not of course change the size of log files already full until next time they are used.

If the log size is decreased for instance to save space, the function `inc_wrap_file/1` can be used to force the log to wrap.

```
chunk(Log, Continuation)
```

```
chunk(Log, Continuation, N) -> {Continuation2, Terms} | {Continuation2, Terms, Badbytes} | eof | {error, Reason}
```

```
bchunk(Log, Continuation)
```

```
bchunk(Log, Continuation, N) -> {Continuation2, Binaries} | {Continuation2, Binaries, Badbytes} | eof | {error, Reason}
```

Types:

- `Log = term()`
- `Continuation = start | cont()`
- `N = integer() > 0 | infinity`
- `Continuation2 = cont()`
- `Terms = [term()]`
- `Badbytes = integer()`
- `Reason = no_such_log | {format_external, Log} | {blocked_log, Log} | {badarg, continuation} | {not_internal_wrap, Log} | {corrupt_log_file, FileName} | {file_error, FileName, FileError}`



- Binaries = [binary()]

The `chunk/2,3` and `bchunk/2,3` functions make it possible to efficiently read the terms which have been appended to an internally formatted log. It minimizes disk I/O by reading 64 kilobyte chunks from the file. The `bchunk/2,3` functions return the binaries read from the file; they do not call `binary_to_term`. Otherwise the work just like `chunk/2,3`.

The first time `chunk` (or `bchunk`) is called, an initial continuation, the `atom start`, must be provided. If there is a disk log process running on the current node, terms are read from that log, otherwise an individual distributed log on some other node is chosen, if such a log exists.

When `chunk/3` is called, `N` controls the maximum number of terms that are read from the log in each chunk. Default is `infinity`, which means that all the terms contained in the 64 kilobyte chunk are read. If less than `N` terms are returned, this does not necessarily mean that the end of the file has been reached.

The `chunk` function returns a tuple `{Continuation2, Terms}`, where `Terms` is a list of terms found in the log. `Continuation2` is yet another continuation which must be passed on to any subsequent calls to `chunk`. With a series of calls to `chunk` it is possible to extract all terms from a log.

The `chunk` function returns a tuple `{Continuation2, Terms, Badbytes}` if the log is opened in read-only mode and the read chunk is corrupt. `Badbytes` is the number of bytes in the file which were found not to be Erlang terms in the chunk. Note also that the log is not repaired. When trying to read chunks from a log opened in read-write mode, the tuple `{corrupt_log_file, FileName}` is returned if the read chunk is corrupt.

`chunk` returns `eof` when the end of the log is reached, or `{error, Reason}` if an error occurs. Should a wrap log file be missing, a message is output on the error log.

When `chunk/2,3` is used with wrap logs, the returned continuation may or may not be valid in the next call to `chunk`. This is because the log may wrap and delete the file into which the continuation points. To make sure this does not happen, the log can be blocked during the search.

```
chunk_info(Continuation) -> InfoList | {error, Reason}
```

Types:

- Continuation = cont()
- Reason = {no\_continuation, Continuation}

The `chunk_info/1` function returns the following pair describing the chunk continuation returned by `chunk/2,3`, `bchunk/2,3`, or `chunk_step/3`:

- {node, Node}. Terms are read from the disk log running on Node.

```
chunk_step(Log, Continuation, Step) -> {ok, Continuation2} | {error, Reason}
```

Types:

- Log = term()
- Continuation = start | cont()
- Step = integer()
- Continuation2 = cont()

- Reason = no\_such\_log | end\_of\_log | {format\_external, Log} | {blocked\_log, Log} | {badarg, continuation} | {file\_error, FileName, FileError}

The function `chunk_step` can be used in conjunction with `chunk/2,3` and `bchunk/2,3` to search through an internally formatted wrap log. It takes as argument a continuation as returned by `chunk/2,3`, `bchunk/2,3`, or `chunk_step/3`, and steps forward (or backward) Step files in the wrap log. The continuation returned points to the first log item in the new current file.

If the atom `start` is given as continuation, a disk log to read terms from is chosen. A local or distributed disk log on the current node is preferred to an individual distributed log on some other node.

If the wrap log is not full because all files have not been used yet, `{error, end_of_log}` is returned if trying to step outside the log.

`close(Log) -> ok | {error, Reason}`

Types:

- Reason = no\_such\_log | nonode | {file\_error, FileName, FileError}

The function `close/1` closes a local or distributed disk log properly. An internally formatted log must be closed before the Erlang system is stopped, otherwise the log is regarded as unclosed and the automatic repair procedure will be activated next time the log is opened.

The disk log process is not terminated as long as there are owners or users of the log. It should be stressed that each and every owner must close the log, possibly by terminating, and that any other process - not only the processes that have opened the log anonymously - can decrement the users counter by closing the log. Attempts to close a log by a process that is not an owner are simply ignored if there are no users.

If the log is blocked by the closing process, the log is also unblocked.

`format_error(Error) -> Chars`

Types:

- Chars = [char() | Chars]

Given the error returned by any function in this module, the function `format_error` returns a descriptive string of the error in English. For file errors, the function `format_error/1` in the `file` module is called.

`inc_wrap_file(Log) -> ok | {error, Reason}`

Types:

- Reason = no\_such\_log | nonode | {read\_only\_mode, Log} | {blocked\_log, Log} | {halt\_log, Log} | {invalid\_header, InvalidHeader} | {file\_error, FileName, FileError}

The `inc_wrap_file/1` function forces the internally formatted disk log to start logging to the next log file. It can be used, for instance, in conjunction with `change_size/2` to reduce the amount of disk space allocated by the disk log.

The owners that subscribe to notifications will normally receive a `wrap` message, but in case of an error with a reason tag of `invalid_header` or `file_error` an `error_status` message will be sent.

`info(Log) -> InfoList | {error, no_such_log}`

The `info/1` function returns a list of `{Tag, Value}` pairs describing the log. If there is a disk log process running on the current node, that log is used as source of information, otherwise an individual distributed log on some other node is chosen, if such a log exists.

The following pairs are returned for all logs:

- `{name, Log}`, where `Log` is the name of the log as given by the `open/1` option name.
- `{file, File}`. For halt logs `File` is the filename, and for wrap logs `File` is the base name.
- `{type, Type}`, where `Type` is the type of the log as given by the `open/1` option type.
- `{format, Format}`, where `Format` is the format of the log as given by the `open/1` option format.
- `{size, Size}`, where `Size` is the size of the log as given by the `open/1` option size, or the size set by `change_size/2`. The value set by `change_size/2` is reflected immediately.
- `{mode, Mode}`, where `Mode` is the mode of the log as given by the `open/1` option mode.
- `{owners, [{pid(), Notify}]}` where `Notify` is the value set by the `open/1` option `notify` or the function `change_notify/3` for the owners of the log.
- `{users, Users}` where `Users` is the number of anonymous users of the log, see the `open/1` option linkto [page 66].
- `{status, Status}`, where `Status` is `ok` or `{blocked, QueueLogRecords}` as set by the functions `block/1,2` and `unblock/1`.
- `{node, Node}`. The information returned by the current invocation of the `info/1` function has been gathered from the disk log process running on `Node`.
- `{distributed, Dist}`. If the log is local on the current node, then `Dist` has the value `local`, otherwise all nodes where the log is distributed are returned as a list.

The following pairs are returned for all logs opened in `read_write` mode:

- `{head, Head}`. Depending of the value of the `open/1` options `head` and `head_func` or set by the function `change_header/2`, the value of `Head` is `none` (default), `{head, H}` (head option) or `{M,F,A}` (`head_func` option).
- `{no_written_items, NoWrittenItems}`, where `NoWrittenItems` is the number of items written to the log since the disk log process was created.

The following pair is returned for halt logs opened in `read_write` mode:

- `{full, Full}`, where `Full` is `true` or `false` depending on whether the halt log is full or not.

The following pairs are returned for wrap logs opened in `read_write` mode:

- `{no_current_bytes, integer() >= 0}` is the number of bytes written to the current wrap log file.
- `{no_current_items, integer() >= 0}` is the number of items written to the current wrap log file, header inclusive.
- `{no_items, integer() >= 0}` is the total number of items in all wrap log files.

- `{current_file, integer()}` is the ordinal for the current wrap log file in the range `1..MaxNoFiles`, where `MaxNoFiles` is given by the `open/1` option size or set by `change_size/2`.
- `{no_overflows, {SinceLogWasOpened, SinceLastInfo}}`, where `SinceLogWasOpened` (`SinceLastInfo`) is the number of times a wrap log file has been filled up and a new one opened or `inc_wrap_file/1` has been called since the disk log was last opened (`info/1` was last called). The first time `info/2` is called after a log was (re)opened or truncated, the two values are equal.

Note that the `chunk/2,3`, `bchunk/2,3`, and `chunk_step/3` functions do not affect any value returned by `info/1`.

`lclose(Log)`

`lclose(Log, Node) -> ok | {error, Reason}`

Types:

- `Node = node()`
- `Reason = no_such_log | {file_error, FileName, FileError}`

The function `lclose/1` closes a local log or an individual distributed log on the current node. The function `lclose/2` closes an individual distributed log on the specified node if the node is not the current one. `lclose(Log)` is equivalent to `lclose(Log, node())`. See also `close/1` [page 62].

If there is no log with the given name on the specified node, `no_such_log` is returned.

`log(Log, Term)`

`blog(Log, Bytes) -> ok | {error, Reason}`

Types:

- `Log = term()`
- `Term = term()`
- `Bytes = binary() | [Byte]`
- `Byte = [Byte] | 0 =< integer() =< 255`
- `Reason = no_such_log | nonode | {read_only_mode, Log} | {format_external, Log} | {blocked_log, Log} | {full, Log} | {invalid_header, InvalidHeader} | {file_error, FileName, FileError}`

The `log/2` and `blog/2` functions synchronously append a term to a disk log. They return `ok` or `{error, Reason}` when the term has been written to disk. If the log is distributed, `ok` is always returned, unless all nodes are down. Terms are written by means of the ordinary `write()` function of the operating system. Hence, there is no guarantee that the term has actually been written to the disk, it might linger in the operating system kernel for a while. To make sure the item is actually written to disk, the `sync/1` function must be called.

The `log/2` function is used for internally formatted logs, and `blog/2` for externally formatted logs. `blog/2` can be used for internally formatted logs as well provided the binary was constructed with a call to `term_to_binary/1`.

The owners that subscribe to notifications will be notified of an error with an `error_status` message if the error reason tag is `invalid_header` or `file_error`.

`log_terms(Log, TermList)`

`blog_terms(Log, BytesList) -> ok | {error, Reason}`

Types:

- `Log = term()`
- `TermList = [term()]`
- `BytesList = [Bytes]`
- `Bytes = binary() | [Byte]`
- `Byte = [Byte] | 0 =< integer() =< 255`
- `Reason = no_such_log | nonode | {read_only_mode, Log} | {format_external, Log} | {blocked_log, Log} | {full, Log} | {invalid_header, InvalidHeader} | {file_error, FileName, FileError}`

The `log_terms/2` and `blog_terms/2` functions synchronously append a list of items to the log. The benefit of using these functions rather than the `log/2` and `blog/2` functions is that of efficiency: the given list is split into as large sublists as possible (limited by the size of wrap log files), and each sublist is logged as one single item, which reduces the overhead.

The `log_terms/2` function is used for internally formatted logs, and `blog_terms/2` for externally formatted logs. `blog_terms/2` can be used for internally formatted logs as well provided the binaries were constructed with calls to `term_to_binary/1`.

The owners that subscribe to notifications will be notified of an error with an `error_status` message if the error reason tag is `invalid_header` or `file_error`.

`open(ArgL) -> OpenRet | DistOpenRet`

Types:

- `ArgL = [Opt]`
- `Opt = {name, term()} | {file, FileName}, {linkto, LinkTo} | {repair, Repair} | {type, Type} | {format, Format} | {size, Size} | {distributed, [Node]} | {notify, bool()} | {head, Head} | {head_func, {M,F,A}} | {mode, Mode}`
- `FileName = string() | atom()`
- `LinkTo = pid() | none`
- `Repair = true | false | truncate`
- `Type = halt | wrap`
- `Format = internal | external`
- `Size = integer() > 0 | infinity | {MaxNoBytes, MaxNoFiles}`
- `MaxNoBytes = integer() > 0`
- `MaxNoFiles = 0 < integer() < 65000`
- `Rec = integer()`
- `Bad = integer()`
- `Head = none | term() | binary() | [Byte]`
- `Byte = [Byte] | 0 =< integer() =< 255`
- `Mode = read_write | read_only`
- `OpenRet = Ret | {error, Reason}`
- `DistOpenRet = {[{Node, Ret}], [{BadNode, {error, DistReason}}]}`
- `Node = BadNode = atom()`
- `Ret = {ok, Log} | {repaired, Log, {recovered, Rec}, {badbytes, Bad}}`
- `DistReason = nodedown | Reason`

- Reason = no\_such\_log | {badarg, Arg} | {size\_mismatch, CurrentSize, NewSize} | {arg\_mismatch, OptionName, CurrentValue, Value} | {name\_already\_open, Log} | {open\_read\_write, Log} | {open\_read\_only, Log} | {need\_repair, Log} | {not\_a\_log\_file, FileName} | {invalid\_index\_file, FileName} | {invalid\_header, InvalidHeader} | {file\_error, FileName, FileError} | {node\_already\_open, Log}

The ArgL parameter is a list of options which have the following meanings:

- {name, Log} specifies the name of the log. This is the name which must be passed on as a parameter in all subsequent logging operations. A name must always be supplied.
- {file, FileName} specifies the name of the file which will be used for logged terms. If this value is omitted and the name of the log is either an atom or a string, the file name will default to `lists:concat([Log, ".LOG"])` for halt logs. For wrap logs, this will be the base name of the files. Each file in a wrap log will be called `<base_name>.N`, where N is an integer. Each wrap log will also have two files called `<base_name>.idx` and `<base_name>.siz`.
- {linkto, LinkTo}. If LinkTo is a pid, that pid becomes an owner of the log. If LinkTo is none the log records that it is used anonymously by some process by incrementing the users counter. By default, the process which calls `open/1` owns the log.
- {repair, Repair}. If Repair is true, the current log file will be repaired, if needed. As the restoration is initiated, a message is output on the error log. If false is given, no automatic repair will be attempted. Instead, the tuple {error, {need\_repair, Log}} is returned if an attempt is made to open a corrupt log file. If truncate is given, the log file will be truncated, creating an empty log. Default is true, which has no effect on logs opened in read-only mode.
- {type, Type} is the type of the log. Default is halt.
- {format, Format} specifies the format of the disk log. Default is internal.
- {size, Size} specifies the size of the log. When a halt log has reached its maximum size, all attempts to log more items are rejected. The default size is infinity, which for halt implies that there is no maximum size. For wrap logs, the Size parameter may be either a pair {MaxNoBytes, MaxNoFiles} or infinity. In the latter case, if the files of an already existing wrap log with the same name can be found, the size is read from the existing wrap log, otherwise an error is returned. Wrap logs write at most MaxNoBytes bytes on each file and use MaxNoFiles files before starting all over with the first wrap log file. Regardless of MaxNoBytes, at least the header (if there is one) and one item is written on each wrap log file before wrapping to the next file. When opening an existing wrap log, it is not necessary to supply a value for the option Size, but any supplied value must equal the current size of the log, otherwise the tuple {error, {size\_mismatch, CurrentSize, NewSize}} is returned.
- {distributed, Nodes}. This option can be used for adding members to a distributed disk log. The default value is [], which means that the log is local on the current node.
- {notify, bool()}. If true, the owners of the log are notified when certain events occur in the log. Default is false. The owners are sent one of the following messages when an event occurs:
  - {disk\_log, Node, Log, {wrap, NoLostItems}} is sent when a wrap log has filled up one of its files and a new file is opened. NoLostItems is the number of previously logged items that have been lost when truncating existing files.

- `{disk_log, Node, Log, {truncated, NoLostItems}}` is sent when a log has been truncated or reopened. For halt logs `NoLostItems` is the number of items written on the log since the disk log process was created. For wrap logs `NoLostItems` is the number of items on all wrap log files.
- `{disk_log, Node, Log, {read_only, Items}}` is sent when an asynchronous log attempt is made to a log file opened in read-only mode. `Items` is the items from the log attempt.
- `{disk_log, Node, Log, {blocked_log, Items}}` is sent when an asynchronous log attempt is made to a blocked log that does not queue log attempts. `Items` is the items from the log attempt.
- `{disk_log, Node, Log, {format_external, Items}}` is sent when `alog/2` or `alog_terms/2` is used for internally formatted logs. `Items` is the items from the log attempt.
- `{disk_log, Node, Log, full}` is sent when an attempt to log items to a wrap log would write more bytes than the limit set by the `size` option.
- `{disk_log, Node, Log, {error_status, Status}}` is sent when the error status changes. The error status is defined by the outcome of the last attempt to log items to a the log or to truncate the log or the last use of `sync/1`, `inc_wrap_file/1` or `change_size/2`. `Status` is one of `ok` and `{error, Error}`, the former being the initial value.
- `{head, Head}` specifies a header to be written first on the log file. If the log is a wrap log, the item `Head` is written first in each new file. `Head` should be a term if the format is `internal`, and a deep list of bytes (or a binary) otherwise. Default is `none`, which means that no header is written first on the file.
- `{head_func, {M,F,A}}` specifies a function to be called each time a new log file is opened. The call `M:F(A)` is assumed to return `{ok, Head}`. The item `Head` is written first in each file. `Head` should be a term if the format is `internal`, and a deep list of bytes (or a binary) otherwise.
- `{mode, Mode}` specifies if the log is to be opened in read-only or read-write mode. It defaults to `read_write`.

The `open/1` function returns `{ok, Log}` if the log file was successfully opened. If the file was successfully repaired, the tuple `{repaired, Log, {recovered, Rec}, {badbytes, Bad}}` is returned, where `Rec` is the number of whole Erlang terms found in the file and `Bad` is the number of bytes in the file which were non-Erlang terms. If the `distributed` parameter was given, `open/1` returns a list of successful replies and a list of erroneous replies. Each reply is tagged with the node name.

When a disk log is opened in read-write mode, any existing log file is checked for. If there is none a new empty log is created, otherwise the existing file is opened at the position after the last logged item, and the logging of items will commence from there. If the format is `internal` and the existing file is not recognized as an internally formatted log, a tuple `{error, {not_a_log_file, FileName}}` is returned.

The `open/1` function cannot be used for changing the values of options of an already open log; when there are prior owners or users of a log, all option values except `name`, `linkto` and `notify` are just checked against the values that have been supplied before as option values to `open/1`, `change_header/2`, `change_notify/3` or `change_size/2`. As a consequence, none of the options except `name` is mandatory. If some given value differs from the current value, a tuple `{error, {arg_mismatch, OptionName, CurrentValue, Value}}` is returned. Caution: an owner's attempt to open a log as owner once again is acknowledged with the return value `{ok, Log}`, but the state of the disk log is not affected in any way.

If a log with a given name is local on some node, and one tries to open the log distributed on the same node, then the tuple `{error, {node_already_open, Name}}` is returned. The same tuple is returned if the log is distributed on some node, and one tries to open the log locally on the same node. Opening individual distributed disk logs for the first time adds those logs to a (possibly empty) distributed disk log. The option values supplied are used on all nodes mentioned by the `distributed` option. Individual distributed logs know nothing about each other's option values, so each node can be given unique option values by creating a distributed log with several calls to `open/1`.

It is possible to open a log file more than once by giving different values to the option name or by using the same file when distributing a log on different nodes. It is up to the user of the `disk_log` module to ensure that no more than one disk log process has write access to any file, or the file may be corrupted.

If an attempt to open a log file for the first time fails, the disk log process terminates with the EXIT message `{{failed, Reason}, [{disk_log, open, 1}]}`. The function returns `{error, Reason}` for all other errors.

```
pid2name(Pid) -> {ok, Log} | undefined
```

Types:

- Log = term()
- Pid = pid()

The `pid2name/1` function returns the name of the log given the pid of a disk log process on the current node, or `undefined` if the given pid is not a disk log process.

This function is meant to be used for debugging only.

```
reopen(Log, File)
```

```
reopen(Log, File, Head)
```

```
breopen(Log, File, BHead) -> ok | {error, Reason}
```

Types:

- Log = term()
- File = string()
- Head = term()
- BHead = binary() | [Byte]
- Byte = [Byte] | 0 =< integer() =< 255
- Reason = no\_such\_log | nonode | {read\_only\_mode, Log} | {blocked\_log, Log} | {same\_file\_name, Log} | {invalid\_index\_file, FileName} | {invalid\_header, InvalidHeader} | {file\_error, FileName, FileError}

The `reopen` functions first rename the log file to `File` and then re-create a new log file. In case of a wrap log, `File` is used as the base name of the renamed files. By default the header given to `open/1` is written first in the newly opened log file, but if the `Head` or the `BHead` argument is given, this item is used instead. The header argument is used once only; next time a wrap log file is opened, the header given to `open/1` is used.

The `reopen/2,3` functions are used for internally formatted logs, and `breopen/3` for externally formatted logs.

The owners that subscribe to notifications will receive a `truncate` message.

Upon failure to reopen the log, the disk log process terminates with the EXIT message `{{failed, Error}, [{disk_log, Fun, Arity}]}`, and other processes that have requests queued receive the message `{disk_log, Node, {error, disk_log_stopped}}`.



`sync(Log) -> ok | {error, Reason}`

Types:

- `Log = term()`
- `Reason = no_such_log | nonode | {read_only_mode, Log} | {blocked_log, Log} | {file_error, FileName, FileError}`

The `sync/1` function ensures that the contents of the log are actually written to the disk. This is usually a rather expensive operation.

`truncate(Log)`

`truncate(Log, Head)`

`btruncate(Log, BHead) -> ok | {error, Reason}`

Types:

- `Log = term()`
- `Head = term()`
- `BHead = binary() | [Byte]`
- `Byte = [Byte] | 0 =< integer() =< 255`
- `Reason = no_such_log | nonode | {read_only_mode, Log} | {blocked_log, Log} | {invalid_header, InvalidHeader} | {file_error, FileName, FileError}`

The `truncate` functions remove all items from a disk log. If the `Head` or the `BHead` argument is given, this item is written first in the newly truncated log, otherwise the header given to `open/1` is used. The header argument is only used once; next time a wrap log file is opened, the header given to `open/1` is used.

The `truncate/1,2` functions are used for internally formatted logs, and `btruncate/2` for externally formatted logs.

The owners that subscribe to notifications will receive a `truncate` message.

If the attempt to truncate the log fails, the disk log process terminates with the `EXIT` message `{{failed, Reason}, [{disk_log, Fun, Arity}]}`, and other processes that have requests queued receive the message `{disk_log, Node, {error, disk_log_stopped}}`.

`unlock(Log) -> ok | {error, Reason}`

Types:

- `Log = term()`
- `Reason = no_such_log | nonode | {not_blocked, Log} | {not_blocked_by_pid, Log}`

The `unlock/1` function unblocks a log. A log can only be unblocked by the blocking process.

## See Also

`file(3)` [page 176], `pg2(3)` [page 264], `wrap_log_reader(3)` [page 283]

# erl\_boot\_server

Erlang Module

This server is used to assist diskless Erlang nodes which fetch all Erlang code from another machine.

This server is used to fetch all code, including the start script, if an Erlang runtime system is started with the `-loader inet` command line flag. All hosts specified with the `-hosts Host` command line flag must have one instance of this server running.

This server can be started with the `kernel` configuration parameter `start_boot_server`.

## Exports

```
start(Slaves) -> {ok, Pid} | {error, What}
```

Types:

- Slaves = [Host]
- Host = atom()
- Pid = pid()
- What = term()

Starts the boot server. `Slaves` is a list of IP addresses for hosts which are allowed to use this server as a boot server.

```
start_link(Slaves) -> {ok, Pid} | {error, What}
```

Types:

- Slaves = [Host]
- Host = atom()
- Pid = pid()
- What = term()

Starts the boot server and links to the caller. This function is used to start the server if it is included in a supervision tree.

```
add_slave(Slave) -> ok | {error, What}
```

Types:

- Slave = Host
- Host = atom()
- What = term()

Adds a `Slave` node to the list of allowed slave hosts.

```
delete_slave(Slave) -> ok | {error, What}
```

Types:

- Slave = Host
- Host = atom()
- What = void()

Deletes a Slave node from the list of allowed slave hosts.

`which_slaves()` -> Slaves

Types:

- Slaves = [Host]
- Host = atom()

Returns the current list of allowed slave hosts.

## SEE ALSO

`init(3)` [page 246], `erl_prim_loader(3)` [page 87]

# erl\_ddll

## Erlang Module

The `erl_ddll` module provides an interface for loading and unloading *erlang linked in drivers* in runtime.

### Note:

This is a large reference document. For casual use of the module, as well as for most real world applications, the descriptions of the functions `load/2` [page 75] and `unload/1` [page 85] are enough to get going.

The driver should be provided as a dynamically linked library in a object code format specific for the platform in use, i. e. `.so` files on most Unix systems and `.ddl` files on windows. An erlang linked in driver has to provide specific interfaces to the emulator, so this module is not designed for loading arbitrary dynamic libraries. For further information about erlang drivers, refer to the ERTS reference manual section [erl\_driver].

When describing a set of functions, (i.e. a module, a part of a module or an application) executing in a process and wanting to use a `ddl`-driver, we use the term *user*. There can be several users in one process (different modules needing the same driver) and several processes running the same code, making up several *users* of a driver. In the basic scenario, each user loads the driver before starting to use it and unloads the driver when done. The reference counting keeps track of processes as well as the number of loads by each process, so that the driver will only be unloaded when no one wants it (it has no user). The driver also keeps track of ports that are opened towards it, so that one can delay unloading until all ports are closed or kill all ports using the driver when it is unloaded.

The interface supports two basic scenarios of loading and unloading. Each scenario can also have the option of either killing ports when the driver is unloading, or waiting for the ports to close themselves. The scenarios are:

**Load and unload on a “when needed basis”** This (most common) scenario simply supports that each user [page 72] of the driver loads it when it is needed and unloads it when the user [page 72] no longer have any use for it. The driver is always reference counted and as long as a process keeping the driver loaded is still alive, the driver is present in the system.

Each user [page 72] of the driver use *literally* the same pathname for the driver when demanding load, but the users [page 72] are not really concerned with if the driver is already loaded from the filesystem or if the object code has to be loaded from filesystem.

Two pairs of functions support this scenario:

***load/2 and unload/1*** When using the `load/unload` interfaces, the driver will not *actually* get unloaded until the *last port* using the driver is closed. The function `unload/1` can return immediately, as the users [page 72] are not really concerned with when the actual unloading occurs. The driver will actually get unloaded when no one needs it any longer.

If a process having the driver loaded dies, it will have the same effect as if unloading was done.

When loading, the function `load/2` returns `ok` as soon as there is any instance of the driver present, so that if a driver is waiting to get unloaded (due to open ports), it will simply change state to no longer need unloading.

***load\_driver/2 and unload\_driver/1*** These interfaces is intended to be used when it is considered an error that ports are open towards a driver that no user [page 72] has loaded. The ports still open when the last user [page 72] calls `unload_driver/1` or when the last process having the driver loaded dies, will get killed with reason `driver_unloaded`.

The function names `load_driver` and `unload_driver` are kept for backward compatibility.

***Loading and reloading for code replacement*** This scenario occurs when the driver code might need replacement during operation of the Erlang emulator. Implementing driver code replacement is somewhat more tedious than beam code replacement, as one driver cannot be loaded as both “old” and “new” code. All users [page 72] of a driver must have it closed (no open ports) before the old code can be unloaded and the new code can be loaded.

The actual unloading/loading is done as one atomic operation, blocking all processes in the system from using the driver concerned while in progress.

The preferred way to do driver code replacement is to let *one single process* keep track of the driver. When the process start, the driver is loaded. When replacement is required, the driver is reloaded. Unload is probably never done, or done when the process exits. If more than one user [page 72] has a driver loaded when code replacement is demanded, the replacement cannot occur until the last “other” user [page 72] has unloaded the driver.

Demanding reload when a reload is already in progress is always an error. Using the high level functions, it is also an error to demand reloading when more than one user [page 72] has the driver loaded. To simplify driver replacement, avoid designing your system so that more than than one user [page 72] has the driver loaded.

The two functions for reloading drivers should be used together with corresponding load functions, to support the two different behaviors concerning open ports:

***load/2 and reload/2*** This pair of functions is used when reloading should be done after the last open port towards the driver is closed.

As `reload/2` actually waits for the reloading to occur, a misbehaving process keeping open ports towards the driver (or keeping the driver loaded) might cause infinite waiting for reload. Timeouts has to be provided outside of the process demanding the reload or by using the low-level interface `try_load/3` [page 80] in combination with driver monitors (see below).

***load\_driver/2 and reload\_driver/2*** This pair of functions are used when open ports towards the driver should be killed with reason `driver_unloaded` to allow for new driver code to get loaded.

If, however, another process has the driver loaded, calling `reload_driver` returns the error code `pending_process`. As stated earlier, the recommended

design is to not allow other users [page 72] than the “driver reloader” to actually demand loading of the concerned driver.

## Exports

`demonitor(MonitorRef) -> ok`

Types:

- `MonitorRef = ref()`

Removes a driver monitor in much the same way as `erlang:demonitor/1` [page 98] does with process monitors. See `monitor/2` [page 77], `try_load/3` [page 80] and `try_unload/2` [page 83] for details about how to create driver monitors.

The function throws a `badarg` exception if the parameter is not a `ref()`.

`info() -> AllInfoList`

Types:

- `AllInfoList = [ DriverInfo ]`
- `DriverInfo = {DriverName, InfoList}`
- `DriverName = string()`
- `InfoList = [ InfoItem ]`
- `InfoItem = {Tag, Value}`
- `Tag = atom()`
- `Value = term()`

Returns a list of tuples `{DriverName, InfoList}`, where `InfoList` is the result of calling `info/1` [page 74] for that `DriverName`. Only dynamically linked in drivers are included in the list.

`info(Name) -> InfoList`

Types:

- `Name = string() | atom()`
- `InfoList = [ InfoItem ]`
- `InfoItem = {Tag, Value}`
- `Tag = atom()`
- `Value = term()`

Returns a list of tuples `{Tag, Value}`, where `Tag` is the information item and `Value` is the result of calling `info/2` [page 75] with this driver name and this tag. The result being a tuple list containing all information available about a driver.

The different tags that will appear in the list are:

- `processes`
- `driver_options`
- `port_count`
- `linked_in_driver`
- `permanent`

- awaiting\_load
- awaiting\_unload

For a detailed description of each value, please read the description of `info/2` [page 75] below.

The function throws a `badarg` exception if the driver is not present in the system.

`info(Name, Tag) -> Value`

Types:

- Name = `string()` | `atom()`
- Tag = `processes` | `driver_options` | `port_count` | `linked_in_driver` | `permanent` | `awaiting_load` | `awaiting_unload`
- Value = `term()`

This function returns specific information about one aspect of a driver. The `Tag` parameter specifies which aspect to get information about. The `Value` return differs between different tags:

***processes*** Return all processes containing users [page 72] of the specific drivers as a list of tuples `{pid(), int()}`, where the `int()` denotes the number of users in the process `pid()`.

***driver\_options*** Return a list of the driver options provided when loading, as well as any options set by the driver itself during initialization. The currently only valid option being `kill_ports`.

***port\_count*** Return the number of ports (an `int()`) using the driver.

***linked\_in\_driver*** Return a `bool()`, being `true` if the driver is a statically linked in one and `false` otherwise.

***permanent*** Return a `bool()`, being `true` if the driver has made itself permanent (and is *not* a statically linked in driver). `false` otherwise.

***awaiting\_load*** Return a list of all processes having monitors for loading active, each process returned as `{pid(), int()}`, where the `int()` is the number of monitors held by the process `pid()`.

***awaiting\_unload*** Return a list of all processes having monitors for unloading active, each process returned as `{pid(), int()}`, where the `int()` is the number of monitors held by the process `pid()`.

If the options `linked_in_driver` or `permanent` return `true`, all other options will return the value `linked_in_driver` or `permanent` respectively.

The function throws a `badarg` exception if the driver is not present in the system or the tag is not supported.

`load(Path, Name) -> ok | {error, ErrorDesc}`

Types:

- Path = Name = `string()` | `atom()`
- ErrorDesc = `term()`

Loads and links the dynamic driver `Name`. `Path` is a file path to the directory containing the driver. `Name` must be a sharable object/dynamic library. Two drivers with different `Path` parameters cannot be loaded under the same name. The `Name` is a string or atom containing at least one character.

The `Name` given should correspond to the filename of the actual dynamically loadable object file residing in the directory given as `Path`, but *without* the extension (i.e. `.so`). The driver name provided in the driver initialization routine must correspond with the filename, in much the same way as erlang module names correspond to the names of the `.beam` files.

If the driver has been previously unloaded, but is still present due to open ports against it, a call to `load/2` will stop the unloading and keep the driver (as long as the `Path` is the same) and `ok` is returned. If one actually wants the object code to be reloaded, one uses `reload/2` [page 78] or the low-level interface `try_load/3` [page 80] instead. Please refer to the description of different scenarios [page 72] for loading/unloading in the introduction.

If more than one process tries to load an already loaded driver with the same `Path`, or if the same process tries to load it several times, the function will return `ok`. The emulator will keep track of the `load/2` calls, so that a corresponding number of `unload/2` calls will have to be done from the same process before the driver will actually get unloaded. It is therefore safe for an application to load a driver that is shared between processes or applications when needed. It can safely be unloaded without causing trouble for other parts of the system.

It is not allowed to load several drivers with the same name but with different `Path` parameters.

#### Note:

Note especially that the `Path` is interpreted literally, so that all loaders of the same driver needs to give the same *literal*`Path` string, even though different paths might point out the same directory in the filesystem (due to use of relative paths and links).

On success, the function returns `ok`. On failure, the return value is `{error, ErrorDesc}`, where `ErrorDesc` is an opaque term to be translated into human readable form by the `format_error/1` [page 86] function.

For more control over the error handling, again use the `try_load/3` [page 80] interface instead.

The function throws a `badarg` exception if the parameters are not given as described above.

```
load_driver(Path, Name) -> ok | {error, ErrorDesc}
```

Types:

- `Path = Name = string() | atom()`
- `ErrorDesc = term()`



Works essentially as `load/2`, but will load the driver with options other options. All ports that are using the driver will get killed with the reason `driver_unloaded` when the driver is to be unloaded.

The number of loads and unloads by different users [page 72] influence the actual loading and unloading of a driver file. The port killing will therefore only happen when the *lastuser* [page 72] unloads the driver, or the last process having loaded the driver exits.

This interface (or at least the name of the functions) is kept for backward compatibility. Using `try_load/3` [page 80] with `{driver_options, [kill_ports]}` in the option list will give the same effect regarding the port killing.

The function throws a `badarg` exception if the parameters are not given as described above.

```
monitor(Tag, Item) -> MonitorRef
```

Types:

- Tag = driver
- Item = {Name, When}
- Name = atom() | string()
- When = loaded | unloaded | unloaded\_only
- MonitorRef = ref()

This function creates a driver monitor and works in many ways as the function `erlang:monitor/2` [page 119], does for processes. When a driver changes state, the monitor results in a monitor-message being sent to the calling process. The `MonitorRef` returned by this function is included in the message sent.

As with process monitors, each driver monitor set will only generate *one single message*. The monitor is “destroyed” after the message is sent and there is then no need to call `demonitor/1` [page 74].

The `MonitorRef` can also be used in subsequent calls to `demonitor/1` [page 74] to remove a monitor.

The function accepts the following parameters:

**Tag** The monitor tag is always `driver` as this function can only be used to create driver monitors. In the future, driver monitors will be integrated with process monitors, why this parameter has to be given for consistence.

**Item** The `Item` parameter specifies which driver one wants to monitor (the name of the driver) as well as which state change one wants to monitor. The parameter is a tuple of arity two whose first element is the driver name and second element is either of:

**loaded** Notify me when the driver is reloaded (or loaded if loading is underway). It only makes sense to monitor drivers that are in the process of being loaded or reloaded. One cannot monitor a future-to-be driver name for loading, that will only result in a 'DOWN' message being immediately sent. Monitoring for loading is therefore most useful when triggered by the `try_load/3` [page 80] function, where the monitor is created *because* the driver is in such a pending state.

Setting a driver monitor for loading will eventually lead to one of the following messages being sent:

- { **'UP', ref(), driver, Name, loaded** } This message is sent, either immediately if the driver is already loaded and no reloading is pending, or when reloading is executed if reloading is pending.  
The user [page 72] is expected to know if reloading is demanded prior to creating a monitor for loading.
- { **'UP', ref(), driver, Name, permanent** } This message will be sent if reloading was expected, but the (old) driver made itself permanent prior to reloading. It will also be sent if the driver was permanent or statically linked in when trying to create the monitor.
- { **'DOWN', ref(), driver, Name, load\_cancelled** } This message will arrive if reloading was underway, but the user [page 72] having requested reload cancelled it by either dying or calling `try_unload/2` [page 83] (or `unload/1/unload_driver/1`) again before it was reloaded.
- { **'DOWN', ref(), driver, Name, {load\_failure, Failure}** } This message will arrive if reloading was underway but the loading for some reason failed. The `Failure` term is one of the errors that can be returned from `try_load/3` [page 80]. The error term can be passed to `format_error/1` [page 86] for translation into human readable form. Note that the translation has to be done in the same running erlang virtual machine as the error was detected in.

**unloaded** Monitor when a driver gets unloaded. If one monitors a driver that is not present in the system, one will immediately get notified that the driver got unloaded. There is no guarantee that the driver was actually ever loaded. A driver monitor for unload will eventually result in one of the following messages being sent:

- { **'DOWN', ref(), driver, Name, unloaded** } The driver instance monitored is now unloaded. As the unload might have been due to a `reload/2` request, the driver might once again have been loaded when this message arrives.
- { **'UP', ref(), driver, Name, unload\_cancelled** } This message will be sent if unloading was expected, but while the driver was waiting for all ports to get closed, a new user [page 72] of the driver appeared and the unloading was cancelled.  
This message appears when an `{ok, pending_driver}` was returned from `try_unload/2` [page 83] for the last user [page 72] of the driver and then a `{ok, already_loaded}` is returned from a call to `try_load/3` [page 80].  
If one wants to *really* monitor when the driver gets unloaded, this message will distort the picture, no unloading was really done. The `unloaded_only` option creates a monitor similar to an `unloaded` monitor, but does never result in this message.
- { **'UP', ref(), driver, Name, permanent** } This message will be sent if unloading was expected, but the driver made itself permanent prior to unloading. It will also be sent if trying to monitor a permanent or statically linked in driver.

**unloaded\_only** A monitor created as `unloaded_only` behaves exactly as one created as `unloaded` with the exception that the `{'UP', ref(), driver, Name, unload_cancelled}` message will never be sent, but the monitor instead persists until the driver *really* gets unloaded.

The function throws a `badarg` exception if the parameters are not given as described above.

```
reload(Path, Name) -> ok | {error, ErrorDesc}
```

Types:

- Path = Name = string() | atom()
- ErrorDesc = pending\_process | OpaqueError
- OpaqueError = term()

Reloads the driver named Name from a possibly different Path than was previously used. This function is used in the code change scenario [page 72] described in the introduction.

If there are other users [page 72] of this driver, the function will return {error, pending\_process}, but if there are no more users, the function call will hang until all open ports are closed.

**Note:**

Avoid mixing several users [page 72] with driver reload requests.

If one wants to avoid hanging on open ports, one should use the try\_load/3 [page 80] function instead.

The Name and Path parameters have exactly the same meaning as when calling the plain load/2 [page 75] function.

**Note:**

Avoid mixing several users [page 72] with driver reload requests.

On success, the function returns ok. On failure, the function returns an opaque error, with the exception of the pending\_process error described above. The opaque errors are to be translated into human readable form by the format\_error/1 [page 86] function. For more control over the error handling, again use the try\_load/3 [page 80] interface instead.

The function throws a badarg exception if the parameters are not given as described above.

```
reload_driver(Path, Name) -> ok | {error, ErrorDesc}
```

Types:

- Path = Name = string() | atom()
- ErrorDesc = pending\_process | OpaqueError
- OpaqueError = term()

Works exactly as `reload/2` [page 78], but for drivers loaded with the `load_driver/2` [page 76] interface.

As this interface implies that ports are being killed when the last user disappears, the function won't hang waiting for ports to get closed.

For further details, see the scenarios [page 72] in the module description and refer to the `reload/2` [page 78] function description.

The function throws a `badarg` exception if the parameters are not given as described above.

```
try_load(Path, Name, OptionList) -> {ok, Status} | {ok, PendingStatus, Ref} | {error, ErrorDesc}
```

Types:

- Path = Name = string() | atom()
- OptionList = [ Option ]
- Option = {driver\_options, DriverOptionList} | {monitor, MonitorOption} | {reload, ReloadOption}
- DriverOptionList = [ DriverOption ]
- DriverOption = kill\_ports
- MonitorOption = pending\_driver | pending
- ReloadOption = pending\_driver | pending
- Status = loaded | already\_loaded | PendingStatus
- PendingStatus = pending\_driver | pending\_process
- Ref = ref()
- ErrorDesc = ErrorAtom | OpaqueError
- ErrorAtom = linked\_in\_driver | inconsistent | permanent | not\_loaded\_by\_this\_process | not\_loaded | pending\_reload | pending\_process

This function provides more control than the `load/2/reload/2` and `load_driver/2/reload_driver/2` interfaces. It will never wait for completion of other operations related to the driver, but immediately return the status of the driver as either:

**{ok, loaded}** The driver was actually loaded and is immediately usable.

**{ok, already\_loaded}** The driver was already loaded by another process and/or is in use by a living port. The load by you is registered and a corresponding `try_unload` is expected sometime in the future.

**{ok, pending\_driver}** or **{ok, pending\_driver, ref()}** The load request is registered, but the loading is delayed due to the fact that an earlier instance of the driver is still waiting to get unloaded (there are open ports using it). Still, unload is expected when you are done with the driver. This return value will *mostly* happen when the `{reload, pending_driver}` or `{reload, pending}` options are used, but *can* happen when another user [page 72] is unloading a driver in parallel and the `kill_ports` driver option is set. In other words, this return value will always need to be handled!

**{ok, pending\_process}** or **{ok, pending\_process, ref()}** The load request is registered, but the loading is delayed due to the fact that an earlier instance of the driver is still waiting to get unloaded by another user [page 72] (not only by a port, in which case `{ok, pending_driver}` would have been returned). Still, unload is expected when you are done with the driver. This return value will *only* happen when the `{reload, pending}` option is used.

When the function returns `{ok, pending_driver}` or `{ok, pending_process}`, one might want to get information about when the driver is *actually* loaded. This can be achieved by using the `{monitor, PendingOption}` option.

When monitoring is requested, and a corresponding `{ok, pending_driver}` or `{ok, pending_process}` would be returned, the function will instead return a tuple `{ok, PendingStatus, ref()}` and the process will, at a later time when the driver actually gets loaded, get a monitor message. The monitor message one can expect is described in the `monitor/2` [page 77] function description.

### Note:

Note that in case of loading, monitoring can *not* only get triggered by using the `{reload, ReloadOption}` option, but also in special cases where the load-error is transient, why `{monitor, pending_driver}` should be used under basically *all* real world circumstances!

The function accepts the following parameters:

**Path** The filesystem path to the directory where the driver object file is situated. The filename of the object file (minus extension) must correspond to the driver name (used in the name parameter) and the driver must identify itself with the very same name. The Path might be provided as an *io\_list*, meaning it can be a list of other *io\_lists*, characters (eight bit integers) or binaries, all to be flattened into a sequence of characters.

The (possibly flattened) Path parameter must be consistent throughout the system, a driver should, by all users [page 72], be loaded using the same *literalPath*. The exception is when *reloading* is requested, in which case the Path may be specified differently. Note that all users [page 72] trying to load the driver at a later time will need to use the *newPath* if the Path is changed using a `reload` option. This is yet another reason to have *only one loader* of a driver one wants to upgrade in a running system!

**Name** The name parameter is the name of the driver to be used in subsequent calls to `open_port` [page 123]. The name can be specified either as an `io_list()` or as an `atom()`. The name given when loading is used to find the actual object file (with the help of the Path and the system implied extension suffix, i.e. `.so`). The name by which the driver identifies itself must also be consistent with this Name parameter, much as a beam-file's module name much correspond to its filename.

**OptionList** A number of options can be specified to control the loading operation. The options are given as a list of two-tuples, the tuples having the following values and meanings:

`{driver_options, DriverOptionsList}` This option is to provide options that will change its general behavior and will “stick” to the driver throughout its lifespan.

The driver options for a given driver name need always to be consistent, *even when the driver is reloaded*, meaning that they are as much a part of the driver as the actual name.

Currently the only allowed driver option is `kill_ports`, which means that all ports opened towards the driver are killed with the exit-reason `driver_unloaded` when no process any longer has the driver loaded. This situation arises either when the last user [page 72] calls `try_unload/2` [page 83], or the last process having loaded the driver exits.

**{monitor, MonitorOption}** A `MonitorOption` tells `try_load/3` to trigger a driver monitor under certain conditions. When the monitor is triggered, the function will return a three-tuple `{ok, PendingStatus, ref()}`, where the `ref()` is the monitor ref for the driver monitor.

Only one `MonitorOption` can be specified and it is either the `atom pending`, which means that a monitor should be created whenever a load operation is delayed, and the `atom pending_driver`, in which a monitor is created whenever the operation is delayed due to open ports towards an otherwise unused driver. The `pending_driver` option is of little use, but is present for completeness, it is very well defined which reload-options might give rise to which delays. It might, however, be a good idea to use the same `MonitorOption` as the `ReloadOption` if present.

If reloading is not requested, it might still be useful to specify the `monitor` option, as forced unloads (`kill_ports` driver option or the `kill_ports` option to `try_unload/2` [page 83]) will trigger a transient state where driver loading cannot be performed until all closing ports are actually closed. So, as `try_unload` can, in almost all situations, return `{ok, pending_driver}`, one should always specify at least `{monitor, pending_driver}` in production code (see the monitor discussion above).

**{reload, ReloadOption}** This option is used when one wants to *reload* a driver from disk, most often in a code upgrade scenario. Having a `reload` option also implies that the `Path` parameter need *not* be consistent with earlier loads of the driver.

To reload a driver, the process needs to have previously loaded the driver, i.e. there has to be an active user [page 72] of the driver in the process.

The `reload` option can be either the `atom pending`, in which reloading is requested for any driver and will be effectuated when *all* ports opened against the driver are closed. The replacement of the driver will in this case take place regardless of if there are still pending users [page 72] having the driver loaded! The option also triggers port-killing (if the `kill_ports` driver option is used) even though there are pending users, making it usable for forced driver replacement, but laying a lot of responsibility on the driver users [page 72]. The `pending` option is seldom used as one does not want other users [page 72] to have loaded the driver when code change is underway.

The more useful option is `pending_driver`, which means that reloading will be queued if the driver is *not* loaded by any other users [page 72], but the driver has opened ports, in which case `{ok, pending_driver}` will be returned (a `monitor` option is of course recommended).

If the driver is unloaded (not present in the system), the error code `not_loaded` will be returned. The `reload` option is intended for when the user has already loaded the driver in advance.

The function might return numerous errors, of which some only can be returned given a certain combination of options.

A number of errors are opaque and can only be interpreted by passing them to the `format_error/1` [page 86] function, but some can be interpreted directly:

**{error, linked\_in\_driver}** The driver with the specified name is an erlang statically linked in driver, which cannot be manipulated with this API.

**{error, inconsistent}** The driver has already been loaded with either other `DriverOptions` or a different *literal* `Path` argument. This can happen even if a `reload` option is given, if the `DriverOptions` differ from the current.

**{error, permanent}** The driver has requested itself to be permanent, making it behave like an erlang linked in driver and it can no longer be manipulated with this API.

**{error, pending\_process}** The driver is loaded by other users [page 72] when the {reload, pending\_driver} option was given.

**{error, pending\_reload}** Driver reload is already requested by another user [page 72] when the {reload, ReloadOption} option was given.

**{error, not\_loaded\_by\_this\_process}** Appears when the reload option is given. The driver Name is present in the system, but there is no user [page 72] of it in this process.

**{error, not\_loaded}** Appears when the reload option is given. The driver Name is not in the system. Only drivers loaded by this process can be reloaded.

All other error codes are to be translated by the format\_error/1 [page 86] function. Note that calls to format\_error should be performed from the same running instance of the erlang virtual machine as the error was detected in, due to system dependent behavior concerning error values.

If the arguments or options are malformed, the function will throw a badarg exception.

```
try_unload(Name, OptionList) -> {ok, Status} | {ok, PendingStatus, Ref} | {error, ErrorAtom}
```

Types:

- Name = string() | atom()
- OptionList = [ Option ]
- Option = {monitor, MonitorOption} | kill\_ports
- MonitorOption = pending\_driver | pending
- Status = unloaded | PendingStatus
- PendingStatus = pending\_driver | pending\_process
- Ref = ref()
- ErrorAtom = linked\_in\_driver | not\_loaded | not\_loaded\_by\_this\_process | permanent

This is the low level function to unload (or decrement reference counts of) a driver. It can be used to force port killing, in much the same way as the driver option kill\_ports implicitly does, and it can trigger a monitor either due to other users [page 72] still having the driver loaded or that there are open ports using the driver.

Unloading can be described as the process of telling the emulator that this particular part of the code in this particular process (i.e. this user [page 72]) no longer needs the driver. That can, if there are no other users, trigger actual unloading of the driver, in which case the driver name disappears from the system and (if possible) the memory occupied by the driver executable code is reclaimed. If the driver has the kill\_ports option set, or if kill\_ports was specified as an option to this function, all pending ports using this driver will get killed when unloading is done by the last user [page 72]. If no port-killing is involved and there are open ports, the actual unloading is delayed until there are no more open ports using the driver. If, in this case, another user [page 72] (or even this user) loads the driver again before the driver is actually unloaded, the unloading will never take place.

To allow the user [page 72] that *requests unloading* to wait for *actual unloading* to take place, monitor triggers can be specified in much the same way as when loading. As users [page 72] of this function however seldom are interested in more than decrementing the reference counts, monitoring is more seldom needed. If the

`kill_ports` option is used however, monitor triggering is crucial, as the ports are not guaranteed to have been killed until the driver is unloaded, why a monitor should be triggered for at least the `pending_driver` case.

The possible monitor messages that can be expected are the same as when using the `unloaded` option to the `monitor/2` [page 77] function.

The function will return one of the following statuses upon success:

**{ok, unloaded}** The driver was immediately unloaded, meaning that the driver name is now free to use by other drivers and, if the underlying OS permits it, the memory occupied by the driver object code is now reclaimed.

The driver can only be unloaded when there are no open ports using it and there are no more users [page 72] requiring it to be loaded.

**{ok, pending\_driver}** or **{ok, pending\_driver, ref()}** This return value indicates that this call removed the last user [page 72] from the driver, but there are still open ports using it. When all ports are closed and no new users [page 72] have arrived, the driver will actually be reloaded and the name and memory reclaimed.

This return value is valid even when the option `kill_ports` was used, as killing ports may not be a process that completes immediately. The condition is, in that case, however transient. Monitors are as always useful to detect when the driver is really unloaded.

**{ok, pending\_process}** or **{ok, pending\_process, ref()}** The unload request is registered, but there are still other users [page 72] holding the driver. Note that the term `pending_process` might refer to the running process, there might be more than one user [page 72] in the same process.

This is a normal, healthy return value if the call was just placed to inform the emulator that you have no further use of the driver. It is actually the most common return value in the most common scenario [page 72] described in the introduction.

The function accepts the following parameters:

**Name** The name parameter is the name of the driver to be unloaded. The name can be specified either as an `io_list()` or as an `atom()`.

**OptionList** The `OptionList` argument can be used to specify certain behavior regarding ports as well as triggering monitors under certain conditions:

**kill\_ports** Force killing of all ports opened using this driver, with the exit reason `driver_unloaded`, if you are the *lastuser* [page 72] of the driver.

If there are other users [page 72] having the driver loaded, this option will have no effect.

If one wants the consistent behavior of killing ports when the last user [page 72] unloads, one should use the driver option `kill_ports` when loading the driver instead.

**{monitor, MonitorOption}** This option creates a driver monitor if the condition given in `MonitorOptions` is true. The valid options are:

**pending\_driver** Create a driver monitor if the return value is to be `{ok, pending_driver}`.

**pending** Create a monitor if the return value will be either `{ok, pending_driver}` or `{ok, pending_process}`.



The `pending_driverMonitorOption` is by far the most useful and it has to be used to ensure that the driver has really been unloaded and the ports closed whenever the `kill_ports` option is used or the driver may have been loaded with the `kill_ports` driver option.

By using the `monitor-triggers` in the call to `try_unload` one can be sure that the monitor is actually added before the unloading is executed, meaning that the monitor will always get properly triggered, which would not be the case if one called `erl_ddll:monitor/2` separately.

The function may return several error conditions, of which all are well specified (no opaque values):

**{error, linked\_in\_driver}** You were trying to unload an erlang statically linked in driver, which cannot be manipulated with this interface (and cannot be unloaded at all).

**{error, not\_loaded}** The driver `Name` is not present in the system.

**{error, not\_loaded\_by\_this\_process}** The driver `Name` is present in the system, but there is no user [page 72] of it in this process.

As a special case, drivers can be unloaded from processes that has done no corresponding call to `try_load/3` if, and only if, there are *no users of the driver at all*, which may happen if the process containing the last user dies.

**{error, permanent}** The driver has made itself permanent, in which case it can no longer be manipulated by this interface (much like a statically linked in driver).

The function throws a `badarg` exception if the parameters are not given as described above.

```
unload(Name) -> ok | {error, ErrorDesc}
```

Types:

- Name = string() | atom()
- ErrorDesc = term()

Unloads, or at least dereferences the driver named `Name`. If the caller is the last user [page 72] of the driver, and there are no more open ports using the driver, the driver will actually get unloaded. In all other cases, actual unloading will be delayed until all ports are closed and there are no remaining users [page 72].

If there are other users [page 72] of the driver, the reference counts of the driver is merely decreased, so that the caller is no longer considered a user of the driver. For usage scenarios, see the description [page 72] in the beginning of this document.

The `ErrorDesc` returned is an opaque value to be passed further on to the `format_error/1` [page 86] function. For more control over the operation, use the `try_unload/2` [page 83] interface.

The function throws a `badarg` exception if the parameters are not given as described above.

```
unload_driver(Name) -> ok | {error, ErrorDesc}
```

Types:

- Name = string() | atom()
- ErrorDesc = term()

Unloads, or at least dereferences the driver named `Name`. If the caller is the last user [page 72] of the driver, all remaining open ports using the driver will get killed with the reason `driver_unloaded` and the driver will eventually get unloaded.

If there are other users [page 72] of the driver, the reference counts of the driver is merely decreased, so that the caller is no longer considered a user [page 72]. For usage scenarios, see the description [page 72] in the beginning of this document.

The `ErrorDesc` returned is an opaque value to be passed further on to the `format_error/1` [page 86] function. For more control over the operation, use the `try_unload/2` [page 83] interface.

The function throws a `badarg` exception if the parameters are not given as described above.

```
loaded_drivers() -> {ok, Drivers}
```

Types:

- `Drivers = [Driver()]`
- `Driver = string()`

Returns a list of all the available drivers, both (statically) linked-in and dynamically loaded ones.

The driver names are returned as a list of strings rather than a list of atoms for historical reasons.

More information about drivers can be obtained using one of the `info` [page 74] functions.

```
format_error(ErrorDesc) -> string()
```

Types:

- `ErrorDesc` – see below

Takes an `ErrorDesc` returned by `load`, `unload` or `reload` functions and returns a string which describes the error or warning.

### Note:

Due to peculiarities in the dynamic loading interfaces on different platform, the returned string is only guaranteed to describe the correct error *if `format_error/1` is called in the same instance of the erlang virtual machine as the error appeared in* (meaning the same operating system process)!

## SEE ALSO

`erl_driver(4)`, `driver_entry(4)`

# erl\_prim\_loader

Erlang Module

`erl_prim_loader` is used to load all Erlang modules into the system. The start script is also fetched with this low level loader.

`erl_prim_loader` knows about the environment and how to fetch modules. The loader could, for example, fetch files using the file system (with absolute file names as input), or a database (where the binary format of a module is stored).

The `-loader Loader` command line flag can be used to choose the method used by the `erl_prim_loader`. Two Loader methods are supported by the Erlang runtime system: `efile` and `inet`. If another loader is required, then it has to be implemented by the user. The Loader provided by the user must fulfill the protocol defined below, and it is started with the `erl_prim_loader` by evaluating `open_port({spawn, Loader}, [binary])`.

## Exports

```
start(Id, Loader, Hosts) -> {ok, Pid} | {error, What}
```

Types:

- Id = term()
- Loader = atom() | string()
- Hosts = [Host]
- Host = atom()
- Pid = pid()
- What = term()

Starts the Erlang low level loader. This function is called by the `init` process (and module). The `init` process reads the command line flags `-id Id`, `-loader Loader`, and `-hosts Hosts`. These are the arguments supplied to the `start/3` function.

If `-loader` is not given, the default loader is `efile` which tells the system to read from the file system.

If `-loader` is `inet`, the `-id Id`, `-hosts Hosts`, and `-setcookie Cookie` flags must also be supplied. `Hosts` identifies hosts which this node can contact in order to load modules. One Erlang runtime system with a `erl_boot_server` process must be started on each of hosts given in `Hosts` in order to answer the requests. See `erl_boot_server(3)`.

If `-loader` is something else, the given port program is started. The port program is supposed to follow the protocol specified below.

```
get_file(File) -> {ok, Bin, FullName} | error
```

Types:

- File = string()
- Bin = binary()
- FullName = string()

This function fetches a file using the low level loader. `File` is either an absolute file name or just the name of the file, for example `"lists.beam"`. If an internal path is set to the loader, this path is used to find the file. If a user supplied loader is used, the path can be stripped off if it is obsolete, and the loader does not use a path. `FullName` is the complete name of the fetched file. `Bin` is the contents of the file as a binary.

`get_path()` -> {ok, Path}

Types:

- Path = [Dir]
- Dir = string()

This function gets the path set in the loader. The path is set by the `init` process according to information found in the start script.

`set_path(Path)` -> ok

Types:

- Path = [Dir]
- Dir = string()

This function sets the path of the loader if `init` interprets a `path` command in the start script.

## Protocol

The following protocol must be followed if a user provided loader port program is used. The Loader port program is started with the command `open_port({spawn, Loader}, [binary])`. The protocol is as follows:

Function	Send	Receive
<code>get_file</code>	[102   FileName]	[121   BinaryFile] (on success) [122] (failure)
<code>stop</code>	<code>eof</code>	<code>terminate</code>

## Command Line Flags

The `erl_prim_loader` module interprets the following command line flags:

- `-loader Loader` Specifies the name of the loader used by `erl_prim_loader`. `Loader` can be `efile` (use the local file system), or `inet` (load using the `boot_server` on another Erlang node). If `Loader` is user defined, the defined `Loader` port program is started.  
If the `-loader` flag is omitted, it defaults to `efile`.
- `-hosts Hosts` Specifies which other Erlang nodes the `inet` loader can use. This flag is mandatory if the `-loader inet` flag is present. On each host, there must be on Erlang node with the `erl_boot_server` which handles the load requests. `Hosts` is a list of IP addresses (hostnames are not acceptable).
- `-id Id` Specifies the identity of the Erlang runtime system. If the system runs as a distributed node, `Id` must be identical to the name supplied with the `-sname` or `-name` distribution flags.
- `-setcookie Cookie` Specifies the cookie of the Erlang runtime system. This flag is mandatory if the `-loader inet` flag is present.

## SEE ALSO

`init(3)` [page 246], `erl_boot_server(3)` [page 70]

# erlang

## Erlang Module

By convention, most built-in functions (BIFs) are seen as being in the module `erlang`. A number of the BIFs are viewed more or less as part of the Erlang programming language and are *auto-imported*. Thus, it is not necessary to specify the module name and both the calls `atom_to_list(Erlang)` and `erlang:atom_to_list(Erlang)` are identical.

In the text, auto-imported BIFs are listed without module prefix. BIFs listed with module prefix are not auto-imported.

BIFs may fail for a variety of reasons. All BIFs fail with reason `badarg` if they are called with arguments of an incorrect type. The other reasons that may make BIFs fail are described in connection with the description of each individual BIF.

Some BIFs may be used in guard tests, these are marked with “Allowed in guard tests”.

## DATA TYPES

```
ext_binary()
  a binary data object,
  structured according to the Erlang external term format
```

```
iodata() = iolist() | binary()
```

```
iolist() = [char() | binary() | iolist()]
  a binary is allowed as the tail of the list
```

## Exports

```
abs(Number) -> int() | float()
```

Types:

- Number = number()

Returns an integer or float which is the arithmetical absolute value of Number.

```
> abs(-3.33).
3.33
> abs(-3).
3
```

Allowed in guard tests.

```
adler32(Data) -> int()
```

Types:

- Data = iodata()

Computes and returns the Adler32 checksum for Data.

```
adler32(OldAdler, Data) -> int()
```

Types:

- OldAdler = int()
- Data = iodata()

Continue computing the Adler32 checksum by combining the previous checksum, OldAdler, with the checksum of Data.

The following code:

```
X = adler32(Data1),
Y = adler32(X,Data2).
```

- would assign the same value to Y as this would:

```
Y = adler32([Data1,Data2]).
```

```
adler32_combine(FirstAdler, SecondAdler, SecondSize) -> int()
```

Types:

- FirstAdler = SecondAdler = int()
- SecondSize = int()

Combines two previously computed Adler32 checksums. This computation requires the size of the data object for the second checksum to be known.

The following code:

```
Y = adler32(Data1),
Z = adler32(Y,Data2).
```

- would assign the same value to Z as this would:

```
X = adler32(Data1),
Y = adler32(Data2),
Z = adler32_combine(X,Y,iolist_size(Data2)).
```

```
erlang:append_element(Tuple1, Term) -> Tuple2
```

Types:

- Tuple1 = Tuple2 = tuple()
- Term = term()

Returns a new tuple which has one element more than Tuple1, and contains the elements in Tuple1 followed by Term as the last element. Semantically equivalent to `list_to_tuple(tuple_to_list(Tuple ++ [Term]))`, but much faster.

```
> erlang:append_element({one, two}, three).
{one,two,three}
```

```
apply(Fun, Args) -> term() | empty()
```

Types:

- Fun = fun()
- Args = [term()]

Call a fun, passing the elements in Args as arguments.

Note: If the number of elements in the arguments are known at compile-time, the call is better written as Fun(Arg1, Arg2, ... ArgN).

### Warning:

Earlier, Fun could also be given as {Module, Function}, equivalent to apply(Module, Function, Args). This usage is deprecated and will stop working in a future release of Erlang/OTP.

apply(Module, Function, Args) -> term() | empty()

Types:

- Module = Function = atom()
- Args = [term()]

Returns the result of applying Function in Module to Args. The applied function must be exported from Module. The arity of the function is the length of Args.

```
> apply(lists, reverse, [[a, b, c]]).
[c,b,a]
```

apply can be used to evaluate BIFs by using the module name erlang.

```
> apply(erlang, atom_to_list, ['Erlang']).
"Erlang"
```

Note: If the number of arguments are known at compile-time, the call is better written as Module:Function(Arg1, Arg2, ..., ArgN).

Failure: error\_handler:undefined\_function/3 is called if the applied function is not exported. The error handler can be redefined (see process\_flag/2 [page 129]). If the error\_handler is undefined, or if the user has redefined the default error\_handler so the replacement module is undefined, an error with the reason undef is generated.

atom\_to\_list(Atom) -> string()

Types:

- Atom = atom()

Returns a string which corresponds to the text representation of Atom.

```
> atom_to_list('Erlang').
"Erlang"
```

binary\_to\_list(Binary) -> [char()]

Types:

- Binary = binary()

Returns a list of integers which correspond to the bytes of Binary.



`binary_to_list(Binary, Start, Stop) -> [char()]`

Types:

- Binary = binary()
- Start = Stop = 1..byte\_size(Binary)

As `binary_to_list/1`, but returns a list of integers corresponding to the bytes from position `Start` to position `Stop` in `Binary`. Positions in the binary are numbered starting from 1.

`bitstring_to_list(Bitstring) -> [char()|bitstring()]`

Types:

- Bitstring = bitstring()

Returns a list of integers which correspond to the bytes of `Bitstring`. If the number of bits in the binary is not divisible by 8, the last element of the list will be a bitstring containing the remaining bits (1 up to 7 bits).

`binary_to_term(Binary) -> term()`

Types:

- Binary = ext\_binary()

Returns an Erlang term which is the result of decoding the binary object `Binary`, which must be encoded according to the Erlang external term format. See also `term_to_binary/1` [page 156].

`bit_size(Bitstring) -> int()`

Types:

- Bitstring = bitstring()

Returns an integer which is the size in bits of `Bitstring`.

```
> bit_size(<<433:16,3:3>>).
```

```
19
```

```
> bit_size(<<1,2,3>>).
```

```
24
```

Allowed in guard tests.

`erlang:bump_reductions(Reductions) -> void()`

Types:

- Reductions = int()

This implementation-dependent function increments the reduction counter for the calling process. In the Beam emulator, the reduction counter is normally incremented by one for each function and BIF call, and a context switch is forced when the counter reaches 1000.

**Warning:**

This BIF might be removed in a future version of the Beam machine without prior warning. It is unlikely to be implemented in other Erlang implementations.

`byte_size(Bitstring) -> int()`

Types:

- Bitstring = bitstring()

Returns an integer which is the number of bytes needed to contain `Bitstring`. (That is, if the number of bits in `Bitstring` is not divisible by 8, the resulting number of bytes will be rounded *up*.)

```
> byte_size(<<433:16,3:3>>).
```

```
3
```

```
> byte_size(<<1,2,3>>).
```

```
3
```

Allowed in guard tests.

`erlang:cancel_timer(TimerRef) -> Time | false`

Types:

- TimerRef = ref()
- Time = int()

Cancels a timer, where `TimerRef` was returned by either `erlang:send_after/3` [page 138] or `erlang:start_timer/3` [page 145]. If the timer is there to be removed, the function returns the time in milliseconds left until the timer would have expired, otherwise `false` (which means that `TimerRef` was never a timer, that it has already been cancelled, or that it has already delivered its message).

See also `erlang:send_after/3` [page 138], `erlang:start_timer/3` [page 145], and `erlang:read_timer/1` [page 136].

Note: Cancelling a timer does not guarantee that the message has not already been delivered to the message queue.

`check_process_code(Pid, Module) -> bool()`

Types:

- Pid = pid()
- Module = atom()

Returns `true` if the process `Pid` is executing old code for `Module`. That is, if the current call of the process executes old code for this module, or if the process has references to old code for this module, or if the process contains funs that references old code for this module. Otherwise, it returns `false`.

```
> check_process_code(Pid, lists).
false
```

See also code(3) [page 47].

`concat_binary(ListOfBinaries)`

Do not use; use `list_to_binary/1` [page 112] instead.

`crc32(Data) -> int()`

Types:

- Data = `iodata()`

Computes and returns the `crc32` (IEEE 802.3 style) checksum for Data.

`crc32(OldCrc, Data) -> int()`

Types:

- OldCrc = `int()`
- Data = `iodata()`

Continue computing the `crc32` checksum by combining the previous checksum, `OldCrc`, with the checksum of Data.

The following code:

```
X = crc32(Data1),
Y = crc32(X,Data2).
```

- would assign the same value to Y as this would:

```
Y = crc32([Data1,Data2]).
```

`crc32_combine(FirstCrc, SecondCrc, SecondSize) -> int()`

Types:

- FirstCrc = SecondCrc = `int()`
- SecondSize = `int()`

Combines two previously computed `crc32` checksums. This computation requires the size of the data object for the second checksum to be known.

The following code:

```
Y = crc32(Data1),
Z = crc32(Y,Data2).
```

- would assign the same value to Z as this would:

```
X = crc32(Data1),
Y = crc32(Data2),
Z = crc32_combine(X,Y,iolist_size(Data2)).
```

`date() -> {Year, Month, Day}`

Types:

- Year = Month = Day = `int()`

Returns the current date as {Year, Month, Day}.

The time zone and daylight saving time correction depend on the underlying OS.

```
> date().
{1995,2,19}
```

```
decode_packet(Type,Bin,Options) -> {ok,Packet,Rest} | {more,Length} | {error,Reason}
```

Types:

- Bin = binary()
- Options = [Opt]
- Packet = binary() | HttpPacket
- Rest = binary()
- Length = int() | undefined
- Reason = term()
- Type, Opt – see below
- 
- HttpPacket = HttpRequest | HttpResponse | HttpHeaders | http\_eoh | HttpError
- HttpRequest = {http\_request, HttpMethod, HttpUri, HttpVersion}
- HttpResponse = {http\_response, HttpVersion, integer(), string() }
- HttpHeaders = {http\_header, int(), HttpField, Reserved=term(), Value=string() }
- HttpError = {http\_error, string() }
- HttpMethod = HttpMethodAtom | string()
- HttpMethodAtom = 'OPTIONS' | 'GET' | 'HEAD' | 'POST' | 'PUT' | 'DELETE' | 'TRACE'
- HttpUri = '\*' | {absoluteURI, http|https, Host=string(), Port=int() | undefined, Path=string() } | {scheme, Scheme=string(), string() } | {abs\_path, string} | string()
- HttpVersion = {Major=int(), Minor=int() }
- HttpField = HttpFieldAtom | string()
- HttpFieldAtom = 'Cache-Control' | 'Connection' | 'Date' | 'Pragma' | 'Transfer-Encoding' | 'Upgrade' | 'Via' | 'Accept' | 'Accept-Charset' | 'Accept-Encoding' | 'Accept-Language' | 'Authorization' | 'From' | 'Host' | 'If-Modified-Since' | 'If-Match' | 'If-None-Match' | 'If-Range' | 'If-Unmodified-Since' | 'Max-Forwards' | 'Proxy-Authorization' | 'Range' | 'Referer' | 'User-Agent' | 'Age' | 'Location' | 'Proxy-Authenticate' | 'Public' | 'Retry-After' | 'Server' | 'Vary' | 'Warning' | 'Www-Authenticate' | 'Allow' | 'Content-Base' | 'Content-Encoding' | 'Content-Language' | 'Content-Length' | 'Content-Location' | 'Content-Md5' | 'Content-Range' | 'Content-Type' | 'Etag' | 'Expires' | 'Last-Modified' | 'Accept-Ranges' | 'Set-Cookie' | 'Set-Cookie2' | 'X-Forwarded-For' | 'Cookie' | 'Keep-Alive' | 'Proxy-Connection'
- 

Decodes the binary Bin according to the packet protocol specified by Type. Very similar to the packet handling done by sockets with the option {packet,Type}.

If an entire packet is contained in Bin it is returned together with the remainder of the binary as {ok,Packet,Rest}.

If Bin does not contain the entire packet, {more,Length} is returned. Length is either the expected *total size* of the packet or undefined if the expected packet size is not known. decode\_packet can then be called again with more data added.

If the packet does not conform to the protocol format {error,Reason} is returned.

The following values of `Type` are valid:

- `raw` | `0` No packet handling is done. Entire binary is returned unless it is empty.
- `1` | `2` | `4` Packets consist of a header specifying the number of bytes in the packet, followed by that number of bytes. The length of header can be one, two, or four bytes; the order of the bytes is big-endian. The header will be stripped off when the packet is returned.
- `line` A packet is a line terminated with newline. The newline character is included in the returned packet unless the line was truncated according to the option `line_length`.
- `asn1` | `cdr` | `sunrm` | `fcgi` | `tpkt` The header is *not* stripped off.  
The meanings of the packet types are as follows:
  - `asn1` - **ASN.1 BER**
  - `sunrm` - **Sun's RPC encoding**
  - `cdr` - **CORBA (GIOP 1.1)**
  - `fcgi` - **Fast CGI**
  - `tpkt` - **TPKT format [RFC1006 ]**
- `http` | `httph` The Hypertext Transfer Protocol. The packets are returned with the format according to `HttpPacket` described above. A packet is either a request, a response, a header or an end of header mark. Invalid lines are returned as `HttpError`.  
Recognized request methods and header fields are returned as atoms. Others are returned as strings.  
The protocol type `http` should only be used for the first line when a `HttpRequest` or a `HttpResponse` is expected. The following calls should use `httph` to get `HTTPHeader`'s until `http_eoh` is returned that marks the end of the headers and the beginning of any following message body.

The following options are available:

- `{packet_size, int()}` Sets the max allowed size of the packet body. If the packet header indicates that the length of the packet is longer than the max allowed length, the packet is considered invalid. Default is 0 which means no size limit.
  - `{line_length, int()}` Applies only to line oriented protocols (`line`, `http`). Lines longer than this will be truncated.
- ```
> erlang:decode_packet(1,<<3,"abcd">>,[]).
{ok,<<"abc">>,<<"d">>}
> erlang:decode_packet(1,<<5,"abcd">>,[]).
{more,6}
```

```
delete_module(Module) -> true | undefined
```

Types:

- `Module = atom()`

Makes the current code for `Module` become old code, and deletes all references for this module from the export table. Returns `undefined` if the module does not exist, otherwise `true`.

**Warning:**

This BIF is intended for the code server (see `code(3)` [page 47]) and should not be used elsewhere.

Failure: `badarg` if there is already an old version of `Module`.

```
erlang:demonitor(MonitorRef) -> true
```

Types:

- `MonitorRef = ref()`

If `MonitorRef` is a reference which the calling process obtained by calling `erlang:monitor/2` [page 119], this monitoring is turned off. If the monitoring is already turned off, nothing happens.

Once `erlang:demonitor(MonitorRef)` has returned it is guaranteed that no `{'DOWN', MonitorRef, _, _, _}` message due to the monitor will be placed in the callers message queue in the future. A `{'DOWN', MonitorRef, _, _, _}` message might have been placed in the callers message queue prior to the call, though. Therefore, in most cases, it is advisable to remove such a 'DOWN' message from the message queue after monitoring has been stopped. `erlang:demonitor(MonitorRef, [flush])` [page 98] can be used instead of `erlang:demonitor(MonitorRef)` if this cleanup is wanted.

**Note:**

Prior to OTP release R11B (erts version 5.5) `erlang:demonitor/1` behaved completely asynchronous, i.e., the monitor was active until the “demonitor signal” reached the monitored entity. This had one undesirable effect, though. You could never know when you were guaranteed *not* to receive a DOWN message due to the monitor.

Current behavior can be viewed as two combined operations: asynchronously send a “demonitor signal” to the monitored entity and ignore any future results of the monitor.

Failure: It is an error if `MonitorRef` refers to a monitoring started by another process. Not all such cases are cheap to check; if checking is cheap, the call fails with `badarg` (for example if `MonitorRef` is a remote reference).

```
erlang:demonitor(MonitorRef, OptionList) -> true
```

Types:

- `MonitorRef = ref()`
- `OptionList = [Option]`
- `Option = flush`

`erlang:demonitor(MonitorRef, [])` is equivalent to `erlang:demonitor(MonitorRef)` [page 98].

Currently the following Options are valid:

`flush` Remove (one) `{_, MonitorRef, _, _, _}` message, if there is one, from the callers message queue after monitoring has been stopped.

Calling `erlang:demonitor(MonitorRef, [flush])` is equivalent to:

```
erlang:demonitor(MonitorRef),
receive
    {_, MonitorRef, _, _, _} ->
        true
after 0 ->
    true
end
```

**Note:**

More options may be added in the future.

Failure: `badarg` if `OptionList` is not a list, or if `Option` is not a valid option, or the same failure as for `erlang:demonitor/1` [page 98]

`disconnect_node(Node) -> bool() | ignored`

Types:

- `Node = atom()`

Forces the disconnection of a node. This will appear to the node `Node` as if the local node has crashed. This BIF is mainly used in the Erlang network authentication protocols. Returns `true` if disconnection succeeds, otherwise `false`. If the local node is not alive, the function returns `ignored`.

`erlang:display(Term) -> true`

Types:

- `Term = term()`

Prints a text representation of `Term` on the standard output.

**Warning:**

This BIF is intended for debugging only.

`element(N, Tuple) -> term()`

Types:

- `N = 1..tuple_size(Tuple)`
- `Tuple = tuple()`

Returns the `N`th element (numbering from 1) of `Tuple`.

```
> element(2, {a, b, c}).
b
```

Allowed in guard tests.

```
erase() -> [{Key, Val}]
```

Types:

- Key = Val = term()

Returns the process dictionary and deletes it.

```
> put(key1, {1, 2, 3}),
put(key2, [a, b, c]),
erase().
[{key1, {1, 2, 3}}, {key2, [a, b, c]}]
```

```
erase(Key) -> Val | undefined
```

Types:

- Key = Val = term()

Returns the value Val associated with Key and deletes it from the process dictionary.

Returns undefined if no value is associated with Key.

```
> put(key1, {merry, lambs, are, playing}),
X = erase(key1),
{X, erase(key1)}.
{{merry, lambs, are, playing}, undefined}
```

```
erlang:error(Reason)
```

Types:

- Reason = term()

Stops the execution of the calling process with the reason Reason, where Reason is any term. The actual exit reason will be {Reason, Where}, where Where is a list of the functions most recently called (the current function first). Since evaluating this function causes the process to terminate, it has no return value.

```
> catch erlang:error(foobar).
{'EXIT', {foobar, [{erl_eval, do_apply, 5},
                  {erl_eval, expr, 5},
                  {shell, exprs, 6},
                  {shell, eval_exprs, 6},
                  {shell, eval_loop, 3}]}}}
```

```
erlang:error(Reason, Args)
```

Types:

- Reason = term()
- Args = [term()]



Stops the execution of the calling process with the reason `Reason`, where `Reason` is any term. The actual exit reason will be `{Reason, Where}`, where `Where` is a list of the functions most recently called (the current function first). `Args` is expected to be the list of arguments for the current function; in Beam it will be used to provide the actual arguments for the current function in the `Where` term. Since evaluating this function causes the process to terminate, it has no return value.

`exit(Reason)`

Types:

- `Reason = term()`

Stops the execution of the calling process with the exit reason `Reason`, where `Reason` is any term. Since evaluating this function causes the process to terminate, it has no return value.

```
> exit(foobar).
** exception exit: foobar
> catch exit(foobar).
{'EXIT',foobar}
```

`exit(Pid, Reason) -> true`

Types:

- `Pid = pid()`
- `Reason = term()`

Sends an exit signal with exit reason `Reason` to the process `Pid`.

The following behavior apply if `Reason` is any term except `normal` or `kill`:

If `Pid` is not trapping exits, `Pid` itself will exit with exit reason `Reason`. If `Pid` is trapping exits, the exit signal is transformed into a message `{'EXIT', From, Reason}` and delivered to the message queue of `Pid`. `From` is the pid of the process which sent the exit signal. See also `process_flag/2` [page 129].

If `Reason` is the atom `normal`, `Pid` will not exit. If it is trapping exits, the exit signal is transformed into a message `{'EXIT', From, normal}` and delivered to its message queue.

If `Reason` is the atom `kill`, that is if `exit(Pid, kill)` is called, an untrappable exit signal is sent to `Pid` which will unconditionally exit with exit reason `killed`.

`erlang:fault(Reason)`

Types:

- `Reason = term()`

This function is deprecated and will be removed in the next release. Used `erlang:error(Reason)` [page 100] instead.

`erlang:fault(Reason, Args)`

Types:

- `Reason = term()`
- `Args = [term()]`

This function is deprecated and will be removed in the next release. Use `erlang:error(Reason, Args)` [page 100] instead.

`float(Number) -> float()`

Types:

- Number = number()

Returns a float by converting Number to a float.

```
> float(55).
55.0
```

Allowed in guard tests.

### Note:

Note that if used on the top-level in a guard, it will test whether the argument is a floating point number; for clarity, use `is_float/1` [page 109] instead.

When `float/1` is used in an expression in a guard, such as `'float(A) == 4.0'`, it converts a number as described above.

`float_to_list(Float) -> string()`

Types:

- Float = float()

Returns a string which corresponds to the text representation of Float.

```
> float_to_list(7.0).
"7.0000000000000000000000e+00"
```

`erlang:fun_info(Fun) -> [{Item, Info}]`

Types:

- Fun = fun()
- Item, Info – see below

Returns a list containing information about the fun Fun. Each element of the list is a tuple. The order of the tuples is not defined, and more tuples may be added in a future release.

### Warning:

This BIF is mainly intended for debugging, but it can occasionally be useful in library functions that might need to verify, for instance, the arity of a fun.

There are two types of funs with slightly different semantics:

A fun created by `fun M:F/A` is called an *external* fun. Calling it will always call the function F with arity A in the latest code for module M. Note that module M does not even need to be loaded when the fun `fun M:F/A` is created.

All other funs are called *local*. When a local fun is called, the same version of the code that created the fun will be called (even if newer version of the module has been loaded).

The following elements will always be present in the list for both local and external funs:

{type, Type} Type is either local or external.

{module, Module} Module (an atom) is the module name.

If Fun is a local fun, Module is the module in which the fun is defined.

If Fun is an external fun, Module is the module that the fun refers to.

{name, Name} Name (an atom) is a function name.

If Fun is a local fun, Name is the name of the local function that implements the fun. (This name was generated by the compiler, and is generally only of informational use. As it is a local function, it is not possible to call it directly.) If no code is currently loaded for the fun, [] will be returned instead of an atom.

If Fun is an external fun, Name is the name of the exported function that the fun refers to.

{arity, Arity} Arity is the number of arguments that the fun should be called with.

{env, Env} Env (a list) is the environment or free variables for the fun. (For external funs, the returned list is always empty.)

The following elements will only be present in the list if Fun is local:

{pid, Pid} Pid is the pid of the process that originally created the fun.

{index, Index} Index (an integer) is an index into the module's fun table.

{new\_index, Index} Index (an integer) is an index into the module's fun table.

{new\_uniq, Uniq} Uniq (a binary) is a unique value for this fun.

{uniq, Uniq} Uniq (an integer) is a unique value for this fun.

```
erlang:fun_info(Fun, Item) -> {Item, Info}
```

Types:

- Fun = fun()
- Item, Info – see below

Returns information about Fun as specified by Item, in the form {Item,Info}.

For any fun, Item can be any of the atoms module, name, arity, or env.

For a local fun, Item can also be any of the atoms index, new\_index, new\_uniq, uniq, and pid. For an external fun, the value of any of these items is always the atom undefined.

See erlang:fun\_info/1 [page 102].

```
erlang:fun_to_list(Fun) -> string()
```

Types:

- Fun = fun()

Returns a string which corresponds to the text representation of Fun.

```
erlang:function_exported(Module, Function, Arity) -> bool()
```

Types:

- Module = Function = atom()
- Arity = int()

Returns true if the module `Module` is loaded and contains an exported function `Function/Arity`; otherwise false.

Returns false for any BIF (functions implemented in C rather than in Erlang).

```
garbage_collect() -> true
```

Forces an immediate garbage collection of the currently executing process. The function should not be used, unless it has been noticed – or there are good reasons to suspect – that the spontaneous garbage collection will occur too late or not at all. Improper use may seriously degrade system performance.

Compatibility note: In versions of OTP prior to R7, the garbage collection took place at the next context switch, not immediately. To force a context switch after a call to `erlang:garbage_collect()`, it was sufficient to make any function call.

```
garbage_collect(Pid) -> bool()
```

Types:

- Pid = pid()

Works like `erlang:garbage_collect()` but on any process. The same caveats apply. Returns false if `Pid` refers to a dead process; true otherwise.

```
get() -> [{Key, Val}]
```

Types:

- Key = Val = term()

Returns the process dictionary as a list of `{Key, Val}` tuples.

```
> put(key1, merry),
put(key2, lambs),
put(key3, {are, playing}),
get().
[{key1,merry},{key2,lambs},{key3,{are,playing}}]
```

```
get(Key) -> Val | undefined
```

Types:

- Key = Val = term()

Returns the value `Val` associated with `Key` in the process dictionary, or `undefined` if `Key` does not exist.

```
> put(key1, merry),
put(key2, lambs),
put({any, [valid, term]}, {are, playing}),
get({any, [valid, term]}).
{are,playing}
```

```
erlang:get_cookie() -> Cookie | nocookie
```

Types:

- Cookie = atom()

Returns the magic cookie of the local node, if the node is alive; otherwise the atom `nocookie`.

```
get_keys(Val) -> [Key]
```

Types:

- Val = Key = term()

Returns a list of keys which are associated with the value `Val` in the process dictionary.

```
> put(mary, {1, 2}),
   put(had, {1, 2}),
   put(a, {1, 2}),
   put(little, {1, 2}),
   put(dog, {1, 3}),
   put(lamb, {1, 2}),
   get_keys({1, 2}).
[mary, had, a, little, lamb]
```

```
erlang:get_stacktrace() -> [{Module, Function, Arity | Args}]
```

Types:

- Module = Function = atom()
- Arity = int()
- Args = [term()]

Get the call stack back-trace (*stacktrace*) of the last exception in the calling process as a list of `{Module, Function, Arity}` tuples. The `Arity` field in the first tuple may be the argument list of that function call instead of an arity integer, depending on the exception.

If there has not been any exceptions in a process, the stacktrace is `[]`. After a code change for the process, the stacktrace may also be reset to `[]`.

The stacktrace is the same data as the `catch` operator returns, for example:

```
{'EXIT', {badarg, Stacktrace}} = catch abs(x)
```

See also `erlang:error/1` [page 100] and `erlang:error/2` [page 100].

```
group_leader() -> GroupLeader
```

Types:

- GroupLeader = pid()

Returns the pid of the group leader for the process which evaluates the function.

Every process is a member of some process group and all groups have a *group leader*. All IO from the group is channeled to the group leader. When a new process is spawned, it gets the same group leader as the spawning process. Initially, at system start-up, `init` is both its own group leader and the group leader of all processes.

```
group_leader(GroupLeader, Pid) -> true
```

Types:

- `GroupLeader = Pid = pid()`

Sets the group leader of `Pid` to `GroupLeader`. Typically, this is used when a processes started from a certain shell should have another group leader than `init`.

See also `group_leader/0` [page 105].

`halt()`

Halts the Erlang runtime system and indicates normal exit to the calling environment. Has no return value.

```
> halt().
os_prompt%
```

`halt(Status)`

Types:

- `Status = int()>=0 | string()`

`Status` must be a non-negative integer, or a string. Halts the Erlang runtime system. Has no return value. If `Status` is an integer, it is returned as an exit status of Erlang to the calling environment. If `Status` is a string, produces an Erlang crash dump with `String` as slogan, and then exits with a non-zero status code.

Note that on many platforms, only the status codes 0-255 are supported by the operating system.

`erlang:hash(Term, Range) -> Hash`

Returns a hash value for `Term` within the range `1..Range`. The allowed range is `1..227-1`.

### Warning:

This BIF is deprecated as the hash value may differ on different architectures. Also the hash values for integer terms larger than `227` as well as large binaries are very poor. The BIF is retained for backward compatibility reasons (it may have been used to hash records into a file), but all new code should use one of the BIFs `erlang:phash/2` or `erlang:phash2/1,2` instead.

`hd(List) -> term()`

Types:

- `List = [term()]`

Returns the head of `List`, that is, the first element.

```
> hd([1,2,3,4,5]).
1
```

Allowed in guard tests.

Failure: `badarg` if `List` is the empty list `[]`.

`erlang:hibernate(Module, Function, Args)`

Types:

- `Module = Function = atom()`
- `Args = [term()]`

Puts the calling process into a wait state where its memory allocation has been reduced as much as possible, which is useful if the process does not expect to receive any messages in the near future.

The process will be awoken when a message is sent to it, and control will resume in `Module:Function` with the arguments given by `Args` with the call stack emptied, meaning that the process will terminate when that function returns. Thus `erlang:hibernate/3` will never return to its caller.

If the process has any message in its message queue, the process will be awoken immediately in the same way as described above.

In more technical terms, what `erlang:hibernate/3` does is the following. It discards the call stack for the process. Then it garbage collects the process. After the garbage collection, all live data is in one continuous heap. The heap is then shrunk to the exact same size as the live data which it holds (even if that size is less than the minimum heap size for the process).

If the size of the live data in the process is less than the minimum heap size, the first garbage collection occurring after the process has been awoken will ensure that the heap size is changed to a size not smaller than the minimum heap size.

Note that emptying the call stack means that any surrounding `catch` is removed and has to be re-inserted after hibernation. One effect of this is that processes started using `proc_lib` (also indirectly, such as `gen_server` processes), should use `[proc_lib:hibernate/3]` instead to ensure that the exception handler continues to work when the process wakes up.

`integer_to_list(Integer) -> string()`

Types:

- `Integer = int()`

Returns a string which corresponds to the text representation of `Integer`.

```
> integer_to_list(77).  
"77"
```

`erlang:integer_to_list(Integer, Base) -> string()`

Types:

- `Integer = int()`
- `Base = 2..36`

Returns a string which corresponds to the text representation of `Integer` in base `Base`.

```
> erlang:integer_to_list(1023, 16).  
"3FF"
```

`iolist_to_binary(IoListOrBinary) -> binary()`

Types:

- `IoListOrBinary = iolist() | binary()`

Returns a binary which is made from the integers and binaries in `IoListOrBinary`.

```
> Bin1 = <<1,2,3>>.
<<1,2,3>>
> Bin2 = <<4,5>>.
<<4,5>>
> Bin3 = <<6>>.
<<6>>
> iolist_to_binary([Bin1,1,[2,3,Bin2],4|Bin3]).
<<1,2,3,1,2,3,4,5,4,6>>
```

`iolist_size(Item) -> int()`

Types:

- `Item = iolist() | binary()`

Returns an integer which is the size in bytes of the binary that would be the result of `iolist_to_binary(Item)`.

```
> iolist_size([1,2|<<3,4>>]).
4
```

`is_alive() -> bool()`

Returns `true` if the local node is alive; that is, if the node can be part of a distributed system. Otherwise, it returns `false`.

`is_atom(Term) -> bool()`

Types:

- `Term = term()`

Returns `true` if `Term` is an atom; otherwise returns `false`.

Allowed in guard tests.

`is_binary(Term) -> bool()`

Types:

- `Term = term()`

Returns `true` if `Term` is a binary; otherwise returns `false`.

A binary always contains a complete number of bytes.

Allowed in guard tests.

`is_bitstring(Term) -> bool()`

Types:

- `Term = term()`

Returns `true` if `Term` is a bitstring (including a binary); otherwise returns `false`.

Allowed in guard tests.

`is_boolean(Term) -> bool()`

Types:



- `Term = term()`

Returns `true` if `Term` is either the atom `true` or the atom `false` (i.e. a boolean); otherwise returns `false`.

Allowed in guard tests.

`erlang:is_builtin(Module, Function, Arity) -> bool()`

Types:

- `Module = Function = atom()`
- `Arity = int()`

Returns `true` if `Module:Function/Arity` is a BIF implemented in C; otherwise returns `false`. This BIF is useful for builders of cross reference tools.

`is_float(Term) -> bool()`

Types:

- `Term = term()`

Returns `true` if `Term` is a floating point number; otherwise returns `false`.

Allowed in guard tests.

`is_function(Term) -> bool()`

Types:

- `Term = term()`

Returns `true` if `Term` is a fun; otherwise returns `false`.

Allowed in guard tests.

`is_function(Term, Arity) -> bool()`

Types:

- `Term = term()`
- `Arity = int()`

Returns `true` if `Term` is a fun that can be applied with `Arity` number of arguments; otherwise returns `false`.

Allowed in guard tests.

### **Warning:**

Currently, `is_function/2` will also return `true` if the first argument is a tuple fun (a tuple containing two atoms). In a future release, tuple funs will no longer be supported and `is_function/2` will return `false` if given a tuple fun.

`is_integer(Term) -> bool()`

Types:

- `Term = term()`

Returns `true` if `Term` is an integer; otherwise returns `false`.

Allowed in guard tests.

`is_list(Term) -> bool()`

Types:

- `Term = term()`

Returns `true` if `Term` is a list with zero or more elements; otherwise returns `false`.

Allowed in guard tests.

`is_number(Term) -> bool()`

Types:

- `Term = term()`

Returns `true` if `Term` is either an integer or a floating point number; otherwise returns `false`.

Allowed in guard tests.

`is_pid(Term) -> bool()`

Types:

- `Term = term()`

Returns `true` if `Term` is a pid (process identifier); otherwise returns `false`.

Allowed in guard tests.

`is_port(Term) -> bool()`

Types:

- `Term = term()`

Returns `true` if `Term` is a port identifier; otherwise returns `false`.

Allowed in guard tests.

`is_process_alive(Pid) -> bool()`

Types:

- `Pid = pid()`

`Pid` must refer to a process at the local node. Returns `true` if the process exists and is alive, that is, is not exiting and has not exited. Otherwise, returns `false`.

`is_record(Term, RecordTag) -> bool()`

Types:

- `Term = term()`
- `RecordTag = atom()`

Returns true if `Term` is a tuple and its first element is `RecordTag`. Otherwise, returns false.

**Note:**

Normally the compiler treats calls to `is_record/2` specially. It emits code to verify that `Term` is a tuple, that its first element is `RecordTag`, and that the size is correct. However, if the `RecordTag` is not a literal atom, the `is_record/2` BIF will be called instead and the size of the tuple will not be verified.

Allowed in guard tests, if `RecordTag` is a literal atom.

```
is_record(Term, RecordTag, Size) -> bool()
```

Types:

- `Term = term()`
- `RecordTag = atom()`
- `Size = int()`

`RecordTag` must be an atom. Returns true if `Term` is a tuple, its first element is `RecordTag`, and its size is `Size`. Otherwise, returns false.

Allowed in guard tests, provided that `RecordTag` is a literal atom and `Size` is a literal integer.

**Note:**

This BIF is documented for completeness. In most cases `is_record/2` should be used.

```
is_reference(Term) -> bool()
```

Types:

- `Term = term()`

Returns true if `Term` is a reference; otherwise returns false.

Allowed in guard tests.

```
is_tuple(Term) -> bool()
```

Types:

- `Term = term()`

Returns true if `Term` is a tuple; otherwise returns false.

Allowed in guard tests.

```
length(List) -> int()
```

Types:

- `List = [term()]`

Returns the length of `List`.

```
> length([1,2,3,4,5,6,7,8,9]).
9
```

Allowed in guard tests.

```
link(Pid) -> true
```

Types:

- Pid = pid() | port()

Creates a link between the calling process and another process (or port) Pid, if there is not such a link already. If a process attempts to create a link to itself, nothing is done. Returns true.

If Pid does not exist, the behavior of the BIF depends on if the calling process is trapping exits or not (see `process_flag/2` [page 129]):

- If the calling process is not trapping exits, and checking Pid is cheap – that is, if Pid is local – `link/1` fails with reason `noproc`.
- Otherwise, if the calling process is trapping exits, and/or Pid is remote, `link/1` returns true, but an exit signal with reason `noproc` is sent to the calling process.

```
list_to_atom(String) -> atom()
```

Types:

- String = string()

Returns the atom whose text representation is String.

```
> list_to_atom("Erlang").
'Erlang'
```

```
list_to_binary(IoList) -> binary()
```

Types:

- IoList = iolist()

Returns a binary which is made from the integers and binaries in IoList.

```
> Bin1 = <<1,2,3>>.
<<1,2,3>>
> Bin2 = <<4,5>>.
<<4,5>>
> Bin3 = <<6>>.
<<6>>
> list_to_binary([Bin1,1,[2,3,Bin2],4|Bin3]).
<<1,2,3,1,2,3,4,5,4,6>>
```

```
list_to_bitstring(BitstringList) -> bitstring()
```

Types:

- BitstringList = [BitstringList | bitstring() | char()]

Returns a bitstring which is made from the integers and bitstrings in BitstringList. (The last tail in BitstringList is allowed to be a bitstring.)

```

> Bin1 = <<1,2,3>>.
<<1,2,3>>
> Bin2 = <<4,5>>.
<<4,5>>
> Bin3 = <<6,7:4,>>.
<<6>>
> list_to_binary([Bin1,1,[2,3,Bin2],4|Bin3]).
<<1,2,3,1,2,3,4,5,4,6,7:46>>

```

`list_to_existing_atom(String) -> atom()`

Types:

- String = string()

Returns the atom whose text representation is String, but only if there already exists such atom.

Failure: badarg if there does not already exist an atom whose text representation is String.

`list_to_float(String) -> float()`

Types:

- String = string()

Returns the float whose text representation is String.

```

> list_to_float("2.2017764e+0").
2.2017764

```

Failure: badarg if String contains a bad representation of a float.

`list_to_integer(String) -> int()`

Types:

- String = string()

Returns an integer whose text representation is String.

```

> list_to_integer("123").
123

```

Failure: badarg if String contains a bad representation of an integer.

`erlang:list_to_integer(String, Base) -> int()`

Types:

- String = string()
- Base = 2..36

Returns an integer whose text representation in base Base is String.

```

> erlang:list_to_integer("3FF", 16).
1023

```

Failure: badarg if String contains a bad representation of an integer.

`list_to_pid(String) -> pid()`

Types:

- String = string()

Returns a pid whose text representation is String.

**Warning:**

This BIF is intended for debugging and for use in the Erlang operating system. It should not be used in application programs.

```
> list_to_pid("<0.4.1>").
<0.4.1>
```

Failure: badarg if String contains a bad representation of a pid.

`list_to_tuple(List) -> tuple()`

Types:

- List = [term()]

Returns a tuple which corresponds to List. List can contain any Erlang terms.

```
> list_to_tuple([share, ['Ericsson.B', 163]]).
{share, ['Ericsson.B', 163]}
```

`load_module(Module, Binary) -> {module, Module} | {error, Reason}`

Types:

- Module = atom()
- Binary = binary()
- Reason = badfile | not\_purged | badfile

If Binary contains the object code for the module Module, this BIF loads that object code. Also, if the code for the module Module already exists, all export references are replaced so they point to the newly loaded code. The previously loaded code is kept in the system as old code, as there may still be processes which are executing that code. It returns either {module, Module}, or {error, Reason} if loading fails. Reason is one of the following:

`badfile` The object code in Binary has an incorrect format.

`not_purged` Binary contains a module which cannot be loaded because old code for this module already exists.

`badfile` The object code contains code for another module than Module

**Warning:**

This BIF is intended for the code server (see `code(3)` [page 47]) and should not be used elsewhere.

`erlang:loaded() -> [Module]`

Types:

- Module = atom()

Returns a list of all loaded Erlang modules (current and/or old code), including preloaded modules.

See also `code(3)` [page 47].

`erlang:localtime()` -> {Date, Time}

Types:

- Date = {Year, Month, Day}
- Time = {Hour, Minute, Second}
- Year = Month = Day = Hour = Minute = Second = int()

Returns the current local date and time {{Year, Month, Day}, {Hour, Minute, Second}}.

The time zone and daylight saving time correction depend on the underlying OS.

```
> erlang:localtime().
{{1996,11,6},{14,45,17}}
```

`erlang:localtime_to_universaltime({Date1, Time1})` -> {Date2, Time2}

Types:

- Date1 = Date2 = {Year, Month, Day}
- Time1 = Time2 = {Hour, Minute, Second}
- Year = Month = Day = Hour = Minute = Second = int()

Converts local date and time to Universal Time Coordinated (UTC), if this is supported by the underlying OS. Otherwise, no conversion is done and {Date1, Time1} is returned.

```
> erlang:localtime_to_universaltime({{1996,11,6},{14,45,17}}).
{{1996,11,6},{13,45,17}}
```

Failure: badarg if Date1 or Time1 do not denote a valid date or time.

`erlang:localtime_to_universaltime({Date1, Time1}, IsDst)` -> {Date2, Time2}

Types:

- Date1 = Date2 = {Year, Month, Day}
- Time1 = Time2 = {Hour, Minute, Second}
- Year = Month = Day = Hour = Minute = Second = int()
- IsDst = true | false | undefined

Converts local date and time to Universal Time Coordinated (UTC) just like `erlang:localtime_to_universaltime/1`, but the caller decides if daylight saving time is active or not.

If `IsDst == true` the {Date1, Time1} is during daylight saving time, if `IsDst == false` it is not, and if `IsDst == undefined` the underlying OS may guess, which is the same as calling `erlang:localtime_to_universaltime({Date1, Time1})`.

```
> erlang:localtime_to_universaltime({{1996,11,6},{14,45,17}}, true).
{{1996,11,6},{12,45,17}}
> erlang:localtime_to_universaltime({{1996,11,6},{14,45,17}}, false).
{{1996,11,6},{13,45,17}}
> erlang:localtime_to_universaltime({{1996,11,6},{14,45,17}}, undefined).
{{1996,11,6},{13,45,17}}
```

Failure: badarg if Date1 or Time1 do not denote a valid date or time.

`make_ref() -> ref()`

Returns an almost unique reference.

The returned reference will re-occur after approximately  $2^{82}$  calls; therefore it is unique enough for practical purposes.

```
> make_ref().
#Ref<0.0.0.135>
```

`erlang:make_tuple(Arity, InitialValue) -> tuple()`

Types:

- Arity = int()
- InitialValue = term()

Returns a new tuple of the given Arity, where all elements are InitialValue.

```
> erlang:make_tuple(4, []).
{[], [], [], []}
```

`erlang:md5(Data) -> Digest`

Types:

- Data = iodata()
- Digest = binary()

Computes an MD5 message digest from Data, where the length of the digest is 128 bits (16 bytes). Data is a binary or a list of small integers and binaries.

See The MD5 Message Digest Algorithm (RFC 1321) for more information about MD5.

### Warning:

The MD5 Message Digest Algorithm is *not* considered safe for code-signing or software integrity purposes.

`erlang:md5_final(Context) -> Digest`

Types:

- Context = Digest = binary()

Finishes the update of an MD5 Context and returns the computed MD5 message digest.

`erlang:md5_init() -> Context`



Types:

- Context = binary()

Creates an MD5 context, to be used in subsequent calls to `md5_update/2`.

`erlang:md5_update(Context, Data) -> NewContext`

Types:

- Data = iodata()
- Context = NewContext = binary()

Updates an MD5 Context with Data, and returns a NewContext.

`erlang:memory() -> [{Type, Size}]`

Types:

- Type, Size – see below

Returns a list containing information about memory dynamically allocated by the Erlang emulator. Each element of the list is a tuple `{Type, Size}`. The first element `Type` is an atom describing memory type. The second element `Size` is memory size in bytes. A description of each memory type follows:

`total` The total amount of memory currently allocated, which is the same as the sum of memory size for `processes` and `system`.

`processes` The total amount of memory currently allocated by the Erlang processes.

`processes_used` The total amount of memory currently used by the Erlang processes. This memory is part of the memory presented as `processes` memory.

`system` The total amount of memory currently allocated by the emulator that is not directly related to any Erlang process.

Memory presented as `processes` is not included in this memory.

`atom` The total amount of memory currently allocated for atoms.

This memory is part of the memory presented as `system` memory.

`atom_used` The total amount of memory currently used for atoms.

This memory is part of the memory presented as `atom` memory.

`binary` The total amount of memory currently allocated for binaries.

This memory is part of the memory presented as `system` memory.

`code` The total amount of memory currently allocated for Erlang code.

This memory is part of the memory presented as `system` memory.

`ets` The total amount of memory currently allocated for ets tables.

This memory is part of the memory presented as `system` memory.

`maximum` The maximum total amount of memory allocated since the emulator was started.

This tuple is only present when the emulator is run with instrumentation.

For information on how to run the emulator with instrumentation see `[instrument(3)]` and/or `[erl(1)]`.

**Note:**

The `system` value is not complete. Some allocated memory that should be part of the `system` value are not.

When the emulator is run with instrumentation, the `system` value is more accurate, but memory directly allocated by `malloc` (and friends) are still not part of the `system` value. Direct calls to `malloc` are only done from OS specific runtime libraries and perhaps from user implemented Erlang drivers that do not use the memory allocation functions in the driver interface.

Since the `total` value is the sum of `processes` and `system` the error in `system` will propagate to the `total` value.

The different amounts of memory that are summed are *not* gathered atomically which also introduce an error in the result.

The different values has the following relation to each other. Values beginning with an uppercase letter is not part of the result.

```
total = processes + system
processes = processes_used + ProcessesNotUsed
system = atom + binary + code + ets + OtherSystem
atom = atom_used + AtomNotUsed
```

```
RealTotal = processes + RealSystem
RealSystem = system + MissedSystem
```

More tuples in the returned list may be added in the future.

**Note:**

The `total` value is supposed to be the total amount of memory dynamically allocated by the emulator. Shared libraries, the code of the emulator itself, and the emulator stack(s) are not supposed to be included. That is, the `total` value is *not* supposed to be equal to the total size of all pages mapped to the emulator. Furthermore, due to fragmentation and pre-reservation of memory areas, the size of the memory segments which contain the dynamically allocated memory blocks can be substantially larger than the total size of the dynamically allocated memory blocks.

**Note:**

Since erts version 5.6.4 `erlang:memory/0` requires that all `[erts_alloc(3)]` allocators are enabled (default behaviour).

Failure:

`notsup` If an `[erts_alloc(3)]` allocator has been disabled.

```
erlang:memory(Type | [Type]) -> Size | [{Type, Size}]
```

Types:

- Type, Size – see below

Returns the memory size in bytes allocated for memory of type `Type`. The argument can also be given as a list of `Type` atoms, in which case a corresponding list of `{Type, Size}` tuples is returned.

**Note:**

Since erts version 5.6.4 `erlang:memory/1` requires that all `[erts_alloc(3)]` allocators are enabled (default behaviour).

Failures:

`badarg` If `Type` is not one of the memory types listed in the documentation of `erlang:memory/0` [page 117].

`badarg` If `maximum` is passed as `Type` and the emulator is not run in instrumented mode.

`notsup` If an `[erts_alloc(3)]` allocator has been disabled.

See also `erlang:memory/0` [page 117].

`module_loaded(Module) -> bool()`

Types:

- `Module = atom()`

Returns `true` if the module `Module` is loaded, otherwise returns `false`. It does not attempt to load the module.

**Warning:**

This BIF is intended for the code server (see `code(3)` [page 47]) and should not be used elsewhere.

`erlang:monitor(Type, Item) -> MonitorRef`

Types:

- `Type = process`
- `Item = pid() | {RegName, Node} | RegName`
- `RegName = atom()`
- `Node = node()`
- `MonitorRef = reference()`

The calling process starts monitoring `Item` which is an object of type `Type`.

Currently only processes can be monitored, i.e. the only allowed `Type` is `process`, but other types may be allowed in the future.

`Item` can be:

`pid()` The `pid` of the process to monitor.

`{RegName, Node}` A tuple consisting of a registered name of a process and a node name. The process residing on the node `Node` with the registered name `RegName` will be monitored.

`RegName` The process locally registered as `RegName` will be monitored.

**Note:**

When a process is monitored by registered name, the process that has the registered name at the time when `erlang:monitor/2` is called will be monitored. The monitor will not be effected, if the registered name is unregistered.

A 'DOWN' message will be sent to the monitoring process if `Item` dies, if `Item` does not exist, or if the connection is lost to the node which `Item` resides on. A 'DOWN' message has the following pattern:

```
{'DOWN', MonitorRef, Type, Object, Info}
```

where `MonitorRef` and `Type` are the same as described above, and:

`Object` A reference to the monitored object:

- the pid of the monitored process, if `Item` was specified as a pid.
- `{RegName, Node}`, if `Item` was specified as `{RegName, Node}`.
- `{RegName, Node}`, if `Item` was specified as `RegName`. `Node` will in this case be the name of the local node (`node()`).

`Info` Either the exit reason of the process, `noproc` (non-existing process), or `noconnection` (no connection to `Node`).

**Note:**

If/when `erlang:monitor/2` is extended (e.g. to handle other item types than `process`), other possible values for `Object`, and `Info` in the 'DOWN' message will be introduced.

The monitoring is turned off either when the 'DOWN' message is sent, or when `erlang:demonitor/1` [page 98] is called.

If an attempt is made to monitor a process on an older node (where remote process monitoring is not implemented or one where remote process monitoring by registered name is not implemented), the call fails with `badarg`.

Making several calls to `erlang:monitor/2` for the same `Item` is not an error; it results in as many, completely independent, monitorings.

**Note:**

The format of the 'DOWN' message changed in the 5.2 version of the emulator (OTP release R9B) for monitor *by registered name*. The Object element of the 'DOWN' message could in earlier versions sometimes be the pid of the monitored process and sometimes be the registered name. Now the Object element is always a tuple consisting of the registered name and the node name. Processes on new nodes (emulator version 5.2 or greater) will always get 'DOWN' messages on the new format even if they are monitoring processes on old nodes. Processes on old nodes will always get 'DOWN' messages on the old format.

```
monitor_node(Node, Flag) -> true
```

Types:

- Node = node()
- Flag = bool()

Monitors the status of the node Node. If Flag is true, monitoring is turned on; if Flag is false, monitoring is turned off.

Making several calls to `monitor_node(Node, true)` for the same Node is not an error; it results in as many, completely independent, monitorings.

If Node fails or does not exist, the message `{nodedown, Node}` is delivered to the process. If a process has made two calls to `monitor_node(Node, true)` and Node terminates, two `nodedown` messages are delivered to the process. If there is no connection to Node, there will be an attempt to create one. If this fails, a `nodedown` message is delivered.

Nodes connected through hidden connections can be monitored as any other node.

Failure: `badarg` if the local node is not alive.

```
erlang:monitor_node(Node, Flag, Options) -> true
```

Types:

- Node = node()
- Flag = bool()
- Options = [Option]
- Option = `allow_passive_connect`

Behaves as `monitor_node/2` except that it allows an extra option to be given, namely `allow_passive_connect`. The option allows the BIF to wait the normal net connection timeout for the *monitored node* to connect itself, even if it cannot be actively connected from this node (i.e. it is blocked). The state where this might be useful can only be achieved by using the kernel option `dist_auto_connect` once. If that kernel option is not used, the `allow_passive_connect` option has no effect.

**Note:**

The `allow_passive_connect` option is used internally and is seldom needed in applications where the network topology and the kernel options in effect is known in advance.

Failure: `badarg` if the local node is not alive or the option list is malformed.

`node()` -> `Node`

Types:

- `Node = node()`

Returns the name of the local node. If the node is not alive, `nonode@nohost` is returned instead.

Allowed in guard tests.

`node(Arg)` -> `Node`

Types:

- `Arg = pid() | port() | ref()`
- `Node = node()`

Returns the node where `Arg` is located. `Arg` can be a pid, a reference, or a port. If the local node is not alive, `nonode@nohost` is returned.

Allowed in guard tests.

`nodes()` -> `Nodes`

Types:

- `Nodes = [node()]`

Returns a list of all visible nodes in the system, excluding the local node. Same as `nodes(visible)`.

`nodes(Arg | [Arg])` -> `Nodes`

Types:

- `Arg = visible | hidden | connected | this | known`
- `Nodes = [node()]`

Returns a list of nodes according to argument given. The result returned when the argument is a list, is the list of nodes satisfying the disjunction(s) of the list elements.

`Arg` can be any of the following:

`visible` Nodes connected to this node through normal connections.

`hidden` Nodes connected to this node through hidden connections.

`connected` All nodes connected to this node.

`this` This node.

`known` Nodes which are known to this node, i.e., connected, previously connected, etc.

Some equalities: `[node()] = nodes(this)`, `nodes(connected) = nodes([visible, hidden])`, and `nodes() = nodes(visible)`.

If the local node is not alive, `nodes(this) == nodes(known) == [nonode@nohost]`, for any other `Arg` the empty list `[]` is returned.

`now()` -> `{MegaSecs, Secs, MicroSecs}`

Types:

- `MegaSecs = Secs = MicroSecs = int()`

Returns the tuple `{MegaSecs, Secs, MicroSecs}` which is the elapsed time since 00:00 GMT, January 1, 1970 (zero hour) on the assumption that the underlying OS supports this. Otherwise, some other point in time is chosen. It is also guaranteed that subsequent calls to this BIF returns continuously increasing values. Hence, the return value from `now()` can be used to generate unique time-stamps. It can only be used to check the local time of day if the time-zone info of the underlying operating system is properly configured.

`open_port(PortName, PortSettings) -> port()`

Types:

- `PortName = {spawn, Command} | {fd, In, Out}`
- `Command = string()`
- `In = Out = int()`
- `PortSettings = [Opt]`
- `Opt = {packet, N} | stream | {line, L} | {cd, Dir} | {env, Env} | exit_status | use_stdio | nouse_stdio | stderr_to_stdout | in | out | binary | eof`
- `N = 1 | 2 | 4`
- `L = int()`
- `Dir = string()`
- `Env = [{Name, Val}]`
- `Name = string()`
- `Val = string() | false`

Returns a port identifier as the result of opening a new Erlang port. A port can be seen as an external Erlang process. `PortName` is one of the following:

`{spawn, Command}` Starts an external program. `Command` is the name of the external program which will be run. `Command` runs outside the Erlang work space unless an Erlang driver with the name `Command` is found. If found, that driver will be started. A driver runs in the Erlang workspace, which means that it is linked with the Erlang runtime system.

When starting external programs on Solaris, the system call `vfork` is used in preference to `fork` for performance reasons, although it has a history of being less robust. If there are problems with using `vfork`, setting the environment variable `ERL_NO_VFORK` to any value will cause `fork` to be used instead.

`{fd, In, Out}` Allows an Erlang process to access any currently opened file descriptors used by Erlang. The file descriptor `In` can be used for standard input, and the file descriptor `Out` for standard output. It is only used for various servers in the Erlang operating system (`shell` and `user`). Hence, its use is very limited.

`PortSettings` is a list of settings for the port. Valid settings are:

`{packet, N}` Messages are preceded by their length, sent in `N` bytes, with the most significant byte first. Valid values for `N` are 1, 2, or 4.

`stream` Output messages are sent without packet lengths. A user-defined protocol must be used between the Erlang process and the external object.

- `{line, L}` Messages are delivered on a per line basis. Each line (delimited by the OS-dependent newline sequence) is delivered in one single message. The message data format is `{Flag, Line}`, where `Flag` is either `eof` or `noeof` and `Line` is the actual data delivered (without the newline sequence).
- `L` specifies the maximum line length in bytes. Lines longer than this will be delivered in more than one message, with the `Flag` set to `noeof` for all but the last message. If end of file is encountered anywhere else than immediately following a newline sequence, the last line will also be delivered with the `Flag` set to `noeof`. In all other cases, lines are delivered with `Flag` set to `eof`.
- The `{packet, N}` and `{line, L}` settings are mutually exclusive.
- `{cd, Dir}` This is only valid for `{spawn, Command}`. The external program starts using `Dir` as its working directory. `Dir` must be a string. Not available on VxWorks.
- `{env, Env}` This is only valid for `{spawn, Command}`. The environment of the started process is extended using the environment specifications in `Env`.
- `Env` should be a list of tuples `{Name, Val}`, where `Name` is the name of an environment variable, and `Val` is the value it is to have in the spawned port process. Both `Name` and `Val` must be strings. The one exception is `Val` being the atom `false` (in analogy with `os:getenv/1`), which removes the environment variable. Not available on VxWorks.
- `exit_status` This is only valid for `{spawn, Command}` where `Command` refers to an external program.
- When the external process connected to the port exits, a message of the form `{Port, {exit_status, Status}}` is sent to the connected process, where `Status` is the exit status of the external process. If the program aborts, on Unix the same convention is used as the shells do (i.e., `128+signal`).
- If the `eof` option has been given as well, the `eof` message and the `exit_status` message appear in an unspecified order.
- If the port program closes its `stdout` without exiting, the `exit_status` option will not work.
- `use_stdio` This is only valid for `{spawn, Command}`. It allows the standard input and output (file descriptors 0 and 1) of the spawned (UNIX) process for communication with Erlang.
- `nouse_stdio` The opposite of `use_stdio`. Uses file descriptors 3 and 4 for communication with Erlang.
- `stderr_to_stdout` Affects ports to external programs. The executed program gets its standard error file redirected to its standard output file. `stderr_to_stdout` and `nouse_stdio` are mutually exclusive.
- `in` The port can only be used for input.
- `out` The port can only be used for output.
- `binary` All IO from the port are binary data objects as opposed to lists of bytes.
- `eof` The port will not be closed at the end of the file and produce an exit signal. Instead, it will remain open and a `{Port, eof}` message will be sent to the process holding the port.
- `hide` When running on Windows, suppress creation of a new console window when spawning the port program. (This option has no effect on other platforms.)

The default is `stream` for all types of port and `use_stdio` for spawned ports.

Failure: If the port cannot be opened, the exit reason is `badarg`, `system_limit`, or the Posix error code which most closely describes the error, or `EINVAL` if no Posix code is appropriate:



`badarg` Bad input arguments to `open_port`.

`system_limit` All available ports in the Erlang emulator are in use.

`enomem` There was not enough memory to create the port.

`eagain` There are no more available operating system processes.

`enametoolong` The external command given was too long.

`emfile` There are no more available file descriptors (for the operating system process that the Erlang emulator runs in).

`enfile` The file table is full (for the entire operating system).

During use of a port opened using `{spawn, Name}`, errors arising when sending messages to it are reported to the owning process using signals of the form `{'EXIT', Port, PosixCode}`. See `file(3)` for possible values of `PosixCode`.

The maximum number of ports that can be open at the same time is 1024 by default, but can be configured by the environment variable `ERL_MAX_PORTS`.

`erlang:phash(Term, Range) -> Hash`

Types:

- `Term = term()`
- `Range = 1..232`
- `Hash = 1..Range`

Portable hash function that will give the same hash for the same Erlang term regardless of machine architecture and ERTS version (the BIF was introduced in ERTS 4.9.1.1). `Range` can be between 1 and  $2^{32}$ , the function returns a hash value for `Term` within the range `1..Range`.

This BIF could be used instead of the old deprecated `erlang:hash/2` BIF, as it calculates better hashes for all data-types, but consider using `phash2/1,2` instead.

`erlang:phash2(Term [, Range]) -> Hash`

Types:

- `Term = term()`
- `Range = 1..232`
- `Hash = 0..Range-1`

Portable hash function that will give the same hash for the same Erlang term regardless of machine architecture and ERTS version (the BIF was introduced in ERTS 5.2). `Range` can be between 1 and  $2^{32}$ , the function returns a hash value for `Term` within the range `0..Range-1`. When called without the `Range` argument, a value in the range `0..227-1` is returned.

This BIF should always be used for hashing terms. It distributes small integers better than `phash/2`, and it is faster for bignums and binaries.

Note that the range `0..Range-1` is different from the range of `phash/2` (`1..Range`).

`pid_to_list(Pid) -> string()`

Types:

- `Pid = pid()`

Returns a string which corresponds to the text representation of `Pid`.

**Warning:**

This BIF is intended for debugging and for use in the Erlang operating system. It should not be used in application programs.

`port_close(Port) -> true`

Types:

- `Port = port() | atom()`

Closes an open port. Roughly the same as `Port ! {self(), close}` except for the error behaviour (see below), and that the port does *not* reply with `{Port, closed}`. Any process may close a port with `port_close/1`, not only the port owner (the connected process).

For comparison: `Port ! {self(), close}` fails with `badarg` if `Port` cannot be sent to (i.e., `Port` refers neither to a port nor to a process). If `Port` is a closed port nothing happens. If `Port` is an open port and the calling process is the port owner, the port replies with `{Port, closed}` when all buffers have been flushed and the port really closes, but if the calling process is not the port owner the *port owner* fails with `badsig`.

Note that any process can close a port using `Port ! {PortOwner, close}` just as if it itself was the port owner, but the reply always goes to the port owner.

In short: `port_close(Port)` has a cleaner and more logical behaviour than `Port ! {self(), close}`.

Failure: `badarg` if `Port` is not an open port or the registered name of an open port.

`port_command(Port, Data) -> true`

Types:

- `Port = port() | atom()`
- `Data = iodata()`

Sends data to a port. Same as `Port ! {self(), {command, Data}}` except for the error behaviour (see below). Any process may send data to a port with `port_command/2`, not only the port owner (the connected process).

For comparison: `Port ! {self(), {command, Data}}` fails with `badarg` if `Port` cannot be sent to (i.e., `Port` refers neither to a port nor to a process). If `Port` is a closed port the data message disappears without a sound. If `Port` is open and the calling process is not the port owner, the *port owner* fails with `badsig`. The port owner fails with `badsig` also if `Data` is not a valid IO list.

Note that any process can send to a port using `Port ! {PortOwner, {command, Data}}` just as if it itself was the port owner.

In short: `port_command(Port, Data)` has a cleaner and more logical behaviour than `Port ! {self(), {command, Data}}`.

Failure: `badarg` if `Port` is not an open port or the registered name of an open port.

`port_connect(Port, Pid) -> true`

Types:

- Port = port() | atom()
- Pid = pid()

Sets the port owner (the connected port) to Pid. Roughly the same as Port ! {self(), {connect, Pid}} except for the following:

- The error behavior differs, see below.
- The port does *not* reply with {Port, connected}.
- The new port owner gets linked to the port.

The old port owner stays linked to the port and have to call unlink(Port) if this is not desired. Any process may set the port owner to be any process with port\_connect/2.

For comparison: Port ! {self(), {connect, Pid}} fails with badarg if Port cannot be sent to (i.e., Port refers neither to a port nor to a process). If Port is a closed port nothing happens. If Port is an open port and the calling process is the port owner, the port replies with {Port, connected} to the old port owner. Note that the old port owner is still linked to the port, and that the new is not. If Port is an open port and the calling process is not the port owner, the *port owner* fails with badsig. The port owner fails with badsig also if Pid is not an existing local pid.

Note that any process can set the port owner using Port ! {PortOwner, {connect, Pid}} just as if it itself was the port owner, but the reply always goes to the port owner.

In short: port\_connect(Port, Pid) has a cleaner and more logical behaviour than Port ! {self(), {connect, Pid}}.

Failure: badarg if Port is not an open port or the registered name of an open port, or if Pid is not an existing local pid.

port\_control(Port, Operation, Data) -> Res

Types:

- Port = port() | atom()
- Operation = int()
- Data = Res = iodata()

Performs a synchronous control operation on a port. The meaning of Operation and Data depends on the port, i.e., on the port driver. Not all port drivers support this control feature.

Returns: a list of integers in the range 0 through 255, or a binary, depending on the port driver. The meaning of the returned data also depends on the port driver.

Failure: badarg if Port is not an open port or the registered name of an open port, if Operation cannot fit in a 32-bit integer, if the port driver does not support synchronous control operations, or if the port driver so decides for any reason (probably something wrong with Operation or Data).

erlang:port\_call(Port, Operation, Data) -> term()

Types:

- Port = port() | atom()
- Operation = int()
- Data = term()

Performs a synchronous call to a port. The meaning of `Operation` and `Data` depends on the port, i.e., on the port driver. Not all port drivers support this feature.

`Port` is a port identifier, referring to a driver.

`Operation` is an integer, which is passed on to the driver.

`Data` is any Erlang term. This data is converted to binary term format and sent to the port.

Returns: a term from the driver. The meaning of the returned data also depends on the port driver.

Failure: `badarg` if `Port` is not an open port or the registered name of an open port, if `Operation` cannot fit in a 32-bit integer, if the port driver does not support synchronous control operations, or if the port driver so decides for any reason (probably something wrong with `Operation` or `Data`).

```
erlang:port_info(Port) -> [{Item, Info}] | undefined
```

Types:

- `Port` = `port()` | `atom()`
- `Item, Info` – see below

Returns a list containing tuples with information about the `Port`, or `undefined` if the port is not open. The order of the tuples is not defined, nor are all the tuples mandatory.

`{registered_name, RegName}` `RegName` (an atom) is the registered name of the port. If the port has no registered name, this tuple is not present in the list.

`{id, Index}` `Index` (an integer) is the internal index of the port. This index may be used to separate ports.

`{connected, Pid}` `Pid` is the process connected to the port.

`{links, Pids}` `Pids` is a list of pids to which processes the port is linked.

`{name, String}` `String` is the command name set by `open_port`.

`{input, Bytes}` `Bytes` is the total number of bytes read from the port.

`{output, Bytes}` `Bytes` is the total number of bytes written to the port.

Failure: `badarg` if `Port` is not a local port.

```
erlang:port_info(Port, Item) -> {Item, Info} | undefined | []
```

Types:

- `Port` = `port()` | `atom()`
- `Item, Info` – see below

Returns information about `Port` as specified by `Item`, or `undefined` if the port is not open. Also, if `Item` == `registered_name` and the port has no registered name, `[]` is returned.

For valid values of `Item`, and corresponding values of `Info`, see `erlang:port_info/1` [page 128].

Failure: `badarg` if `Port` is not a local port.

```
erlang:port_to_list(Port) -> string()
```

Types:

- Port = port()

Returns a string which corresponds to the text representation of the port identifier `Port`.

**Warning:**

This BIF is intended for debugging and for use in the Erlang operating system. It should not be used in application programs.

`erlang:ports() -> [port()]`

Returns a list of all ports on the local node.

`pre_loaded() -> [Module]`

Types:

- Module = atom()

Returns a list of Erlang modules which are pre-loaded in the system. As all loading of code is done through the file system, the file system must have been loaded previously. Hence, at least the module `init` must be pre-loaded.

`erlang:process_display(Pid, Type) -> void()`

Types:

- Pid = pid()
- Type = backtrace

Writes information about the local process `Pid` on standard error. The currently allowed value for the atom `Type` is `backtrace`, which shows the contents of the call stack, including information about the call chain, with the current function printed first. The format of the output is not further defined.

`process_flag(Flag, Value) -> OldValue`

Types:

- Flag, Value, OldValue – see below

Sets certain flags for the process which calls this function. Returns the old value of the flag.

`process_flag(trap_exit, Boolean)` When `trap_exit` is set to `true`, exit signals arriving to a process are converted to `{'EXIT', From, Reason}` messages, which can be received as ordinary messages. If `trap_exit` is set to `false`, the process exits if it receives an exit signal other than `normal` and the exit signal is propagated to its linked processes. Application processes should normally not trap exits. See also `exit/2` [page 101].

`process_flag(error_handler, Module)` This is used by a process to redefine the error handler for undefined function calls and undefined registered processes. Inexperienced users should not use this flag since code auto-loading is dependent on the correct operation of the error handling module.

`process_flag(min_heap_size, MinHeapSize)` This changes the minimum heap size for the calling process.

`process_flag(priority, Level)` This sets the process priority. `Level` is an atom.

There are currently four priority levels: `low`, `normal`, `high`, and `max`. The default priority level is `normal`. *NOTE:* The `max` priority level is reserved for internal use in the Erlang runtime system, and should *not* be used by others.

Internally in each priority level processes are scheduled in a round robin fashion.

Execution of processes on priority `normal` and priority `low` will be interleaved.

Processes on priority `low` will be selected for execution less frequently than processes on priority `normal`.

When there are runnable processes on priority `high` no processes on priority `low`, or `normal` will be selected for execution. Note, however, that this does *not* mean that no processes on priority `low`, or `normal` will be able to run when there are processes on priority `high` running. On the runtime system with SMP support there might be more processes running in parallel than processes on priority `high`, i.e., a `low`, and a `high` priority process might execute at the same time.

When there are runnable processes on priority `max` no processes on priority `low`, `normal`, or `high` will be selected for execution. As with the `high` priority, processes on lower priorities might execute in parallel with processes on priority `max`.

Scheduling is preemptive. Regardless of priority, a process is preempted when it has consumed more than a certain amount of reductions since the last time it was selected for execution.

*NOTE:* You should not depend on the scheduling to remain exactly as it is today. Scheduling, at least on the runtime system with SMP support, is very likely to be modified in the future in order to better utilize available processor cores.

There is currently *no* automatic mechanism for avoiding priority inversion, such as priority inheritance, or priority ceilings. When using priorities you have to take this into account and handle such scenarios by yourself.

Making calls from a `high` priority process into code that you don't have control over may cause the `high` priority process to wait for a processes with lower priority, i.e., effectively decreasing the priority of the `high` priority process during the call. Even if this isn't the case with one version of the code that you don't have under your control, it might be the case in a future version of it. This might, for example, happen if a `high` priority process triggers code loading, since the code server runs on priority `normal`.

Other priorities than `normal` are normally not needed. When other priorities are used, they need to be used with care, especially the `high` priority *must* be used with care. A process on `high` priority should only perform work for short periods of time. Busy looping for long periods of time in a `high` priority process will most likely cause problems, since there are important servers in OTP running on priority `normal`.

`process_flag(save_calls, N)` When there are runnable processes on priority `max` no processes on priority `low`, `normal`, or `high` will be selected for execution. As with the `high` priority, processes on lower priorities might execute in parallel with processes on priority `max`.

`N` must be an integer in the interval 0..10000. If `N > 0`, call saving is made active for the process, which means that information about the `N` most recent global function calls, BIF calls, sends and receives made by the process are saved in a list, which can be retrieved with `process_info(Pid, last_calls)`. A global function call is one in which the module of the function is explicitly mentioned. Only a fixed amount of information is saved: a tuple `{Module, Function, Arity}` for function calls, and the mere atoms `send`, `'receive'` and `timeout` for sends and receives (`'receive'` when a message is received and `timeout` when a receive times

out). If  $N = 0$ , call saving is disabled for the process, which is the default. Whenever the size of the call saving list is set, its contents are reset.

`process_flag(sensitive, Boolean)` Set or clear the `sensitive` flag for the current process. When a process has been marked as sensitive by calling `process_flag(sensitive, true)`, features in the run-time system that can be used for examining the data and/or inner working of the process are silently disabled.

Features that are disabled include (but are not limited to) the following:

Tracing: Trace flags can still be set for the process, but no trace messages of any kind will be generated. (If the `sensitive` flag is turned off, trace messages will again be generated if there are any trace flags set.)

Sequential tracing: The sequential trace token will be propagated as usual, but no sequential trace messages will be generated.

`process_info/1,2` cannot be used to read out the message queue or the process dictionary (both will be returned as empty lists).

Stack back-traces cannot be displayed for the process.

In crash dumps, the stack, messages, and the process dictionary will be omitted.

If `{save_calls, N}` has been set for the process, no function calls will be saved to the call saving list. (The call saving list will not be cleared; furthermore, send, receive, and timeout events will still be added to the list.)

`process_flag(Pid, Flag, Value) -> OldValue`

Types:

- `Pid = pid()`
- `Flag, Value, OldValue` – see below

Sets certain flags for the process `Pid`, in the same manner as `process_flag/2` [page 129]. Returns the old value of the flag. The allowed values for `Flag` are only a subset of those allowed in `process_flag/2`, namely: `save_calls`.

Failure: `badarg` if `Pid` is not a local process.

`process_info(Pid) -> InfoResult`

Types:

- `Pid = pid()`
- `Item = atom()`
- `Info = term()`
- `InfoTuple = {Item, Info}`
- `InfoTupleList = [InfoTuple]`
- `InfoResult = InfoTupleList | undefined`

Returns a list containing `InfoTuples` with miscellaneous information about the process identified by `Pid`, or `undefined` if the process is not alive.

The order of the `InfoTuples` is not defined, nor are all the `InfoTuples` mandatory. The `InfoTuples` part of the result may be changed without prior notice. Currently `InfoTuples` with the following `Items` are part of the result: `current_function`, `initial_call`, `status`, `message_queue_len`, `messages`, `links`, `dictionary`, `trap_exit`, `error_handler`, `priority`, `group_leader`, `total_heap_size`, `heap_size`, `stack_size`, `reductions`, and `garbage_collection`. If the process identified by `Pid` has a registered name also an `InfoTuple` with `Item == registered_name` will appear.

See `process_info/2` [page 132] for information about specific `InfoTuples`.

**Warning:**

This BIF is intended for *debugging only*, use `process_info/2` [page 132] for all other purposes.

Failure: `badarg` if `Pid` is not a local process.

```
process_info(Pid, ItemSpec) -> InfoResult
```

Types:

- `Pid` = `pid()`
- `Item` = `atom()`
- `Info` = `term()`
- `ItemList` = `[Item]`
- `ItemSpec` = `Item` | `ItemList`
- `InfoTuple` = `{Item, Info}`
- `InfoTupleList` = `[InfoTuple]`
- `InfoResult` = `InfoTuple` | `InfoTupleList` | `undefined` | `[]`

Returns information about the process identified by `Pid` as specified by the `ItemSpec`, or `undefined` if the process is not alive.

If the process is alive and `ItemSpec` is a single `Item`, the returned value is the corresponding `InfoTuple` unless `ItemSpec == registered_name` and the process has no registered name. In this case `[]` is returned. This strange behavior is due to historical reasons, and is kept for backward compatibility.

If `ItemSpec` is an `ItemList`, the result is an `InfoTupleList`. The `InfoTuples` in the `InfoTupleList` will appear with the corresponding `Items` in the same order as the `Items` appeared in the `ItemList`. Valid `Items` may appear multiple times in the `ItemList`.

**Note:**

If `registered_name` is part of an `ItemList` and the process has no name registered a `{registered_name, []}` `InfoTuple` *will* appear in the resulting `InfoTupleList`. This behavior is different than when `ItemSpec == registered_name`, and than when `process_info/1` is used.

Currently the following `InfoTuples` with corresponding `Items` are valid:

`{backtrace, Bin}` The binary `Bin` contains the same information as the output from `erlang:process_display(Pid, backtrace)`. Use `binary_to_list/1` to obtain the string of characters from the binary.

`{binary, BinInfo}` `BinInfo` is a list containing miscellaneous information about binaries currently being referred to by this process. This `InfoTuple` may be changed or removed without prior notice.

`{catchlevel, CatchLevel}` `CatchLevel` is the number of currently active catches in this process. This `InfoTuple` may be changed or removed without prior notice.



- `{current_function, {Module, Function, Args}}` `Module, Function, Args` is the current function call of the process.
- `{dictionary, Dictionary}` `Dictionary` is the dictionary of the process.
- `{error_handler, Module}` `Module` is the error handler module used by the process (for undefined function calls, for example).
- `{garbage_collection, GCInfo}` `GCInfo` is a list which contains miscellaneous information about garbage collection for this process. The content of `GCInfo` may be changed without prior notice.
- `{group_leader, GroupLeader}` `GroupLeader` is group leader for the IO of the process.
- `{heap_size, Size}` `Size` is the size in words of youngest heap generation of the process. This generation currently include the stack of the process. This information is highly implementation dependent, and may change if the implementation change.
- `{initial_call, {Module, Function, Arity}}` `Module, Function, Arity` is the initial function call with which the process was spawned.
- `{links, Pids}` `Pids` is a list of pids, with processes to which the process has a link.
- `{last_calls, false|Calls}` The value is `false` if call saving is not active for the process (see `process_flag/3` [page 131]). If call saving is active, a list is returned, in which the last element is the most recent called.
- `{memory, Size}` `Size` is the size in bytes of the process. This includes call stack, heap and internal structures.
- `{message_binary, BinInfo}` `BinInfo` is a list containing miscellaneous information about binaries currently being referred to by the message area. This `InfoTuple` is only valid on an emulator using the hybrid heap type. This `InfoTuple` may be changed or removed without prior notice.
- `{message_queue_len, MessageQueueLen}` `MessageQueueLen` is the number of messages currently in the message queue of the process. This is the length of the list `MessageQueue` returned as the info item `messages` (see below).
- `{messages, MessageQueue}` `MessageQueue` is a list of the messages to the process, which have not yet been processed.
- `{monitored_by, Pids}` A list of pids that are monitoring the process (with `erlang:monitor/2`).
- `{monitors, Monitors}` A list of monitors (started by `erlang:monitor/2`) that are active for the process. For a local process monitor or a remote process monitor by pid, the list item is `{process, Pid}`, and for a remote process monitor by name, the list item is `{process, {RegName, Node}}`.
- `{priority, Level}` `Level` is the current priority level for the process. For more information on priorities see `process_flag(priority, Level)` [page 130].
- `{reductions, Number}` `Number` is the number of reductions executed by the process.
- `{registered_name, Atom}` `Atom` is the registered name of the process. If the process has no registered name, this tuple is not present in the list.
- `{sequential_trace_token, [] | SequentialTraceToken}` `SequentialTraceToken` the sequential trace token for the process. This `InfoTuple` may be changed or removed without prior notice.
- `{stack_size, Size}` `Size` is the stack size of the process in words.

- {status, Status} Status is the status of the process. Status is waiting (waiting for a message), running, runnable (ready to run, but another process is running), or suspended (suspended on a “busy” port or by the `erlang:suspend_process/[1,2]` BIF).
- {suspending, SuspendeeList} SuspendeeList is a list of {Suspendee, ActiveSuspendCount, OutstandingSuspendCount} tuples. Suspendee is the pid of a process that have been or is to be suspended by the process identified by Pid via the `erlang:suspend_process/2` [page 146] BIF, or the `erlang:suspend_process/1` [page 148] BIF. ActiveSuspendCount is the number of times the Suspendee has been suspended by Pid. OutstandingSuspendCount is the number of not yet completed suspend requests sent by Pid. That is, if ActiveSuspendCount  $\neq$  0, Suspendee is currently in the suspended state, and if OutstandingSuspendCount  $\neq$  0 the asynchronous option of `erlang:suspend_process/2` has been used and the suspendee has not yet been suspended by Pid. Note that the ActiveSuspendCount and OutstandingSuspendCount are not the total suspend count on Suspendee, only the parts contributed by Pid.
- {total\_heap\_size, Size} Size is the total size in words of all heap fragments of the process. This currently include the stack of the process.
- {trace, InternalTraceFlags} InternalTraceFlags is an integer representing internal trace flag for this process. This InfoTuple may be changed or removed without prior notice.
- {trap\_exit, Boolean} Boolean is true if the process is trapping exits, otherwise it is false.

Note however, that not all implementations support every one of the above Items.

Failure: badarg if Pid is not a local process, or if Item is not a valid Item.

`processes()` -> [pid()]

Returns a list of process identifiers corresponding to all the processes currently existing on the local node.

Note that a process that is exiting, exists but is not alive, i.e., `is_process_alive/1` will return false for a process that is exiting, but its process identifier will be part of the result returned from `processes/0`.

> processes().  
[<0.0.0>, <0.2.0>, <0.4.0>, <0.5.0>, <0.7.0>, <0.8.0>]

`purge_module(Module)` -> void()

Types:

- Module = atom()

Removes old code for Module. Before this BIF is used, `erlang:check_process_code/2` should be called to check that no processes are executing old code in the module.

### Warning:

This BIF is intended for the code server (see `code(3)` [page 47]) and should not be used elsewhere.

Failure: badarg if there is no old code for Module.

```
put(Key, Val) -> OldVal | undefined
```

Types:

- Key = Val = OldVal = term()

Adds a new Key to the process dictionary, associated with the value Val, and returns undefined. If Key already exists, the old value is deleted and replaced by Val and the function returns the old value.

### Note:

The values stored when put is evaluated within the scope of a catch will not be retracted if a throw is evaluated, or if an error occurs.

```
> X = put(name, walrus), Y = put(name, carpenter),
   Z = get(name),
   {X, Y, Z}.
{undefined, walrus, carpenter}
```

```
erlang:raise(Class, Reason, Stacktrace)
```

Types:

- Class = error | exit | throw
- Reason = term()
- Stacktrace = [{Module, Function, Arity | Args} | {Fun, Args}]
- Module = Function = atom()
- Arity = int()
- Args = [term()]
- Fun = [fun()]

Stops the execution of the calling process with an exception of given class, reason and call stack backtrace (*stacktrace*).

### Warning:

This BIF is intended for debugging and for use in the Erlang operating system. In general, it should be avoided in applications, unless you know very well what you are doing.

Class is one of error, exit or throw, so if it were not for the stacktrace `erlang:raise(Class, Reason, Stacktrace)` is equivalent to `erlang:Class(Reason)`. Reason is any term and Stacktrace is a list as returned from `get_stacktrace()`, that is a list of 3-tuples {Module, Function, Arity | Args} where Module and Function are atoms and the third element is an integer arity or an argument list. The stacktrace may also contain {Fun, Args} tuples where Fun is a local fun and Args is an argument list.

The stacktrace is used as the exception stacktrace for the calling process; it will be truncated to the current maximum stacktrace depth.

Because evaluating this function causes the process to terminate, it has no return value - unless the arguments are invalid, in which case the function *returns the error reason*, that is `badarg`. If you want to be really sure not to return you can call `erlang:error(erlang:raise(Class, Reason, Stacktrace))` and hope to distinguish exceptions later.

```
erlang:read_timer(TimerRef) -> int() | false
```

Types:

- `TimerRef = ref()`

`TimerRef` is a timer reference returned by `erlang:send_after/3` [page 138] or `erlang:start_timer/3` [page 145]. If the timer is active, the function returns the time in milliseconds left until the timer will expire, otherwise `false` (which means that `TimerRef` was never a timer, that it has been cancelled, or that it has already delivered its message).

See also `erlang:send_after/3` [page 138], `erlang:start_timer/3` [page 145], and `erlang:cancel_timer/1` [page 94].

```
erlang:ref_to_list(Ref) -> string()
```

Types:

- `Ref = ref()`

Returns a string which corresponds to the text representation of `Ref`.

### Warning:

This BIF is intended for debugging and for use in the Erlang operating system. It should not be used in application programs.

```
register(RegName, Pid | Port) -> true
```

Types:

- `RegName = atom()`
- `Pid = pid()`
- `Port = port()`

Associates the name `RegName` with a `pid` or a port identifier. `RegName`, which must be an atom, can be used instead of the `pid` / port identifier in the send operator (`RegName ! Message`).

```
> register(db, Pid).
true
```

Failure: `badarg` if `Pid` is not an existing, local process or port, if `RegName` is already in use, if the process or port is already registered (already has a name), or if `RegName` is the atom `undefined`.

```
registered() -> [RegName]
```

Types:

- `RegName = atom()`

Returns a list of names which have been registered using `register/2` [page 136].

```
> registered().
[code_server, file_server, init, user, my_db]
```

`erlang:resume_process(Suspendee) -> true`

Types:

- `Suspendee = pid()`

Decreases the suspend count on the process identified by `Suspendee`. `Suspendee` should previously have been suspended via `erlang:suspend_process/2` [page 146], or `erlang:suspend_process/1` [page 148] by the process calling `erlang:resume_process(Suspendee)`. When the suspend count on `Suspendee` reach zero, `Suspendee` will be resumed, i.e., the state of the `Suspendee` is changed from suspended into the state `Suspendee` was in before it was suspended.

### Warning:

This BIF is intended for debugging only.

Failures:

`badarg` If `Suspendee` isn't a process identifier.

`badarg` If the process calling `erlang:resume_process/1` had not previously increased the suspend count on the process identified by `Suspendee`.

`badarg` If the process identified by `Suspendee` is not alive.

`round(Number) -> int()`

Types:

- `Number = number()`

Returns an integer by rounding `Number`.

```
> round(5.5).
6
```

Allowed in guard tests.

`self() -> pid()`

Returns the pid (process identifier) of the calling process.

```
> self().
<0.26.0>
```

Allowed in guard tests.

`erlang:send(Dest, Msg) -> Msg`

Types:

- `Dest = pid() | port() | RegName | {RegName, Node}`
- `Msg = term()`

- RegName = atom()
- Node = node()

Sends a message and returns `Msg`. This is the same as `Dest ! Msg`.

`Dest` may be a remote or local pid, a (local) port, a locally registered name, or a tuple `{RegName, Node}` for a registered name at another node.

```
erlang:send(Dest, Msg, [Option]) -> Res
```

Types:

- Dest = pid() | port() | RegName | {RegName, Node}
- RegName = atom()
- Node = node()
- Msg = term()
- Option = nosuspend | noconnect
- Res = ok | nosuspend | noconnect

Sends a message and returns `ok`, or does not send the message but returns something else (see below). Otherwise the same as `erlang:send/2` [page 137]. See also `erlang:send_nosuspend/2,3` [page 139]. for more detailed explanation and warnings.

The possible options are:

`nosuspend` If the sender would have to be suspended to do the send, `nosuspend` is returned instead.

`noconnect` If the destination node would have to be auto-connected before doing the send, `noconnect` is returned instead.

**Warning:**

As with `erlang:send_nosuspend/2,3`: Use with extreme care!

```
erlang:send_after(Time, Dest, Msg) -> TimerRef
```

Types:

- Time = int()
- 0 <= Time <= 4294967295
- Dest = pid() | RegName
- LocalPid = pid() (of a process, alive or dead, on the local node)
- Msg = term()
- TimerRef = ref()

Starts a timer which will send the message `Msg` to `Dest` after `Time` milliseconds.

If `Dest` is an atom, it is supposed to be the name of a registered process. The process referred to by the name is looked up at the time of delivery. No error is given if the name does not refer to a process.

If `Dest` is a pid, the timer will be automatically canceled if the process referred to by the pid is not alive, or when the process exits. This feature was introduced in erts version 5.4.11. Note that timers will not be automatically canceled when `Dest` is an atom.

See also `erlang:start_timer/3` [page 145], `erlang:cancel_timer/1` [page 94], and `erlang:read_timer/1` [page 136].

Failure: `badarg` if the arguments does not satisfy the requirements specified above.

```
erlang:send_nosuspend(Dest, Msg) -> bool()
```

Types:

- `Dest = pid() | port() | RegName | {RegName, Node}`
- `RegName = atom()`
- `Node = node()`
- `Msg = term()`

The same as `erlang:send(Dest, Msg, [nosuspend])` [page 138], but returns `true` if the message was sent and `false` if the message was not sent because the sender would have had to be suspended.

This function is intended for send operations towards an unreliable remote node without ever blocking the sending (Erlang) process. If the connection to the remote node (usually not a real Erlang node, but a node written in C or Java) is overloaded, this function *will not send the message* but return `false` instead.

The same happens, if `Dest` refers to a local port that is busy. For all other destinations (allowed for the ordinary send operator '!'') this function sends the message and returns `true`.

This function is only to be used in very rare circumstances where a process communicates with Erlang nodes that can disappear without any trace causing the TCP buffers and the drivers queue to be over-full before the node will actually be shut down (due to tick timeouts) by `net_kernel`. The normal reaction to take when this happens is some kind of premature shutdown of the other node.

Note that ignoring the return value from this function would result in *unreliable* message passing, which is contradictory to the Erlang programming model. The message is *not* sent if this function returns `false`.

Note also that in many systems, transient states of overloaded queues are normal. The fact that this function returns `false` does not in any way mean that the other node is guaranteed to be non-responsive, it could be a temporary overload. Also a return value of `true` does only mean that the message could be sent on the (TCP) channel without blocking, the message is not guaranteed to have arrived at the remote node. Also in the case of a disconnected non-responsive node, the return value is `true` (mimics the behaviour of the ! operator). The expected behaviour as well as the actions to take when the function returns `false` are application and hardware specific.

### Warning:

Use with extreme care!

```
erlang:send_nosuspend(Dest, Msg, Options) -> bool()
```

Types:

- Dest = pid() | port() | RegName | {RegName, Node}
- RegName = atom()
- Node = node()
- Msg = term()
- Option = noconnect

The same as `erlang:send(Dest, Msg, [nosuspend | Options])` [page 138], but with boolean return value.

This function behaves like `erlang:send_nosuspend/2` [page 139], but takes a third parameter, a list of options. The only currently implemented option is `noconnect`. The option `noconnect` makes the function return `false` if the remote node is not currently reachable by the local node. The normal behaviour is to try to connect to the node, which may stall the process for a shorter period. The use of the `noconnect` option makes it possible to be absolutely sure not to get even the slightest delay when sending to a remote process. This is especially useful when communicating with nodes who expect to always be the connecting part (i.e. nodes written in C or Java).

Whenever the function returns `false` (either when a suspend would occur or when `noconnect` was specified and the node was not already connected), the message is guaranteed *not* to have been sent.

### Warning:

Use with extreme care!

```
erlang:set_cookie(Node, Cookie) -> true
```

Types:

- Node = node()
- Cookie = atom()

Sets the magic cookie of `Node` to the atom `Cookie`. If `Node` is the local node, the function also sets the cookie of all other unknown nodes to `Cookie` (see [Distributed Erlang] in the Erlang Reference Manual).

Failure: `function_clause` if the local node is not alive.

```
setelement(Index, Tuple1, Value) -> Tuple2
```

Types:

- Index = 1..tuple\_size(Tuple1)
- Tuple1 = Tuple2 = tuple()
- Value = term()

Returns a tuple which is a copy of the argument `Tuple1` with the element given by the integer argument `Index` (the first element is the element with index 1) replaced by the argument `Value`.

```
> setelement(2, {10, green, bottles}, red).
{10,red,bottles}
```



`size(Item) -> int()`

Types:

- `Item = tuple() | binary()`

Returns an integer which is the size of the argument `Item`, which must be either a tuple or a binary.

```
> size({morni, mulle, bwange}).  
3
```

Allowed in guard tests.

`spawn(Fun) -> pid()`

Types:

- `Fun = fun()`

Returns the pid of a new process started by the application of `Fun` to the empty list `[]`. Otherwise works like `spawn/3` [page 141].

`spawn(Node, Fun) -> pid()`

Types:

- `Node = node()`
- `Fun = fun()`

Returns the pid of a new process started by the application of `Fun` to the empty list `[]` on `Node`. If `Node` does not exist, a useless pid is returned. Otherwise works like `spawn/3` [page 141].

`spawn(Module, Function, Args) -> pid()`

Types:

- `Module = Function = atom()`
- `Args = [term()]`

Returns the pid of a new process started by the application of `Module:Function` to `Args`. The new process created will be placed in the system scheduler queue and be run some time later.

`error_handler:undefined_function(Module, Function, Args)` is evaluated by the new process if `Module:Function/Arity` does not exist (where `Arity` is the length of `Args`). The error handler can be redefined (see `process_flag/2` [page 129]). If `error_handler` is undefined, or the user has redefined the default `error_handler` its replacement is undefined, a failure with the reason `undef` will occur.

```
> spawn(speed, regulator, [high_speed, thin_cut]).  
<0.13.1>
```

`spawn(Node, Module, Function, ArgumentList) -> pid()`

Types:

- `Node = node()`
- `Module = Function = atom()`
- `Args = [term()]`

Returns the pid of a new process started by the application of `Module:Function` to `Args` on `Node`. If `Node` does not exist, a useless pid is returned. Otherwise works like `spawn/3` [page 141].

`spawn_link(Fun) -> pid()`

Types:

- `Fun = fun()`

Returns the pid of a new process started by the application of `Fun` to the empty list `[]`. A link is created between the calling process and the new process, atomically. Otherwise works like `spawn/3` [page 141].

`spawn_link(Node, Fun) ->`

Types:

- `Node = node()`
- `Fun = fun()`

Returns the pid of a new process started by the application of `Fun` to the empty list `[]` on `Node`. A link is created between the calling process and the new process, atomically. If `Node` does not exist, a useless pid is returned (and due to the link, an exit signal with exit reason `noconnection` will be received). Otherwise works like `spawn/3` [page 141].

`spawn_link(Module, Function, Args) -> pid()`

Types:

- `Module = Function = atom()`
- `Args = [term()]`

Returns the pid of a new process started by the application of `Module:Function` to `Args`. A link is created between the calling process and the new process, atomically. Otherwise works like `spawn/3` [page 141].

`spawn_link(Node, Module, Function, Args) -> pid()`

Types:

- `Node = node()`
- `Module = Function = atom()`
- `Args = [term()]`

Returns the pid of a new process started by the application of `Module:Function` to `Args` on `Node`. A link is created between the calling process and the new process, atomically. If `Node` does not exist, a useless pid is returned (and due to the link, an exit signal with exit reason `noconnection` will be received). Otherwise works like `spawn/3` [page 141].

`spawn_monitor(Fun) -> {pid(),reference()}`

Types:

- `Fun = fun()`

Returns the pid of a new process started by the application of `Fun` to the empty list `[]` and reference for a monitor created to the new process. Otherwise works like `spawn/3` [page 141].

`spawn_monitor(Module, Function, Args) -> {pid(),reference()}`

Types:

- `Module = Function = atom()`
- `Args = [term()]`

A new process is started by the application of `Module:Function` to `Args`, and the process is monitored at the same time. Returns the pid and a reference for the monitor. Otherwise works like `spawn/3` [page 141].

`spawn_opt(Fun, [Option]) -> pid() | {pid(),reference()}`

Types:

- `Fun = fun()`
- `Option = link | monitor | {priority, Level} | {fullsweep_after, Number} | {min_heap_size, Size}`
- `Level = low | normal | high`
- `Number = int()`
- `Size = int()`

Returns the pid of a new process started by the application of `Fun` to the empty list `[]`. Otherwise works like `spawn_opt/4` [page 143].

If the option `monitor` is given, the newly created process will be monitored and both the pid and reference for the monitor will be returned.

`spawn_opt(Node, Fun, [Option]) -> pid()`

Types:

- `Node = node()`
- `Fun = fun()`
- `Option = link | {priority, Level} | {fullsweep_after, Number} | {min_heap_size, Size}`
- `Level = low | normal | high`
- `Number = int()`
- `Size = int()`

Returns the pid of a new process started by the application of `Fun` to the empty list `[]` on `Node`. If `Node` does not exist, a useless pid is returned. Otherwise works like `spawn_opt/4` [page 143].

`spawn_opt(Module, Function, Args, [Option]) -> pid() | {pid(),reference()}`

Types:

- `Module = Function = atom()`
- `Args = [term()]`
- `Option = link | monitor | {priority, Level} | {fullsweep_after, Number} | {min_heap_size, Size}`
- `Level = low | normal | high`
- `Number = int()`
- `Size = int()`

Works exactly like `spawn/3` [page 141], except that an extra option list is given when creating the process.

If the option `monitor` is given, the newly created process will be monitored and both the `pid` and reference for the monitor will be returned.

`link` Sets a link to the parent process (like `spawn_link/3` does).

`monitor` Monitor the new process (just like `erlang:monitor/2` [page 119] does).

`{priority, Level}` Sets the priority of the new process. Equivalent to executing `process_flag(priority, Level)` [page 130] in the start function of the new process, except that the priority will be set before the process is selected for execution for the first time. For more information on priorities see `process_flag(priority, Level)` [page 130].

`{fullsweep_after, Number}` This option is only useful for performance tuning. In general, you should not use this option unless you know that there is problem with execution times and/or memory consumption, and you should measure to make sure that the option improved matters.

The Erlang runtime system uses a generational garbage collection scheme, using an “old heap” for data that has survived at least one garbage collection. When there is no more room on the old heap, a fullsweep garbage collection will be done.

The `fullsweep_after` option makes it possible to specify the maximum number of generational collections before forcing a fullsweep even if there is still room on the old heap. Setting the number to zero effectively disables the general collection algorithm, meaning that all live data is copied at every garbage collection.

Here are a few cases when it could be useful to change `fullsweep_after`. Firstly, if binaries that are no longer used should be thrown away as soon as possible. (Set `Number` to zero.) Secondly, a process that mostly have short-lived data will be fullswept seldom or never, meaning that the old heap will contain mostly garbage. To ensure a fullsweep once in a while, set `Number` to a suitable value such as 10 or 20. Thirdly, in embedded systems with limited amount of RAM and no virtual memory, one might want to preserve memory by setting `Number` to zero. (The value may be set globally, see `erlang:system_flag/2` [page 148].)

`{min_heap_size, Size}` This option is only useful for performance tuning. In general, you should not use this option unless you know that there is problem with execution times and/or memory consumption, and you should measure to make sure that the option improved matters.

Gives a minimum heap size in words. Setting this value higher than the system default might speed up some processes because less garbage collection is done. Setting too high value, however, might waste memory and slow down the system due to worse data locality. Therefore, it is recommended to use this option only for fine-tuning an application and to measure the execution time with various `Size` values.

```
spawn_opt(Node, Module, Function, Args, [Option]) -> pid()
```

Types:

- `Node` = `node()`
- `Module` = `Function` = `atom()`
- `Args` = `[term()]`
- `Option` = `link` | `{priority, Level}` | `{fullsweep_after, Number}` | `{min_heap_size, Size}`

- Level = low | normal | high
- Number = int()
- Size = int()

Returns the pid of a new process started by the application of `Module:Function` to `Args` on `Node`. If `Node` does not exist, a useless pid is returned. Otherwise works like `spawn_opt/4` [page 143].

`split_binary(Bin, Pos) -> {Bin1, Bin2}`

Types:

- Bin = Bin1 = Bin2 = binary()
- Pos = 1..byte\_size(Bin)

Returns a tuple containing the binaries which are the result of splitting `Bin` into two parts at position `Pos`. This is not a destructive operation. After the operation, there will be three binaries altogether.

```
> B = list_to_binary("0123456789").
<<"0123456789">>
> byte_size(B).
10
> {B1, B2} = split_binary(B,3).
{<<"012">>, <<"3456789">>}
> byte_size(B1).
3
> byte_size(B2).
7
```

`erlang:start_timer(Time, Dest, Msg) -> TimerRef`

Types:

- Time = int()
- 0 <= Time <= 4294967295
- Dest = LocalPid | RegName
- LocalPid = pid() (of a process, alive or dead, on the local node)
- RegName = atom()
- Msg = term()
- TimerRef = ref()

Starts a timer which will send the message `{timeout, TimerRef, Msg}` to `Dest` after `Time` milliseconds.

If `Dest` is an atom, it is supposed to be the name of a registered process. The process referred to by the name is looked up at the time of delivery. No error is given if the name does not refer to a process.

If `Dest` is a pid, the timer will be automatically canceled if the process referred to by the pid is not alive, or when the process exits. This feature was introduced in erts version 5.4.11. Note that timers will not be automatically canceled when `Dest` is an atom.

See also `erlang:send_after/3` [page 138], `erlang:cancel_timer/1` [page 94], and `erlang:read_timer/1` [page 136].

Failure: `badarg` if the arguments does not satisfy the requirements specified above.

`statistics(Type) -> Res`

Types:

- Type, Res – see below

Returns information about the system as specified by Type:

`context_switches` Returns `{ContextSwitches, 0}`, where `ContextSwitches` is the total number of context switches since the system started.

`exact_reductions` Returns `{Total_Exact_Reductions, Exact_Reductions_Since_Last_Call}`.

*NOTE:* `statistics(exact_reductions)` is a more expensive operation than `statistics(reductions)` [page 146] especially on an Erlang machine with SMP support.

`garbage_collection` Returns `{Number_of_GC_s, Words_Reclaimed, 0}`. This information may not be valid for all implementations.

`io` Returns `{{input, Input}, {output, Output}}`, where `Input` is the total number of bytes received through ports, and `Output` is the total number of bytes output to ports.

`reductions` Returns `{Total_Reductions, Reductions_Since_Last_Call}`.

*NOTE:* From erts version 5.5 (OTP release R11B) this value does not include reductions performed in current time slices of currently scheduled processes. If an exact value is wanted, use `statistics(exact_reductions)` [page 146].

`run_queue` Returns the length of the run queue, that is, the number of processes that are ready to run.

`runtime` Returns `{Total_Run_Time, Time_Since_Last_Call}`.

`wall_clock` Returns `{Total_Wallclock_Time, Wallclock_Time_Since_Last_Call}`. `wall_clock` can be used in the same manner as `runtime`, except that real time is measured as opposed to runtime or CPU time.

All times are in milliseconds.

```
> statistics(runtime).
{1690,1620}
> statistics(reductions).
{2046,11}
> statistics(garbage_collection).
{85,23961,0}
```

`erlang:suspend_process(Suspendee, OptList) -> true | false`

Types:

- Suspendee = pid()
- OptList = [Opt]
- Opt = atom()

Increases the suspend count on the process identified by `Suspendee` and puts it in the suspended state if it isn't already in the suspended state. A suspended process will not be scheduled for execution until the process has been resumed.

A process can be suspended by multiple processes and can be suspended multiple times by a single process. A suspended process will not leave the suspended state until its suspend count reach zero. The suspend count of `Suspendee` is decreased when `erlang:resume_process(Suspendee)` [page 137] is called by the same process that called `erlang:suspend_process(Suspendee)`. All increased suspend counts on other processes acquired by a process will automatically be decreased when the process terminates.

Currently the following options (`Opts`) are available:

- `asynchronous` A suspend request is sent to the process identified by `Suspendee`. `Suspendee` will eventually suspend unless it is resumed before it was able to suspend. The caller of `erlang:suspend_process/2` will return immediately, regardless of whether the `Suspendee` has suspended yet or not. Note that the point in time when the `Suspendee` will actually suspend cannot be deduced from other events in the system. The only guarantee given is that the `Suspendee` will *eventually* suspend (unless it is resumed). If the `asynchronous` option has *not* been passed, the caller of `erlang:suspend_process/2` will be blocked until the `Suspendee` has actually suspended.
- `unless_suspending` The process identified by `Suspendee` will be suspended unless the calling process already is suspending the `Suspendee`. If `unless_suspending` is combined with the `asynchronous` option, a suspend request will be sent unless the calling process already is suspending the `Suspendee` or if a suspend request already has been sent and is in transit. If the calling process already is suspending the `Suspendee`, or if combined with the `asynchronous` option and a send request already is in transit, `false` is returned and the suspend count on `Suspendee` will remain unchanged.

If the suspend count on the process identified by `Suspendee` was increased, `true` is returned; otherwise, `false` is returned.

### **Warning:**

This BIF is intended for debugging only.

### Failures:

- `badarg` If `Suspendee` isn't a process identifier.
- `badarg` If the process identified by `Suspendee` is same the process as the process calling `erlang:suspend_process/2`.
- `badarg` If the process identified by `Suspendee` is not alive.
- `badarg` If the process identified by `Suspendee` resides on another node.
- `badarg` If `OptList` isn't a proper list of valid `Opts`.
- `system_limit` If the process identified by `Suspendee` has been suspended more times by the calling process than can be represented by the currently used internal data structures. The current system limit is larger than 2 000 000 000 suspends, and it will never be less than that.

`erlang:suspend_process(Suspendee) -> true`

Types:

- Suspendee = pid()

Suspends the process identified by Suspendee. The same as calling `erlang:suspend_process(Suspendee, [])` [page 146]. For more information see the documentation of `erlang:suspend_process/2` [page 146].

**Warning:**

This BIF is intended for debugging only.

`erlang:system_flag(Flag, Value) -> OldValue`

Types:

- Flag, Value, OldValue – see below

Sets various system properties of the Erlang node. Returns the old value of the flag.

`erlang:system_flag(backtrace_depth, Depth)` Sets the maximum depth of call stack back-traces in the exit reason element of 'EXIT' tuples.

`erlang:system_flag(fullsweep_after, Number)` Number is a non-negative integer which indicates how many times generational garbage collections can be done without forcing a fullsweep collection. The value applies to new processes; processes already running are not affected.

In low-memory systems (especially without virtual memory), setting the value to 0 can help to conserve memory.

An alternative way to set this value is through the (operating system) environment variable `ERL_FULLSWEEP_AFTER`.

`erlang:system_flag(min_heap_size, MinHeapSize)` Sets the default minimum heap size for processes. The size is given in words. The new `min_heap_size` only effects processes spawned after the change of `min_heap_size` has been made. The `min_heap_size` can be set for individual processes by use of `spawn_opt/N` [page 143] or `process_flag/2` [page 129].

`erlang:system_flag(multi_scheduling, BlockState)` BlockState = block | unblock

If multi-scheduling is enabled, more than one scheduler thread is used by the emulator. Multi-scheduling can be blocked. When multi-scheduling has been blocked, only one scheduler thread will schedule Erlang processes.

If BlockState `== block`, multi-scheduling will be blocked. If BlockState `== unblock` and no-one else is blocking multi-scheduling and this process has only blocked one time, multi-scheduling will be unblocked. One process can block multi-scheduling multiple times. If a process has blocked multiple times, it has to unblock exactly as many times as it has blocked before it has released its multi-scheduling block. If a process that has blocked multi-scheduling exits, it will release its blocking of multi-scheduling.

The return values are disabled, blocked, or enabled. The returned value describes the state just after the call to `erlang:system_flag(multi_scheduling, BlockState)` has been made. The return values are described in the documentation of `erlang:system_info(multi_scheduling)` [page 152].



*NOTE:* Blocking of multi-scheduling should normally not be needed. If you feel that you need to block multi-scheduling, think through the problem at least a couple of times again. Blocking multi-scheduling should only be used as a last resort since it will most likely be a *very inefficient* way to solve the problem.

See also `erlang:system_info(multi_scheduling)` [page 152],  
`erlang:system_info(multi_scheduling_blockers)` [page 152], and  
`erlang:system_info(schedulers)` [page 153].

`erlang:system_flag(trace_control_word, TCW)` Sets the value of the node's trace control word to TCW. TCW should be an unsigned integer. For more information see documentation of the `[set_tcw]` function in the match specification documentation in the ERTS User's Guide.

### Note:

The `schedulers` option has been removed as of erts version 5.5.3. The number of scheduler threads is determined at emulator boot time, and cannot be changed after that.

`erlang:system_info(Type) -> Res`

Types:

- Type, Res – see below

Returns various information about the current system (emulator) as specified by Type:

`allocated_areas` Returns a list of tuples with information about miscellaneous allocated memory areas.

Each tuple contains an atom describing type of memory as first element and amount of allocated memory in bytes as second element. In those cases when there is information present about allocated and used memory, a third element is present. This third element contains the amount of used memory in bytes.

`erlang:system_info(allocated_areas)` is intended for debugging, and the content is highly implementation dependent. The content of the results will therefore change when needed without prior notice.

*Note:* The sum of these values is *not* the total amount of memory allocated by the emulator. Some values are part of other values, and some memory areas are not part of the result. If you are interested in the total amount of memory allocated by the emulator see `erlang:memory/0,1` [page 117].

`allocator` Returns {Allocator, Version, Features, Settings}.

Types:

- Allocator = undefined | elib\_malloc | glibc
- Version = [int()]
- Features = [atom()]
- Settings = [{Subsystem, [{Parameter, Value}]}]
- Subsystem = atom()
- Parameter = atom()
- Value = term()

Explanation:

- `Allocator` corresponds to the `malloc()` implementation used. If `Allocator` equals `undefined`, the `malloc()` implementation used could not be identified. Currently `elib_malloc` and `glibc` can be identified.
- `Version` is a list of integers (but not a string) representing the version of the `malloc()` implementation used.
- `Features` is a list of atoms representing allocation features used.
- `Settings` is a list of subsystems, their configurable parameters, and used values. Settings may differ between different combinations of platforms, allocators, and allocation features. Memory sizes are given in bytes.

See also “System Flags Effecting `erts_alloc`” in `[erts_alloc(3)]`.

`alloc_util_allocators` Returns a list of the names of all allocators using the ERTS internal `alloc_util` framework as atoms. For more information see the [“the `alloc_util` framework” section in the `erts_alloc(3)`] documentation.

`{allocator, Alloc}` Returns information about the specified allocator. As of `erts` version 5.6.1 the return value is a list of `{instance, InstanceNo, InstanceInfo}` tuples where `InstanceInfo` contains information about a specific instance of the allocator. If `Alloc` is not a recognized allocator, `undefined` is returned. If `Alloc` is disabled, `false` is returned.

*Note:* The information returned is highly implementation dependent and may be changed, or removed at any time without prior notice. It was initially intended as a tool when developing new allocators, but since it might be of interest for others it has been briefly documented.

The recognized allocators are listed in `[erts_alloc(3)]`. After reading the `erts_alloc(3)` documentation, the returned information should more or less speak for itself. But it can be worth explaining some things. Call counts are presented by two values. The first value is `giga` calls, and the second value is `calls`. `mbs`, and `sbs` are abbreviations for, respectively, multi-block carriers, and single-block carriers. Sizes are presented in bytes. When it is not a size that is presented, it is the amount of something. Sizes and amounts are often presented by three values, the first is current value, the second is maximum value since the last call to `erlang:system_info({allocator, Alloc})`, and the third is maximum value since the emulator was started. If only one value is present, it is the current value. `fix_alloc` memory block types are presented by two values. The first value is memory pool size and the second value used memory size.

`{allocator_sizes, Alloc}` Returns various size information for the specified allocator. The information returned is a subset of the information returned by `erlang:system_info({allocator, Alloc})` [page 150].

`c_compiler_used` Returns a two-tuple describing the C compiler used when compiling the runtime system. The first element is an atom describing the name of the compiler, or `undefined` if unknown. The second element is a term describing the version of the compiler, or `undefined` if unknown.

`check_io` Returns a list containing miscellaneous information regarding the emulators internal I/O checking. Note, the content of the returned list may vary between platforms and over time. The only thing guaranteed is that a list is returned.

`compat_rel` Returns the compatibility mode of the local node as an integer. The integer returned represents the Erlang/OTP release which the current emulator has been set to be backward compatible with. The compatibility mode can be configured at startup by using the command line flag `+R`, see `[erl(1)]`.

`creation` Returns the creation of the local node as an integer. The creation is changed when a node is restarted. The creation of a node is stored in process identifiers,

- port identifiers, and references. This makes it (to some extent) possible to distinguish between identifiers from different incarnations of a node. Currently valid creations are integers in the range 1..3, but this may (probably will) change in the future. If the node is not alive, 0 is returned.
- `debug_compiled` Returns `true` if the emulator has been debug compiled; otherwise, `false`.
- `dist` Returns a binary containing a string of distribution information formatted as in Erlang crash dumps. For more information see the [“How to interpret the Erlang crash dumps”] chapter in the ERTS User’s Guide.
- `dist_ctrl` Returns a list of tuples `{Node, ControllingEntity}`, one entry for each connected remote node. The `Node` is the name of the node and the `ControllingEntity` is the port or pid responsible for the communication to that node. More specifically, the `ControllingEntity` for nodes connected via TCP/IP (the normal case) is the socket actually used in communication with the specific node.
- `driver_version` Returns a string containing the erlang driver version used by the runtime system. It will be on the form [“<major ver>.<minor ver>”].
- `elib_malloc` If the emulator uses the `elib_malloc` memory allocator, a list of two-element tuples containing status information is returned; otherwise, `false` is returned. The list currently contains the following two-element tuples (all sizes are presented in bytes):
- `{heap_size, Size}` Where `Size` is the current heap size.
  - `{max_allocated_size, Size}` Where `Size` is the maximum amount of memory allocated on the heap since the emulator started.
  - `{allocated_size, Size}` Where `Size` is the current amount of memory allocated on the heap.
  - `{free_size, Size}` Where `Size` is the current amount of free memory on the heap.
  - `{no_allocated_blocks, No}` Where `No` is the current number of allocated blocks on the heap.
  - `{no_free_blocks, No}` Where `No` is the current number of free blocks on the heap.
  - `{smallest_allocated_block, Size}` Where `Size` is the size of the smallest allocated block on the heap.
  - `{largest_free_block, Size}` Where `Size` is the size of the largest free block on the heap.
- `fullsweep_after` Returns `{fullsweep_after, int()}` which is the `fullsweep_after` garbage collection setting used by default. For more information see `garbage_collection` described below.
- `garbage_collection` Returns a list describing the default garbage collection settings. A process spawned on the local node by a `spawn` or `spawn_link` will use these garbage collection settings. The default settings can be changed by use of `system_flag/2` [page 148]. `spawn_opt/4` [page 143] can spawn a process that does not use the default settings.
- `global_heaps_size` Returns the current size of the shared (global) heap.
- `heap_sizes` Returns a list of integers representing valid heap sizes in words. All Erlang heaps are sized from sizes in this list.
- `heap_type` Returns the heap type used by the current emulator. Currently the following heap types exist:

- `private` Each process has a heap reserved for its use and no references between heaps of different processes are allowed. Messages passed between processes are copied between heaps.
- `shared` One heap for use by all processes. Messages passed between processes are passed by reference.
- `hybrid` A hybrid of the `private` and `shared` heap types. A shared heap as well as private heaps are used.
- `info` Returns a binary containing a string of miscellaneous system information formatted as in Erlang crash dumps. For more information see the ["How to interpret the Erlang crash dumps"] chapter in the ERTS User's Guide.
- `kernel_poll` Returns `true` if the emulator uses some kind of kernel-poll implementation; otherwise, `false`.
- `loaded` Returns a binary containing a string of loaded module information formatted as in Erlang crash dumps. For more information see the ["How to interpret the Erlang crash dumps"] chapter in the ERTS User's Guide.
- `logical_processors` Returns the number of logical processors detected on the system as an integer or the atom `unknown` if the emulator wasn't able to detect any.
- `machine` Returns a string containing the Erlang machine name.
- `modified_timing_level` Returns the modified timing level (an integer) if modified timing has been enabled; otherwise, `undefined`. See the `+T` command line flag in the documentation of the `[erl(1)]` command for more information on modified timing.
- `multi_scheduling` Returns `disabled`, `blocked`, or `enabled`. A description of the return values:
- `disabled` The emulator has only one scheduler thread. The emulator does not have SMP support, or have been started with only one scheduler thread.
  - `blocked` The emulator has more than one scheduler thread, but all scheduler threads but one have been blocked, i.e., only one scheduler thread will schedule Erlang processes and execute Erlang code.
  - `enabled` The emulator has more than one scheduler thread, and no scheduler threads have been blocked, i.e., all available scheduler threads will schedule Erlang processes and execute Erlang code.
- See also `erlang:system_flag(multi_scheduling, BlockState)` [page 148], `erlang:system_info(multi_scheduling_blockers)` [page 152], and `erlang:system_info(schedulers)` [page 153].
- `multi_scheduling_blockers` Returns a list of PIDs when multi-scheduling is blocked; otherwise, the empty list. The PIDs in the list is PIDs of the processes currently blocking multi-scheduling. A PID will only be present once in the list, even if the corresponding process has blocked multiple times.
- See also `erlang:system_flag(multi_scheduling, BlockState)` [page 148], `erlang:system_info(multi_scheduling)` [page 152], and `erlang:system_info(schedulers)` [page 153].
- `otp_release` Returns a string containing the OTP release number.
- `process_count` Returns the number of processes currently existing at the local node as an integer. The same value as `length(processes())` returns.
- `process_limit` Returns the maximum number of concurrently existing processes at the local node as an integer. This limit can be configured at startup by using the command line flag `+P`, see `[erl(1)]`.

- `procs` Returns a binary containing a string of process and port information formatted as in Erlang crash dumps. For more information see the [“How to interpret the Erlang crash dumps”] chapter in the ERTS User’s Guide.
- `scheduler_id` Returns the scheduler id (`SchedulerId`) of the scheduler thread that the calling process is executing on. `SchedulerId` is a positive integer; where  $1 \leq \text{SchedulerId} \leq \text{erlang:system\_info}(\text{schedulers})$ . See also `erlang:system\_info(schedulers)` [page 153].
- `schedulers` Returns the number of scheduler threads used by the emulator. A scheduler thread schedules Erlang processes and Erlang ports, and execute Erlang code and Erlang linked in driver code.  
The number of scheduler threads is determined at emulator boot time and cannot be changed after that.  
See also `erlang:system\_info(scheduler\_id)` [page 153], `erlang:system\_flag(multi\_scheduling, BlockState)` [page 148], `erlang:system\_info(multi\_scheduling)` [page 152], and `erlang:system\_info(multi\_scheduling\_blockers)` [page 152].
- `smp\_support` Returns `true` if the emulator has been compiled with `smp` support; otherwise, `false`.
- `system\_version` Returns a string containing the emulator type and version as well as some important properties such as the size of the thread pool, etc.
- `system\_architecture` Returns a string containing the processor and OS architecture the emulator is built for.
- `threads` Returns `true` if the emulator has been compiled with thread support; otherwise, `false` is returned.
- `thread\_pool\_size` Returns the number of async threads in the async thread pool used for asynchronous driver calls (`[driver\_async()]`) as an integer.
- `trace\_control\_word` Returns the value of the node’s trace control word. For more information see documentation of the function `get\_tcw` in “Match Specifications in Erlang”, [ERTS User’s Guide].
- `version` Returns a string containing the version number of the emulator.
- `wordsize` Returns the word size in bytes as an integer, i.e. on a 32-bit architecture 4 is returned, and on a 64-bit architecture 8 is returned.

**Note:**

The `scheduler` argument has changed name to `scheduler_id`. This in order to avoid mixup with the `schedulers` argument. The `scheduler` argument was introduced in ERTS version 5.5 and renamed in ERTS version 5.5.1.

`erlang:system_monitor()` -> `MonSettings`

Types:

- `MonSettings` -> `{MonitorPid, Options} | undefined`
- `MonitorPid` = `pid()`
- `Options` = `[Option]`
- `Option` = `{long_gc, Time} | {large_heap, Size} | busy_port | busy_dist_port`

- Time = Size = int()

Returns the current system monitoring settings set by `erlang:system_monitor/2` [page 154] as `{MonitorPid, Options}`, or undefined if there are no settings. The order of the options may be different from the one that was set.

`erlang:system_monitor(undefined | {MonitorPid, Options}) -> MonSettings`

Types:

- MonitorPid, Options, MonSettings – see below

When called with the argument `undefined`, all system performance monitoring settings are cleared.

Calling the function with `{MonitorPid, Options}` as argument, is the same as calling `erlang:system_monitor(MonitorPid, Options)` [page 154].

Returns the previous system monitor settings just like `erlang:system_monitor/0` [page 153].

`erlang:system_monitor(MonitorPid, [Option]) -> MonSettings`

Types:

- MonitorPid = pid()
- Option = {long\_gc, Time} | {large\_heap, Size} | busy\_port | busy\_dist\_port
- Time = Size = int()
- MonSettings = {OldMonitorPid, [Option]}
- OldMonitorPid = pid()

Sets system performance monitoring options. `MonitorPid` is a local pid that will receive system monitor messages, and the second argument is a list of monitoring options:

`{long_gc, Time}` If a garbage collection in the system takes at least `Time` wallclock milliseconds, a message `{monitor, GcPid, long_gc, Info}` is sent to `MonitorPid`. `GcPid` is the pid that was garbage collected and `Info` is a list of two-element tuples describing the result of the garbage collection. One of the tuples is `{timeout, GcTime}` where `GcTime` is the actual time for the garbage collection in milliseconds. The other tuples are tagged with `heap_size`, `heap_block_size`, `stack_size`, `mbuf_size`, `old_heap_size`, and `old_heap_block_size`. These tuples are explained in the documentation of the `gc_start` [page 160] trace message (see `erlang:trace/3` [page 157]). New tuples may be added, and the order of the tuples in the `Info` list may be changed at any time without prior notice.

`{large_heap, Size}` If a garbage collection in the system results in the allocated size of a heap being at least `Size` words, a message `{monitor, GcPid, large_heap, Info}` is sent to `MonitorPid`. `GcPid` and `Info` are the same as for `long_gc` above, except that the tuple tagged with `timeout` is not present. *Note:* As of erts version 5.6 the monitor message is sent if the sum of the sizes of all memory blocks allocated for all heap generations is equal to or larger than `Size`. Previously the monitor message was sent if the memory block allocated for the youngest generation was equal to or larger than `Size`.

`busy_port` If a process in the system gets suspended because it sends to a busy port, a message `{monitor, SusPid, busy_port, Port}` is sent to `MonitorPid`. `SusPid` is the pid that got suspended when sending to `Port`.

`busy_dist_port` If a process in the system gets suspended because it sends to a process on a remote node whose inter-node communication was handled by a busy port, a message `{monitor, SusPid, busy_dist_port, Port}` is sent to `MonitorPid`. `SusPid` is the pid that got suspended when sending through the inter-node communication port `Port`.

Returns the previous system monitor settings just like `erlang:system_monitor/0` [page 153].

**Note:**

If a monitoring process gets so large that it itself starts to cause system monitor messages when garbage collecting, the messages will enlarge the process's message queue and probably make the problem worse.

Keep the monitoring process neat and do not set the system monitor limits too tight.

Failure: `badarg` if `MonitorPid` does not exist.

`erlang:system_profile()` -> `ProfilerSettings`

Types:

- `ProfilerSettings` -> `{ProfilerPid, Options}` | `undefined`
- `ProfilerPid` = `pid()` | `port()`
- `Options` = `[Option]`
- `Option` = `runnable_procs` | `runnable_ports` | `scheduler` | `exclusive`

Returns the current system profiling settings set by `erlang:system_profile/2` [page 155] as `{ProfilerPid, Options}`, or `undefined` if there are no settings. The order of the options may be different from the one that was set.

`erlang:system_profile(ProfilerPid, Options)` -> `ProfilerSettings`

Types:

- `ProfilerSettings` -> `{ProfilerPid, Options}` | `undefined`
- `ProfilerPid` = `pid()` | `port()`
- `Options` = `[Option]`
- `Option` = `runnable_procs` | `runnable_ports` | `scheduler` | `exclusive`

Sets system profiler options. `ProfilerPid` is a local pid or port that will receive profiling messages. The receiver is excluded from all profiling. The second argument is a list of profiling options:

`runnable_procs` If a process is put into or removed from the runqueue a message, `{profile, Pid, State, Mfa, Ts}`, is sent to `ProfilerPid`. Running processes that is reinserted into the runqueue after completing its reductions does not trigger this message.

`runnable_ports` If a port is put into or removed from the runqueue a message, `{profile, Port, State, 0, Ts}`, is sent to `ProfilerPid`.

`scheduler` If a scheduler is put to sleep or awoken a message, `{profile, scheduler, Id, State, NoScheds, Ts}`, is sent to `ProfilerPid`.

`exclusive` If a synchronous call to a port from a process is done, the calling process is considered not runnable during the call runtime to the port. The calling process is notified as `inactive` and subsequently `active` when the port callback returns.

**Note:**

`erlang:system_profile` is considered experimental and its behaviour may change in the future.

`term_to_binary(Term) -> ext_binary()`

Types:

- Term = term()

Returns a binary data object which is the result of encoding Term according to the Erlang external term format.

This can be used for a variety of purposes, for example writing a term to a file in an efficient way, or sending an Erlang term to some type of communications channel not supported by distributed Erlang.

See also `binary_to_term/1` [page 93].

`term_to_binary(Term, [Option]) -> ext_binary()`

Types:

- Term = term()
- Option = `compressed` | `{compressed,Level}` | `{minor_version,Version}`

Returns a binary data object which is the result of encoding Term according to the Erlang external term format.

If the option `compressed` is provided, the external term format will be compressed. The compressed format is automatically recognized by `binary_to_term/1` in R7B and later.

It is also possible to specify a compression level by giving the option `{compressed,Level}`, where Level is an integer from 0 through 9. 0 means that no compression will be done (it is the same as not giving any `compressed` option); 1 will take the least time but may not compress as well as the higher levels; 9 will take the most time and may produce a smaller result. Note the “mays” in the preceding sentence; depending on the input term, level 9 compression may or may not produce a smaller result than level 1 compression.

Currently, `compressed` gives the same result as `{compressed,6}`.

The option `{minor_version,Version}` can be use to control some details of the encoding. This option was introduced in R11B-4. Currently, the allowed values for Version are 0 and 1.

`{minor_version,1}` forces any floats in the term to be encoded in a more space-efficient and exact way (namely in the 64-bit IEEE format, rather than converted to a textual representation). `binary_to_term/1` in R11B-4 and later is able decode the new representation.

`{minor_version,0}` is currently the default, meaning that floats will be encoded using a textual representation; this option is useful if you want to ensure that releases prior to R11B-4 can decode resulting binary.



See also `binary_to_term/1` [page 93].

`throw(Any)`

Types:

- `Any = term()`

A non-local return from a function. If evaluated within a `catch`, `catch` will return the value `Any`.

```
> catch throw({hello, there}).  
{hello,there}
```

Failure: `nocatch` if not evaluated within a `catch`.

`time() -> {Hour, Minute, Second}`

Types:

- `Hour = Minute = Second = int()`

Returns the current time as `{Hour, Minute, Second}`.

The time zone and daylight saving time correction depend on the underlying OS.

```
> time().  
{9,42,44}
```

`tl(List1) -> List2`

Types:

- `List1 = List2 = [term()]`

Returns the tail of `List1`, that is, the list minus the first element.

```
> tl([geesties, guilies, beasties]).  
[guilies, beasties]
```

Allowed in guard tests.

Failure: `badarg` if `List` is the empty list `[]`.

`erlang:trace(PidSpec, How, FlagList) -> int()`

Types:

- `PidSpec = pid() | existing | new | all`
- `How = bool()`
- `FlagList = [Flag]`
- `Flag` – see below

Turns on (if `How == true`) or off (if `How == false`) the trace flags in `FlagList` for the process or processes represented by `PidSpec`.

`PidSpec` is either a `pid` for a local process, or one of the following atoms:

`existing` All processes currently existing.

`new` All processes that will be created in the future.

`all` All currently existing processes and all processes that will be created in the future.

FlagList can contain any number of the following flags (the “message tags” refers to the list of messages following below):

- all Set all trace flags except {tracer, Tracer} and cpu\_timestamp that are in their nature different than the others.
- send Trace sending of messages.  
Message tags: send, send\_to\_non\_existing\_process.
- 'receive' Trace receiving of messages.  
Message tags: 'receive'.
- procs Trace process related events.  
Message tags: spawn, exit, register, unregister, link, unlink, getting\_linked, getting\_unlinked.
- call Trace certain function calls. Specify which function calls to trace by calling erlang:trace\_pattern/3 [page 162].  
Message tags: call, return\_from.
- silent Used in conjunction with the call trace flag. The call, return\_from and return\_to trace messages are inhibited if this flag is set, but if there are match specs they are executed as normal.  
Silent mode is inhibited by executing erlang:trace(\_, false, [silent|\_]), or by a match spec executing the {silent, false} function.  
The silent trace flag facilitates setting up a trace on many or even all processes in the system. Then the interesting trace can be activated and deactivated using the {silent, Bool} match spec function, giving a high degree of control of which functions with which arguments that triggers the trace.  
Message tags: call, return\_from, return\_to. Or rather, the absence of.
- return\_to Used in conjunction with the call trace flag. Trace the actual return from a traced function back to its caller. Only works for functions traced with the local option to erlang:trace\_pattern/3 [page 162].  
The semantics is that a trace message is sent when a call traced function actually returns, that is, when a chain of tail recursive calls is ended. There will be only one trace message sent per chain of tail recursive calls, why the properties of tail recursiveness for function calls are kept while tracing with this flag. Using call and return\_to trace together makes it possible to know exactly in which function a process executes at any time.  
To get trace messages containing return values from functions, use the {return\_trace} match\_spec action instead.  
Message tags: return\_to.
- running Trace scheduling of processes.  
Message tags: in, and out.
- exiting Trace scheduling of an exiting processes.  
Message tags: in\_exiting, out\_exiting, and out\_exited.
- garbage\_collection Trace garbage collections of processes.  
Message tags: gc\_start, gc\_end.
- timestamp Include a time stamp in all trace messages. The time stamp (Ts) is of the same form as returned by erlang:now().
- cpu\_timestamp A global trace flag for the Erlang node that makes all trace timestamps be in CPU time, not wallclock. It is only allowed with PidSpec==all. If the host machine operating system does not support high resolution CPU time measurements, trace/3 exits with badarg.

`arity` Used in conjunction with the `call` trace flag. `{M, F, Arity}` will be specified instead of `{M, F, Args}` in call trace messages.

`set_on_spawn` Makes any process created by a traced process inherit its trace flags, including the `set_on_spawn` flag.

`set_on_first_spawn` Makes the first process created by a traced process inherit its trace flags, excluding the `set_on_first_spawn` flag.

`set_on_link` Makes any process linked by a traced process inherit its trace flags, including the `set_on_link` flag.

`set_on_first_link` Makes the first process linked to by a traced process inherit its trace flags, excluding the `set_on_first_link` flag.

`{tracer, Tracer}` Specify where to send the trace messages. `Tracer` must be the pid of a local process or the port identifier of a local port. If this flag is not given, trace messages will be sent to the process that called `erlang:trace/3`.

The effect of combining `set_on_first_link` with `set_on_link` is the same as having `set_on_first_link` alone. Likewise for `set_on_spawn` and `set_on_first_spawn`.

If the `timestamp` flag is not given, the tracing process will receive the trace messages described below. `Pid` is the pid of the traced process in which the traced event has occurred. The third element of the tuple is the message tag.

If the `timestamp` flag is given, the first element of the tuple will be `trace_ts` instead and the timestamp is added last in the tuple.

`{trace, Pid, 'receive', Msg}` When `Pid` receives the message `Msg`.

`{trace, Pid, send, Msg, To}` When `Pid` sends the message `Msg` to the process `To`.

`{trace, Pid, send_to_non_existing_process, Msg, To}` When `Pid` sends the message `Msg` to the non-existing process `To`.

`{trace, Pid, call, {M, F, Args}}` When `Pid` calls a traced function. The return values of calls are never supplied, only the call and its arguments.

Note that the trace flag `arity` can be used to change the contents of this message, so that `Arity` is specified instead of `Args`.

`{trace, Pid, return_to, {M, F, Arity}}` When `Pid` returns *to* the specified function. This trace message is sent if both the `call` and the `return_to` flags are set, and the function is set to be traced on *local* function calls. The message is only sent when returning from a chain of tail recursive function calls where at least one call generated a call trace message (that is, the functions match specification matched and `{message, false}` was not an action).

`{trace, Pid, return_from, {M, F, Arity}, ReturnValue}` When `Pid` returns *from* the specified function. This trace message is sent if the `call` flag is set, and the function has a match specification with a `return_trace` or `exception_trace` action.

`{trace, Pid, exception_from, {M, F, Arity}, {Class, Value}}` When `Pid` exits *from* the specified function due to an exception. This trace message is sent if the `call` flag is set, and the function has a match specification with an `exception_trace` action.

`{trace, Pid, spawn, Pid2, {M, F, Args}}` When `Pid` spawns a new process `Pid2` with the specified function call as entry point.

Note that `Args` is supposed to be the argument list, but may be any term in the case of an erroneous spawn.

`{trace, Pid, exit, Reason}` When `Pid` exits with reason `Reason`.  
`{trace, Pid, link, Pid2}` When `Pid` links to a process `Pid2`.  
`{trace, Pid, unlink, Pid2}` When `Pid` removes the link from a process `Pid2`.  
`{trace, Pid, getting_linked, Pid2}` When `Pid` gets linked to a process `Pid2`.  
`{trace, Pid, getting_unlinked, Pid2}` When `Pid` gets unlinked from a process `Pid2`.  
`{trace, Pid, register, RegName}` When `Pid` gets the name `RegName` registered.  
`{trace, Pid, unregister, RegName}` When `Pid` gets the name `RegName` unregistered. Note that this is done automatically when a registered process exits.  
`{trace, Pid, in, {M, F, Arity} | 0}` When `Pid` is scheduled to run. The process will run in function `{M, F, Arity}`. On some rare occasions the current function cannot be determined, then the last element `Arity` is 0.  
`{trace, Pid, out, {M, F, Arity} | 0}` When `Pid` is scheduled out. The process was running in function `{M, F, Arity}`. On some rare occasions the current function cannot be determined, then the last element `Arity` is 0.  
`{trace, Pid, gc_start, Info}` Sent when garbage collection is about to be started. `Info` is a list of two-element tuples, where the first element is a key, and the second is the value. You should not depend on the tuples have any defined order. Currently, the following keys are defined:  
`heap_size` The size of the used part of the heap.  
`heap_block_size` The size of the memory block used for storing the heap and the stack.  
`old_heap_size` The size of the used part of the old heap.  
`old_heap_block_size` The size of the memory block used for storing the old heap.  
`stack_size` The actual size of the stack.  
`recent_size` The size of the data that survived the previous garbage collection.  
`mbuf_size` The combined size of message buffers associated with the process.  
All sizes are in words.  
`{trace, Pid, gc_end, Info}` Sent when garbage collection is finished. `Info` contains the same kind of list as in the `gc_start` message, but the sizes reflect the new sizes after garbage collection.

If the tracing process dies, the flags will be silently removed.

Only one process can trace a particular process. For this reason, attempts to trace an already traced process will fail.

Returns: A number indicating the number of processes that matched `PidSpec`. If `PidSpec` is a `pid`, the return value will be 1. If `PidSpec` is `all` or `existing` the return value will be the number of processes running, excluding tracer processes. If `PidSpec` is `new`, the return value will be 0.

Failure: If specified arguments are not supported. For example `cpu_timestamp` is not supported on all platforms.

`erlang:trace_delivered(Tracee) -> Ref`

Types:

- `Tracee = pid() | all`
- `Ref = reference()`

The delivery of trace messages is dislocated on the time-line compared to other events in the system. If you know that the Tracee has passed some specific point in its execution, and you want to know when at least all trace messages corresponding to events up to this point have reached the tracer you can use

`erlang:trace_delivered(Tracee)`. A `{trace_delivered, Tracee, Ref}` message is sent to the caller of `erlang:trace_delivered(Tracee)` when it is guaranteed that all trace messages have been delivered to the tracer up to the point that the Tracee had reached at the time of the call to `erlang:trace_delivered(Tracee)`.

Note that the `trace_delivered` message does *not* imply that trace messages have been delivered; instead, it implies that all trace messages that *should* be delivered have been delivered. It is not an error if Tracee isn't, and hasn't been traced by someone, but if this is the case, *no* trace messages will have been delivered when the `trace_delivered` message arrives.

Note that Tracee has to refer to a process currently, or previously existing on the same node as the caller of `erlang:trace_delivered(Tracee)` resides on. The special Tracee atom `all` denotes all processes that currently are traced in the node.

An example: Process A is tracee, port B is tracer, and process C is the port owner of B. C wants to close B when A exits. C can ensure that the trace isn't truncated by calling `erlang:trace_delivered(A)` when A exits and wait for the `{trace_delivered, A, Ref}` message before closing B.

Failure: `badarg` if Tracee does not refer to a process (dead or alive) on the same node as the caller of `erlang:trace_delivered(Tracee)` resides on.

`erlang:trace_info(PidOrFunc, Item) -> Res`

Types:

- `PidOrFunc = pid() | new | {Module, Function, Arity} | on_load`
- `Module = Function = atom()`
- `Arity = int()`
- `Item, Res` – see below

Returns trace information about a process or function.

To get information about a process, `PidOrFunc` should be a `pid` or the atom `new`. The atom `new` means that the default trace state for processes to be created will be returned. `Item` must have one of the following values:

`flags` Return a list of atoms indicating what kind of traces is enabled for the process.

The list will be empty if no traces are enabled, and one or more of the followings atoms if traces are enabled: `send`, `'receive'`, `set_on_spawn`, `call`, `return_to`, `procs`, `set_on_first_spawn`, `set_on_link`, `running`, `garbage_collection`, `timestamp`, and `arity`. The order is arbitrary.

`tracer` Return the identifier for process or port tracing this process. If this process is not being traced, the return value will be `[]`.

To get information about a function, `PidOrFunc` should be a three-element tuple: `{Module, Function, Arity}` or the atom `on_load`. No wildcards are allowed. Returns undefined if the function does not exist or `false` if the function is not traced at all. `Item` must have one of the following values:

`traced` Return `global` if this function is traced on global function calls, `local` if this function is traced on local function calls (i.e local and global function calls), and `false` if neither local nor global function calls are traced.

- `match_spec` Return the match specification for this function, if it has one. If the function is locally or globally traced but has no match specification defined, the returned value is `[]`.
- `meta` Return the meta trace tracer process or port for this function, if it has one. If the function is not meta traced the returned value is `false`, and if the function is meta traced but has once detected that the tracer proc is invalid, the returned value is `[]`.
- `meta_match_spec` Return the meta trace match specification for this function, if it has one. If the function is meta traced but has no match specification defined, the returned value is `[]`.
- `call_count` Return the call count value for this function or `true` for the pseudo function `on_load` if call count tracing is active. Return `false` otherwise. See also `erlang:trace_pattern/3` [page 162].
- `all` Return a list containing the `{Item, Value}` tuples for all other items, or return `false` if no tracing is active for this function.

The actual return value will be `{Item, Value}`, where `Value` is the requested information as described above. If a pid for a dead process was given, or the name of a non-existing function, `Value` will be undefined.

If `PidOrFunc` is the `on_load`, the information returned refers to the default value for code that will be loaded.

```
erlang:trace_pattern(MFA, MatchSpec) -> int()
```

The same as `erlang:trace_pattern(MFA, MatchSpec, [])` [page 162], retained for backward compatibility.

```
erlang:trace_pattern(MFA, MatchSpec, FlagList) -> int()
```

Types:

- `MFA, MatchSpec, FlagList` – see below

This BIF is used to enable or disable call tracing for exported functions. It must be combined with `erlang:trace/3` [page 157] to set the `call` trace flag for one or more processes.

Conceptually, call tracing works like this: Inside the Erlang virtual machine there is a set of processes to be traced and a set of functions to be traced. Tracing will be enabled on the intersection of the set. That is, if a process included in the traced process set calls a function included in the traced function set, the trace action will be taken. Otherwise, nothing will happen.

Use `erlang:trace/3` [page 157] to add or remove one or more processes to the set of traced processes. Use `erlang:trace_pattern/2` to add or remove exported functions to the set of traced functions.

The `erlang:trace_pattern/3` BIF can also add match specifications to an exported function. A match specification comprises a pattern that the arguments to the function must match, a guard expression which must evaluate to `true` and an action to be performed. The default action is to send a trace message. If the pattern does not match or the guard fails, the action will not be executed.

The `MFA` argument should be a tuple like `{Module, Function, Arity}` or the atom `on_load` (described below). It can be the module, function, and arity for an exported function (or a BIF in any module). The `'_'` atom can be used to mean any of that kind. Wildcards can be used in any of the following ways:

`{Module,Function,'_'}_` All exported functions of any arity named `Function` in module `Module`.

`{Module,'_','_'}_` All exported functions in module `Module`.

`{'_','_','_'}_` All exported functions in all loaded modules.

Other combinations, such as `{Module,'_',Arity}`, are not allowed. Local functions will match wildcards only if the `local` option is in the `FlagList`.

If the MFA argument is the atom `on_load`, the match specification and flag list will be used on all modules that are newly loaded.

The `MatchSpec` argument can take any of the following forms:

`false` Disable tracing for the matching function(s). Any match specification will be removed.

`true` Enable tracing for the matching function(s).

`MatchSpecList` A list of match specifications. An empty list is equivalent to `true`. See the ERTS User's Guide for a description of match specifications.

`restart` For the `FlagList` option `call_count`: restart the existing counters. The behaviour is undefined for other `FlagList` options.

`pause` For the `FlagList` option `call_count`: pause the existing counters. The behaviour is undefined for other `FlagList` options.

The `FlagList` parameter is a list of options. The following options are allowed:

`global` Turn on or off call tracing for global function calls (that is, calls specifying the module explicitly). Only exported functions will match and only global calls will generate trace messages. This is the default.

`local` Turn on or off call tracing for all types of function calls. Trace messages will be sent whenever any of the specified functions are called, regardless of how they are called. If the `return_to` flag is set for the process, a `return_to` message will also be sent when this function returns to its caller.

`meta` | `{meta, Pid}` Turn on or off meta tracing for all types of function calls. Trace messages will be sent to the tracer process or port `Pid` whenever any of the specified functions are called, regardless of how they are called. If no `Pid` is specified, `self()` is used as a default tracer process.

Meta tracing traces all processes and does not care about the process trace flags set by `trace/3`, the trace flags are instead fixed to `[call, timestamp]`.

The match spec function `{return_trace}` works with meta trace and send its trace message to the same tracer process.

`call_count` Starts (`MatchSpec == true`) or stops (`MatchSpec == false`) call count tracing for all types of function calls. For every function a counter is incremented when the function is called, in any process. No process trace flags need to be activated.

If call count tracing is started while already running, the count is restarted from zero. Running counters can be paused with `MatchSpec == pause`. Paused and running counters can be restarted from zero with `MatchSpec == restart`.

The counter value can be read with `erlang:trace_info/2` [page 161].

The `global` and `local` options are mutually exclusive and `global` is the default (if no options are specified). The `call_count` and `meta` options perform a kind of local tracing, and can also not be combined with `global`. A function can be either globally or locally traced. If global tracing is specified for a specified set of functions; local, meta and call count tracing for the matching set of local functions will be disabled, and vice versa.

When disabling trace, the option must match the type of trace that is set on the function, so that local tracing must be disabled with the `local` option and global tracing with the `global` option (or no option at all), and so forth.

There is no way to directly change part of a match specification list. If a function has a match specification, you can replace it with a completely new one. If you need to change an existing match specification, use the `erlang:trace_info/2` [page 161] BIF to retrieve the existing match specification.

Returns the number of exported functions that matched the MFA argument. This will be zero if none matched at all.

`trunc(Number) -> int()`

Types:

- `Number = number()`

Returns an integer by the truncating `Number`.

```
> trunc(5.5).
5
```

Allowed in guard tests.

`tuple_size(Tuple) -> int()`

Types:

- `Tuple = tuple()`

Returns an integer which is the number of elements in `Tuple`.

```
> tuple_size({morni, mulle, bwange}).
3
```

Allowed in guard tests.

`tuple_to_list(Tuple) -> [term()]`

Types:

- `Tuple = tuple()`

Returns a list which corresponds to `Tuple`. `Tuple` may contain any Erlang terms.

```
> tuple_to_list({share, {'Ericsson.B', 163}}).
[share, {'Ericsson.B', 163}]
```

`erlang:universaltime() -> {Date, Time}`

Types:

- `Date = {Year, Month, Day}`
- `Time = {Hour, Minute, Second}`
- `Year = Month = Day = Hour = Minute = Second = int()`



Returns the current date and time according to Universal Time Coordinated (UTC), also called GMT, in the form `{{Year, Month, Day}, {Hour, Minute, Second}}` if supported by the underlying operating system. If not, `erlang:universaltime()` is equivalent to `erlang:localtime()`.

```
> erlang:universaltime().
{{1996,11,6},{14,18,43}}
```

```
erlang:universaltime_to_localtime({Date1, Time1}) -> {Date2, Time2}
```

Types:

- `Date1 = Date2 = {Year, Month, Day}`
- `Time1 = Time2 = {Hour, Minute, Second}`
- `Year = Month = Day = Hour = Minute = Second = int()`

Converts Universal Time Coordinated (UTC) date and time to local date and time, if this is supported by the underlying OS. Otherwise, no conversion is done, and `{Date1, Time1}` is returned.

```
> erlang:universaltime_to_localtime({{1996,11,6},{14,18,43}}).
{{1996,11,7},{15,18,43}}
```

Failure: badarg if `Date1` or `Time1` do not denote a valid date or time.

```
unlink(Id) -> true
```

Types:

- `Id = pid() | port()`

Removes the link, if there is one, between the calling process and the process or port referred to by `Id`.

Returns `true` and does not fail, even if there is no link to `Id`, or if `Id` does not exist.

Once `unlink(Id)` has returned it is guaranteed that the link between the caller and the entity referred to by `Id` has no effect on the caller in the future (unless the link is setup again). If caller is trapping exits, an `{'EXIT', Id, _}` message due to the link might have been placed in the callers message queue prior to the call, though. Note, the `{'EXIT', Id, _}` message can be the result of the link, but can also be the result of `Id` calling `exit/2`. Therefore, it *may* be appropriate to cleanup the message queue when trapping exits after the call to `unlink(Id)`, as follow:

```
unlink(Id),
receive
    {'EXIT', Id, _} ->
        true
after 0 ->
    true
end
```

**Note:**

Prior to OTP release R11B (erts version 5.5) `unlink/1` behaved completely asynchronous, i.e., the link was active until the “unlink signal” reached the linked entity. This had one undesirable effect, though. You could never know when you were guaranteed *not* to be effected by the link.

Current behavior can be viewed as two combined operations: asynchronously send an “unlink signal” to the linked entity and ignore any future results of the link.

`unregister(RegName) -> true`

Types:

- `RegName = atom()`

Removes the registered name `RegName`, associated with a pid or a port identifier.

```
> unregister(db).  
true
```

Users are advised not to unregister system processes.

Failure: `badarg` if `RegName` is not a registered name.

`whereis(RegName) -> pid() | port() | undefined`

Returns the pid or port identifier with the registered name `RegName`. Returns `undefined` if the name is not registered.

```
> whereis(db).  
<0.43.0>
```

`erlang:yield() -> true`

Voluntarily let other processes (if any) get a chance to execute. Using `erlang:yield()` is similar to `receive after 1 -> ok end`, except that `yield()` is faster.

# error\_handler

Erlang Module

The error handler module defines what happens when certain types of errors occur.

## Exports

`undefined_function(Module, Function, Args) -> term()`

Types:

- `Module = Function = atom()`
- `Args = [term()]`  
A (possibly empty) list of arguments `Arg1, ..., ArgN`

This function is evaluated if a call is made to `Module:Function(Arg1, ..., ArgN)` and `Module:Function/N` is undefined. Note that `undefined_function/3` is evaluated inside the process making the original call.

If `Module` is interpreted, the interpreter is invoked and the return value of the interpreted `Function(Arg1, ..., ArgN)` call is returned.

Otherwise, it returns, if possible, the value of `apply(Module, Function, Args)` after an attempt has been made to autoload `Module`. If this is not possible, the call to `Module:Function(Arg1, ..., ArgN)` fails with exit reason `undef`.

`undefined_lambda(Module, Fun, Args) -> term()`

Types:

- `Module = Function = atom()`
- `Args = [term()]`  
A (possibly empty) list of arguments `Arg1, ..., ArgN`

This function is evaluated if a call is made to `Fun(Arg1, ..., ArgN)` when the module defining the fun is not loaded. The function is evaluated inside the process making the original call.

If `Module` is interpreted, the interpreter is invoked and the return value of the interpreted `Fun(Arg1, ..., ArgN)` call is returned.

Otherwise, it returns, if possible, the value of `apply(Fun, Args)` after an attempt has been made to autoload `Module`. If this is not possible, the call fails with exit reason `undef`.

## Notes

The code in `error_handler` is complex and should not be changed without fully understanding the interaction between the error handler, the `init` process of the code server, and the I/O mechanism of the code.

Changes in the code which may seem small can cause a deadlock as unforeseen consequences may occur. The use of `input` is dangerous in this type of code.

# error\_logger

## Erlang Module

The Erlang *error logger* is an event manager (see [OTP Design Principles] and [gen\_event(3)]), registered as `error_logger`. Error, warning and info events are sent to the error logger from the Erlang runtime system and the different Erlang/OTP applications. The events are, by default, logged to `tty`. Note that an event from a process `P` is logged at the node of the group leader of `P`. This means that log output is directed to the node from which a process was created, which not necessarily is the same node as where it is executing.

Initially, `error_logger` only has a primitive event handler, which buffers and prints the raw event messages. During system startup, the application Kernel replaces this with a *standard event handler*, by default one which writes nicely formatted output to `tty`. Kernel can also be configured so that events are logged to file instead, or not logged at all, see `kernel(6)` [page 32].

Also the SASL application, if started, adds its own event handler, which by default writes supervisor-, crash- and progress reports to `tty`. See [sasl(6)].

It is recommended that user defined applications should report errors through the error logger, in order to get uniform reports. User defined event handlers can be added to handle application specific events. (`add_report_handler/1, 2`). Also, there is a useful event handler in `STDLIB` for multi-file logging of events, see `log_mf_h(3)`.

Warning events was introduced in Erlang/OTP R9C. To retain backwards compatibility, these are by default tagged as errors, thus showing up as error reports in the logs. By using the command line flag `+W <w | i>`, they can instead be tagged as warnings or info. Tagging them as warnings may require rewriting existing user defined event handlers.

## Exports

```
error_msg(Format) -> ok
error_msg(Format, Data) -> ok
format(Format, Data) -> ok
```

Types:

- `Format = string()`
- `Data = [term()]`

Sends a standard error event to the error logger. The `Format` and `Data` arguments are the same as the arguments of `io:format/2`. The event is handled by the standard event handler.

```
1> error_logger:error_msg("An error occurred in ~p~n", [a_module]).
=ERROR REPORT==== 11-Aug-2005::14:03:19 ===
An error occurred in a_module
ok
```

**Warning:**

If called with bad arguments, this function can crash the standard event handler, meaning no further events are logged. When in doubt, use `error_report/1` instead.

```
error_report(Report) -> ok
```

Types:

- Report = [{Tag, Data} | term()] | string() | term()
- Tag = Data = term()

Sends a standard error report event to the error logger. The event is handled by the standard event handler.

```
2> error_logger:error_report([tag1,data1],a_term,{tag2,data})).
```

```
=ERROR REPORT==== 11-Aug-2005::13:45:41 ===
tag1: data1
a_term
tag2: data
ok
```

```
3> error_logger:error_report("Serious error in my module").
```

```
=ERROR REPORT==== 11-Aug-2005::13:45:49 ===
Serious error in my module
ok
```

```
error_report(Type, Report) -> ok
```

Types:

- Type = term()
- Report = [{Tag, Data} | term()] | string() | term()
- Tag = Data = term()

Sends a user defined error report event to the error logger. An event handler to handle the event is supposed to have been added. The event is ignored by the standard event handler.

It is recommended that Report follows the same structure as for `error_report/1`.

```
warning_map() -> Tag
```

Types:

- Tag = error | warning | info

Returns the current mapping for warning events. Events sent using `warning_msg/1,2` or `warning_report/1,2` are tagged as errors (default), warnings or info, depending on the value of the command line flag `+W`.

```
os$ erl
Erlang (BEAM) emulator version 5.4.8 [hipe] [threads:0] [kernel-poll]

Eshell V5.4.8 (abort with ^G)
1> error_logger:warning_map().
error
2> error_logger:warning_msg("Warnings tagged as: ~p~n", [error]).

=ERROR REPORT==== 11-Aug-2005::15:31:23 ===
Warnings tagged as: error
ok
3>
User switch command
--> q
os$ erl +W w
Erlang (BEAM) emulator version 5.4.8 [hipe] [threads:0] [kernel-poll]

Eshell V5.4.8 (abort with ^G)
1> error_logger:warning_map().
warning
2> error_logger:warning_msg("Warnings tagged as: ~p~n", [warning]).

=WARNING REPORT==== 11-Aug-2005::15:31:55 ===
Warnings tagged as: warning
ok
```

```
warning_msg(Format) -> ok
warning_msg(Format, Data) -> ok
```

Types:

- Format = string()
- Data = [term()]

Sends a standard warning event to the error logger. The `Format` and `Data` arguments are the same as the arguments of `io:format/2`. The event is handled by the standard event handler. It is tagged either as an error, warning or info, see `warning_map/0` [page 170].

### Warning:

If called with bad arguments, this function can crash the standard event handler, meaning no further events are logged. When in doubt, use `warning_report/1` instead.

```
warning_report(Report) -> ok
```

Types:

- Report = [{Tag, Data} | term()] | string() | term()

- Tag = Data = term()

Sends a standard warning report event to the error logger. The event is handled by the standard event handler. It is tagged either as an error, warning or info, see `warning_map/0` [page 170].

```
warning_report(Type, Report) -> ok
```

Types:

- Type = term()
- Report = [{Tag, Data} | term()] | string() | term()
- Tag = Data = term()

Sends a user defined warning report event to the error logger. An event handler to handle the event is supposed to have been added. The event is ignored by the standard event handler. It is tagged either as an error, warning or info, depending on the value of `warning_map/0` [page 170].

```
info_msg(Format) -> ok
```

```
info_msg(Format, Data) -> ok
```

Types:

- Format = string()
- Data = [term()]

Sends a standard information event to the error logger. The `Format` and `Data` arguments are the same as the arguments of `io:format/2`. The event is handled by the standard event handler.

```
1> error_logger:info_msg("Something happened in ~p~n", [a_module]).
```

```
=INFO REPORT==== 11-Aug-2005::14:06:15 ===
Something happened in a_module
ok
```

### Warning:

If called with bad arguments, this function can crash the standard event handler, meaning no further events are logged. When in doubt, use `info_report/1` instead.

```
info_report(Report) -> ok
```

Types:

- Report = [{Tag, Data} | term()] | string() | term()
- Tag = Data = term()

Sends a standard information report event to the error logger. The event is handled by the standard event handler.



```

2> error_logger:info_report([{tag1,data1},a_term,{tag2,data}]).
=INFO REPORT==== 11-Aug-2005::13:55:09 ===
    tag1: data1
    a_term
    tag2: data
ok
3> error_logger:info_report("Something strange happened").
=INFO REPORT==== 11-Aug-2005::13:55:36 ===
Something strange happened
ok

```

`info_report(Type, Report) -> ok`

Types:

- Type = term()
- Report = [{Tag, Data} | term()] | string() | term()
- Tag = Data = term()

Sends a user defined information report event to the error logger. An event handler to handle the event is supposed to have been added. The event is ignored by the standard event handler.

It is recommended that Report follows the same structure as for `info_report/1`.

`add_report_handler(Handler) -> Result`

`add_report_handler(Handler, Args) -> Result`

Types:

- Handler, Args, Result – see `gen_event:add_handler/3`

Adds a new event handler to the error logger. The event handler must be implemented as a `gen_event` callback module, see `[gen_event(3)]`.

`Handler` is typically the name of the callback module and `Args` is an optional term (defaults to `[]`) passed to the initialization callback function `Module:init/1`. The function returns `ok` if successful.

The event handler must be able to handle the events `[page 174]` described below.

`delete_report_handler(Handler) -> Result`

Types:

- Handler, Result – see `gen_event:delete_handler/3`

Deletes an event handler from the error logger by calling `gen_event:delete_handler(error_logger, Handler, [])`, see `[gen_event(3)]`.

`tty(Flag) -> ok`

Types:

- Flag = bool()

Enables (`Flag == true`) or disables (`Flag == false`) printout of standard events to the `tty`.

This is done by adding or deleting the standard event handler for output to `tty`, thus calling this function overrides the value of the Kernel `error_logger` configuration parameter.

```
logfile(Request) -> ok | Filename | {error, What}
```

Types:

- `Request = {open, Filename} | close | filename`
- `Filename = atom() | string()`
- `What = already_have_logfile | no_log_file | term()`

Enables or disables printout of standard events to a file.

This is done by adding or deleting the standard event handler for output to file, thus calling this function overrides the value of the Kernel `error_logger` configuration parameter.

Enabling file logging can be used in combination with calling `tty(false)`, in order to have a silent system, where all standard events are logged to a file only. There can only be one active log file at a time.

`Request` is one of:

`{open, Filename}` Opens the log file `Filename`. Returns `ok` if successful, or `{error, already_have_logfile}` if logging to file is already enabled, or an error tuple if another error occurred. For example, if `Filename` could not be opened.

`close` Closes the current log file. Returns `ok`, or `{error, What}`.

`filename` Returns the name of the log file `Filename`, or `{error, no_log_file}` if logging to file is not enabled.

## Events

All event handlers added to the error logger must handle the following events. `Gleader` is the group leader pid of the process which sent the event, and `Pid` is the process which sent the event.

`{error, Gleader, {Pid, Format, Data}}` Generated when `error_msg/1,2` or `format` is called.

`{error_report, Gleader, {Pid, std_error, Report}}` Generated when `error_report/1` is called.

`{error_report, Gleader, {Pid, Type, Report}}` Generated when `error_report/2` is called.

`{warning_msg, Gleader, {Pid, Format, Data}}` Generated when `warning_msg/1,2` is called, provided that warnings are set to be tagged as warnings.

`{warning_report, Gleader, {Pid, std_warning, Report}}` Generated when `warning_report/1` is called, provided that warnings are set to be tagged as warnings.

`{warning_report, Gleader, {Pid, Type, Report}}` Generated when `warning_report/2` is called, provided that warnings are set to be tagged as warnings.

{info\_msg, Gleader, {Pid, Format, Data}} Generated when info\_msg/1,2 is called.

{info\_report, Gleader, {Pid, std\_info, Report}} Generated when info\_report/1 is called.

{info\_report, Gleader, {Pid, Type, Report}} Generated when info\_report/2 is called.

Note that also a number of system internal events may be received, a catch-all clause last in the definition of the event handler callback function `Module:handle_event/2` is necessary. This also holds true for `Module:handle_info/2`, as there are a number of system internal messages the event handler must take care of as well.

## SEE ALSO

`gen_event(3)`, `log_mf.h(3)`, `kernel(6)`, `sasl(6)`

# file

Erlang Module

The module `file` provides an interface to the file system.

On operating systems with thread support, it is possible to let file operations be performed in threads of their own, allowing other Erlang processes to continue executing in parallel with the file operations. See the command line flag `+A` in `[erl(1)]`.

## DATA TYPES

`iodata()` = `iolist()` | `binary()`

`iolist()` = `[char() | binary() | iolist()]`

`io_device()`

as returned by `file:open/2`, a process handling IO protocols

`name()` = `string()` | `atom()` | `DeepList`

`DeepList` = `[char() | atom() | DeepList]`

`posix()`

an atom which is named from the Posix error codes used in Unix, and in the runtime libraries of most C compilers

`ext_posix()` = `posix()` | `badarg`

`time()` = `{{Year, Month, Day}, {Hour, Minute, Second}}`

`Year = Month = Day = Hour = Minute = Second = int()`

Must denote a valid date and time

## Exports

`change_group(Filename, Gid) -> ok | {error, Reason}`

Types:

- `Filename` = `name()`
- `Gid` = `int()`
- `Reason` = `ext_posix()`

Changes group of a file. See `write_file_info/2` [page 194].

`change_owner(Filename, Uid) -> ok | {error, Reason}`

Types:

- Filename = name()
- Uid = int()
- Reason = ext\_posix()

Changes owner of a file. See `write_file_info/2` [page 194].

`change_owner(Filename, Uid, Gid) -> ok | {error, Reason}`

Types:

- Filename = name()
- Uid = int()
- Gid = int()
- Reason = ext\_posix()

Changes owner and group of a file. See `write_file_info/2` [page 194].

`change_time(Filename, Mtime) -> ok | {error, Reason}`

Types:

- Filename = name()
- Mtime = time()
- Reason = ext\_posix()

Changes the modification and access times of a file. See `write_file_info/2` [page 194].

`change_time(Filename, Mtime, Atime) -> ok | {error, Reason}`

Types:

- Filename = name()
- Mtime = Atime = time()
- Reason = ext\_posix()

Changes the modification and last access times of a file. See `write_file_info/2` [page 194].

`close(IODevice) -> ok | {error, Reason}`

Types:

- IoDevice = io\_device()
- Reason = ext\_posix() | terminated

Closes the file referenced by `IODevice`. It mostly returns `ok`, expect for some severe errors such as out of memory.

Note that if the option `delayed_write` was used when opening the file, `close/1` might return an old write error and not even try to close the file. See `open/2` [page 182].

`consult(Filename) -> {ok, Terms} | {error, Reason}`

Types:

- Filename = name()
- Terms = [term()]
- Reason = ext\_posix() | terminated | system\_limit | {Line, Mod, Term}
- Line, Mod, Term – see below

Reads Erlang terms, separated by '.', from `Filename`. Returns one of the following:

- `{ok, Terms}` The file was successfully read.
- `{error, atom()}` An error occurred when opening the file or reading it. See `open/2` [page 182] for a list of typical error codes.
- `{error, {Line, Mod, Term}}` An error occurred when interpreting the Erlang terms in the file. Use `format_error/1` to convert the three-element tuple to an English description of the error.

Example:

```
f.txt: {person, "kalle", 25}.
       {person, "pelle", 30}.

1> file:consult("f.txt").
{ok, [{person,"kalle",25},{person,"pelle",30}]}
```

`copy(Source, Destination) ->`

`copy(Source, Destination, ByteCount) -> {ok, BytesCopied} | {error, Reason}`

Types:

- `Source = Destination = io_device() | Filename | {Filename, Modes}`
- `Filename = name()`
- `Modes = [Mode]` – see `open/2`
- `ByteCount = int() >= 0 | infinity`
- `BytesCopied = int()`

Copies `ByteCount` bytes from `Source` to `Destination`. `Source` and `Destination` refer to either filenames or IO devices from e.g. `open/2`. `ByteCount` defaults `infinity`, denoting an infinite number of bytes.

The argument `Modes` is a list of possible modes, see `open/2` [page 182], and defaults to `[]`.

If both `Source` and `Destination` refer to filenames, the files are opened with `[read, binary]` and `[write, binary]` prepended to their mode lists, respectively, to optimize the copy.

If `Source` refers to a filename, it is opened with `read` mode prepended to the mode list before the copy, and closed when done.

If `Destination` refers to a filename, it is opened with `write` mode prepended to the mode list before the copy, and closed when done.

Returns `{ok, BytesCopied}` where `BytesCopied` is the number of bytes that actually was copied, which may be less than `ByteCount` if end of file was encountered on the source. If the operation fails, `{error, Reason}` is returned.

Typical error reasons: As for `open/2` if a file had to be opened, and as for `read/2` and `write/2`.

`del_dir(Dir) -> ok | {error, Reason}`

Types:

- `Dir = name()`
- `Reason = ext_posix()`

Tries to delete the directory `Dir`. The directory must be empty before it can be deleted. Returns `ok` if successful.

Typical error reasons are:

`eaccess` Missing search or write permissions for the parent directories of `Dir`.

`eexist` The directory is not empty.

`enoent` The directory does not exist.

`enotdir` A component of `Dir` is not a directory. On some platforms, `enoent` is returned instead.

`EINVAL` Attempt to delete the current directory. On some platforms, `eaccess` is returned instead.

```
delete(Filename) -> ok | {error, Reason}
```

Types:

- `Filename` = `name()`
- `Reason` = `ext_posix()`

Tries to delete the file `Filename`. Returns `ok` if successful.

Typical error reasons are:

`ENOENT` The file does not exist.

`EACCESS` Missing permission for the file or one of its parents.

`EPERM` The file is a directory and the user is not super-user.

`ENOTDIR` A component of the file name is not a directory. On some platforms, `ENOENT` is returned instead.

`EINVAL` `Filename` had an improper type, such as tuple.

### Warning:

In a future release, a bad type for the `Filename` argument will probably generate an exception.

```
eval(Filename) -> ok | {error, Reason}
```

Types:

- `Filename` = `name()`
- `Reason` = `ext_posix()` | `terminated` | `system_limit` | `{Line, Mod, Term}`
- `Line, Mod, Term` – see below

Reads and evaluates Erlang expressions, separated by `'.'` (or `','`, a sequence of expressions is also an expression), from `Filename`. The actual result of the evaluation is not returned; any expression sequence in the file must be there for its side effect. Returns one of the following:

`ok` The file was read and evaluated.

`{error, atom()}` An error occurred when opening the file or reading it. See `open/2` for a list of typical error codes.

`{error, {Line, Mod, Term}}` An error occurred when interpreting the Erlang expressions in the file. Use `format_error/1` to convert the three-element tuple to an English description of the error.

`eval(Filename, Bindings) -> ok | {error, Reason}`

Types:

- `Filename = name()`
- `Bindings` – see `erl_eval(3)`
- `Reason = ext_posix() | terminated | system_limit | {Line, Mod, Term}`
- `Line, Mod, Term` – see `eval/1`

The same as `eval/1` but the variable bindings `Bindings` are used in the evaluation. See `[erl_eval(3)]` about variable bindings.

`file_info(Filename) -> {ok, FileInfo} | {error, Reason}`

This function is obsolete. Use `read_file_info/1` instead.

`format_error(Reason) -> Chars`

Types:

- `Reason = atom() | {Line, Mod, Term}`
- `Line, Mod, Term` – see `eval/1`
- `Chars = [char() | Chars]`

Given the error reason returned by any function in this module, returns a descriptive string of the error in English.

`get_cwd() -> {ok, Dir} | {error, Reason}`

Types:

- `Dir = string()`
- `Reason = posix()`

Returns `{ok, Dir}`, where `Dir` is the current working directory of the file server.

### Note:

In rare circumstances, this function can fail on Unix. It may happen if read permission does not exist for the parent directories of the current directory.

Typical error reasons are:

`eaccess` Missing read permission for one of the parents of the current directory.

`get_cwd(Drive) -> {ok, Dir} | {error, Reason}`

Types:

- `Drive = string()` – see below
- `Dir = string()`



- Reason = ext\_posix()

Drive should be of the form “Letter:”, for example “c:”. Returns {ok, Dir} or {error, Reason}, where Dir is the current working directory of the drive specified.

This function returns {error, enotsup} on platforms which have no concept of current drive (Unix, for example).

Typical error reasons are:

enotsup The operating system have no concept of drives.

eaccess The drive does not exist.

EINVAL The format of Drive is invalid.

list\_dir(Dir) -> {ok, Filenames} | {error, Reason}

Types:

- Dir = name()
- Filenames = [Filename]
- Filename = string()
- Reason = ext\_posix()

Lists all the files in a directory. Returns {ok, Filenames} if successful. Otherwise, it returns {error, Reason}. Filenames is a list of the names of all the files in the directory. The names are not sorted.

Typical error reasons are:

eaccess Missing search or write permissions for Dir or one of its parent directories.

ENOENT The directory does not exist.

make\_dir(Dir) -> ok | {error, Reason}

Types:

- Dir = name()
- Reason = ext\_posix()

Tries to create the directory Dir. Missing parent directories are *not* created. Returns ok if successful.

Typical error reasons are:

eaccess Missing search or write permissions for the parent directories of Dir.

EEXIST There is already a file or directory named Dir.

ENOENT A component of Dir does not exist.

ENOSPC There is a no space left on the device.

ENOTDIR A component of Dir is not a directory. On some platforms, ENOENT is returned instead.

make\_link(Existing, New) -> ok | {error, Reason}

Types:

- Existing = New = name()
- Reason = ext\_posix()

Makes a hard link from `Existing` to `New`, on platforms that support links (Unix). This function returns `ok` if the link was successfully created, or `{error, Reason}`. On platforms that do not support links, `{error, enotsup}` is returned.

Typical error reasons:

`eaccess` Missing read or write permissions for the parent directories of `Existing` or `New`.

`eexist` `New` already exists.

`enotsup` Hard links are not supported on this platform.

```
make_symlink(Name1, Name2) -> ok | {error, Reason}
```

Types:

- `Name1 = Name2 = name()`
- `Reason = ext_posix()`

This function creates a symbolic link `Name2` to the file or directory `Name1`, on platforms that support symbolic links (most Unix systems). `Name1` need not exist. This function returns `ok` if the link was successfully created, or `{error, Reason}`. On platforms that do not support symbolic links, `{error, enotsup}` is returned.

Typical error reasons:

`eaccess` Missing read or write permissions for the parent directories of `Name1` or `Name2`.

`eexist` `Name2` already exists.

`enotsup` Symbolic links are not supported on this platform.

```
open(Filename, Modes) -> {ok, IoDevice} | {error, Reason}
```

Types:

- `Filename = name()`
- `Modes = [Mode]`
- `Mode = read | write | append | raw | binary | {delayed_write, Size, Delay} | delayed_write | {read_ahead, Size} | read_ahead | compressed`
- `Size = Delay = int()`
- `IoDevice = io_device()`
- `Reason = ext_posix() | system_limit`

Opens the file `Filename` in the mode determined by `Modes`, which may contain one or more of the following items:

`read` The file, which must exist, is opened for reading.

`write` The file is opened for writing. It is created if it does not exist. If the file exists, and if `write` is not combined with `read`, the file will be truncated.

`append` The file will be opened for writing, and it will be created if it does not exist. Every write operation to a file opened with `append` will take place at the end of the file.

`raw` The `raw` option allows faster access to a file, because no Erlang process is needed to handle the file. However, a file opened in this way has the following limitations:

- The functions in the `io` module cannot be used, because they can only talk to an Erlang process. Instead, use the `read/2` and `write/2` functions.

- Only the Erlang process which opened the file can use it.
- A remote Erlang file server cannot be used; the computer on which the Erlang node is running must have access to the file system (directly or through NFS).

`binary` This option can only be used if the `raw` option is specified as well. When specified, read operations on the file using the `read/2` function will return binaries rather than lists.

`{delayed_write, Size, Delay}` If this option is used, the data in subsequent `write/2` calls is buffered until there are at least `Size` bytes buffered, or until the oldest buffered data is `Delay` milliseconds old. Then all buffered data is written in one operating system call. The buffered data is also flushed before some other file operation than `write/2` is executed.

The purpose of this option is to increase performance by reducing the number of operating system calls, so the `write/2` calls should be for sizes significantly less than `Size`, and not interspersed by too many other file operations, for this to happen.

When this option is used, the result of `write/2` calls may prematurely be reported as successful, and if a write error should actually occur the error is reported as the result of the next file operation, which is not executed.

For example, when `delayed_write` is used, after a number of `write/2` calls, `close/1` might return `{error, enospc}` because there was not enough space on the disc for previously written data, and `close/1` should probably be called again since the file is still open.

`delayed_write` The same as `{delayed_write, Size, Delay}` with reasonable default values for `Size` and `Delay`. (Roughly some 64 KBytes, 2 seconds)

`{read_ahead, Size}` This option activates read data buffering. If `read/2` calls are for significantly less than `Size` bytes, read operations towards the operating system are still performed for blocks of `Size` bytes. The extra data is buffered and returned in subsequent `read/2` calls, giving a performance gain since the number of operating system calls is reduced.

If `read/2` calls are for sizes not significantly less than, or even greater than `Size` bytes, no performance gain can be expected.

`read_ahead` The same as `{read_ahead, Size}` with a reasonable default value for `Size`. (Roughly some 64 KBytes)

`compressed` Makes it possible to read and write gzip compressed files. Note that the file size obtained with `read_file_info/1` will most probably not match the number of bytes that can be read from a compressed file.

Returns:

`{ok, IoDevice}` The file has been opened in the requested mode. `IoDevice` is a reference to the file.

`{error, Reason}` The file could not be opened.

`IoDevice` is really the pid of the process which handles the file. This process is linked to the process which originally opened the file. If any process to which the `IoDevice` is linked terminates, the file will be closed and the process itself will be terminated. An `IoDevice` returned from this call can be used as an argument to the IO functions (see `[io(3)]`).

**Note:**

In previous versions of `file`, modes were given as one of the atoms `read`, `write`, or `read_write` instead of a list. This is still allowed for reasons of backwards compatibility, but should not be used for new code. Also note that `read_write` is not allowed in a mode list.

Typical error reasons:

- `enoent` The file does not exist.
- `eaccess` Missing permission for reading the file or searching one of the parent directories.
- `eisdir` The named file is not a regular file. It may be a directory, a fifo, or a device.
- `enotdir` A component of the file name is not a directory. On some platforms, `enoent` is returned instead.
- `enospc` There is a no space left on the device (if `write` access was specified).

```
path_consult(Path, Filename) -> {ok, Terms, FullName} | {error, Reason}
```

Types:

- Path = [Dir]
- Dir = name()
- Filename = name()
- Terms = [term()]
- FullName = string()
- Reason = `ext_posix()` | `terminated` | `system_limit` | {Line, Mod, Term}
- Line, Mod, Term – see below

Searches the path `Path` (a list of directory names) until the file `Filename` is found. If `Filename` is an absolute filename, `Path` is ignored. Then reads Erlang terms, separated by '.', from the file. Returns one of the following:

- {ok, Terms, FullName} The file was successfully read. `FullName` is the full name of the file.
- {error, `enoent`} The file could not be found in any of the directories in `Path`.
- {error, `atom()`} An error occurred when opening the file or reading it. See `open/2` [page 182] for a list of typical error codes.
- {error, {Line, Mod, Term}} An error occurred when interpreting the Erlang terms in the file. Use `format_error/1` to convert the three-element tuple to an English description of the error.

```
path_eval(Path, Filename) -> {ok, FullName} | {error, Reason}
```

Types:

- Path = [Dir]
- Dir = name()
- Filename = name()
- FullName = string()

- Reason = ext\_posix() | terminated | system\_limit | {Line, Mod, Term}
- Line, Mod, Term – see below

Searches the path `Path` (a list of directory names) until the file `Filename` is found. If `Filename` is an absolute file name, `Path` is ignored. Then reads and evaluates Erlang expressions, separated by `'.'` (or `'.'`, a sequence of expressions is also an expression), from the file. The actual result of evaluation is not returned; any expression sequence in the file must be there for its side effect. Returns one of the following:

- {ok, FullName} The file was read and evaluated. `FullName` is the full name of the file.
- {error, enoent} The file could not be found in any of the directories in `Path`.
- {error, atom()} An error occurred when opening the file or reading it. See `open/2` [page 182] for a list of typical error codes.
- {error, {Line, Mod, Term}} An error occurred when interpreting the Erlang expressions in the file. Use `format_error/1` to convert the three-element tuple to an English description of the error.

`path_open(Path, Filename, Modes) -> {ok, IoDevice, FullName} | {error, Reason}`

Types:

- Path = [Dir]
- Dir = name()
- Filename = name()
- Modes = [Mode] – see `open/2`
- IoDevice = io\_device()
- FullName = string()
- Reason = ext\_posix() | system\_limit

Searches the path `Path` (a list of directory names) until the file `Filename` is found. If `Filename` is an absolute file name, `Path` is ignored. Then opens the file in the mode determined by `Modes`. Returns one of the following:

- {ok, IoDevice, FullName} The file has been opened in the requested mode. `IoDevice` is a reference to the file and `FullName` is the full name of the file.
- {error, enoent} The file could not be found in any of the directories in `Path`.
- {error, atom()} The file could not be opened.

`path_script(Path, Filename) -> {ok, Value, FullName} | {error, Reason}`

Types:

- Path = [Dir]
- Dir = name()
- Filename = name()
- Value = term()
- FullName = string()
- Reason = ext\_posix() | terminated | system\_limit | {Line, Mod, Term}
- Line, Mod, Term – see below

Searches the path `Path` (a list of directory names) until the file `Filename` is found. If `Filename` is an absolute file name, `Path` is ignored. Then reads and evaluates Erlang expressions, separated by `' '` (or `' , '`, a sequence of expressions is also an expression), from the file. Returns one of the following:

`{ok, Value, FullName}` The file was read and evaluated. `FullName` is the full name of the file and `Value` the value of the last expression.

`{error, enoent}` The file could not be found in any of the directories in `Path`.

`{error, atom()}` An error occurred when opening the file or reading it. See `open/2` [page 182] for a list of typical error codes.

`{error, {Line, Mod, Term}}` An error occurred when interpreting the Erlang expressions in the file. Use `format_error/1` to convert the three-element tuple to an English description of the error.

```
path_script(Path, Filename, Bindings) -> {ok, Value, FullName} | {error, Reason}
```

Types:

- `Path` = `[Dir]`
- `Dir` = `name()`
- `Filename` = `name()`
- `Bindings` – see `erl_eval(3)`
- `Value` = `term()`
- `FullName` = `string()`
- `Reason` = `posix()` | `terminated` | `system_limit` | `{Line, Mod, Term}`
- `Line, Mod, Term` – see `path_script/2`

The same as `path_script/2` but the variable bindings `Bindings` are used in the evaluation. See [`erl_eval(3)`] about variable bindings.

```
pid2name(Pid) -> string() | undefined
```

Types:

- `Pid` = `pid()`

If `Pid` is an IO device, that is, a pid returned from `open/2`, this function returns the filename, or rather:

`{ok, Filename}` If this node's file server is not a slave, the file was opened by this node's file server, (this implies that `Pid` must be a local pid) and the file is not closed. `Filename` is the filename in flat string format.

`undefined` In all other cases.

### Warning:

This function is intended for debugging only.

```
position(IoDevice, Location) -> {ok, NewPosition} | {error, Reason}
```

Types:

- `IoDevice = io_device()`
- `Location = Offset | {bof, Offset} | {cur, Offset} | {eof, Offset} | bof | cur | eof`
- `Offset = int()`
- `NewPosition = int()`
- `Reason = ext_posix() | terminated`

Sets the position of the file referenced by `IoDevice` to `Location`. Returns `{ok, NewPosition}` (as absolute offset) if successful, otherwise `{error, Reason}`. `Location` is one of the following:

`Offset` The same as `{bof, Offset}`.

`{bof, Offset}` Absolute offset.

`{cur, Offset}` Offset from the current position.

`{eof, Offset}` Offset from the end of file.

`bof | cur | eof` The same as above with `Offset 0`.

Typical error reasons are:

`EINVAL` Either `Location` was illegal, or it evaluated to a negative offset in the file. Note that if the resulting position is a negative value, the result is an error, and after the call the file position is undefined.

```
pread(IoDevice, LocNums) -> {ok, DataL} | eof | {error, Reason}
```

Types:

- `IoDevice = io_device()`
- `LocNums = [{Location, Number}]`
- `Location` – see `position/2`
- `Number = int()`
- `DataL = [Data]`
- `Data = [char()] | binary()`
- `Reason = ext_posix() | terminated`

Performs a sequence of `pread/3` in one operation, which is more efficient than calling them one at a time. Returns `{ok, [Data, ...]}` or `{error, Reason}`, where each `Data`, the result of the corresponding `pread`, is either a list or a binary depending on the mode of the file, or `eof` if the requested position was beyond end of file.

```
pread(IoDevice, Location, Number) -> {ok, Data} | eof | {error, Reason}
```

Types:

- `IoDevice = io_device()`
- `Location` – see `position/2`
- `Number = int()`
- `Data = [char()] | binary()`
- `Reason = ext_posix() | terminated`

Combines `position/2` and `read/2` in one operation, which is more efficient than calling them one at a time. If `IoDevice` has been opened in raw mode, some restrictions apply: `Location` is only allowed to be an integer; and the current position of the file is undefined after the operation.

```
pwrite(IoDevice, LocBytes) -> ok | {error, {N, Reason}}
```

Types:

- IoDevice = io\_device()
- LocBytes = [{Location, Bytes}]
- Location – see position/2
- Bytes = iodata()
- N = int()
- Reason = ext\_posix() | terminated

Performs a sequence of pwrite/3 in one operation, which is more efficient than calling them one at a time. Returns ok or {error, {N, Reason}}, where N is the number of successful writes that was done before the failure.

```
pwrite(IoDevice, Location, Bytes) -> ok | {error, Reason}
```

Types:

- IoDevice = io\_device()
- Location – see position/2
- Bytes = iodata()
- Reason = ext\_posix() | terminated

Combines position/2 and write/2 in one operation, which is more efficient than calling them one at a time. If IoDevice has been opened in raw mode, some restrictions apply: Location is only allowed to be an integer; and the current position of the file is undefined after the operation.

```
read(IoDevice, Number) -> {ok, Data} | eof | {error, Reason}
```

Types:

- IoDevice = io\_device()
- Number = int()
- Data = [char()] | binary()
- Reason = ext\_posix() | terminated

Reads Number bytes from the file referenced by IoDevice. This function is the only way to read from a file opened in raw mode (although it works for normally opened files, too). Returns:

{ok, Data} If the file was opened in binary mode, the read bytes are returned in a binary, otherwise in a list. The list or binary will be shorter than the number of bytes requested if end of file was reached.

eof Returned if Number>0 and end of file was reached before anything at all could be read.

{error, Reason} An error occurred.

Typical error reasons:

ebadf The file is not opened for reading.

```
read_file(Filename) -> {ok, Binary} | {error, Reason}
```

Types:



- Filename = name()
- Binary = binary()
- Reason = ext\_posix() | terminated | system\_limit

Returns {ok, Binary}, where Binary is a binary data object that contains the contents of Filename, or {error, Reason} if an error occurs.

Typical error reasons:

enoent The file does not exist.

eaccess Missing permission for reading the file, or for searching one of the parent directories.

eisdir The named file is a directory.

enotdir A component of the file name is not a directory. On some platforms, enoent is returned instead.

enomem There is not enough memory for the contents of the file.

```
read_file_info(Filename) -> {ok, FileInfo} | {error, Reason}
```

Types:

- Filename = name()
- FileInfo = #file\_info{}
- Reason = ext\_posix()

Retrieves information about a file. Returns {ok, FileInfo} if successful, otherwise {error, Reason}. FileInfo is a record file\_info, defined in the Kernel include file file.hrl. Include the following directive in the module from which the function is called:

```
-include_lib("kernel/include/file.hrl").
```

The record file\_info contains the following fields.

size = int() Size of file in bytes.

type = device | directory | regular | other The type of the file.

access = read | write | read\_write | none The current system access to the file.

atime = time() The last (local) time the file was read.

mtime = time() The last (local) time the file was written.

ctime = time() The interpretation of this time field depends on the operating system. On Unix, it is the last time the file or the inode was changed. In Windows, it is the create time.

mode = int() The file permissions as the sum of the following bit values:

- 8#00400** read permission: owner
- 8#00200** write permission: owner
- 8#00100** execute permission: owner
- 8#00040** read permission: group
- 8#00020** write permission: group
- 8#00010** execute permission: group
- 8#00004** read permission: other
- 8#00002** write permission: other

**8#00001** execute permission: other

**16#800** set user id on execution

**16#400** set group id on execution

On Unix platforms, other bits than those listed above may be set.

`links = int()` Number of links to the file (this will always be 1 for file systems which have no concept of links).

`major_device = int()` Identifies the file system where the file is located. In Windows, the number indicates a drive as follows: 0 means A:, 1 means B:, and so on.

`minor_device = int()` Only valid for character devices on Unix. In all other cases, this field is zero.

`inode = int()` Gives the inode number. On non-Unix file systems, this field will be zero.

`uid = int()` Indicates the owner of the file. Will be zero for non-Unix file systems.

`gid = int()` Gives the group that the owner of the file belongs to. Will be zero for non-Unix file systems.

Typical error reasons:

`eaccess` Missing search permission for one of the parent directories of the file.

`enoent` The file does not exist.

`enotdir` A component of the file name is not a directory. On some platforms, `enoent` is returned instead.

```
read_link(Name) -> {ok, Filename} | {error, Reason}
```

Types:

- Name = `name()`
- Filename = `string()`
- Reason = `ext_posix()`

This function returns `{ok, Filename}` if `Name` refers to a symbolic link or `{error, Reason}` otherwise. On platforms that do not support symbolic links, the return value will be `{error, enotsup}`.

Typical error reasons:

`EINVAL` Linkname does not refer to a symbolic link.

`ENOENT` The file does not exist.

`ENOTSUP` Symbolic links are not supported on this platform.

```
read_link_info(Name) -> {ok, FileInfo} | {error, Reason}
```

Types:

- Name = `name()`
- FileInfo = `#file_info{}`, see `read_file_info/1`
- Reason = `ext_posix()`

This function works like `read_file_info/1`, except that if `Name` is a symbolic link, information about the link will be returned in the `file_info` record and the `type` field of the record will be set to `symlink`.

If `Name` is not a symbolic link, this function returns exactly the same result as `read_file_info/1`. On platforms that do not support symbolic links, this function is always equivalent to `read_file_info/1`.

```
rename(Source, Destination) -> ok | {error, Reason}
```

Types:

- `Source = Destination = name()`
- `Reason = ext_posix()`

Tries to rename the file `Source` to `Destination`. It can be used to move files (and directories) between directories, but it is not sufficient to specify the destination only. The destination file name must also be specified. For example, if `bar` is a normal file and `foo` and `baz` are directories, `rename("foo/bar", "baz")` returns an error, but `rename("foo/bar", "baz/bar")` succeeds. Returns `ok` if it is successful.

### Note:

Renaming of open files is not allowed on most platforms (see `eaccess` below).

Typical error reasons:

`eaccess` Missing read or write permissions for the parent directories of `Source` or `Destination`. On some platforms, this error is given if either `Source` or `Destination` is open.

`eexist` `Destination` is not an empty directory. On some platforms, also given when `Source` and `Destination` are not of the same type.

`EINVAL` `Source` is a root directory, or `Destination` is a sub-directory of `Source`.

`EISDIR` `Destination` is a directory, but `Source` is not.

`ENOENT` `Source` does not exist.

`ENOTDIR` `Source` is a directory, but `Destination` is not.

`EXDEV` `Source` and `Destination` are on different file systems.

```
script(Filename) -> {ok, Value} | {error, Reason}
```

Types:

- `Filename = name()`
- `Value = term()`
- `Reason = ext_posix() | terminated | system_limit | {Line, Mod, Term}`
- `Line, Mod, Term` – see below

Reads and evaluates Erlang expressions, separated by `'.'` (or `','`, a sequence of expressions is also an expression), from the file. Returns one of the following:

`{ok, Value}` The file was read and evaluated. `Value` is the value of the last expression.

`{error, atom()}` An error occurred when opening the file or reading it. See `open/2` [page 182] for a list of typical error codes.

`{error, {Line, Mod, Term}}` An error occurred when interpreting the Erlang expressions in the file. Use `format_error/1` to convert the three-element tuple to an English description of the error.

`script(Filename, Bindings) -> {ok, Value} | {error, Reason}`

Types:

- `Filename = name()`
- `Bindings` – see `erl_eval(3)`
- `Value = term()`
- `Reason = ext_posix() | terminated | system_limit | {Line, Mod, Term}`
- `Line, Mod, Term` – see below

The same as `script/1` but the variable bindings `Bindings` are used in the evaluation. See `[erl_eval(3)]` about variable bindings.

`set_cwd(Dir) -> ok | {error, Reason}`

Types:

- `Dir = name()`
- `Reason = ext_posix()`

Sets the current working directory of the file server to `Dir`. Returns `ok` if successful.

Typical error reasons are:

`enoent` The directory does not exist.

`enotdir` A component of `Dir` is not a directory. On some platforms, `enoent` is returned.

`eaccess` Missing permission for the directory or one of its parents.

`badarg` `Filename` had an improper type, such as tuple.

### Warning:

In a future release, a bad type for the `Filename` argument will probably generate an exception.

`sync(IODevice) -> ok | {error, Reason}`

Types:

- `IODevice = io_device()`
- `Reason = ext_posix() | terminated`

Makes sure that any buffers kept by the operating system (not by the Erlang runtime system) are written to disk. On some platforms, this function might have no effect.

Typical error reasons are:

`enospc` Not enough space left to write the file.

`truncate(IODevice) -> ok | {error, Reason}`

Types:

- IoDevice = io\_device()
- Reason = ext\_posix() | terminated

Truncates the file referenced by IoDevice at the current position. Returns ok if successful, otherwise {error, Reason}.

```
write(IoDevice, Bytes) -> ok | {error, Reason}
```

Types:

- IoDevice = io\_device()
- Bytes = iodata()
- Reason = ext\_posix() | terminated

Writes Bytes to the file referenced by IoDevice. This function is the only way to write to a file opened in raw mode (although it works for normally opened files, too). Returns ok if successful, and {error, Reason} otherwise.

Typical error reasons are:

- ebadf The file is not opened for writing.
- enospc There is a no space left on the device.

```
write_file(Filename, Bytes) -> ok | {error, Reason}
```

Types:

- Filename = name()
- Bytes = iodata()
- Reason = ext\_posix() | terminated | system\_limit

Writes the contents of the iodata term Bytes to the file Filename. The file is created if it does not exist. If it exists, the previous contents are overwritten. Returns ok, or {error, Reason}.

Typical error reasons are:

- enoent A component of the file name does not exist.
- enotdir A component of the file name is not a directory. On some platforms, enoent is returned instead.
- enospc There is a no space left on the device.
- eaccess Missing permission for writing the file or searching one of the parent directories.
- eisdir The named file is a directory.

```
write_file(Filename, Bytes, Modes) -> ok | {error, Reason}
```

Types:

- Filename = name()
- Bytes = iodata()
- Modes = [Mode] – see open/2
- Reason = ext\_posix() | terminated | system\_limit

Same as `write_file/2`, but takes a third argument `Modes`, a list of possible modes, see `open/2` [page 182]. The mode flags `binary` and `write` are implicit, so they should not be used.

```
write_file_info(Filename, FileInfo) -> ok | {error, Reason}
```

Types:

- `Filename` = `name()`
- `FileInfo` = `#file_info{}` – see also `read_file_info/1`
- `Reason` = `ext_posix()`

Change file information. Returns `ok` if successful, otherwise `{error, Reason}`. `FileInfo` is a record `file_info`, defined in the Kernel include file `file.hrl`. Include the following directive in the module from which the function is called:

```
-include_lib("kernel/include/file.hrl").
```

The following fields are used from the record, if they are given.

`atime` = `time()` The last (local) time the file was read.

`mtime` = `time()` The last (local) time the file was written.

`ctime` = `time()` On Unix, any value give for this field will be ignored (the “`ctime`” for the file will be set to the current time). On Windows, this field is the new creation time to set for the file.

`mode` = `int()` The file permissions as the sum of the following bit values:

- 8#00400** read permission: owner
- 8#00200** write permission: owner
- 8#00100** execute permission: owner
- 8#00040** read permission: group
- 8#00020** write permission: group
- 8#00010** execute permission: group
- 8#00004** read permission: other
- 8#00002** write permission: other
- 8#00001** execute permission: other
- 16#800** set user id on execution
- 16#400** set group id on execution

On Unix platforms, other bits than those listed above may be set.

`uid` = `int()` Indicates the owner of the file. Ignored for non-Unix file systems.

`gid` = `int()` Gives the group that the owner of the file belongs to. Ignored non-Unix file systems.

Typical error reasons:

`eaccess` Missing search permission for one of the parent directories of the file.

`enoent` The file does not exist.

`enotdir` A component of the file name is not a directory. On some platforms, `enoent` is returned instead.

## POSIX Error Codes

- `eaccess` - permission denied
- `eagain` - resource temporarily unavailable
- `ebadf` - bad file number
- `ebusy` - file busy
- `edquot` - disk quota exceeded
- `eexist` - file already exists
- `efault` - bad address in system call argument
- `efbig` - file too large
- `eintr` - interrupted system call
- `EINVAL` - invalid argument
- `EIO` - IO error
- `EISDIR` - illegal operation on a directory
- `eloop` - too many levels of symbolic links
- `EMFILE` - too many open files
- `EMLINK` - too many links
- `ENAMETOOLONG` - file name too long
- `ENFILE` - file table overflow
- `ENODEV` - no such device
- `ENOENT` - no such file or directory
- `ENOMEM` - not enough memory
- `ENOSPC` - no space left on device
- `ENOTBLK` - block device required
- `ENOTDIR` - not a directory
- `ENOTSUP` - operation not supported
- `ENXIO` - no such device or address
- `EPERM` - not owner
- `EPIPE` - broken pipe
- `EROFS` - read-only file system
- `ESPIPE` - invalid seek
- `ESRCH` - no such process
- `ESTALE` - stale remote file handle
- `EXDEV` - cross-domain link

## Performance

Some operating system file operations, for example a `sync/1` or `close/1` on a huge file, may block their calling thread for seconds. If this befalls the emulator main thread, the response time is no longer in the order of milliseconds, depending on the definition of “soft” in soft real-time system.

If the device driver thread pool is active, file operations are done through those threads instead, so the emulator can go on executing Erlang processes. Unfortunately, the time for serving a file operation increases due to the extra scheduling required from the operating system.

If the device driver thread pool is disabled or of size 0, large file reads and writes are segmented into several smaller, which enables the emulator to server other processes during the file operation. This gives the same effect as when using the thread pool, but with larger overhead. Other file operations, for example `sync/1` or `close/1` on a huge file, still are a problem.

For increased performance, raw files are recommended. Raw files uses the file system of the node's host machine. For normal files (non-raw), the file server is used to find the files, and if the node is running its file server as slave to another node's, and the other node runs on some other host machine, they may have different file systems. This is seldom a problem, but you have now been warned.

A normal file is really a process so it can be used as an IO device (see `io`). Therefore when data is written to a normal file, the sending of the data to the file process, copies all data that are not binaries. Opening the file in binary mode and writing binaries is therefore recommended. If the file is opened on another node, or if the file server runs as slave to another node's, also binaries are copied.

Caching data to reduce the number of file operations, or rather the number of calls to the file driver, will generally increase performance. The following function writes 4 MBytes in 23 seconds when tested:

```
create_file_slow(Name, N) when integer(N), N >= 0 ->
    {ok, FD} = file:open(Name, [raw, write, delayed_write, binary]),
    ok = create_file_slow(FD, 0, N),
    ok = ?FILE_MODULE:close(FD),
    ok.

create_file_slow(FD, M, M) ->
    ok;
create_file_slow(FD, M, N) ->
    ok = file:write(FD, <<M:32/unsigned>>),
    create_file_slow(FD, M+1, N).
```

The following, functionally equivalent, function collects 1024 entries into a list of 128 32-byte binaries before each call to `file:write/2` and so does the same work in 0.52 seconds, which is 44 times faster.

```
create_file(Name, N) when integer(N), N >= 0 ->
    {ok, FD} = file:open(Name, [raw, write, delayed_write, binary]),
    ok = create_file(FD, 0, N),
    ok = ?FILE_MODULE:close(FD),
    ok.

create_file(FD, M, M) ->
    ok;
create_file(FD, M, N) when M + 1024 =< N ->
    create_file(FD, M, M + 1024, []),
    create_file(FD, M + 1024, N);
create_file(FD, M, N) ->
    create_file(FD, M, N, []).
```



```

create_file(FD, M, M, R) ->
    ok = file:write(FD, R);
create_file(FD, M, N0, R) when M + 8 =&lt; N0 ->
    N1 = N0-1, N2 = N0-2, N3 = N0-3, N4 = N0-4,
    N5 = N0-5, N6 = N0-6, N7 = N0-7, N8 = N0-8,
    create_file(FD, M, N8,
                [<<N8:32/unsigned, N7:32/unsigned,
                 N6:32/unsigned, N5:32/unsigned,
                 N4:32/unsigned, N3:32/unsigned,
                 N2:32/unsigned, N1:32/unsigned>> | R]);
create_file(FD, M, N0, R) ->
    N1 = N0-1,
    create_file(FD, M, N1, [<<N1:32/unsigned>> | R]).

```

**Note:**

Trust only your own benchmarks. If the list length in `create_file/2` above is increased, it will run slightly faster, but consume more memory and cause more memory fragmentation. How much this affects your application is something that this simple benchmark can not predict.

If the size of each binary is increased to 64 bytes, it will also run slightly faster, but the code will be twice as clumsy. In the current implementation are binaries larger than 64 bytes stored in memory common to all processes and not copied when sent between processes, while these smaller binaries are stored on the process heap and copied when sent like any other term.

So, with a binary size of 68 bytes `create_file/2` runs 30 percent slower than with 64 bytes, and will cause much more memory fragmentation. Note that if the binaries were to be sent between processes (for example a non-raw file) the results would probably be completely different.

A raw file is really a port. When writing data to a port, it is efficient to write a list of binaries. There is no need to flatten a deep list before writing. On Unix hosts, scatter output, which writes a set of buffers in one operation, is used when possible. In this way `file:write(FD, [Bin1, Bin2 | Bin3])` will write the contents of the binaries without copying the data at all except for perhaps deep down in the operating system kernel.

For raw files, `pwrite/2` and `pread/2` are efficiently implemented. The file driver is called only once for the whole operation, and the list iteration is done in the file driver.

The options `delayed_write` and `read_ahead` to `file:open/2` makes the file driver cache data to reduce the number of operating system calls. The function `create_file/2` in the example above takes 60 seconds without the `delayed_write` option, which is 2.6 times slower.

And, as a really bad example, `create_file_slow/2` above without the `raw`, `binary` and `delayed_write` options, that is it calls `file:open(Name, [write])`, needs 1 min 20 seconds for the job, which is 3.5 times slower than the first example, and 150 times slower than the optimized `create_file/2`.

## Warnings

If an error occurs when accessing an open file with the `io` module, the process which handles the file will exit. The dead file process might hang if a process tries to access it later. This will be fixed in a future release.

## SEE ALSO

[filename(3)]

# gen\_sctp

Erlang Module

The `gen_sctp` module provides functions for communicating with sockets using the SCTP protocol. The implementation assumes that the OS kernel supports SCTP (RFC2960)<sup>1</sup> through the user-level Sockets API Extensions.<sup>2</sup> During development this implementation was tested on Linux Fedora Core 5.0 (kernel 2.6.15-2054 or later is needed), and on Solaris 10, 11. During OTP adaptation it was tested on SUSE Linux Enterprise Server 10 (x86\_64) kernel 2.6.16.27-0.6-smp, with `lksctp-tools-1.0.6`, briefly on Solaris 10, and later on SUSE Linux Enterprise Server 10 Service Pack 1 (x86\_64) kernel 2.6.16.54-0.2.3-smp with `lksctp-tools-1.0.7`.

Record definitions for the `gen_sctp` module can be found using:

```
-include_lib("kernel/include/inet_sctp.hrl").
```

These record definitions use the “new” spelling ‘adaptation’, not the deprecated ‘adaption’, regardless of which spelling the underlying C API uses.

## CONTENTS

- DATA TYPES [page 199]
- EXPORTS [page 200]
- SCTP SOCKET OPTIONS [page 204]
- SCTP EXAMPLES [page 210]
- SEE ALSO [page 212]
- AUTHORS [page 212]

## DATA TYPES

`assoc_id()` An opaque term returned in for example `#sctp_paddr_change{}` that identifies an association for an SCTP socket. The term is opaque except for the special value 0 that has a meaning such as “the whole endpoint” or “all future associations”.

`charlist()` = `[char()]`

`iolist()` = `[char() | binary()]`

`ip_address()` Represents an address of an SCTP socket. It is a tuple as explained in `inet(3)` [page 234].

`port_number()` = 0 .. 65535

<sup>1</sup>URL: <http://www.rfc-archive.org/getrfc.php?rfc=2960>

<sup>2</sup>URL: <http://tools.ietf.org/html/draft-ietf-tsvwg-sctpsocket-13>

`posix()` See `inet(3)`; POSIX Error Codes. [page 241]  
`sctp_option()` One of the SCTP Socket Options. [page 204]  
`sctp_socket()` Socket identifier returned from `open/*`.  
`timeout() = int() | infinity` Timeout used in SCTP connect and receive calls.

## Exports

`abort(sctp_socket(), Assoc) -> ok | {error, posix()}`

Types:

- `Assoc = #sctp_assoc_change{}`

Abnormally terminates the association given by `Assoc`, without flushing of unsent data. The socket itself remains open. Other associations opened on this socket are still valid, and it can be used in new associations.

`close(sctp_socket()) -> ok | {error, posix()}`

Completely closes the socket and all associations on it. The unsent data is flushed as in `eof/2`. The `close/1` call is blocking or otherwise depending of the value of the `linger` [page 205] socket option [page 204]. If `close` does not linger or `linger` timeout expires, the call returns and the data is flushed in the background.

`connect(Socket, Addr, Port, Opts) -> {ok, Assoc} | {error, posix()}`

Same as `connect(Socket, Addr, Port, Opts, infinity)`.

`connect(Socket, Addr, Port, [Opt], Timeout) -> {ok, Assoc} | {error, posix()}`

Types:

- `Socket = sctp_socket()`
- `Addr = ip_address() | Host`
- `Port = port_number()`
- `Opt = sctp_option()`
- `Timeout = timeout()`
- `Host = atom() | string()`
- `Assoc = #sctp_assoc_change{}`

Establishes a new association for the socket `Socket`, with the peer (SCTP server socket) given by `Addr` and `Port`. The `Timeout`, is expressed in milliseconds.

A socket can be associated with multiple peers. The result of `connect/*` is an `#sctp_assoc_change{}` event which contains, in particular, the new Association ID: [page 199]

```

#sctp_assoc_change{
    state           = atom(),
    error           = atom(),
    outbound_streams = int(),
    inbound_streams = int(),
    assoc_id        = assoc_id()
}
  
```

The number of outbound and inbound streams can be set by giving an `sctp_initmsg` option to `connect` as in:

```
connect(Socket, Ip, Port,
        [{sctp_initmsg,#sctp_initmsg{num_ostreams=OutStreams,
                                     max_instreams=MaxInStreams}}])
```

All options `Opt` are set on the socket before the association is attempted. If an option record has got undefined field values, the options record is first read from the socket for those values. In effect, `Opt` option records only define field values to change before connecting.

The returned `outbound_streams` and `inbound_streams` are the actual stream numbers on the socket, which may be different from the requested values (`OutStreams` and `MaxInStreams` respectively) if the peer requires lower values.

The following values of state are possible:

- `comm_up`: association successfully established. This indicates a successful completion of `connect`.
- `cant_assoc`: association cannot be established (`connect/* failure`).

All other states do not normally occur in the output from `connect/*`. Rather, they may occur in `#sctp_assoc_change{}` events received instead of data in `recv/*` [page 202] calls. All of them indicate losing the association due to various error conditions, and are listed here for the sake of completeness. The `error` field may provide more detailed diagnostics.

- `comm_lost`;
- `restart`;
- `shutdown_comp`.

```
controlling_process(sctp_socket(), pid()) -> ok
```

Assigns a new controlling process `Pid` to `Socket`. Same implementation as `gen_udp:controlling_process/2`.

```
eof(Socket, Assoc) -> ok | {error, Reason}
```

Types:

- `Socket` = `sctp_socket()`
- `Assoc` = `#sctp_assoc_change{}`

Gracefully terminates the association given by `Assoc`, with flushing of all unsent data. The socket itself remains open. Other associations opened on this socket are still valid, and it can be used in new associations.

```
listen(Socket, IsServer) -> ok | {error, Reason}
```

Types:

- `Socket` = `sctp_socket()`
- `IsServer` = `bool()`

Sets up a socket to listen on the IP address and port number it is bound to. `IsServer` must be 'true' or 'false'. In the contrast to TCP, in SCTP there is no listening queue length. If `IsServer` is 'true' the socket accepts new associations, i.e. it will become an SCTP server socket.

```
open() -> {ok, Socket} | {error, posix()}
open(Port) -> {ok, Socket} | {error, posix()}
open([Opt]) -> {ok, Socket} | {error, posix()}
open(Port, [Opt]) -> {ok, Socket} | {error, posix()}
```

Types:

- `Opt` = {`ip,IP`} | {`ifaddr,IP`} | {`port,Port`} | `sctp_option()`
- `IP` = `ip_address()` | any | loopback
- `Port` = `port_number()`

Creates an SCTP socket and binds it to the local addresses specified by all {`ip,IP`} (or synonymously {`ifaddr,IP`}) options (this feature is called SCTP multi-homing). The default `IP` and `Port` are any and 0, meaning bind to all local addresses on any one free port.

A default set of socket options [page 204] is used. In particular, the socket is opened in binary [page 204] and passive [page 204] mode, and with reasonably large kernel [page 205] and driver buffers. [page 205]

```
recv(sctp_socket()) -> {ok, {FromIP, FromPort, AncData, BinMsg}} | {error, Reason}
recv(sctp_socket(), timeout()) -> {ok, {FromIP, FromPort, AncData, Data}} | {error, Reason}
```

Types:

- `FromIP` = `ip_address()`
- `FromPort` = `port_number()`
- `AncData` = [#`sctp_sndrcvinfo`{}]
- `Data` = `binary()` | `charlist()` | #`sctp_sndrcvinfo`{ } | #`sctp_assoc_change`{ } | #`sctp_paddr_change`{ } | #`sctp_adaptation_event`{ }
- `Reason` = `posix()` | #`sctp_send_failed`{ } | #`sctp_paddr_change`{ } | #`sctp_pdapi_event`{ } | #`sctp_remote_error`{ } | #`sctp_shutdown_event`{ }

Receives the `Data` message from any association of the socket. If the receive times out {`error,timeout` is returned. The default timeout is infinity. `FromIP` and `FromPort` indicate the sender's address.

`AncData` is a list of Ancillary Data items which may be received along with the main `Data`. This list can be empty, or contain a single #`sctp_sndrcvinfo`{ } [page 208] record, if receiving of such ancillary data is enabled (see option `sctp_events` [page 208]). It is enabled by default, since such ancillary data provide an easy way of determining the association and stream over which the message has been received. (An alternative way would be to get the Association ID from the `FromIP` and `FromPort` using the `sctp_get_peer_addr_info` [page 210] socket option, but this would still not produce the Stream number).

The actual `Data` received may be a `binary()`, or `list()` of bytes (integers in the range 0 through 255) depending on the socket mode, or an SCTP Event. The following SCTP Events are possible:

- #`sctp_sndrcvinfo`{ } [page 208]

- #sctp\_assoc\_change{} [page 200];

- 

```
#sctp_paddr_change{
    addr      = ip_address(),
    state     = atom(),
    error     = int(),
    assoc_id  = assoc_id()
}
```

Indicates change of the status of the peer's IP address given by `addr` within the association `assoc_id`. Possible values of `state` (mostly self-explanatory) include:

- `addr_unreachable`;
- `addr_available`;
- `addr_removed`;
- `addr_added`;
- `addr_made_prim`.

In case of an error (e.g. `addr_unreachable`), the `error` field provides additional diagnostics. In such cases, the `#sctp_paddr_change{}` Event is automatically converted into an error term returned by `gen_sctp:recv`. The error field value can be converted into a string using `error_string/1`.

- 

```
#sctp_send_failed{
    flags     = true | false,
    error     = int(),
    info     = #sctp_sndrcvinfo{},
    assoc_id  = assoc_id()
    data     = binary()
}
```

The sender may receive this event if a send operation fails. The `flags` is a Boolean specifying whether the data have actually been transmitted over the wire; `error` provides extended diagnostics, use `error_string/1`; `info` is the original `#sctp_sndrcvinfo{}` [page 208] record used in the failed send/\*, [page 204] and `data` is the whole original data chunk attempted to be sent.

In the current implementation of the Erlang/SCTP binding, this Event is internally converted into an error term returned by `recv/*`.

- 

```
#sctp_adaptation_event{
    adaptation_ind = int(),
    assoc_id      = assoc_id()
}
```

Delivered when a peer sends an Adaptation Layer Indication parameter (configured through the option `sctp_adaptation_layer` [page 207]). Note that with the current implementation of the Erlang/SCTP binding, this event is disabled by default.

-

```
#sctp_pdapi_event{
    indication = sctp_partial_delivery_aborted,
    assoc_id   = assoc_id()
}
```

A partial delivery failure. In the current implementation of the Erlang/SCTP binding, this Event is internally converted into an error term returned by `recv/*`.

```
send(Socket, SndRcvInfo, Data) -> ok | {error, Reason}
```

Types:

- Socket = `sctp_socket()`
- SndRcvInfo = `#sctp_sndrcvinfo{}`
- Data = `binary() | iolist()`

Sends the Data message with all sending parameters from a `#sctp_sndrcvinfo{}` [page 208] record. This way, the user can specify the PPID (passed to the remote end) and Context (passed to the local SCTP layer) which can be used for example for error identification. However, such a fine level of user control is rarely required. The `send/4` function is sufficient for most applications.

```
send(Socket, Assoc, Stream, Data) -> ok | {error, Reason}
```

Types:

- Socket = `sctp_socket()`
- Assoc = `#sctp_assoc_change{}` | `assoc_id()`
- Stream = `integer()`
- Data = `binary() | iolist()`

Sends Data message over an existing association and given stream.

```
error_string(integer()) -> ok | string() | undefined
```

Translates an SCTP error number from for example `#sctp_remote_error{}` or `#sctp_send_failed{}` into an explanatory string, or one of the atoms `ok` for no error and `undefined` for an unrecognized error.

## SCTP SOCKET OPTIONS

The set of admissible SCTP socket options is by construction orthogonal to the sets of TCP, UDP and generic INET options: only those options which are explicitly listed below are allowed for SCTP sockets. Options can be set on the socket using `gen_sctp:open/1,2` or `inet:setopts/2`, retrieved using `inet:getopts/2`, and when calling `gen_sctp:connect/4,5` options can be changed.

`{mode, list|binary}` **or just** `list` **or** `binary`. Determines the type of data returned from `gen_sctp:recv/1,2`.

`{active, true|false|once}` • If `false` (passive mode, the default), the caller needs to do an explicit `gen_sctp:recv` call in order to retrieve the available data from the socket.



- If `true` (full active mode), the pending data or events are sent to the owning process.  
*NB:* This can cause the message queue to overflow, as there is no way to throttle the sender in this case (no flow control!).
- If once, only one message is automatically placed in the message queue, after that the mode is automatically re-set to passive. This provides flow control as well as the possibility for the receiver to listen for its incoming SCTP data interleaved with other inter-process messages.

`{buffer, int() }` Determines the size of the user-level software buffer used by the SCTP driver. Not to be confused with `sndbuf` and `recbuf` options which correspond to the kernel socket buffers. It is recommended to have `val(buffer) >= max(val(sndbuf), val(recbuf))`. In fact, the `val(buffer)` is automatically set to the above maximum when `sndbuf` or `recbuf` values are set.

`{tos, int() }` Sets the Type-Of-Service field on the IP datagrams being sent, to the given value, which effectively determines a prioritization policy for the outbound packets. The acceptable values are system-dependent. TODO: we do not provide symbolic names for these values yet.

`{priority, int() }` A protocol-independent equivalent of `tos` above. Setting `priority` implies setting `tos` as well.

`{dontroute, true|false }` By default `false`. If `true`, the kernel does not send packets via any gateway, only sends them to directly connected hosts.

`{reuseaddr, true|false }` By default `false`. If `true`, the local binding address `{IP,Port}` of the socket can be re-used immediately: no waiting in the `CLOSE_WAIT` state is performed (may be required for high-throughput servers).

`{linger, {true|false, int() }` Determines the timeout in seconds for flushing unsent data in the `gen_sctp:close/1` socket call. If the 1st component of the value tuple is `false`, the 2nd one is ignored, which means that `gen_sctp:close/1` returns immediately not waiting for data to be flushed. Otherwise, the 2nd component is the flushing time-out in seconds.

`{sndbuf, int() }` The size, in bytes, of the \*kernel\* send buffer for this socket. Sending errors would occur for datagrams larger than `val(sndbuf)`. Setting this option also adjusts the size of the driver buffer (see `buffer` above).

`{recbuf, int() }` The size, in bytes, of the \*kernel\* recv buffer for this socket. Sending errors would occur for datagrams larger than `val(sndbuf)`. Setting this option also adjusts the size of the driver buffer (see `buffer` above).

`{sctp_rtoinfo, #sctp_rtoinfo{}}`

```
#sctp_rtoinfo{
    assoc_id = assoc_id(),
    initial  = int(),
    max      = int(),
    min      = int()
}
```

Determines re-transmission time-out parameters, in milliseconds, for the association(s) given by `assoc_id`. If `assoc_id = 0` (default) indicates the whole endpoint. See RFC2960<sup>3</sup> and Sockets API Extensions for SCTP<sup>4</sup> for the exact semantics of the fields values.

<sup>3</sup>URL: <http://www.rfc-archive.org/getrfc.php?rfc=2960>

<sup>4</sup>URL: <http://tools.ietf.org/html/draft-ietf-tsvwg-sctpsocket-13>

```
{sctp_associnfo, #sctp_assocparams{}}
    #sctp_assocparams{
        assoc_id           = assoc_id(),
        asocmaxrxt         = int(),
        number_peer_destinations = int(),
        peer_rwnd          = int(),
        local_rwnd         = int(),
        cookie_life        = int()
    }
```

Determines association parameters for the association(s) given by `assoc_id`. `assoc_id = 0` (default) indicates the whole endpoint. See Sockets API Extensions for SCTP<sup>5</sup> for the discussion of their semantics. Rarely used.

```
{sctp_initmsg, #sctp_initmsg{}}
    #sctp_initmsg{
        num_ostreams     = int(),
        max_instreams    = int(),
        max_attempts     = int(),
        max_init_timeo   = int()
    }
```

Determines the default parameters which this socket attempts to negotiate with its peer while establishing an association with it. Should be set after `open/*` but before the first `connect/*`. `#sctp_initmsg{}` can also be used as ancillary data with the first call of `send/*` to a new peer (when a new association is created).

- `num_ostreams`: number of outbound streams;
- `max_instreams`: max number of in-bound streams;
- `max_attempts`: max re-transmissions while establishing an association;
- `max_init_timeo`: time-out in milliseconds for establishing an association.

`{sctp_autoclose, int()|infinity}` Determines the time (in seconds) after which an idle association is automatically closed.

`{sctp_nodelay, true|false}` Turns on/off the Nagle algorithm for merging small packets into larger ones (which improves throughput at the expense of latency).

`{sctp_disable_fragments, true|false}` If `true`, induces an error on an attempt to send a message which is larger than the current PMTU size (which would require fragmentation/re-assembling). Note that message fragmentation does not affect the logical atomicity of its delivery; this option is provided for performance reasons only.

`{sctp_i_want_mapped_v4_addr, true|false}` Turns on/off automatic mapping of IPv4 addresses into IPv6 ones (if the socket address family is `AF_INET6`).

`{sctp_maxseg, int()}` Determines the maximum chunk size if message fragmentation is used. If 0, the chunk size is limited by the Path MTU only.

```
{sctp_primary_addr, #sctp_prim{}}
    #sctp_prim{
        assoc_id = assoc_id(),
        addr     = {IP, Port}
    }
    IP = ip_address()
    Port = port_number()
```

<sup>5</sup>URL: <http://tools.ietf.org/html/draft-ietf-tsvwg-sctpsocket-13>

For the association given by `assoc_id`, `{IP,Port}` must be one of the peer's addresses. This option determines that the given address is treated by the local SCTP stack as the peer's primary address.

```
{sctp_set_peer_primary_addr, #sctp_setpeerprim{}}

#sctp_setpeerprim{
    assoc_id = assoc_id(),
    addr     = {IP, Port}
}
IP = ip_address()
Port = port_number()
```

When set, informs the peer that it should use `{IP, Port}` as the primary address of the local endpoint for the association given by `assoc_id`.

```
{sctp_adaptation_layer, #sctp_setadaptation{}}

#sctp_setadaptation{
    adaptation_ind = int()
}

```

When set, requests that the local endpoint uses the value given by `adaptation_ind` as the Adaptation Indication parameter for establishing new associations. See RFC2960<sup>6</sup> and Sockets API Extensions for SCTP<sup>7</sup> for more details.

```
{sctp_peer_addr_params, #sctp_paddrparams{}}

#sctp_paddrparams{
    assoc_id  = assoc_id(),
    address   = {IP, Port},
    hbinterval = int(),
    pathmaxrxt = int(),
    pathmtu   = int(),
    sackdelay = int(),
    flags     = list()
}
IP = ip_address()
Port = port_number()
```

This option determines various per-address parameters for the association given by `assoc_id` and the peer address `address` (the SCTP protocol supports multi-homing, so more than 1 address can correspond to a given association).

- `hbinterval`: heartbeat interval, in milliseconds;
- `pathmaxrxt`: max number of retransmissions before this address is considered unreachable (and an alternative address is selected);
- `pathmtu`: fixed Path MTU, if automatic discovery is disabled (see `flags` below);
- `sackdelay`: delay in milliseconds for SAC messages (if the delay is enabled, see `flags` below);
- `flags`: the following flags are available:
  - `hb_enable`: enable heartbeat;
  - `hb_disable`: disable heartbeat;

<sup>6</sup>URL: <http://www.rfc-archive.org/getrfc.php?rfc=2960>

<sup>7</sup>URL: <http://tools.ietf.org/html/draft-ietf-tsvwg-sctpsocket-13>

- hb\_demand: initiate heartbeat immediately;
- pmtud\_enable: enable automatic Path MTU discovery;
- pmtud\_disable: disable automatic Path MTU discovery;
- sackdelay\_enable: enable SAC delay;
- sackdelay\_disable: disable SAC delay.

```
{sctp_default_send_param, #sctp_sndrcvinfo{}}
```

```
#sctp_sndrcvinfo{
    stream      = int(),
    ssn        = int(),
    flags       = list(),
    ppid       = int(),
    context     = int(),
    timetolive = int(),
    tsn        = int(),
    cumtsn     = int(),
    assoc_id   = assoc_id()
}
```

`#sctp_sndrcvinfo{}` is used both in this socket option, and as ancillary data while sending or receiving SCTP messages. When set as an option, it provides a default values for subsequent `gen_sctp:sendcalls` on the association given by `assoc_id`. `assoc_id = 0` (default) indicates the whole endpoint. The following fields typically need to be specified by the sender:

- `sinfo_stream`: stream number (0-base) within the association to send the messages through;
- `sinfo_flags`: the following flags are recognised:
  - `unordered`: the message is to be sent unordered;
  - `addr_over`: the address specified in `gen_sctp:send` overwrites the primary peer address;
  - `abort`: abort the current association without flushing any unsent data;
  - `eof`: gracefully shut down the current association, with flushing of unsent data.

Other fields are rarely used. See RFC2960<sup>8</sup> and Sockets API Extensions for SCTP<sup>9</sup> for full information.

```
{sctp_events, #sctp_event_subscribe{}}
```

```
#sctp_event_subscribe{
    data_io_event           = true | false,
    association_event       = true | false,
    address_event          = true | false,
    send_failure_event      = true | false,
    peer_error_event        = true | false,
    shutdown_event         = true | false,
    partial_delivery_event  = true | false,
    adaptation_layer_event = true | false
}
```

<sup>8</sup>URL: <http://www.rfc-archive.org/getrfc.php?rfc=2960>

<sup>9</sup>URL: <http://tools.ietf.org/html/draft-ietf-tsvwg-sctpsocket-13>

This option determines which SCTP Events [page 202] are to be received (via `recv/*` [page 202]) along with the data. The only exception is `data_io_event` which enables or disables receiving of `#sctp_sndrcvinfo{}` [page 208] ancillary data, not events. By default, all flags except `adaptation_layer_event` are enabled, although `sctp_data_io_event` and `association_event` are used by the driver itself and not exported to the user level.

```
{sctp_delayed_ack_time, #sctp_assoc_value{}}

    #sctp_assoc_value{
        assoc_id    = assoc_id(),
        assoc_value = int()
    }
```

Rarely used. Determines the ACK time (given by `assoc_value` in milliseconds) for the given association or the whole endpoint if `assoc_value = 0` (default).

```
{sctp_status, #sctp_status{}}

    #sctp_status{
        assoc_id      = assoc_id(),
        state         = atom(),
        rwnd          = int(),
        unackdata     = int(),
        penddata     = int(),
        instrms       = int(),
        outstrms      = int(),
        fragmentation_point = int(),
        primary       = #sctp_paddrinfo{ }
    }
```

This option is read-only. It determines the status of the SCTP association given by `assoc_id`. Possible values of `state` follows. The state designations are mostly self-explanatory. `state_empty` is the default which means that no other state is active:

- `sctp_state_empty`
- `sctp_state_closed`
- `sctp_state_cookie_wait`
- `sctp_state_cookie_echoed`
- `sctp_state_established`
- `sctp_state_shutdown_pending`
- `sctp_state_shutdown_sent`
- `sctp_state_shutdown_received`
- `sctp_state_shutdown_ack_sent`

The semantics of other fields is the following:

- `sstat_rwnd`: the association peer's current receiver window size;
- `sstat_unackdata`: number of unacked data chunks;
- `sstat_penddata`: number of data chunks pending receipt;
- `sstat_instrms`: number of inbound streams;
- `sstat_outstrms`: number of outbound streams;
- `sstat_fragmentation_point`: message size at which SCTP fragmentation will occur;

- `sstat_primary`: information on the current primary peer address (see below for the format of `#sctp_paddrinfo{}`).

```
{sctp_get_peer_addr_info, #sctp_paddrinfo{}}

#sctp_paddrinfo{
    assoc_id = assoc_id(),
    address  = {IP, Port},
    state    = inactive | active,
    cwnd     = int(),
    srtt     = int(),
    rto      = int(),
    mtu      = int()
}
IP = ip_address()
Port = port_number()
```

This option is read-only. It determines the parameters specific to the peer's address given by `address` within the association given by `assoc_id`. The `address` field must be set by the caller; all other fields are filled in on return. If `assoc_id = 0` (default), the address is automatically translated into the corresponding association ID. This option is rarely used; see RFC2960<sup>10</sup> and Sockets API Extensions for SCTP<sup>11</sup> for the semantics of all fields.

## SCTP EXAMPLES

- Example of an Erlang SCTP Server which receives SCTP messages and prints them on the standard output:

```
-module(sctp_server).

-export([server/0,server/1,server/2]).
-include_lib("kernel/include/inet.hrl").
-include_lib("kernel/include/inet_sctp.hrl").

server() ->
    server([any,2006]).

server([Host,Port]) when is_list(Host), is_list(Port) ->
    {ok, #hostent{h_addr_list = [IP|_]}} = inet:gethostbyname(Host),
    io:format("~w -> ~w~n", [Host, IP]),
    server([IP, list_to_integer(Port)]);

server(IP, Port) when is_tuple(IP) orlse IP == any orlse IP == loopback,
    is_integer(Port) ->
    {ok,S} = gen_sctp:open([ip,IP],{port,Port}],[{sctp_recbuf,65536}]),
    io:format("Listening on ~w:~w. ~w~n", [IP,Port,S]),
    ok     = gen_sctp:listen(S, true),
    server_loop(S).
```

<sup>10</sup>URL: <http://www.rfc-archive.org/getrfc.php?rfc=2960>

<sup>11</sup>URL: <http://tools.ietf.org/html/draft-ietf-tsvwg-sctpsocket-13>

```

server_loop(S) ->
  case gen_sctp:recv(S) of
  {error, Error} ->
    io:format("SCTP RECV ERROR: ~p~n", [Error]);
  Data ->
    io:format("Error: ~p~n", [Data])
  end,
  server_loop(S).

```

- Example of an Erlang SCTP Client which interacts with the above Server. Note that in this example, the Client creates an association with the Server with 5 outbound streams. For this reason, sending of "Test 0" over Stream 0 succeeds, but sending of "Test 5" over Stream 5 fails. The client then aborts the association, which results in the corresponding Event being received on the Server side.

```

-module(sctp_client).

-export([client/0, client/1, client/2]).
-include("inet.hrl").

client() ->
  client([localhost]).

client([Host]) ->
  client([Host,2006]);

client([Host, Port]) when is_list(Host), is_list(Port) ->
  client(Host,list_to_integer(Port)),
  init:stop();

client(Host, Port) when is_integer(Port) ->
  {ok,S}      = gen_sctp:open(),
  {ok Assoc} = gen_sctp:connect
    (S, Host, Port, [{sctp_initmsg,#sctp_initmsg{num_ostreams=5}}]),
  io:format("Connection Successful, Assoc=~p~n", [Assoc]),

  io:write(gen_sctp:send(S, Assoc, 0, <<"Test 0">>)),
  io:nl(),
  timer:sleep(10000),
  io:write(gen_sctp:send(S, Assoc, 5, <<"Test 5">>)),
  io:nl(),
  timer:sleep(10000),
  io:write(gen_sctp:abort(S, Assoc)),
  io:nl(),

  timer:sleep(1000),
  gen_sctp:close(S).

```

## SEE ALSO

inet(3) [page 234], gen\_tcp(3) [page 213], gen\_upd(3) [page 220], RFC2960<sup>12</sup> (Stream Control Transmission Protocol), Sockets API Extensions for SCTP.<sup>13</sup>

---

<sup>12</sup>URL: <http://www.rfc-archive.org/getrfc.php?rfc=2960>

<sup>13</sup>URL: <http://tools.ietf.org/html/draft-ietf-tsvwg-sctpsocket-13>



# gen\_tcp

Erlang Module

The `gen_tcp` module provides functions for communicating with sockets using the TCP/IP protocol.

The following code fragment provides a simple example of a client connecting to a server at port 5678, transferring a binary and closing the connection:

```
client() ->
    SomeHostInNet = "localhost" % to make it runnable on one machine
    {ok, Sock} = gen_tcp:connect(SomeHostInNet, 5678,
                               [binary, {packet, 0}]),
    ok = gen_tcp:send(Sock, "Some Data"),
    ok = gen_tcp:close(Sock).
```

At the other end a server is listening on port 5678, accepts the connection and receives the binary:

```
server() ->
    {ok, LSock} = gen_tcp:listen(5678, [binary, {packet, 0},
                                       {active, false}]),
    {ok, Sock} = gen_tcp:accept(LSock),
    {ok, Bin} = do_recv(Sock, []),
    ok = gen_tcp:close(Sock),
    Bin.

do_recv(Sock, Bs) ->
    case gen_tcp:recv(Sock, 0) of
    {ok, B} ->
        do_recv(Sock, [Bs, B]);
    {error, closed} ->
        {ok, list_to_binary(Bs)}
    end.
```

For more examples, see the examples [page 217] section.

## DATA TYPES

`ip_address()`  
see `inet(3)`

`posix()`  
see `inet(3)`

`socket()`  
as returned by `accept/1,2` and `connect/3,4`

## Exports

`connect(Address, Port, Options) -> {ok, Socket} | {error, Reason}`

`connect(Address, Port, Options, Timeout) -> {ok, Socket} | {error, Reason}`

Types:

- Address = string() | atom() | ip\_address()
- Port = 0..65535
- Options = [Opt]
- Opt – see below
- Timeout = int() | infinity
- Socket = socket()
- Reason = posix()

Connects to a server on TCP port `Port` on the host with IP address `Address`. The `Address` argument can be either a hostname, or an IP address.

The available options are:

`list` Received Packet is delivered as a list.

`binary` Received Packet is delivered as a binary.

`{ip, ip_address()}` If the host has several network interfaces, this option specifies which one to use.

`{port, Port}` Specify which local port number to use.

`{fd, int()}` If a socket has somehow been connected without using `gen_tcp`, use this option to pass the file descriptor for it.

`inet6` Set up the socket for IPv6.

`inet` Set up the socket for IPv4.

**Opt** See `inet:setopts/2` [page 238].

Packets can be sent to the returned socket `Socket` using `send/2`. Packets sent from the peer are delivered as messages:

`{tcp, Socket, Data}`

If the socket is closed, the following message is delivered:

`{tcp_closed, Socket}`

If an error occurs on the socket, the following message is delivered:

`{tcp_error, Socket, Reason}`

unless `{active, false}` is specified in the option list for the socket, in which case packets are retrieved by calling `recv/2`.

The optional `Timeout` parameter specifies a timeout in milliseconds. The default value is `infinity`.

### Note:

The default values for options given to `connect` can be affected by the Kernel configuration parameter `inet_default_connect_options`. See `inet(3)` [page 234] for details.

```
listen(Port, Options) -> {ok, ListenSocket} | {error, Reason}
```

Types:

- Port = 0..65535
- Options = [Opt]
- Opt – see below
- ListenSocket – see below
- Reason = posix()

Sets up a socket to listen on the port Port on the local host.

If Port == 0, the underlying OS assigns an available port number, use `inet:port/1` to retrieve it.

The available options are:

`list` Received Packet is delivered as a list.

`binary` Received Packet is delivered as a binary.

`{backlog, B}` B is an integer  $\geq 0$ . The backlog value defaults to 5. The backlog value defines the maximum length that the queue of pending connections may grow to.

`{ip, ip_address()}` If the host has several network interfaces, this option specifies which one to listen on.

`{fd, Fd}` If a socket has somehow been connected without using `gen_tcp`, use this option to pass the file descriptor for it.

`inet6` Set up the socket for IPv6.

`inet` Set up the socket for IPv4.

`Opt` See `inet:setopts/2` [page 238].

The returned socket `ListenSocket` can only be used in calls to `accept/1,2`.

### Note:

The default values for options given to `listen` can be affected by the Kernel configuration parameter `inet_default_listen_options`. See `inet(3)` [page 234] for details.

```
accept(ListenSocket) -> {ok, Socket} | {error, Reason}
```

```
accept(ListenSocket, Timeout) -> {ok, Socket} | {error, Reason}
```

Types:

- ListenSocket – see `listen/2`
- Timeout = `int()` | `infinity`
- Socket = `socket()`
- Reason = `closed` | `timeout` | `posix()`

Accepts an incoming connection request on a listen socket. `Socket` must be a socket returned from `listen/2`. `Timeout` specifies a timeout value in ms, defaults to `infinity`.

Returns `{ok, Socket}` if a connection is established, or `{error, closed}` if `ListenSocket` is closed, or `{error, timeout}` if no connection is established within the specified time. May also return a POSIX error value if something else goes wrong, see `inet(3)` for possible error values.

Packets can be sent to the returned socket `Socket` using `send/2`. Packets sent from the peer are delivered as messages:

```
{tcp, Socket, Data}
```

unless `{active, false}` was specified in the option list for the listen socket, in which case packets are retrieved by calling `recv/2`.

**Note:**

It is worth noting that the `accept` call does *not* have to be issued from the socket owner process. Using version 5.5.3 and higher of the emulator, multiple simultaneous `accept` calls can be issued from different processes, which allows for a pool of acceptor processes handling incoming connections.

```
send(Socket, Packet) -> ok | {error, Reason}
```

Types:

- `Socket = socket()`
- `Packet = [char()] | binary()`
- `Reason = posix()`

Sends a packet on a socket.

There is no `send` call with timeout option, you use the `send_timeout` socket option if timeouts are desired. See the examples [page 217] section.

```
recv(Socket, Length) -> {ok, Packet} | {error, Reason}
```

```
recv(Socket, Length, Timeout) -> {ok, Packet} | {error, Reason}
```

Types:

- `Socket = socket()`
- `Length = int()`
- `Packet = [char()] | binary()`
- `Timeout = int() | infinity`
- `Reason = closed | posix()`

This function receives a packet from a socket in passive mode. A closed socket is indicated by a return value `{error, closed}`.

The `Length` argument is only meaningful when the socket is in `raw` mode and denotes the number of bytes to read. If `Length = 0`, all available bytes are returned. If `Length > 0`, exactly `Length` bytes are returned, or an error; possibly discarding less than `Length` bytes of data when the socket gets closed from the other side.

The optional `Timeout` parameter specifies a timeout in milliseconds. The default value is `infinity`.

```
controlling_process(Socket, Pid) -> ok | {error, Reason}
```

Types:

- Socket = socket()
- Pid = pid()
- Reason = closed | not\_owner | posix()

Assigns a new controlling process `Pid` to `Socket`. The controlling process is the process which receives messages from the socket. If called by any other process than the current controlling process, `{error, eperm}` is returned.

```
close(Socket) -> ok | {error, Reason}
```

Types:

- Socket = socket()
- Reason = posix()

Closes a TCP socket.

```
shutdown(Socket, How) -> ok | {error, Reason}
```

Types:

- Socket = socket()
- How = read | write | read\_write
- Reason = posix()

Immediately close a socket in one or two directions.

`How == write` means closing the socket for writing, reading from it is still possible.

To be able to handle that the peer has done a shutdown on the write side, the `{exit_on_close, false}` option is useful.

## Examples

The following example illustrates usage of the `{active,once}` option and multiple accepts by implementing a server as a number of worker processes doing accept on one single listen socket. The `start/2` function takes the number of worker processes as well as a port number to listen for incoming connections on. If `LPort` is specified as 0, an ephemeral portnumber is used, why the `start` function returns the actual portnumber allocated:

```
start(Num,LPort) ->
  case gen_tcp:listen(LPort,[{active, false},{packet,2}]) of
    {ok, ListenSock} ->
      start_servers(Num,ListenSock),
      {ok, Port} = inet:port(ListenSock),
      Port;
    {error,Reason} ->
      {error,Reason}
  end.

start_servers(0,_) ->
  ok;
start_servers(Num,LS) ->
```

```

spawn(?MODULE,server,[LS]),
start_servers(Num-1,LS).

server(LS) ->
case gen_tcp:accept(LS) of
  {ok,S} ->
    loop(S),
    server(LS);
  Other ->
    io:format("accept returned ~w - goodbye!\n",[Other]),
    ok
end.

loop(S) ->
inet:setopts(S,[{active,once}]),
receive
  {tcp,S,Data} ->
    Answer = process(Data), % Not implemented in this example
    gen_tcp:send(S,Answer),
    loop(S);
  {tcp_closed,S} ->
    io:format("Socket ~w closed [~w]\n",[S,self()]),
    ok
end.

```

A simple client could look like this:

```

client(PortNo,Message) ->
  {ok,Sock} = gen_tcp:connect("localhost",PortNo,[{active,false},
  {packet,2}]),
  gen_tcp:send(Sock,Message),
  A = gen_tcp:recv(Sock,0),
  gen_tcp:close(Sock),
  A.

```

The fact that the `send` call does not accept a timeout option, is because timeouts on `send` is handled through the socket option `send_timeout`. The behavior of a `send` operation with no receiver is in a very high degree defined by the underlying TCP stack, as well as the network infrastructure. If one wants to write code that handles a hanging receiver that might eventually cause the sender to hang on a `send` call, one writes code like the following.

Consider a process that receives data from a client process that is to be forwarded to a server on the network. The process has connected to the server via TCP/IP and does not get any acknowledge for each message it sends, but has to rely on the `send_timeout` option to detect that the other end is unresponsive. We could use the `send_timeout` option when connecting:

```

...
{ok,Sock} = gen_tcp:connect(HostAddress, Port,
                          [{active,false},
                           {send_timeout, 5000},
                           {packet,2}]),
          loop(Sock), % See below
...

```

In the loop where requests are handled, we can now detect send timeouts:

```

loop(Socket) ->
  receive
    {Client, send_data, Binary} ->
      case gen_tcp:send(Socket,[Binary]) of
        {error, timeout} ->
          io:format("Send timeout, closing!~n",
                    []),
          handle_send_timeout(), % Not implemented here
          Client ! {self(),{error_sending, timeout}},
          %% Usually, it's a good idea to give up in case of a
          %% send timeout, as you never know how much actually
          %% reached the server, maybe only a packet header?!
          gen_tcp:close(Socket);
        {error, OtherSendError} ->
          io:format("Some other error on socket (~p), closing",
                    [OtherSendError]),
          Client ! {self(),{error_sending, OtherSendError}},
          gen_tcp:close(Socket);
        ok ->
          Client ! {self(), data_sent},
          loop(Socket)
      end
  end
end.

```

Usually it would suffice to detect timeouts on receive, as most protocols include some sort of acknowledgment from the server, but if the protocol is strictly one way, the `send_timeout` option comes in handy!

# gen\_udp

Erlang Module

The `gen_udp` module provides functions for communicating with sockets using the UDP protocol.

## DATA TYPES

`ip_address()`  
see `inet(3)`

`posix()`  
see `inet(3)`

`socket()`  
as returned by `open/1,2`

## Exports

`open(Port) -> {ok, Socket} | {error, Reason}`  
`open(Port, Options) -> {ok, Socket} | {error, Reason}`

Types:

- `Port` = 0..65535
- `Options` = [Opt]
- `Opt` - see below
- `Socket` = `socket()`
- `Reason` = `posix()`

Associates a UDP port number (`Port`) with the calling process.

The available options are:

`list` Received Packet is delivered as a list.

`binary` Received Packet is delivered as a binary.

`{ip, ip_address()}` If the host has several network interfaces, this option specifies which one to use.

`{fd, int()}` If a socket has somehow been opened without using `gen_udp`, use this option to pass the file descriptor for it.

`inet6` Set up the socket for IPv6.

`inet` Set up the socket for IPv4.



Opt See `inet:setopts/2` [page 238].

The returned socket `Socket` is used to send packets from this port with `send/4`. When UDP packets arrive at the opened port, they are delivered as messages:

```
{udp, Socket, IP, InPortNo, Packet}
```

Note that arriving UDP packets that are longer than the receive buffer option specifies, might be truncated without warning.

`IP` and `InPortNo` define the address from which `Packet` came. `Packet` is a list of bytes if the option `list` was specified. `Packet` is a binary if the option `binary` was specified.

Default value for the receive buffer option is `{recbuf, 8192}`.

If `Port == 0`, the underlying OS assigns a free UDP port, use `inet:port/1` to retrieve it.

```
send(Socket, Address, Port, Packet) -> ok | {error, Reason}
```

Types:

- `Socket = socket()`
- `Address = string() | atom() | ip_address()`
- `Port = 0..65535`
- `Packet = [char()] | binary()`
- `Reason = not_owner | posix()`

Sends a packet to the specified address and port. The `Address` argument can be either a hostname, or an IP address.

```
recv(Socket, Length) -> {ok, {Address, Port, Packet}} | {error, Reason}
```

```
recv(Socket, Length, Timeout) -> {ok, {Address, Port, Packet}} | {error, Reason}
```

Types:

- `Socket = socket()`
- `Length = int()`
- `Address = ip_address()`
- `Port = 0..65535`
- `Packet = [char()] | binary()`
- `Timeout = int() | infinity`
- `Reason = not_owner | posix()`

This function receives a packet from a socket in passive mode.

The optional `Timeout` parameter specifies a timeout in milliseconds. The default value is `infinity`.

```
controlling_process(Socket, Pid) -> ok
```

Types:

- `Socket = socket()`
- `Pid = pid()`

Assigns a new controlling process `Pid` to `Socket`. The controlling process is the process which receives messages from the socket.

`close(Socket) -> ok | {error, Reason}`

Types:

- Socket = `socket()`
- Reason = `not_owner` | `posix()`

Closes a UDP socket.

# global

## Erlang Module

This documentation describes the Global module which consists of the following functionalities:

- registration of global names;
- global locks;
- maintenance of the fully connected network.

These services are controlled via the process `global_name_server` which exists on every node. The global name server is started automatically when a node is started. With the term *global* is meant over a system consisting of several Erlang nodes.

The ability to globally register names is a central concept in the programming of distributed Erlang systems. In this module, the equivalent of the `register/2` and `whereis/1` BIFs (for local name registration) are implemented, but for a network of Erlang nodes. A registered name is an alias for a process identifier (pid). The global name server monitors globally registered pids. If a process terminates, the name will also be globally unregistered.

The registered names are stored in replica global name tables on every node. There is no central storage point. Thus, the translation of a name to a pid is fast, as it is always done locally. When any action is taken which results in a change to the global name table, all tables on other nodes are automatically updated.

Global locks have lock identities and are set on a specific resource. For instance, the specified resource could be a pid. When a global lock is set, access to the locked resource is denied for all other resources other than the lock requester.

Both the registration and lock functionalities are atomic. All nodes involved in these actions will have the same view of the information.

The global name server also performs the critical task of continuously monitoring changes in node configuration: if a node which runs a globally registered process goes down, the name will be globally unregistered. To this end the global name server subscribes to `nodeup` and `nodedown` messages sent from the `net_kernel` module. Relevant Kernel application variables in this context are `net_setuptime`, `net_ticktime`, and `dist_auto_connect`. See also `kernel(6)` [page 34].

The server will also maintain a fully connected network. For example, if node `N1` connects to node `N2` (which is already connected to `N3`), the global name servers on the nodes `N1` and `N3` will make sure that also `N1` and `N3` are connected. If this is not desired, the command line flag `-connect_all false` can be used (see also `[erl(1)]`). In this case the name registration facility cannot be used, but the lock mechanism will still work.

If the global name server fails to connect nodes (`N1` and `N3` in the example above) a warning event is sent to the error logger. The presence of such an event does not exclude the possibility that the nodes will later connect—one can for example try the

command `rpc:call(N1, net_adm, ping, [N2])` in the Erlang shell—but it indicates some kind of problem with the network.

**Note:**

If the fully connected network is not set up properly, the first thing to try is to increase the value of `net_setuptime`.

## Exports

`del_lock(Id)`

`del_lock(Id, Nodes) -> void()`

Types:

- `Id = {ResourceId, LockRequesterId}`
- `ResourceId = term()`
- `LockRequesterId = term()`
- `Nodes = [node()]`

Deletes the lock `Id` synchronously.

`notify_all_name(Name, Pid1, Pid2) -> none`

Types:

- `Name = term()`
- `Pid1 = Pid2 = pid()`

This function can be used as a name resolving function for `register_name/3` and `re_register_name/3`. It unregisters both pids, and sends the message `{global_name_conflict, Name, OtherPid}` to both processes.

`random_exit_name(Name, Pid1, Pid2) -> Pid1 | Pid2`

Types:

- `Name = term()`
- `Pid1 = Pid2 = pid()`

This function can be used as a name resolving function for `register_name/3` and `re_register_name/3`. It randomly chooses one of the pids for registration and kills the other one.

`random_notify_name(Name, Pid1, Pid2) -> Pid1 | Pid2`

Types:

- `Name = term()`
- `Pid1 = Pid2 = pid()`

This function can be used as a name resolving function for `register_name/3` and `re_register_name/3`. It randomly chooses one of the pids for registration, and sends the message `{global_name_conflict, Name}` to the other pid.

```
register_name(Name, Pid)
register_name(Name, Pid, Resolve) -> yes | no
```

Types:

- Name = term()
- Pid = pid()
- Resolve = fun() or {Module, Function} where
- Resolve(Name, Pid, Pid2) -> Pid | Pid2 | none

Globally associates the name `Name` with a `pid`, that is, Globally notifies all nodes of a new global name in a network of Erlang nodes.

When new nodes are added to the network, they are informed of the globally registered names that already exist. The network is also informed of any global names in newly connected nodes. If any name clashes are discovered, the `Resolve` function is called. Its purpose is to decide which `pid` is correct. If the function crashes, or returns anything other than one of the `pids`, the name is unregistered. This function is called once for each name clash.

There are three pre-defined resolve functions: `random_exit_name/3`, `random_notify_name/3`, and `notify_all_name/3`. If no `Resolve` function is defined, `random_exit_name` is used. This means that one of the two registered processes will be selected as correct while the other is killed.

This function is completely synchronous. This means that when this function returns, the name is either registered on all nodes or none.

The function returns `yes` if successful, `no` if it fails. For example, `no` is returned if an attempt is made to register an already registered process or to register a process with a name that is already in use.

### Note:

Releases up to and including OTP R10 did not check if the process was already registered. As a consequence the global name table could become inconsistent. The old (buggy) behavior can be chosen by giving the Kernel application variable `global_multi_name_action` the value `allow`.

If a process with a registered name dies, or the node goes down, the name is unregistered on all nodes.

```
registered_names() -> [Name]
```

Types:

- Name = term()

Returns a lists of all globally registered names.

```
re_register_name(Name, Pid)
re_register_name(Name, Pid, Resolve) -> void()
```

Types:

- Name = term()
- Pid = pid()

- Resolve = fun() or {Module, Function} where
- Resolve(Name, Pid, Pid2) -> Pid | Pid2 | none

Atomically changes the registered name Name on all nodes to refer to Pid.

The Resolve function has the same behavior as in register\_name/2,3.

send(Name, Msg) -> Pid

Types:

- Name = term()
- Msg = term()
- Pid = pid()

Sends the message Msg to the pid globally registered as Name.

Failure: If Name is not a globally registered name, the calling function will exit with reason {badarg, {Name, Msg}}.

set\_lock(Id)

set\_lock(Id, Nodes)

set\_lock(Id, Nodes, Retries) -> boolean()

Types:

- Id = {ResourceId, LockRequesterId}
- ResourceId = term()
- LockRequesterId = term()
- Nodes = [node()]
- Retries = int() >= 0 | infinity

Sets a lock on the specified nodes (or on all nodes if none are specified) on ResourceId for LockRequesterId. If a lock already exists on ResourceId for another requester than LockRequesterId, and Retries is not equal to 0, the process sleeps for a while and will try to execute the action later. When Retries attempts have been made, false is returned, otherwise true. If Retries is infinity, true is eventually returned (unless the lock is never released).

If no value for Retries is given, infinity is used.

This function is completely synchronous.

If a process which holds a lock dies, or the node goes down, the locks held by the process are deleted.

The global name server keeps track of all processes sharing the same lock, that is, if two processes set the same lock, both processes must delete the lock.

This function does not address the problem of a deadlock. A deadlock can never occur as long as processes only lock one resource at a time. But if some processes try to lock two or more resources, a deadlock may occur. It is up to the application to detect and rectify a deadlock.

**Note:**

Some values of ResourceId should be avoided or Erlang/OTP will not work properly. A list of resources to avoid: global, dist\_ac, mnesia\_table\_lock, mnesia\_adjust\_log\_writes, pg2.

`sync() -> void()`

Synchronizes the global name server with all nodes known to this node. These are the nodes which are returned from `erlang:nodes()`. When this function returns, the global name server will receive global information from all nodes. This function can be called when new nodes are added to the network.

`trans(Id, Fun)`

`trans(Id, Fun, Nodes)`

`trans(Id, Fun, Nodes, Retries) -> Res | aborted`

Types:

- `Id = {ResourceId, LockRequesterId}`
- `ResourceId = term()`
- `LockRequesterId = term()`
- `Fun = fun() | {M, F}`
- `Nodes = [node()]`
- `Retries = int() >= 0 | infinity`
- `Res = term()`

Sets a lock on `Id` (using `set_lock/3`). If this succeeds, `Fun()` is evaluated and the result `Res` is returned. Returns `aborted` if the lock attempt failed. If `Retries` is set to `infinity`, the transaction will not abort.

`infinity` is the default setting and will be used if no value is given for `Retries`.

`unregister_name(Name) -> void()`

Types:

- `Name = term()`

Removes the globally registered name `Name` from the network of Erlang nodes.

`whereis_name(Name) -> pid() | undefined`

Types:

- `Name = term()`

Returns the pid with the globally registered name `Name`. Returns `undefined` if the name is not globally registered.

## See Also

`global_group(3)` [page 228], `net_kernel(3)` [page 254].

# global\_group

Erlang Module

The global group function makes it possible to group the nodes in a system into partitions, each partition having its own global name space, refer to `global(3)`. These partitions are called global groups.

The main advantage of dividing systems to global groups is that the background load decreases while the number of nodes to be updated is reduced when manipulating globally registered names.

The Kernel configuration parameter `global_groups` defines the global groups (see also `kernel(6)` [page 32], `config(4)` [page 297]):

```
{global_groups, [GroupTuple]}
```

Types:

- `GroupTuple` = `{GroupName, [Node]}` | `{GroupName, PublishType, [Node]}`
- `GroupName` = `atom()` (naming a global group)
- `PublishType` = `normal` | `hidden`
- `Node` = `atom()` (naming a node)

A `GroupTuple` without `PublishType` is the same as a `GroupTuple` with `PublishType == normal`.

A node started with the command line flag `-hidden`, see `[erl(1)]`, is said to be a *hidden* node. A hidden node will establish hidden connections to nodes not part of the same global group, but normal (visible) connections to nodes part of the same global group.

A global group defined with `PublishType == hidden`, is said to be a hidden global group. All nodes in a hidden global group are hidden nodes, regardless if they are started with the `-hidden` command line flag or not.

For the processes and nodes to run smoothly using the global group functionality, the following criteria must be met:

- An instance of the global group server, `global_group`, must be running on each node. The processes are automatically started and synchronized when a node is started.
- All involved nodes must agree on the global group definition, or the behavior of the system is undefined.
- *All* nodes in the system should belong to exactly one global group.

In the following description, a *group node* is a node belonging to the same global group as the local node.



## Exports

`global_groups()` -> {GroupName, GroupNames} | undefined

Types:

- GroupName = atom()
- GroupNames = [GroupName]

Returns a tuple containing the name of the global group the local node belongs to, and the list of all other known group names. Returns `undefined` if no global groups are defined.

`info()` -> [{Item, Info}]

Types:

- Item, Info – see below

Returns a list containing information about the global groups. Each element of the list is a tuple. The order of the tuples is not defined.

{state, State} If the local node is part of a global group, State == `synced`. If no global groups are defined, State == `no_conf`.

{own\_group\_name, GroupName} The name (atom) of the group that the local node belongs to.

{own\_group\_nodes, Nodes} A list of node names (atoms), the group nodes.

{synced\_nodes, Nodes} A list of node names, the group nodes currently synchronized with the local node.

{sync\_error, Nodes} A list of node names, the group nodes with which the local node has failed to synchronize.

{no\_contact, Nodes} A list of node names, the group nodes to which there are currently no connections.

{other\_groups, Groups} Groups is a list of tuples {GroupName, Nodes}, specifying the name and nodes of the other global groups.

{monitoring, Pids} A list of pids, specifying the processes which have subscribed to `nodeup` and `nodedown` messages.

`monitor_nodes(Flag)` -> ok

Types:

- Flag = bool()

Depending on Flag, the calling process starts subscribing (Flag == `true`) or stops subscribing (Flag == `false`) to node status change messages.

A process which has subscribed will receive the messages {`nodeup`, Node} and {`nodedown`, Node} when a group node connects or disconnects, respectively.

`own_nodes()` -> Nodes

Types:

- Nodes = [Node]
- Node = node()

Returns the names of all group nodes, regardless of their current status.

`registered_names(Where) -> Names`

Types:

- Where = {node, Node} | {group, GroupName}
- Node = node()
- GroupName = atom()
- Names = [Name]
- Name = atom()

Returns a list of all names which are globally registered on the specified node or in the specified global group.

`send(Name, Msg) -> pid() | {badarg, {Name, Msg}}`

`send(Where, Name, Msg) -> pid() | {badarg, {Name, Msg}}`

Types:

- Where = {node, Node} | {group, GroupName}
- Node = node()
- GroupName = atom()
- Name = atom()
- Msg = term()

Searches for Name, globally registered on the specified node or in the specified global group, or – if the Where argument is not provided – in any global group. The global groups are searched in the order in which they appear in the value of the `global_groups` configuration parameter.

If Name is found, the message Msg is sent to the corresponding pid. The pid is also the return value of the function. If the name is not found, the function returns {badarg, {Name, Msg}}.

`sync() -> ok`

Synchronizes the group nodes, that is, the global name servers on the group nodes. Also check the names globally registered in the current global group and unregisters them on any known node not part of the group.

If synchronization is not possible, an error report is sent to the error logger (see also `error_logger(3)`).

Failure: {error, {'invalid global\_groups definition', Bad}} if the `global_groups` configuration parameter has an invalid value Bad.

`whereis_name(Name) -> pid() | undefined`

`whereis_name(Where, Name) -> pid() | undefined`

Types:

- Where = {node, Node} | {group, GroupName}
- Node = node()
- GroupName = atom()
- Name = atom()

Searches for `Name`, globally registered on the specified node or in the specified global group, or – if the `Where` argument is not provided – in any global group. The global groups are searched in the order in which they appear in the value of the `global_groups` configuration parameter.

If `Name` is found, the corresponding `pid` is returned. If the name is not found, the function returns `undefined`.

## NOTE

In the situation where a node has lost its connections to other nodes in its global group, but has connections to nodes in other global groups, a request from another global group may produce an incorrect or misleading result. For example, the isolated node may not have accurate information about registered names in its global group.

Note also that the `send/2,3` function is not secure.

Distribution of applications is highly dependent of the global group definitions. It is not recommended that an application is distributed over several global groups of the obvious reason that the registered names may be moved to another global group at failover/takeover. There is nothing preventing doing this, but the application code must in such case handle the situation.

## SEE ALSO

[`erl(1)`], [`global(3)`] [page 223]

# heart

## Erlang Module

This module contains the interface to the heart process. heart sends periodic heartbeats to an external port program, which is also named heart. The purpose of the heart port program is to check that the Erlang runtime system it is supervising is still running. If the port program has not received any heartbeats within HEART\_BEAT\_TIMEOUT seconds (default is 60 seconds), the system can be rebooted. Also, if the system is equipped with a hardware watchdog timer and is running Solaris, the watchdog can be used to supervise the entire system.

An Erlang runtime system to be monitored by a heart program, should be started with the command line flag `-heart` (see also [erl(1)]). The heart process is then started automatically:

```
% erl -heart ...
```

If the system should be rebooted because of missing heart-beats, or a terminated Erlang runtime system, the environment variable HEART\_COMMAND has to be set before the system is started. If this variable is not set, a warning text will be printed but the system will not reboot. However, if the hardware watchdog is used, it will trigger a reboot HEART\_BEAT\_BOOT\_DELAY seconds later nevertheless (default is 60).

To reboot on the WINDOWS platform HEART\_COMMAND can be set to `heart -shutdown` (included in the Erlang delivery) or of course to any other suitable program which can activate a reboot.

The hardware watchdog will not be started under Solaris if the environment variable HW\_WD\_DISABLE is set.

The HEART\_BEAT\_TIMEOUT and HEART\_BEAT\_BOOT\_DELAY environment variables can be used to configure the heart timeouts, they can be set in the operating system shell before Erlang is started or be specified at the command line:

```
% erl -heart -env HEART_BEAT_TIMEOUT 30 ...
```

The value (in seconds) must be in the range  $10 < X \leq 65535$ .

It should be noted that if the system clock is adjusted with more than HEART\_BEAT\_TIMEOUT seconds, heart will timeout and try to reboot the system. This can happen, for example, if the system clock is adjusted automatically by use of NTP (Network Time Protocol).

In the following descriptions, all function fails with reason badarg if heart is not started.

## Exports

`set_cmd(Cmd) -> ok | {error, {bad_cmd, Cmd}}`

Types:

- `Cmd = string()`

Sets a temporary reboot command. This command is used if a `HEART_COMMAND` other than the one specified with the environment variable should be used in order to reboot the system. The new Erlang runtime system will (if it misbehaves) use the environment variable `HEART_COMMAND` to reboot.

Limitations: The length of the `Cmd` command string must be less than 2047 characters.

`clear_cmd() -> ok`

Clears the temporary boot command. If the system terminates, the normal `HEART_COMMAND` is used to reboot.

`get_cmd() -> {ok, Cmd}`

Types:

- `Cmd = string()`

Get the temporary reboot command. If the command is cleared, the empty string will be returned.

# inet

Erlang Module

Provides access to TCP/IP protocols.

See also *ERTS User's Guide*, *Inet configuration* for more information on how to configure an Erlang runtime system for IP communication.

Two Kernel configuration parameters affect the behaviour of all sockets opened on an Erlang node: `inet_default_connect_options` can contain a list of default options used for all sockets returned when doing `connect`, and `inet_default_listen_options` can contain a list of default options used when issuing a `listen` call. When `accept` is issued, the values of the `listensocket` options are inherited, why no such application variable is needed for `accept`.

Using the Kernel configuration parameters mentioned above, one can set default options for all TCP sockets on a node. This should be used with care, but options like `{delay_send,true}` might be specified in this way. An example of starting an Erlang node with all sockets using delayed send could look like this:

```
$ erl -sname test -kernel \
inet_default_connect_options ' [{delay_send,true}] ' \
inet_default_listen_options ' [{delay_send,true}] '
```

Note that the default option `{active, true}` currently cannot be changed, for internal reasons.

## DATA TYPES

```
#hostent{h_addr_list = [ip_address()] % list of addresses for this host
        h_addrtype = inet | inet6
        h_aliases = [hostname()] % list of aliases
        h_length = int() % length of address in bytes
        h_name = hostname() % official name for host
```

The record is defined in the Kernel include file "inet.hrl"

Add the following directive to the module:

```
-include_lib("kernel/include/inet.hrl").
```

```
hostname() = atom() | string()
```

```
ip_address() = {N1,N2,N3,N4} % IPv4
              | {K1,K2,K3,K4,K5,K6,K7,K8} % IPv6
```

Ni = 0..255

Ki = 0..65535

```
posix()
```

an atom which is named from the Posix error codes used in

Unix, and in the runtime libraries of most C compilers

`socket()`  
see `gen_tcp(3)`, `gen_udp(3)`

Addresses as inputs to functions can be either a string or a tuple. For instance, the IP address 150.236.20.73 can be passed to `gethostbyaddr/1` either as the string "150.236.20.73" or as the tuple {150, 236, 20, 73}.

IPv4 address examples:

| Address      | <code>ip_address()</code> |
|--------------|---------------------------|
| -----        | -----                     |
| 127.0.0.1    | {127,0,0,1}               |
| 192.168.42.2 | {192,168,42,2}            |

IPv6 address examples:

| Address                            | <code>ip_address()</code>                                    |
|------------------------------------|--------------------------------------------------------------|
| -----                              | -----                                                        |
| :::1                               | {0,0,0,0,0,0,0,1}                                            |
| ::192.168.42.2                     | {0,0,0,0,0,0,(192 bsl 8) bor 168,(42 bsl 8) bor 2}           |
| FFFF::192.168.42.2                 | {16#FFFF,0,0,0,0,0,(192 bsl 8) bor 168,(42 bsl 8) bor 2}     |
| 3ffe:b80:1f8d:2:204:acff:fe17:bf38 | {16#3ffe,16#b80,16#1f8d,16#2,16#204,16#acff,16#fe17,16#bf38} |
| fe80::204:acff:fe17:bf38           | {16#fe80,0,0,0,0,16#204,16#acff,16#fe17,16#bf38}             |

A function that may be useful is `inet_parse:address/1`:

```
1> inet_parse:address("192.168.42.2").
{ok, {192,168,42,2}}
2> inet_parse:address("FFFF::192.168.42.2").
{ok, {65535,0,0,0,0,0,49320,10754}}
```

## Exports

`close(Socket) -> ok`

Types:

- Socket = `socket()`

Closes a socket of any type.

`get_rc() -> [{Par, Val}]`

Types:

- Par, Val – see below

Returns the state of the Inet configuration database in form of a list of recorded configuration parameters. (See the ERTS User's Guide, Inet configuration, for more information). Only parameters with other than default values are returned.

`format_error(Posix) -> string()`

Types:

- Posix = posix()

Returns a diagnostic error string. See the section below for possible Posix values and the corresponding strings.

```
getaddr(Host, Family) -> {ok, Address} | {error, posix() }
```

Types:

- Host = ip\_address() | string() | atom()
- Family = inet | inet6
- Address = ip\_address()
- posix() = term()

Returns the IP-address for Host as a tuple of integers. Host can be an IP-address, a single hostname or a fully qualified hostname.

```
getaddrs(Host, Family) -> {ok, Addresses} | {error, posix() }
```

Types:

- Host = ip\_address() | string() | atom()
- Addresses = [ip\_address()]
- Family = inet | inet6

Returns a list of all IP-addresses for Host. Host can be an IP-address, a single hostname or a fully qualified hostname.

```
gethostbyaddr(Address) -> {ok, Hostent} | {error, posix() }
```

Types:

- Address = string() | ip\_address()
- Hostent = #hostent{}

Returns a hostent record given an address.

```
gethostbyname(Name) -> {ok, Hostent} | {error, posix() }
```

Types:

- Hostname = hostname()
- Hostent = #hostent{}

Returns a hostent record given a hostname.

```
gethostbyname(Name, Family) -> {ok, Hostent} | {error, posix() }
```

Types:

- Hostname = hostname()
- Family = inet | inet6
- Hostent = #hostent{}

Returns a hostent record given a hostname, restricted to the given address family.

```
gethostname() -> {ok, Hostname}
```

Types:



- `Hostname = string()`

Returns the local hostname. Will never fail.

`getopts(Socket, Options) -> OptionValues | {error, posix()}`

Types:

- `Socket = term()`
- `Options = [Opt | RawOptReq]`
- `Opt = atom()`
- `RawOptReq = {raw, Protocol, OptionNum, ValueSpec}`
- `Protocol = int()`
- `OptionNum = int()`
- `ValueSpec = ValueSize | ValueBin`
- `ValueSize = int()`
- `ValueBin = binary()`
- `OptionValues = [{Opt, Val} | {raw, Protocol, OptionNum, ValueBin}]`

Gets one or more options for a socket. See `setopts/2` [page 238] for a list of available options.

The number of elements in the returned `OptionValues` list does not necessarily correspond to the number of options asked for. If the operating system fails to support an option, it is simply left out in the returned list. An error tuple is only returned when getting options for the socket is impossible (i.e. the socket is closed or the buffer size in a raw request is too large). This behavior is kept for backward compatibility reasons.

A `RawOptReq` can be used to get information about socket options not (explicitly) supported by the emulator. The use of raw socket options makes the code non portable, but allows the Erlang programmer to take advantage of unusual features present on the current platform.

The `RawOptReq` consists of the tag `raw` followed by the protocol level, the option number and either a binary or the size, in bytes, of the buffer in which the option value is to be stored. A binary should be used when the underlying `getsockopt` requires *input* in the argument field, in which case the size of the binary should correspond to the required buffer size of the return value. The supplied values in a `RawOptReq` correspond to the second, third and fourth/fifth parameters to the `getsockopt` call in the C socket API. The value stored in the buffer is returned as a binary `ValueBin` where all values are coded in the native endianness.

Asking for and inspecting raw socket options require low level information about the current operating system and TCP stack.

As an example, consider a Linux machine where the `TCP_INFO` option could be used to collect TCP statistics for a socket. Lets say we're interested in the `tcpi_sacked` field of the `struct tcp_info` filled in when asking for `TCP_INFO`. To be able to access this information, we need to know both the numeric value of the protocol level `IPPROTO_TCP`, the numeric value of the option `TCP_INFO`, the size of the `struct tcp_info` and the size and offset of the specific field. By inspecting the headers or writing a small C program, we found `IPPROTO_TCP` to be 6, `TCP_INFO` to be 11, the structure size to be 92 (bytes), the offset of `tcpi_sacked` to be 28 bytes and the actual value to be a 32 bit integer. We could use the following code to retrieve the value:

```

get_tcpi_sacked(Socket) ->
    {ok, [{raw,_,_,Info}]} = inet:getopts(Socket, [{raw,6,11,92}]),
    <<_:28/binary,TcpiSacked:32/native,_/binary>> = Info,
    TcpiSacked.

```

Preferably, you would check the machine type, the OS and the kernel version prior to executing anything similar to the code above.

```
peername(Socket) -> {ok, {Address, Port}} | {error, posix()}
```

Types:

- Socket = socket()
- Address = ip\_address()
- Port = int()

Returns the address and port for the other end of a connection.

```
port(Socket) -> {ok, Port}
```

Types:

- Socket = socket()
- Port = int()

Returns the local port number for a socket.

```
sockname(Socket) -> {ok, {Address, Port}} | {error, posix()}
```

Types:

- Socket = socket()
- Address = ip\_address()
- Port = int()

Returns the local address and port number for a socket.

```
setopts(Socket, Options) -> ok | {error, posix()}
```

Types:

- Socket = term()
- Options = [{Opt, Val} | {raw, Protocol, Option, ValueBin}]
- Protocol = int()
- OptionNum = int()
- ValueBin = binary()
- Opt, Val - see below

Sets one or more options for a socket. The following options are available:

`{active, true | false | once}` If the value is `true`, which is the default, everything received from the socket will be sent as messages to the receiving process. If the value is `false` (passive mode), the process must explicitly receive incoming data by calling `gen_tcp:recv/2,3` or `gen_udp:recv/2,3` (depending on the type of socket).

If the value is `once` (`{active, once}`), *one* data message from the socket will be sent to the process. To receive one more message, `setopts/2` must be called again with the `{active, once}` option.

When using `{active, once}`, the socket changes behaviour automatically when data is received. This can sometimes be confusing in combination with connection oriented sockets (i.e. `gen_tcp`) as a socket with `{active, false}` behaviour reports closing differently than a socket with `{active, true}` behaviour. To make programming easier, a socket where the peer closed and this was detected while in `{active, false}` mode, will still generate the message `{tcp_closed, Socket}` when set to `{active, once}` or `{active, true}` mode. It is therefore safe to assume that the message `{tcp_closed, Socket}`, possibly followed by socket port termination (depending on the `exit_on_close` option) will eventually appear when a socket changes back and forth between `{active, true}` and `{active, false}` mode. However, *when* peer closing is detected is all up to the underlying TCP/IP stack and protocol.

Note that `{active, true}` mode provides no flow control; a fast sender could easily overflow the receiver with incoming messages. Use active mode only if your high-level protocol provides its own flow control (for instance, acknowledging received messages) or the amount of data exchanged is small. `{active, false}` mode or use of the `{active, once}` mode provides flow control; the other side will not be able send faster than the receiver can read.

`{broadcast, Boolean}` **(UDP sockets)** Enable/disable permission to send broadcasts.

`{delay_send, Boolean}` Normally, when an Erlang process sends to a socket, the driver will try to immediately send the data. If that fails, the driver will use any means available to queue up the message to be sent whenever the operating system says it can handle it. Setting `{delay_send, true}` will make *all* messages queue up. This makes the messages actually sent onto the network be larger but fewer. The option actually affects the scheduling of send requests versus Erlang processes instead of changing any real property of the socket. Needless to say it is an implementation specific option. Default is `false`.

`{dontroute, Boolean}` Enable/disable routing bypass for outgoing messages.

`{exit_on_close, Boolean}` By default this option is set to `true`.

The only reason to set it to `false` is if you want to continue sending data to the socket after a close has been detected, for instance if the peer has used `gen_tcp:shutdown/2` [page 217] to shutdown the write side.

`{header, Size}` This option is only meaningful if the binary option was specified when the socket was created. If the header option is specified, the first `Size` number bytes of data received from the socket will be elements of a list, and the rest of the data will be a binary given as the tail of the same list. If for example `Size == 2`, the data received will match `[Byte1,Byte2|Binary]`.

`{keepalive, Boolean}` **(TCP/IP sockets)** Enables/disables periodic transmission on a connected socket, when no other data is being exchanged. If the other end does not respond, the connection is considered broken and an error message will be sent to the controlling process. Default disabled.

- `{nodelay, Boolean}` **(TCP/IP sockets)** If `Boolean == true`, the `TCP_NODELAY` option is turned on for the socket, which means that even small amounts of data will be sent immediately.
- `{packet, PacketType}` **(TCP/IP sockets)** Defines the type of packets to use for a socket. The following values are valid:
- `raw` | `0` No packaging is done.
  - `1` | `2` | `4` Packets consist of a header specifying the number of bytes in the packet, followed by that number of bytes. The length of header can be one, two, or four bytes; the order of the bytes is big-endian. Each send operation will generate the header, and the header will be stripped off on each receive operation.
  - `asn1` | `cdr` | `sunrm` | `fcgi` | `tpkt` | `line` These packet types only have effect on receiving. When sending a packet, it is the responsibility of the application to supply a correct header. On receiving, however, there will be one message sent to the controlling process for each complete packet received, and, similarly, each call to `gen_tcp:recv/2,3` returns one complete packet. The header is *not* stripped off. The meanings of the packet types are as follows:
    - `asn1` - ASN.1 BER,
    - `sunrm` - Sun's RPC encoding,
    - `cdr` - CORBA (GIOP 1.1),
    - `fcgi` - Fast CGI,
    - `tpkt` - TPKT format [RFC1006],
    - `line` - Line mode, a packet is a line terminated with newline, lines longer than the receive buffer are truncated.
  - `http` The Hypertext Transfer Protocol. The packets are returned with the format according to `HttpPacket` described in `erlang:decode_packet/3` [page 96]. A socket in passive mode will return `{ok, HttpPacket}` from `gen_tcp:recv` while an active socket will send messages like `{http, Socket, HttpPacket}`. Note that the packet type `httph` is not needed when reading from a socket.
- `{packet_size, Integer}` **(TCP/IP sockets)** Sets the max allowed length of the packet body. If the packet header indicates that the length of the packet is longer than the max allowed length, the packet is considered invalid. The same happens if the packet header is too big for the socket receive buffer.
- `{read_packets, Integer}` **(UDP sockets)** Sets the max number of UDP packets to read without intervention from the socket when data is available. When this many packets have been read and delivered to the destination process, new packets are not read until a new notification of available data has arrived. The default is 5, and if this parameter is set too high the system can become unresponsive due to UDP packet flooding.
- `{recbuf, Integer}` Gives the size of the receive buffer to use for the socket.
- `{reuseaddr, Boolean}` Allows or disallows local reuse of port numbers. By default, reuse is disallowed.
- `{send_timeout, Integer}` Only allowed for connection oriented sockets. Specifies a longest time to wait for a send operation to be accepted by the underlying TCP stack. When the limit is exceeded, the send operation will return `{error, timeout}`. How much of a packet that actually got sent is unknown, why the socket should be closed whenever a timeout has occurred. Default is *infinity*.
- `{sndbuf, Integer}` Gives the size of the send buffer to use for the socket.

`{priority, Integer}` Sets the `SO_PRIORITY` socket level option on platforms where this is implemented. The behaviour and allowed range varies on different systems. The option is ignored on platforms where the option is not implemented. Use with caution.

`{tos, Integer}` Sets `IP_TOS` IP level options on platforms where this is implemented. The behaviour and allowed range varies on different systems. The option is ignored on platforms where the option is not implemented. Use with caution.

In addition to the options mentioned above, *raw* option specifications can be used. The raw options are specified as a tuple of arity four, beginning with the tag *raw*, followed by the protocol level, the option number and the actual option value specified as a binary. This corresponds to the second, third and fourth argument to the `setsockopt` call in the C socket API. The option value needs to be coded in the native endianness of the platform and, if a structure is required, needs to follow the struct alignment conventions on the specific platform.

Using raw socket options require detailed knowledge about the current operating system and TCP stack.

As an example of the usage of raw options, consider a Linux system where you want to set the `TCP_LINGER2` option on the `IPPROTO_TCP` protocol level in the stack. You know that on this particular system it defaults to 60 (seconds), but you would like to lower it to 30 for a particular socket. The `TCP_LINGER2` option is not explicitly supported by `inet`, but you know that the protocol level translates to the number 6, the option number to the number 8 and the value is to be given as a 32 bit integer. You can use this line of code to set the option for the socket named `Sock`:

```
inet:setopts(Sock, [{raw,6,8,<<30:32/native>>}]),
```

As many options are silently discarded by the stack if they are given out of range, it could be a good idea to check that a raw option really got accepted. This code places the value in the variable `TcpLinger2`:

```
{ok, [{raw,6,8,<<TcpLinger2:32/native>>}]=inet:getopts(Sock, [{raw,6,8,4}]),
```

Code such as the examples above is inherently non portable, even different versions of the same OS on the same platform may respond differently to this kind of option manipulation. Use with care.

Note that the default options for TCP/IP sockets can be changed with the Kernel configuration parameters mentioned in the beginning of this document.

## POSIX Error Codes

- `e2big` - argument list too long
- `eaccess` - permission denied
- `eaddrinuse` - address already in use
- `eaddrnotavail` - cannot assign requested address
- `eadv` - advertise error
- `eafnosupport` - address family not supported by protocol family
- `eagain` - resource temporarily unavailable
- `ealign` - `EALIGN`
- `ealready` - operation already in progress

- ebade - bad exchange descriptor
- ebadf - bad file number
- ebadfd - file descriptor in bad state
- ebadmsg - not a data message
- ebadr - bad request descriptor
- ebadrpc - RPC structure is bad
- ebadrqc - bad request code
- ebadslt - invalid slot
- ebfont - bad font file format
- ebusy - file busy
- echild - no children
- echrng - channel number out of range
- ecomm - communication error on send
- econnaborted - software caused connection abort
- econnrefused - connection refused
- econnreset - connection reset by peer
- edeadlk - resource deadlock avoided
- edeadlock - resource deadlock avoided
- edestaddrreq - destination address required
- edirty - mounting a dirty fs w/o force
- edom - math argument out of range
- edotdot - cross mount point
- edquot - disk quota exceeded
- eduppkg - duplicate package name
- eexist - file already exists
- efault - bad address in system call argument
- efbig - file too large
- ehostdown - host is down
- ehostunreach - host is unreachable
- eidrm - identifier removed
- einit - initialization error
- einprogress - operation now in progress
- eintr - interrupted system call
- inval - invalid argument
- eio - I/O error
- eisconn - socket is already connected
- eisdir - illegal operation on a directory
- eisnam - is a named file
- el2hlt - level 2 halted
- el2nsync - level 2 not synchronized
- el3hlt - level 3 halted

- e13rst - level 3 reset
- elbin - ELBIN
- elibacc - cannot access a needed shared library
- elibbad - accessing a corrupted shared library
- elibexec - cannot exec a shared library directly
- elibmax - attempting to link in more shared libraries than system limit
- elibscn - .lib section in a.out corrupted
- elnrng - link number out of range
- eloop - too many levels of symbolic links
- emfile - too many open files
- emlink - too many links
- emsgsize - message too long
- emultihop - multihop attempted
- enametoolong - file name too long
- enavail - not available
- enet - ENET
- enetdown - network is down
- enetreset - network dropped connection on reset
- enetunreach - network is unreachable
- enfile - file table overflow
- enoano - anode table overflow
- enobufs - no buffer space available
- enocsi - no CSI structure available
- enodata - no data available
- enodev - no such device
- enoent - no such file or directory
- enoexec - exec format error
- enolck - no locks available
- enolink - link has be severed
- enomem - not enough memory
- enomsg - no message of desired type
- enonet - machine is not on the network
- enopkg - package not installed
- enoprotoopt - bad proocol option
- enospc - no space left on device
- enosr - out of stream resources or not a stream device
- enosym - unresolved symbol name
- enosys - function not implemented
- enotblk - block device required
- enotconn - socket is not connected
- enotdir - not a directory

- `enotempty` - directory not empty
- `enotnam` - not a named file
- `enotsock` - socket operation on non-socket
- `enotsup` - operation not supported
- `enotty` - inappropriate device for `ioctl`
- `enotuniq` - name not unique on network
- `enxio` - no such device or address
- `eopnotsupp` - operation not supported on socket
- `eperm` - not owner
- `epfnosupport` - protocol family not supported
- `epipe` - broken pipe
- `eproclim` - too many processes
- `eprocunavail` - bad procedure for program
- `eprogmismatch` - program version wrong
- `eprogunavail` - RPC program not available
- `eproto` - protocol error
- `eprotonosupport` - protocol not supported
- `eprototype` - protocol wrong type for socket
- `erange` - math result unrepresentable
- `erefused` - EREFUSED
- `eremchg` - remote address changed
- `eremdev` - remote device
- `eremote` - pathname hit remote file system
- `eremoteio` - remote i/o error
- `eremoterelease` - EREMOTERELEASE
- `erofs` - read-only file system
- `erpcmismatch` - RPC version is wrong
- `erremote` - object is remote
- `eshutdown` - cannot send after socket shutdown
- `esocktnosupport` - socket type not supported
- `espipe` - invalid seek
- `esrch` - no such process
- `esrmnt` - srmount error
- `estale` - stale remote file handle
- `esuccess` - Error 0
- `etime` - timer expired
- `etimedout` - connection timed out
- `etoomanyrefs` - too many references
- `etxtbsy` - text file or pseudo-device busy
- `euclean` - structure needs cleaning
- `eunatch` - protocol driver not attached



- `eusers` - too many users
- `eversion` - version mismatch
- `ewouldblock` - operation would block
- `exdev` - cross-domain link
- `exfull` - message tables full
- `nxdomain` - the hostname or domain name could not be found

# init

Erlang Module

The `init` module is pre-loaded and contains the code for the `init` system process which coordinates the start-up of the system. The first function evaluated at start-up is `boot(BootArgs)`, where `BootArgs` is a list of command line arguments supplied to the Erlang runtime system from the local operating system. See [erl(1)].

`init` reads the boot script which contains instructions on how to initiate the system. See [script(4)] for more information about boot scripts.

`init` also contains functions to restart, reboot, and stop the system.

## Exports

`boot(BootArgs) -> void()`

Types:

- `BootArgs = [binary()]`

Starts the Erlang runtime system. This function is called when the emulator is started and coordinates system start-up.

`BootArgs` are all command line arguments except the emulator flags, that is, flags and plain arguments. See [erl(1)].

`init` itself interprets some of the flags, see Command Line Flags [page 249] below. The remaining flags (“user flags”) and plain arguments are passed to the `init` loop and can be retrieved by calling `get_arguments/0` and `get_plain_arguments/0`, respectively.

`get_args() -> [Arg]`

Types:

- `Arg = atom()`

Returns any plain command line arguments as a list of atoms (possibly empty). It is recommended that `get_plain_arguments/1` is used instead, because of the limited length of atoms.

`get_argument(Flag) -> {ok, Arg} | error`

Types:

- `Flag = atom()`
- `Arg = [Values]`
- `Values = [string()]`

Returns all values associated with the command line user flag `Flag`. If `Flag` is provided several times, each `Values` is returned in preserved order.

```
% erl -a b c -a d
...
1> init:get_argument(a).
{ok, [[ "b", "c"], ["d"]]}
```

There are also a number of flags, which are defined automatically and can be retrieved using this function:

`root` The installation directory of Erlang/OTP, `$ROOT`.

```
2> init:get_argument(root).
{ok, ["/usr/local/otp/releases/otp_beam_solaris8_r10b_patched"]}
```

`progname` The name of the program which started Erlang.

```
3> init:get_argument(progname).
{ok, [ "erl" ]}
```

`home` The home directory.

```
4> init:get_argument(home).
{ok, ["/home/harry"]}
```

Returns error if there is no value associated with `Flag`.

`get_arguments()` -> `Flags`

Types:

- `Flags` = [{`Flag`, `Values`}]
- `Flag` = `atom()`
- `Values` = [`string()`]

Returns all command line flags, as well as the system defined flags, see `get_argument/1`.

`get_plain_arguments()` -> [`Arg`]

Types:

- `Arg` = `string()`

Returns any plain command line arguments as a list of strings (possibly empty).

`get_status()` -> {`InternalStatus`, `ProvidedStatus`}

Types:

- `InternalStatus` = `starting` | `started` | `stopping`
- `ProvidedStatus` = `term()`

The current status of the `init` process can be inspected. During system startup (initialization), `InternalStatus` is `starting`, and `ProvidedStatus` indicates how far the boot script has been interpreted. Each {`progress`, `Info`} term interpreted in the boot script affects `ProvidedStatus`, that is, `ProvidedStatus` gets the value of `Info`.

`reboot()` -> `void()`

All applications are taken down smoothly, all code is unloaded, and all ports are closed before the system terminates. If the `-heart` command line flag was given, the `heart` program will try to reboot the system. Refer to `heart(3)` for more information.

To limit the shutdown time, the time `init` is allowed to spend taking down applications, the `-shutdown_time` command line flag should be used.

`restart()` -> `void()`

The system is restarted *inside* the running Erlang node, which means that the emulator is not restarted. All applications are taken down smoothly, all code is unloaded, and all ports are closed before the system is booted again in the same way as initially started. The same `BootArgs` are used again.

To limit the shutdown time, the time `init` is allowed to spend taking down applications, the `-shutdown_time` command line flag should be used.

`script_id()` -> `Id`

Types:

- `Id = term()`

Get the identity of the boot script used to boot the system. `Id` can be any Erlang term. In the delivered boot scripts, `Id` is `{Name, Vsn}`. `Name` and `Vsn` are strings.

`stop()` -> `void()`

All applications are taken down smoothly, all code is unloaded, and all ports are closed before the system terminates. If the `-heart` command line flag was given, the `heart` program is terminated before the Erlang node terminates. Refer to `heart(3)` for more information.

To limit the shutdown time, the time `init` is allowed to spend taking down applications, the `-shutdown_time` command line flag should be used.

`stop(Status)` -> `void()`

Types:

- `Status = int()>=0 | string()`

All applications are taken down smoothly, all code is unloaded, and all ports are closed before the system terminates by calling `halt(Status)`. If the `-heart` command line flag was given, the `heart` program is terminated before the Erlang node terminates. Refer to `heart(3)` for more information.

To limit the shutdown time, the time `init` is allowed to spend taking down applications, the `-shutdown_time` command line flag should be used.

## Command Line Flags

The `init` module interprets the following command line flags:

- Everything following -- up to the next flag is considered plain arguments and can be retrieved using `get_plain_arguments/0`.
- eval Expr Scans, parses and evaluates an arbitrary expression Expr during system initialization. If any of these steps fail (syntax error, parse error or exception during evaluation), Erlang stops with an error message. Here is an example that seeds the random number generator:

```
% erl -eval '{X,Y,Z}' = now(), random:seed(X,Y,Z).
```

This example uses Erlang as a hexadecimal calculator:

```
% erl -noshell -eval 'R = 16#1F+16#A0, io:format("~.16B~n", [R])' \  
-s erlang halt  
BF
```

If multiple `-eval` expressions are specified, they are evaluated sequentially in the order specified. `-eval` expressions are evaluated sequentially with `-s` and `-run` function calls (this also in the order specified). As with `-s` and `-run`, an evaluation that does not terminate, blocks the system initialization process.

- extra Everything following `-extra` is considered plain arguments and can be retrieved using `get_plain_arguments/0`.
- run Mod [Func [Arg1, Arg2, ...]] Evaluates the specified function call during system initialization. Func defaults to `start`. If no arguments are provided, the function is assumed to be of arity 0. Otherwise it is assumed to be of arity 1, taking the list [Arg1, Arg2, ...] as argument. All arguments are passed as strings. If an exception is raised, Erlang stops with an error message.  
Example:

```
% erl -run foo -run foo bar -run foo bar baz 1 2
```

This starts the Erlang runtime system and evaluates the following functions:

```
foo:start()  
foo:bar()  
foo:bar(["baz", "1", "2"]).
```

The functions are executed sequentially in an initialization process, which then terminates normally and passes control to the user. This means that a `-run` call which does not return will block further processing; to avoid this, use some variant of `spawn` in such cases.

- s Mod [Func [Arg1, Arg2, ...]] Evaluates the specified function call during system initialization. Func defaults to `start`. If no arguments are provided, the function is assumed to be of arity 0. Otherwise it is assumed to be of arity 1, taking the list [Arg1, Arg2, ...] as argument. All arguments are passed as atoms. If an exception is raised, Erlang stops with an error message.  
Example:

```
% erl -s foo -s foo bar -s foo bar baz 1 2
```

This starts the Erlang runtime system and evaluates the following functions:

```
foo:start()  
foo:bar()  
foo:bar([baz, '1', '2']).
```

The functions are executed sequentially in an initialization process, which then terminates normally and passes control to the user. This means that a `-s` call which does not return will block further processing; to avoid this, use some variant of `spawn` in such cases.

Due to the limited length of atoms, it is recommended that `-run` be used instead.

## Example

```
% erl -- a b -children thomas claire -ages 7 3 -- x y  
...
```

```
1> init:get_plain_arguments().  
["a","b","x","y"]  
2> init:get_argument(children).  
{ok, [["thomas","claire"]]}  
3> init:get_argument(ages).  
{ok, [["7","3"]]}  
4> init:get_argument(silly).  
error
```

## SEE ALSO

[erl\\_prim\\_loader\(3\)](#) [page 87], [heart\(3\)](#) [page 232]

# net\_adm

Erlang Module

This module contains various network utility functions.

## Exports

`dns_hostname(Host) -> {ok, Name} | {error, Host}`

Types:

- Host = atom() | string()
- Name = string()

Returns the official name of Host, or {error, Host} if no such name is found. See also `inet(3)`.

`host_file() -> Hosts | {error, Reason}`

Types:

- Hosts = [Host]
- Host = atom()
- Reason = term()

Reads the `.hosts.erlang` file, see the section *Files* below. Returns the hosts in this file as a list, or returns {error, Reason} if the file could not be read. See `file(3)` for possible values of Reason.

`localhost() -> Name`

Types:

- Name = string()

Returns the name of the local host. If Erlang was started with the `-name` command line flag, Name is the fully qualified name.

`names() -> {ok, [{Name, Port}]} | {error, Reason}`

`names(Host) -> {ok, [{Name, Port}]} | {error, Reason}`

Types:

- Name = string()
- Port = int()
- Reason = address | term()

Similar to `epmd -names`, see `epmd(1)`. Host defaults to the local host. Returns the names and associated port numbers of the Erlang nodes that `epmd` at the specified host has registered.

Returns `{error, address}` if `epmd` is not running. See `inet(3)` for other possible values of `Reason`.

```
(arne@dunn)1> net_adm:names().
{ok, [{"arne",40262}]}
```

`ping(Node) -> pong | pang`

Types:

- Node = `node()`

Tries to set up a connection to `Node`. Returns `pang` if it fails, or `pong` if it is successful.

`world() -> [node()]`

`world(Arg) -> [node()]`

Types:

- Arg = `silent` | `verbose`

This function calls `names(Host)` for all hosts which are specified in the Erlang host file `.hosts.erlang`, collects the replies and then evaluates `ping(Node)` on all those nodes. Returns the list of all found nodes, regardless of the return value of `ping(Node)`.

Arg defaults to `silent`. If Arg == `verbose`, the function writes information about which nodes it is pinging to `stdout`.

This function can be useful when a node is started, and the names of the other nodes in the network are not initially known.

Failure: `{error, Reason}` if `host_file()` returns `{error, Reason}`.

`world_list(Hosts) -> [node()]`

`world_list(Hosts, Arg) -> [node()]`

Types:

- Hosts = `[Host]`
- Host = `atom()`
- Arg = `silent` | `verbose`

As `world/0,1`, but the hosts are given as argument instead of being read from `.hosts.erlang`.



## Files

The `.hosts.erlang` file consists of a number of host names written as Erlang terms. It is looked for in the current work directory, the user's home directory, and `$OTP_ROOT` (the root directory of Erlang/OTP), in that order.

The format of the `.hosts.erlang` file must be one host name per line. The host names must be within quotes as shown in the following example:

```
'super.eua.ericsson.se'.  
'renat.eua.ericsson.se'.  
'grouse.eua.ericsson.se'.  
'gauffin1.eua.ericsson.se'.  
^ (new line)
```

# net\_kernel

Erlang Module

The net kernel is a system process, registered as `net_kernel`, which must be running for distributed Erlang to work. The purpose of this process is to implement parts of the BIFs `spawn/4` and `spawn_link/4`, and to provide monitoring of the network.

An Erlang node is started using the command line flag `-name` or `-sname`:

```
$ erl -sname foobar
```

It is also possible to call `net_kernel:start([foobar])` directly from the normal Erlang shell prompt:

```
1> net_kernel:start([foobar, shortnames]).  
{ok, <0.64.0>}  
(foobar@gringotts)2>
```

If the node is started with the command line flag `-sname`, the node name will be `foobar@Host`, where `Host` is the short name of the host (not the fully qualified domain name). If started with the `-name` flag, `Host` is the fully qualified domain name. See `erl(1)`.

Normally, connections are established automatically when another node is referenced. This functionality can be disabled by setting the Kernel configuration parameter `dist_auto_connect` to `false`, see `kernel(6)` [page 32]. In this case, connections must be established explicitly by calling `net_kernel:connect_node/1`.

Which nodes are allowed to communicate with each other is handled by the magic cookie system, see [Distributed Erlang] in the Erlang Reference Manual.

## Exports

`allow(Nodes) -> ok | error`

Types:

- `Nodes = [node()]`

Limits access to the specified set of nodes. Any access attempts made from (or to) nodes not in `Nodes` will be rejected.

Returns error if any element in `Nodes` is not an atom.

`connect_node(Node) -> true | false | ignored`

Types:

- `Node = node()`

Establishes a connection to Node. Returns true if successful, false if not, and ignored if the local node is not alive.

```
monitor_nodes(Flag) -> ok | Error
```

```
monitor_nodes(Flag, Options) -> ok | Error
```

Types:

- Flag = true | false
- Options = [Option]
- Option – see below
- Error = error | {error, term() }

The calling process subscribes or unsubscribes to node status change messages. A nodeup message is delivered to all subscribing process when a new node is connected, and a nodedown message is delivered when a node is disconnected.

If Flag is true, a new subscription is started. If Flag is false, all previous subscriptions – started with the same Options – are stopped. Two option lists are considered the same if they contain the same set of options.

As of kernel version 2.11.4, and erts version 5.5.4, the following is guaranteed:

- nodeup messages will be delivered before delivery of any message from the remote node passed through the newly established connection.
- nodedown messages will not be delivered until all messages from the remote node that have been passed through the connection have been delivered.

Note, that this is *not* guaranteed for kernel versions before 2.11.4.

As of kernel version 2.11.4 subscriptions can also be made before the net\_kernel server has been started, i.e., net\_kernel:monitor\_nodes/[1,2] does not return ignored.

The format of the node status change messages depends on Options. If Options is [], which is the default, the format is:

```
{nodeup, Node} | {nodedown, Node}
  Node = node()
```

If Options /= [], the format is:

```
{nodeup, Node, InfoList} | {nodedown, Node, InfoList}
  Node = node()
  InfoList = [{Tag, Val}]
```

InfoList is a list of tuples. Its contents depends on Options, see below.

Also, when OptionList == [] only visible nodes, that is, nodes that appear in the result of nodes/0 [page 122], are monitored.

Option can be any of the following:

{node\_type, NodeType} Currently valid values for NodeType are:

- visible Subscribe to node status change messages for visible nodes only. The tuple {node\_type, visible} is included in InfoList.
- hidden Subscribe to node status change messages for hidden nodes only. The tuple {node\_type, hidden} is included in InfoList.

all Subscribe to node status change messages for both visible and hidden nodes.

The tuple {node\_type, visible | hidden} is included in InfoList.

nodedown\_reason The tuple {nodedown\_reason, Reason} is included in InfoList in nodedown messages. Reason can be:

connection\_setup\_failed The connection setup failed (after nodeup messages had been sent).

no\_network No network available.

net\_kernel\_terminated The net\_kernel process terminated.

shutdown Unspecified connection shutdown.

connection\_closed The connection was closed.

disconnect The connection was disconnected (forced from the current node).

net\_tick\_timeout Net tick timeout.

send\_net\_tick\_failed Failed to send net tick over the connection.

get\_status\_failed Status information retrieval from the Port holding the connection failed.

get\_net\_ticktime() -> Res

Types:

- Res = NetTicktime | {ongoing\_change\_to, NetTicktime}
- NetTicktime = int()

Gets net\_ticktime (see kernel(6) [page 32]).

Currently defined return values (Res):

NetTicktime net\_ticktime is NetTicktime seconds.

{ongoing\_change\_to, NetTicktime} net\_kernel is currently changing net\_ticktime to NetTicktime seconds.

set\_net\_ticktime(NetTicktime) -> Res

set\_net\_ticktime(NetTicktime, TransitionPeriod) -> Res

Types:

- NetTicktime = int() > 0
- TransitionPeriod = int() >= 0
- Res = unchanged | change\_initiated | {ongoing\_change\_to, NewNetTicktime}
- NewNetTicktime = int() > 0

Sets net\_ticktime (see kernel(6) [page 32]) to NetTicktime seconds.

TransitionPeriod defaults to 60.

Some definitions:

**The minimum transition traffic interval (MTTI)** minimum(NetTicktime, PreviousNetTicktime)\*1000 div 4 milliseconds.

**The transition period** The time of the least number of consecutive MTIs to cover TransitionPeriod seconds following the call to set\_net\_ticktime/2 (i.e. ((TransitionPeriod\*1000 - 1) div MTTI + 1)\*MTTI milliseconds).

If `NetTicktime < PreviousNetTicktime`, the actual `net_ticktime` change will be done at the end of the transition period; otherwise, at the beginning. During the transition period, `net_kernel` will ensure that there will be outgoing traffic on all connections at least every `MTTI` millisecond.

**Note:**

The `net_ticktime` changes have to be initiated on all nodes in the network (with the same `NetTicktime`) before the end of any transition period on any node; otherwise, connections may erroneously be disconnected.

Returns one of the following:

`unchanged` `net_ticktime` already had the value of `NetTicktime` and was left unchanged.

`change_initiated` `net_kernel` has initiated the change of `net_ticktime` to `NetTicktime` seconds.

`{ongoing_change_to, NewNetTicktime}` The request was *ignored*; because, `net_kernel` was busy changing `net_ticktime` to `NewNetTicktime` seconds.

```
start([Name]) -> {ok, pid()} | {error, Reason}
```

```
start([Name, NameType]) -> {ok, pid()} | {error, Reason}
```

```
start([Name, NameType, Ticktime]) -> {ok, pid()} | {error, Reason}
```

Types:

- `Name` = `atom()`
- `NameType` = `shortnames` | `longnames`
- `Reason` = `{already_started, pid()} | term()`

Note that the argument is a list with exactly one, two or three arguments. `NameType` defaults to `longnames` and `Ticktime` to `15000`.

Turns a non-distributed node into a distributed node by starting `net_kernel` and other necessary processes.

```
stop() -> ok | {error, not_allowed | not_found}
```

Turns a distributed node into a non-distributed node. For other nodes in the network, this is the same as the node going down. Only possible when the net kernel was started using `start/1`, otherwise returns `{error, not_allowed}`. Returns `{error, not_found}` if the local node is not alive.

# OS

## Erlang Module

The functions in this module are operating system specific. Careless use of these functions will result in programs that will only run on a specific platform. On the other hand, with careful use these functions can be of help in enabling a program to run on most platforms.

## Exports

`cmd(Command) -> string()`

Types:

- `Command = string() | atom()`

Executes `Command` in a command shell of the target OS, captures the standard output of the command and returns this result as a string. This function is a replacement of the previous `unix:cmd/1`; on a Unix platform they are equivalent.

Examples:

```
LsOut = os:cmd("ls"), % on unix platform
```

```
DirOut = os:cmd("dir"), % on Win32 platform
```

Note that in some cases, standard output of a command when called from another program (for example, `os:cmd/1`) may differ, compared to the standard output of the command when called directly from an OS command shell.

`find_executable(Name) -> Filename | false`

`find_executable(Name, Path) -> Filename | false`

Types:

- `Name = string()`
- `Path = string()`
- `Filename = string()`

These two functions look up an executable program given its name and a search path, in the same way as the underlying operating system. `find_executable/1` uses the current execution path (that is, the environment variable `PATH` on Unix and Windows).

`Path`, if given, should conform to the syntax of execution paths on the operating system. The absolute filename of the executable program `Name` is returned, or `false` if the program was not found.

`getenv() -> [string()]`

Returns a list of all environment variables. Each environment variable is given as a single string on the format "VarName=Value", where VarName is the name of the variable and Value its value.

`getenv(VarName) -> Value | false`

Types:

- VarName = string()
- Value = string()

Returns the Value of the environment variable VarName, or false if the environment variable is undefined.

`getpid() -> Value`

Types:

- Value = string()

Returns the process identifier of the current Erlang emulator in the format most commonly used by the operating system environment. Value is returned as a string containing the (usually) numerical identifier for a process. On Unix, this is typically the return value of the `getpid()` system call. On VxWorks, Value contains the task id (decimal notation) of the Erlang task. On Windows, the process id as returned by the `GetCurrentProcessId()` system call is used.

`putenv(VarName, Value) -> true`

Types:

- VarName = string()
- Value = string()

Sets a new Value for the environment variable VarName.

`type() -> {Osfamily, Osname} | Osfamily`

Types:

- Osfamily = win32 | unix | vxworks
- Osname = atom()

Returns the Osfamily and, in some cases, Osname of the current operating system.

On Unix, Osname will have same value as `uname -s` returns, but in lower case. For example, on Solaris 1 and 2, it will be `sunos`.

In Windows, Osname will be either `nt` (on Windows NT), or `windows` (on Windows 95).

On VxWorks the OS family alone is returned, that is `vxworks`.

**Note:**

Think twice before using this function. Use the `filename` module if you want to inspect or build file names in a portable way. Avoid matching on the Osname atom.

`version() -> {Major, Minor, Release} | VersionString`

Types:

- Major = Minor = Release = integer()
- VersionString = string()

Returns the operating system version. On most systems, this function returns a tuple, but a string will be returned instead if the system has versions which cannot be expressed as three numbers.

**Note:**

Think twice before using this function. If you still need to use it, always call `os:type()` first.



# packages

## Erlang Module

### *Introduction*

Packages are simply namespaces for modules. All old Erlang modules automatically belong to the top level (“empty-string”) namespace, and do not need any changes.

The full name of a packaged module is written as e.g. “`fee.fie.foe.foo`”, i.e., as atoms separated by periods, where the package name is the part up to but not including the last period; in this case “`fee.fie.foe`”. A more concrete example is the module `erl.lang.term`, which is in the package `erl.lang`. Package names can have any number of segments, as in `erl.lang.list.sort`. The atoms in the name can be quoted, as in `foo.'Bar'.baz`, or even the whole name, as in `'foo.bar.baz'` but the concatenation of atoms and periods must not contain two consecutive period characters or end with a period, as in `'foo..bar'`, `foo.'.bar'`, or `foo.'bar.'`. The periods must not be followed by whitespace.

The code loader maps module names onto the file system directory structure. E.g., the module `erl.lang.term` corresponds to a file `.../erl/lang/term.beam` in the search path. Note that the name of the actual object file corresponds to the last part only of the full module name. (Thus, old existing modules such as `lists` simply map to `.../lists.beam`, exactly as before.)

A packaged module in a file “`foo/bar/fred.erl`” is declared as:

```
-module(foo.bar.fred).
```

This can be compiled and loaded from the Erlang shell using `c(fred)`, if your current directory is the same as that of the file. The object file will be named `fred.beam`.

The Erlang search path works exactly as before, except that the package segments will be appended to each directory in the path in order to find the file. E.g., assume the path is `["/usr/lib/erl", "/usr/local/lib/otp/legacy/ebin", "/home/barney/erl"]`. Then, the code for a module named `foo.bar.fred` will be searched for first as `"/usr/lib/erl/foo/bar/fred.beam"`, then `"/usr/local/lib/otp/legacy/ebin/foo/bar/fred.beam"` and lastly `"/home/barney/erl/foo/bar/fred.beam"`. A module like `lists`, which is in the top-level package, will be looked for as `"/usr/lib/erl/lists.beam"`, `"/usr/local/lib/otp/legacy/ebin/lists.beam"` and `"/home/barney/erl/lists.beam"`.

### *Programming*

Normally, if a call is made from one module to another, it is assumed that the called module belongs to the same package as the source module. The compiler automatically expands such calls. E.g., in:

```
-module(foo.bar.m1).  
-export([f/1]).
```

```
f(X) -> m2:g(X).
```

`m2:g(X)` becomes a call to `foo.bar.m2`. If this is not what was intended, the call can be written explicitly, as in

```
-module(foo.bar.m1).
-export([f/1]).
```

```
f(X) -> fee.fie.foe.m2:g(X).
```

Because the called module is given with an explicit package name, no expansion is done in this case.

If a module from another package is used repeatedly in a module, an import declaration can make life easier:

```
-module(foo.bar.m1).
-export([f/1, g/1]).
-import(fee.fie.foe.m2).
```

```
f(X) -> m2:g(X).
g(X) -> m2:h(X).
```

will make the calls to `m2` refer to `fee.fie.foe.m2`. More generally, a declaration `-import(Package.Module)` will cause calls to `Module` to be expanded to `Package.Module`.

Old-style function imports work as normal (but full module names must be used); e.g.:

```
-import(fee.fie.foe.m2, [g/1, h/1]).
```

however, it is probably better to avoid this form of import altogether in new code, since it makes it hard to see what calls are really “remote”.

If it is necessary to call a module in the top-level package from within a named package, the module name can be written either with an initial period as in e.g. “.lists”, or with an empty initial atom, as in “’’.lists”. However, the best way is to use an import declaration - this is most obvious to the eye, and makes sure we don’t forget adding a period somewhere:

```
-module(foo.bar.fred).
-export([f/1]).
-import(lists).
```

```
f(X) -> lists:reverse(X).
```

The dot-syntax for module names can be used in any expression. All segments must be constant atoms, and the result must be a well-formed package/module name. E.g.:

```
spawn(foo.bar.fred, f, [X])
```

is equivalent to `spawn('foo.bar.fred', f, [X])`.

### *The Erlang Shell*

The shell also automatically expands remote calls, however currently no expansions are made by default. The user can change the behaviour by using the `import/1` shell command (or its abbreviation `use/1`). E.g.:

```
1> import(foo.bar.m).
ok
2> m:f().
```

will evaluate `foo.bar.m:f()`. If a new import is made of the same name, this overrides any previous import. (It is likely that in the future, some system packages will be pre-imported.)

In addition, the shell command `import_all/1` (and its alias `use_all/1`) imports all modules currently found in the path for a given package name. E.g., assuming the files `../foo/bar/fred.beam`, `../foo/bar/barney.beam` and `../foo/bar/bambam.beam` can be found from our current path,

```
1> import_all(foo.bar).
```

will make `fred`, `barney` and `bambam` expand to `foo.bar.fred`, `foo.bar.barney` and `foo.bar.bambam`, respectively.

Note: The compiler does not have an “import all” directive, for the reason that Erlang has no compile time type checking. E.g. if the wrong search path is used at compile time, a call `m:f(...)` could be expanded to `foo.bar.m:f(...)` without any warning, instead of the intended `frob.ozz.m:f(...)`, if package `foo.bar` happens to be found first in the path. Explicitly declaring each use of a module makes for safe code.

## Exports

```
no functions exported
```

# pg2

Erlang Module

This module implements process groups. The groups in this module differ from the groups in the module `pg` in several ways. In `pg`, each message is sent to all members in the group. In this module, each message may be sent to one, some, or all members.

A group of processes can be accessed by a common name. For example, if there is a group named `foobar`, there can be a set of processes (which can be located on different nodes) which are all members of the group `foobar`. There is no special functions for sending a message to the group. Instead, client functions should be written with the functions `get_members/1` and `get_local_members/1` to find out which processes are members of the group. Then the message can be sent to one or more members of the group.

If a member terminates, it is automatically removed from the group.

## Warning:

This module is used by the `disk_log` module for managing distributed disk logs. The disk log names are used as group names, which means that some action may need to be taken to avoid name clashes.

## Exports

`create(Name) -> void()`

Types:

- `Name = term()`

Creates a new, empty process group. The group is globally visible on all nodes. If the group exists, nothing happens.

`delete(Name) -> void()`

Types:

- `Name = term()`

Deletes a process group.

`get_closest_pid(Name) -> Pid | {error, Reason}`

Types:

- `Name = term()`
- `Pid = pid()`

- Reason = {no\_process, Name} | {no\_such\_group, Name}

This is a useful dispatch function which can be used from client functions. It returns a process on the local node, if such a process exist. Otherwise, it chooses one randomly.

`get_members(Name) -> [Pid] | {error, Reason}`

Types:

- Name = term()
- Pid = pid()
- Reason = {no\_such\_group, Name}

Returns all processes in the group Name. This function should be used from within a client function that accesses the group. It is therefore optimized for speed.

`get_local_members(Name) -> [Pid] | {error, Reason}`

Types:

- Name = term()
- Pid = pid()
- Reason = {no\_such\_group, Name}

Returns all processes running on the local node in the group Name. This function should be used from within a client function that accesses the group. It is therefore optimized for speed.

`join(Name, Pid) -> ok | {error, Reason}`

Types:

- Name = term()
- Pid = pid()
- Reason = {no\_such\_group, Name}

Joins the process Pid to the group Name. A process can join a group several times; it must then leave the group the same number of times.

`leave(Name, Pid) -> ok | {error, Reason}`

Types:

- Name = term()
- Pid = pid()
- Reason = {no\_such\_group, Name}

Makes the process Pid leave the group Name. If the process is not a member of the group, ok is returned.

`which_groups() -> [Name]`

Types:

- Name = term()

Returns a list of all known groups.

`start()`

`start_link() -> {ok, Pid} | {error, Reason}`

Types:

- Pid = pid()
- Reason = term()

Starts the pg2 server. Normally, the server does not need to be started explicitly, as it is started dynamically if it is needed. This is useful during development, but in a target system the server should be started explicitly. Use configuration parameters for `kernel` for this.

## See Also

`kernel(6)` [page 32], [pg(3)]

# rpc

Erlang Module

This module contains services which are similar to remote procedure calls. It also contains broadcast facilities and parallel evaluators. A remote procedure call is a method to call a function on a remote node and collect the answer. It is used for collecting information on a remote node, or for running a function with some specific side effects on the remote node.

## Exports

```
call(Node, Module, Function, Args) -> Res | {badrpc, Reason}
```

Types:

- Node = node()
- Module = Function = atom()
- Args = [term()]
- Res = term()
- Reason = term()

Evaluates `apply(Module, Function, Args)` on the node `Node` and returns the corresponding value `Res`, or `{badrpc, Reason}` if the call fails.

```
call(Node, Module, Function, Args, Timeout) -> Res | {badrpc, Reason}
```

Types:

- Node = node()
- Module = Function = atom()
- Args = [term()]
- Res = term()
- Reason = timeout | term()
- Timeout = int() | infinity

Evaluates `apply(Module, Function, Args)` on the node `Node` and returns the corresponding value `Res`, or `{badrpc, Reason}` if the call fails. `Timeout` is a timeout value in milliseconds. If the call times out, `Reason` is `timeout`.

If the reply arrives after the call times out, no message will contaminate the caller's message queue, since this function spawns off a middleman process to act as (a void) destination for such an orphan reply. This feature also makes this function more expensive than `call/4` at the caller's end.

```
block_call(Node, Module, Function, Args) -> Res | {badrpc, Reason}
```

Types:

- Node = node()
- Module = Function = atom()
- Args = [term()]
- Res = term()
- Reason = term()

Like `call/4`, but the RPC server at `Node` does not create a separate process to handle the call. Thus, this function can be used if the intention of the call is to block the RPC server from any other incoming requests until the request has been handled. The function can also be used for efficiency reasons when very small fast functions are evaluated, for example BIFs that are guaranteed not to suspend.

```
block_call(Node, Module, Function, Args, Timeout) -> Res | {badrpc, Reason}
```

Types:

- Node = node()
- Module = Function = atom()
- Args = [term()]
- Timeout = int() | infinity
- Res = term()
- Reason = term()

Like `block_call/4`, but with a timeout value in the same manner as `call/5`.

```
async_call(Node, Module, Function, Args) -> Key
```

Types:

- Node = node()
- Module = Function = atom()
- Args = [term()]
- Key – see below

Implements *call streams with promises*, a type of RPC which does not suspend the caller until the result is finished. Instead, a key is returned which can be used at a later stage to collect the value. The key can be viewed as a promise to deliver the answer.

In this case, the key `Key` is returned, which can be used in a subsequent call to `yield/1` or `nb_yield/1,2` to retrieve the value of evaluating `apply(Module, Function, Args)` on the node `Node`.

```
yield(Key) -> Res | {badrpc, Reason}
```

Types:

- Key – see `async_call/4`
- Res = term()
- Reason = term()

Returns the promised answer from a previous `async_call/4`. If the answer is available, it is returned immediately. Otherwise, the calling process is suspended until the answer arrives from `Node`.

```
nb_yield(Key) -> {value, Val} | timeout
```

Types:



- Key – see `async_call/4`
- Val = Res | {badrpc, Reason}
- Res = term()
- Reason = term()

Equivalent to `nb_yield(Key, 0)`.

`nb_yield(Key, Timeout) -> {value, Val} | timeout`

Types:

- Key – see `async_call/4`
- Timeout = int() | infinity
- Val = Res | {badrpc, Reason}
- Res = term()
- Reason = term()

This is a non-blocking version of `yield/1`. It returns the tuple `{value, Val}` when the computation has finished, or `timeout` when `Timeout` milliseconds has elapsed.

`multicall(Module, Function, Args) -> {ResL, BadNodes}`

Types:

- Module = Function = atom()
- Args = [term()]
- ResL = [term()]
- BadNodes = [node()]

Equivalent to `multicall([node()|nodes()], Module, Function, Args, infinity)`.

`multicall(Nodes, Module, Function, Args) -> {ResL, BadNodes}`

Types:

- Nodes = [node()]
- Module = Function = atom()
- Args = [term()]
- ResL = [term()]
- BadNodes = [node()]

Equivalent to `multicall(Nodes, Module, Function, Args, infinity)`.

`multicall(Module, Function, Args, Timeout) -> {ResL, BadNodes}`

Types:

- Module = Function = atom()
- Args = [term()]
- Timeout = int() | infinity
- ResL = [term()]
- BadNodes = [node()]

Equivalent to `multicall([node()|nodes()], Module, Function, Args, Timeout)`.

`multicall(Nodes, Module, Function, Args, Timeout) -> {ResL, BadNodes}`

Types:

- Nodes = [node()]
- Module = Function = atom()
- Args = [term()]
- Timeout = int() | infinity
- ResL = [term()]
- BadNodes = [node()]

In contrast to an RPC, a multicall is an RPC which is sent concurrently from one client to multiple servers. This is useful for collecting some information from a set of nodes, or for calling a function on a set of nodes to achieve some side effects. It is semantically the same as iteratively making a series of RPCs on all the nodes, but the multicall is faster as all the requests are sent at the same time and are collected one by one as they come back.

The function evaluates `apply(Module, Function, Args)` on the specified nodes and collects the answers. It returns `{ResL, Badnodes}`, where `Badnodes` is a list of the nodes that terminated or timed out during computation, and `ResL` is a list of the return values. `Timeout` is a time (integer) in milliseconds, or `infinity`.

The following example is useful when new object code is to be loaded on all nodes in the network, and also indicates some side effects RPCs may produce:

```
%% Find object code for module Mod
{Mod, Bin, File} = code:get_object_code(Mod),

%% and load it on all nodes including this one
{ResL, _} = rpc:multicall(code, load_binary, [Mod, Bin, File,]),

%% and then maybe check the ResL list.
```

```
cast(Node, Module, Function, Args) -> void()
```

Types:

- Node = node()
- Module = Function = atom()
- Args = [term()]

Evaluates `apply(Module, Function, Args)` on the node `Node`. No response is delivered and the calling process is not suspended until the evaluation is complete, as is the case with `call/4,5`.

```
eval_everywhere(Module, Funtion, Args) -> void()
```

Types:

- Module = Function = atom()
- Args = [term()]

Equivalent to `eval_everywhere([node()|nodes()], Module, Function, Args)`.

```
eval_everywhere(Nodes, Module, Function, Args) -> void()
```

Types:

- Nodes = [node()]
- Module = Function = atom()

- `Args = [term()]`

Evaluates `apply(Module, Function, Args)` on the specified nodes. No answers are collected.

`abcast(Name, Msg) -> void()`

Types:

- `Name = atom()`
- `Msg = term()`

Equivalent to `abcast([node()|nodes()], Name, Msg)`.

`abcast(Nodes, Name, Msg) -> void()`

Types:

- `Nodes = [node()]`
- `Name = atom()`
- `Msg = term()`

Broadcasts the message `Msg` asynchronously to the registered process `Name` on the specified nodes.

`sbcast(Name, Msg) -> {GoodNodes, BadNodes}`

Types:

- `Name = atom()`
- `Msg = term()`
- `GoodNodes = BadNodes = [node()]`

Equivalent to `sbcast([node()|nodes()], Name, Msg)`.

`sbcast(Nodes, Name, Msg) -> {GoodNodes, BadNodes}`

Types:

- `Name = atom()`
- `Msg = term()`
- `Nodes = GoodNodes = BadNodes = [node()]`

Broadcasts the message `Msg` synchronously to the registered process `Name` on the specified nodes.

Returns `{GoodNodes, BadNodes}`, where `GoodNodes` is the list of nodes which have `Name` as a registered process.

The function is synchronous in the sense that it is known that all servers have received the message when the call returns. It is not possible to know that the servers have actually processed the message.

Any further messages sent to the servers, after this function has returned, will be received by all servers after this message.

`server_call(Node, Name, ReplyWrapper, Msg) -> Reply | {error, Reason}`

Types:

- `Node = node()`
- `Name = atom()`

- ReplyWrapper = Msg = Reply = term()
- Reason = term()

This function can be used when interacting with a server called `Name` at node `Node`. It is assumed that the server receives messages in the format `{From, Msg}` and replies using `From ! {ReplyWrapper, Node, Reply}`. This function makes such a server call and ensures that the entire call is packed into an atomic transaction which either succeeds or fails. It never hangs, unless the server itself hangs.

The function returns the answer `Reply` as produced by the server `Name`, or `{error, Reason}`.

```
multi_server_call(Name, Msg) -> {Replies, BadNodes}
```

Types:

- Name = atom()
- Msg = term()
- Replies = [Reply]
- Reply = term()
- BadNodes = [node()]

Equivalent to `multi_server_call([node()|nodes()], Name, Msg)`.

```
multi_server_call(Nodes, Name, Msg) -> {Replies, BadNodes}
```

Types:

- Nodes = [node()]
- Name = atom()
- Msg = term()
- Replies = [Reply]
- Reply = term()
- BadNodes = [node()]

This function can be used when interacting with servers called `Name` on the specified nodes. It is assumed that the servers receive messages in the format `{From, Msg}` and reply using `From ! {Name, Node, Reply}`, where `Node` is the name of the node where the server is located. The function returns `{Replies, Badnodes}`, where `Replies` is a list of all `Reply` values and `BadNodes` is a list of the nodes which did not exist, or where the server did not exist, or where the server terminated before sending any reply.

```
safe_multi_server_call(Name, Msg) -> {Replies, BadNodes}
```

```
safe_multi_server_call(Nodes, Name, Msg) -> {Replies, BadNodes}
```

### Warning:

This function is deprecated. Use `multi_server_call/2,3` instead.

In Erlang/OTP R6B and earlier releases, `multi_server_call/2,3` could not handle the case where the remote node exists, but there is no server called `Name`. Instead this function had to be used. In Erlang/OTP R7B and later releases, however, the functions are equivalent, except for this function being slightly slower.

`parallel_eval(FuncCalls) -> ResL`

Types:

- `FuncCalls = [{Module, Function, Args}]`
- `Module = Function = atom()`
- `Args = [term()]`
- `ResL = [term()]`

For every tuple in `FuncCalls`, evaluates `apply(Module, Function, Args)` on some node in the network. Returns the list of return values, in the same order as in `FuncCalls`.

`pmap({Module, Function}, ExtraArgs, List2) -> List1`

Types:

- `Module = Function = atom()`
- `ExtraArgs = [term()]`
- `List1 = [Elem]`
- `Elem = term()`
- `List2 = [term()]`

Evaluates `apply(Module, Function, [Elem|ExtraArgs])`, for every element `Elem` in `List1`, in parallel. Returns the list of return values, in the same order as in `List1`.

`pinfo(Pid) -> [{Item, Info}] | undefined`

Types:

- `Pid = pid()`
- `Item, Info` – see `erlang:process_info/1`

Location transparent version of the BIF `process_info/1`.

`pinfo(Pid, Item) -> {Item, Info} | undefined | []`

Types:

- `Pid = pid()`
- `Item, Info` – see `erlang:process_info/1`

Location transparent version of the BIF `process_info/2`.

# seq\_trace

Erlang Module

Sequential tracing makes it possible to trace all messages resulting from one initial message. Sequential tracing is completely independent of the ordinary tracing in Erlang, which is controlled by the `erlang:trace/3` BIF. See the chapter [What is Sequential Tracing \[page 277\]](#) below for more information about what sequential tracing is and how it can be used.

`seq_trace` provides functions which control all aspects of sequential tracing. There are functions for activation, deactivation, inspection and for collection of the trace output.

## Note:

The implementation of sequential tracing is in beta status. This means that the programming interface still might undergo minor adjustments (possibly incompatible) based on feedback from users.

## Exports

`set_token(Token) -> PreviousToken`

Types:

- `Token = PreviousToken = term() | []`

Sets the trace token for the calling process to `Token`. If `Token == []` then tracing is disabled, otherwise `Token` should be an Erlang term returned from `get_token/0` or `set_token/1`. `set_token/1` can be used to temporarily exclude message passing from the trace by setting the trace token to empty like this:

```
OldToken = seq_trace:set_token([]), % set to empty and save
                                     % old value
% do something that should not be part of the trace
io:format("Exclude the signalling caused by this~n"),
seq_trace:set_token(OldToken), % activate the trace token again
...
```

Returns the previous value of the trace token.

`set_token(Component, Val) -> {Component, OldVal}`

Types:

- `Component = label | serial | Flag`
- `Flag = send | 'receive' | print | timestamp`

- Val = OldVal – see below

Sets the individual Component of the trace token to Val. Returns the previous value of the component.

`set_token(label, Int)` The label component is an integer which identifies all events belonging to the same sequential trace. If several sequential traces can be active simultaneously, label is used to identify the separate traces. Default is 0.

`set_token(serial, SerialValue)` SerialValue = {Previous, Current}. The serial component contains counters which enables the traced messages to be sorted, should never be set explicitly by the user as these counters are updated automatically. Default is {0, 0}.

`set_token(send, Bool)` A trace token flag (true | false) which enables/disables tracing on message sending. Default is false.

`set_token('receive', Bool)` A trace token flag (true | false) which enables/disables tracing on message reception. Default is false.

`set_token(print, Bool)` A trace token flag (true | false) which enables/disables tracing on explicit calls to `seq_trace:print/1`. Default is false.

`set_token(timestamp, Bool)` A trace token flag (true | false) which enables/disables a timestamp to be generated for each traced event. Default is false.

`get_token()` -> TraceToken

Types:

- TraceToken = term() | []

Returns the value of the trace token for the calling process. If [] is returned, it means that tracing is not active. Any other value returned is the value of an active trace token. The value returned can be used as input to the `set_token/1` function.

`get_token(Component)` -> {Component, Val}

Types:

- Component = label | serial | Flag
- Flag = send | 'receive' | print | timestamp
- Val – see `set_token/2`

Returns the value of the trace token component Component. See `set_token/2` [page 274] for possible values of Component and Val.

`print(TraceInfo)` -> void()

Types:

- TraceInfo = term()

Puts the Erlang term TraceInfo into the sequential trace output if the calling process currently is executing within a sequential trace and the print flag of the trace token is set.

`print(Label, TraceInfo)` -> void()

Types:

- Label = int()
- TraceInfo = term()

Same as `print/1` with the additional condition that `TraceInfo` is output only if `Label` is equal to the label component of the trace token.

`reset_trace()` -> `void()`

Sets the trace token to empty for all processes on the local node. The process internal counters used to create the serial of the trace token is set to 0. The trace token is set to empty for all messages in message queues. Together this will effectively stop all ongoing sequential tracing in the local node.

`set_system_tracer(Tracer)` -> `OldTracer`

Types:

- Tracer = OldTracer = pid() | port() | false

Sets the system tracer. The system tracer can be either a process or port denoted by `Tracer`. Returns the previous value (which can be `false` if no system tracer is active).

Failure: {badarg, Info} if `Pid` is not an existing local pid.

`get_system_tracer()` -> `Tracer`

Types:

- Tracer = pid() | port() | false

Returns the pid or port identifier of the current system tracer or `false` if no system tracer is activated.

## Trace Messages Sent To the System Tracer

The format of the messages are:

{seq\_trace, Label, SeqTraceInfo, TimeStamp}

or

{seq\_trace, Label, SeqTraceInfo}

depending on whether the timestamp flag of the trace token is set to `true` or `false`.

Where:

Label = int()

TimeStamp = {Seconds, Milliseconds, Microseconds}

Seconds = Milliseconds = Microseconds = int()

The `SeqTraceInfo` can have the following formats:

{send, Serial, From, To, Message} Used when a process `From` with its trace token flag `print` set to `true` has sent a message.

{'receive', Serial, From, To, Message} Used when a process `To` receives a message with a trace token that has the `'receive'` flag set to `true`.

{print, Serial, From, \_, Info} Used when a process `From` has called `seq_trace:print(Label, TraceInfo)` and has a trace token with the `print` flag set to `true` and `label` set to `Label`.



`Serial` is a tuple `{PreviousSerial, ThisSerial}`, where the first integer `PreviousSerial` denotes the serial counter passed in the last received message which carried a trace token. If the process is the first one in a new sequential trace, `PreviousSerial` is set to the value of the process internal “trace clock”. The second integer `ThisSerial` is the serial counter that a process sets on outgoing messages and it is based on the process internal “trace clock” which is incremented by one before it is attached to the trace token in the message.

## What is Sequential Tracing

Sequential tracing is a way to trace a sequence of messages sent between different local or remote processes, where the sequence is initiated by one single message. In short it works like this:

Each process has a *trace token*, which can be empty or not empty. When not empty the trace token can be seen as the tuple `{Label, Flags, Serial, From}`. The trace token is passed invisibly with each message.

In order to start a sequential trace the user must explicitly set the trace token in the process that will send the first message in a sequence.

The trace token of a process is set each time the process matches a message in a receive statement, according to the trace token carried by the received message, empty or not.

On each Erlang node a process can be set as the *system tracer*. This process will receive trace messages each time a message with a trace token is sent or received (if the trace token flag `send` or `'receive'` is set). The system tracer can then print each trace event, write it to a file or whatever suitable.

### Note:

The system tracer will only receive those trace events that occur locally within the Erlang node. To get the whole picture of a sequential trace that involves processes on several Erlang nodes, the output from the system tracer on each involved node must be merged (off line).

In the following sections Sequential Tracing and its most fundamental concepts are described.

## Trace Token

Each process has a current trace token. Initially the token is empty. When the process sends a message to another process, a copy of the current token will be sent “invisibly” along with the message.

The current token of a process is set in two ways, either

1. explicitly by the process itself, through a call to `seq_trace:set_token`, or
2. when a message is received.

In both cases the current token will be set. In particular, if the token of a message received is empty, the current token of the process is set to empty.

A trace token contains a label, and a set of flags. Both the label and the flags are set in 1 and 2 above.

## Serial

The trace token contains a component which is called `serial`. It consists of two integers `Previous` and `Current`. The purpose is to uniquely identify each traced event within a trace sequence and to order the messages chronologically and in the different branches if any.

The algorithm for updating `Serial` can be described as follows:

Let each process have two counters `prev_cnt` and `curr_cnt` which both are set to 0 when a process is created. The counters are updated at the following occasions:

- *When the process is about to send a message and the trace token is not empty.*  
Let the serial of the trace token be `tprev` and `tcurr`.  
`curr_cnt := curr_cnt + 1`  
`tprev := prev_cnt`  
`tcurr := curr_cnt`  
The trace token with `tprev` and `tcurr` is then passed along with the message.
- *When the process calls `seq_trace:print(Label, Info)`, `Label` matches the label part of the trace token and the trace token print flag is true.*  
The same algorithm as for send above.
- *When a message is received and contains a nonempty trace token.*  
The process trace token is set to the trace token from the message.  
Let the serial of the trace token be `tprev` and `tcurr`.  
`if (curr_cnt < tcurr )`  
    `curr_cnt := tcurr`  
    `prev_cnt := tcurr`

The `curr_cnt` of a process is incremented each time the process is involved in a sequential trace. The counter can reach its limit (27 bits) if a process is very long-lived and is involved in much sequential tracing. If the counter overflows it will not be possible to use the serial for ordering of the trace events. To prevent the counter from overflowing in the middle of a sequential trace the function `seq_trace:reset_trace/0` can be called to reset the `prev_cnt` and `curr_cnt` of all processes in the Erlang node. This function will also set all trace tokens in processes and their message queues to empty and will thus stop all ongoing sequential tracing.

## Performance considerations

The performance degradation for a system which is enabled for Sequential Tracing is negligible as long as no tracing is activated. When tracing is activated there will of course be an extra cost for each traced message but all other messages will be unaffected.

## Ports

Sequential tracing is not performed across ports.

If the user for some reason wants to pass the trace token to a port this has to be done manually in the code of the port controlling process. The port controlling processes have to check the appropriate sequential trace settings (as obtained from `seq_trace:get_token/1` and include trace information in the message data sent to their respective ports.

Similarly, for messages received from a port, a port controller has to retrieve trace specific information, and set appropriate sequential trace flags through calls to `seq_trace:set_token/2`.

## Distribution

Sequential tracing between nodes is performed transparently. This applies to C-nodes built with `ErlInterface` too. A C-node built with `ErlInterface` only maintains one trace token, which means that the C-node will appear as one process from the sequential tracing point of view.

In order to be able to perform sequential tracing between distributed Erlang nodes, the distribution protocol has been extended (in a backward compatible way). An Erlang node which supports sequential tracing can communicate with an older (OTP R3B) node but messages passed within that node can of course not be traced.

## Example of Usage

The example shown here will give rough idea of how the new primitives can be used and what kind of output it will produce.

Assume that we have an initiating process with `Pid == <0.30.0>` like this:

```
-module(seqex) .
-compile(export_all) .

loop(Port) ->
    receive
        {Port,Message} ->
            seq_trace:set_token(label,17),
            seq_trace:set_token('receive',true),
            seq_trace:set_token(print,true),
            seq_trace:print(17,"**** Trace Started ****"),
            call_server ! {self(),the_message};
        {ack,Ack} ->
            ok
    end,
    loop(Port) .
```

And a registered process `call_server` with `Pid == <0.31.0>` like this:

```

loop() ->
  receive
    {PortController,Message} ->
      Ack = {received, Message},
      seq_trace:print(17,"We are here now"),
      PortController ! {ack,Ack}
    end,
  loop().

```

A possible output from the system's sequential\_tracer (inspired by AXE-10 and MD-110) could look like:

```

17:<0.30.0> Info {0,1} WITH
"**** Trace Started ****"
17:<0.31.0> Received {0,2} FROM <0.30.0> WITH
{<0.30.0>,the_message}
17:<0.31.0> Info {2,3} WITH
"We are here now"
17:<0.30.0> Received {2,4} FROM <0.31.0> WITH
{ack,{received,the_message}}

```

The implementation of a system tracer process that produces the printout above could look like this:

```

tracer() ->
  receive
    {seq_trace,Label,TraceInfo} ->
      print_trace(Label,TraceInfo,false);
    {seq_trace,Label,TraceInfo,Ts} ->
      print_trace(Label,TraceInfo,Ts);
    Other -> ignore
  end,
tracer().

print_trace(Label,TraceInfo,false) ->
  io:format("~p:",[Label]),
  print_trace(TraceInfo);
print_trace(Label,TraceInfo,Ts) ->
  io:format("~p ~p:",[Label,Ts]),
  print_trace(TraceInfo).

print_trace({print,Serial,From,_,Info}) ->
  io:format("~p Info ~p WITH~n~p~n", [From,Serial,Info]);
print_trace({'receive',Serial,From,To,Message}) ->
  io:format("~p Received ~p FROM ~p WITH~n~p~n",
    [To,Serial,From,Message]);
print_trace({'send',Serial,From,To,Message}) ->
  io:format("~p Sent ~p TO ~p WITH~n~p~n",
    [From,Serial,To,Message]).

```

The code that creates a process that runs the tracer function above and sets that process as the system tracer could look like this:

```

start() ->
  Pid = spawn(?MODULE,tracer,[]),
  seq_trace:set_system_tracer(Pid), % set Pid as the system tracer

```

ok.

With a function like test/0 below the whole example can be started.

```
test() ->
  P = spawn(?MODULE, loop, [port]),
  register(call_server, spawn(?MODULE, loop, [])),
  start(),
  P ! {port,message}.
```

# user

Erlang Module

`user` is a server which responds to all the messages defined in the I/O interface. The code in `user.erl` can be used as a model for building alternative I/O servers.

# wrap\_log\_reader

Erlang Module

`wrap_log_reader` is a function to read internally formatted wrap disk logs, refer to `disk_log(3)`. `wrap_log_reader` does not interfere with `disk_log` activities; there is however a known bug in this version of the `wrap_log_reader`, see chapter bugs below.

A wrap disk log file consists of several files, called index files. A log file can be opened and closed. It is also possible to open just one index file separately. If a non-existent or a non-internally formatted file is opened, an error message is returned. If the file is corrupt, no attempt to repair it will be done but an error message is returned.

If a log is configured to be distributed, there is a possibility that all items are not loggen on all nodes. `wrap_log_reader` does only read the log on the called node, it is entirely up to the user to be sure that all items are read.

## Exports

`chunk(Continuation)`

`chunk(Continuation, N) -> {Continuation2, Terms} | {Continuation2, Terms, Badbytes} | {Continuation2, eof} | {error, Reason}`

Types:

- `Continuation = continuation()`
- `N = int() > 0 | infinity`
- `Continuation2 = continuation()`
- `Terms = [term()]`
- `Badbytes = integer()`

This function makes it possible to efficiently read the terms which have been appended to a log. It minimises disk I/O by reading large 8K chunks from the file.

The first time `chunk` is called an initial continuation returned from the `open/1`, `open/2` must be provided.

When `chunk/3` is called, `N` controls the maximum number of terms that are read from the log in each chunk. Default is `infinity`, which means that all the terms contained in the 8K chunk are read. If less than `N` terms are returned, this does not necessarily mean that end of file is reached.

The `chunk` function returns a tuple `{Continuation2, Terms}`, where `Terms` is a list of terms found in the log. `Continuation2` is yet another continuation which must be passed on into any subsequent calls to `chunk`. With a series of calls to `chunk` it is then possible to extract all terms from a log.

The `chunk` function returns a tuple `{Continuation2, Terms, Badbytes}` if the log is opened in read only mode and the read chunk is corrupt. `Badbytes` indicates the number of non-Erlang terms found in the chunk. Note also that the log is not repaired.

`chunk` returns `{Continuation2, eof}` when the end of the log is reached, and `{error, Reason}` if an error occurs.

The returned continuation may or may not be valid in the next call to `chunk`. This is because the log may wrap and delete the file into which the continuation points. To make sure this does not happen, the log can be blocked during the search.

`close(Continuation) -> ok`

Types:

- `Continuation = continuation()`

This function closes a log file properly.

`open(Filename) -> OpenRet`

`open(Filename, N) -> OpenRet`

Types:

- `File = string() | atom()`
- `N = integer()`
- `OpenRet = {ok, Continuation} | {error, Reason}`
- `Continuation = continuation()`

`Filename` specifies the name of the file which is to be read.

`N` specifies the index of the file which is to be read. If `N` is omitted the whole wrap log file will be read; if it is specified only the specified index file will be read.

The open function returns `{ok, Continuation}` if the log/index file was successfully opened. The `Continuation` is to be used when chunking or closing the file.

The function returns `{error, Reason}` for all errors.

## Bugs

This version of the `wrap_log_reader` does not detect if the `disk_log` wraps to a new index file between a `wrap_log_reader:open` and the first `wrap_log_reader:chunk`. In this case the chunk will actually read the last logged items in the log file, because the opened index file was truncated by the `disk_log`.

## See Also

`disk_log(3)` [page 56]



# zlib

## Erlang Module

The zlib module provides an API for the zlib library (<http://www.zlib.org>). It is used to compress and decompress data. The data format is described by RFCs 1950 to 1952.

A typical (compress) usage looks like:

```
Z = zlib:open(),
ok = zlib:deflateInit(Z,default),

Compress = fun(end_of_data, _Cont) -> [];
            (Data, Cont) ->
                [zlib:deflate(Z, Data)|Cont(Read(),Cont)]
            end,
Compressed = Compress(Read(),Compress),
Last = zlib:deflate(Z, [], finish),
ok = zlib:deflateEnd(Z),
zlib:close(Z),
list_to_binary([Compressed|Last])
```

In all functions errors, `{'EXIT', {Reason,Backtrace}}`, might be thrown, where Reason describes the error. Typical reasons are:

```
badarg Bad argument
data_error The data contains errors
stream_error Inconsistent stream state
einval Bad value or wrong function called
{need_dictionary,Adler32} See inflate/2
```

## DATA TYPES

```
iodata = iolist() | binary()

iolist = [char() | binary() | iolist()]
        a binary is allowed as the tail of the list

zstream = a zlib stream, see open/0
```

## Exports

`open()` -> Z

Types:

- Z = `zstream()`

Open a zlib stream.

`close(Z)` -> ok

Types:

- Z = `zstream()`

Closes the stream referenced by Z.

`deflateInit(Z)` -> ok

Types:

- Z = `zstream()`

Same as `zlib:deflateInit(Z, default)`.

`deflateInit(Z, Level)` -> ok

Types:

- Z = `zstream()`
- Level = `none` | `default` | `best_speed` | `best_compression` | 0..9

Initialize a zlib stream for compression.

Level decides the compression level to be used, 0 (`none`), gives no compression at all, 1 (`best_speed`) gives best speed and 9 (`best_compression`) gives best compression.

`deflateInit(Z, Level, Method, WindowBits, MemLevel, Strategy)` -> ok

Types:

- Z = `zstream()`
- Level = `none` | `default` | `best_speed` | `best_compression` | 0..9
- Method = `deflated`
- WindowBits = 9..15 | -9..-15
- MemLevel = 1..9
- Strategy = `default` | `filtered` | `huffman_only`

Initiates a zlib stream for compression.

The `Level` parameter decides the compression level to be used, 0 (`none`), gives no compression at all, 1 (`best_speed`) gives best speed and 9 (`best_compression`) gives best compression.

The `Method` parameter decides which compression method to use, currently the only supported method is `deflated`.

The `WindowBits` parameter is the base two logarithm of the window size (the size of the history buffer). It should be in the range 9 through 15. Larger values of this parameter result in better compression at the expense of memory usage. The default value is 15 if `deflateInit/2`. A negative `WindowBits` value suppresses the zlib header (and checksum) from the stream. Note that the zlib source mentions this only as a undocumented feature.

The `MemLevel` parameter specifies how much memory should be allocated for the internal compression state. `MemLevel=1` uses minimum memory but is slow and reduces compression ratio; `MemLevel=9` uses maximum memory for optimal speed. The default value is 8.

The `Strategy` parameter is used to tune the compression algorithm. Use the value `default` for normal data, `filtered` for data produced by a filter (or predictor), or `huffman_only` to force Huffman encoding only (no string match). Filtered data consists mostly of small values with a somewhat random distribution. In this case, the compression algorithm is tuned to compress them better. The effect of `filtered` is to force more Huffman coding and less string matching; it is somewhat intermediate between `default` and `huffman_only`. The `Strategy` parameter only affects the compression ratio but not the correctness of the compressed output even if it is not set appropriately.

`deflate(Z, Data) -> Compressed`

Types:

- `Z = zstream()`
- `Data = iodata()`
- `Compressed = iolist()`

Same as `deflate(Z, Data, none)`.

`deflate(Z, Data, Flush) ->`

Types:

- `Z = zstream()`
- `Data = iodata()`
- `Flush = none | sync | full | finish`
- `Compressed = iolist()`

`deflate/3` compresses as much data as possible, and stops when the input buffer becomes empty. It may introduce some output latency (reading input without producing any output) except when forced to flush.

If the parameter `Flush` is set to `sync`, all pending output is flushed to the output buffer and the output is aligned on a byte boundary, so that the decompressor can get all input data available so far. Flushing may degrade compression for some compression algorithms and so it should be used only when necessary.

If `Flush` is set to `full`, all output is flushed as with `sync`, and the compression state is reset so that decompression can restart from this point if previous compressed data has been damaged or if random access is desired. Using `full` too often can seriously degrade the compression.

If the parameter `Flush` is set to `finish`, pending input is processed, pending output is flushed and `deflate/3` returns. Afterwards the only possible operations on the stream are `deflateReset/1` or `deflateEnd/1`.

`Flush` can be set to `finish` immediately after `deflateInit` if all compression is to be done in one step.

```
zlib:deflateInit(Z),
B1 = zlib:deflate(Z,Data),
B2 = zlib:deflate(Z,<< >>,finish),
zlib:deflateEnd(Z),
list_to_binary([B1,B2])
```

`deflateSetDictionary(Z, Dictionary) -> Adler32`

Types:

- `Z = zstream()`
- `Dictionary = binary()`
- `Adler32 = integer()`

Initializes the compression dictionary from the given byte sequence without producing any compressed output. This function must be called immediately after `deflateInit/[1|2|6]` or `deflateReset/1`, before any call of `deflate/3`. The compressor and decompressor must use exactly the same dictionary (see `inflateSetDictionary/2`). The Adler checksum of the dictionary is returned.

`deflateReset(Z) -> ok`

Types:

- `Z = zstream()`

This function is equivalent to `deflateEnd/1` followed by `deflateInit/[1|2|6]`, but does not free and reallocate all the internal compression state. The stream will keep the same compression level and any other attributes.

`deflateParams(Z, Level, Strategy) -> ok`

Types:

- `Z = zstream()`
- `Level = none | default | best_speed | best_compression | 0..9`
- `Strategy = default | filtered | huffman_only`

Dynamically update the compression level and compression strategy. The interpretation of `Level` and `Strategy` is as in `deflateInit/6`. This can be used to switch between compression and straight copy of the input data, or to switch to a different kind of input data requiring a different strategy. If the compression level is changed, the input available so far is compressed with the old level (and may be flushed); the new level will take effect only at the next call of `deflate/3`.

Before the call of `deflateParams`, the stream state must be set as for a call of `deflate/3`, since the currently available input may have to be compressed and flushed.

`deflateEnd(Z) -> ok`

Types:

- `Z = zstream()`

End the deflate session and cleans all data used. Note that this function will throw an `data_error` exception if the last call to `deflate/3` was not called with `Flush` set to `finish`.

`inflateInit(Z) -> ok`

Types:

- `Z = zstream()`

Initialize a zlib stream for decompression.

`inflateInit(Z, WindowBits) -> ok`

Types:

- `Z = zstream()`
- `WindowBits = 9..15|-9..-15`

Initialize decompression session on zlib stream.

The `WindowBits` parameter is the base two logarithm of the maximum window size (the size of the history buffer). It should be in the range 9 through 15. The default value is 15 if `inflateInit/1` is used. If a compressed stream with a larger window size is given as input, `inflate()` will throw the `data_error` exception. A negative `WindowBits` value makes zlib ignore the zlib header (and checksum) from the stream. Note that the zlib source mentions this only as a undocumented feature.

`inflate(Z, Data) -> DeCompressed`

Types:

- `Z = zstream()`
- `Data = iodata()`
- `DeCompressed = iolist()`

`inflate/2` decompresses as much data as possible. It may some introduce some output latency (reading input without producing any output).

If a preset dictionary is needed at this point (see `inflateSetDictionary` below), `inflate/2` throws a `{need_dictionary, Adler}` exception where `Adler` is the `adler32` checksum of the dictionary chosen by the compressor.

`inflateSetDictionary(Z, Dictionary) -> ok`

Types:

- `Z = zstream()`
- `Dictionary = binary()`

Initializes the decompression dictionary from the given uncompressed byte sequence.

This function must be called immediately after a call of `inflate/2` if this call threw a `{need_dictionary, Adler}` exception. The dictionary chosen by the compressor can be determined from the `Adler` value thrown by the call to `inflate/2`. The compressor and decompressor must use exactly the same dictionary (see `deflateSetDictionary/2`).

Example:

```

unpack(Z, Compressed, Dict) ->
  case catch zlib:inflate(Z, Compressed) of
    {'EXIT', {{need_dictionary, DictID}, -}} ->
      zlib:inflateSetDictionary(Z, Dict),
      Uncompressed = zlib:inflate(Z, []);
    Uncompressed ->
      Uncompressed
  end.

```

`inflateReset(Z)` -> ok

Types:

- Z = `zstream()`

This function is equivalent to `inflateEnd/1` followed by `inflateInit/1`, but does not free and reallocate all the internal decompression state. The stream will keep attributes that may have been set by `inflateInit/[1|2]`.

`inflateEnd(Z)` -> ok

Types:

- Z = `zstream()`

End the inflate session and cleans all data used. Note that this function will throw a `data_error` exception if no end of stream was found (meaning that not all data has been uncompressed).

`setBufSize(Z, Size)` -> ok

Types:

- Z = `zstream()`
- Size = `integer()`

Sets the intermediate buffer size.

`getBufSize(Z)` -> Size

Types:

- Z = `zstream()`
- Size = `integer()`

Get the size of intermediate buffer.

`crc32(Z)` -> CRC

Types:

- Z = `zstream()`
- CRC = `integer()`

Get the current calculated CRC checksum.

`crc32(Z, Binary)` -> CRC

Types:

- Z = `zstream()`

- Binary = binary()
- CRC = integer()

Calculate the CRC checksum for Binary.

```
crc32(Z, PrevCRC, Binary) -> CRC
```

Types:

- Z = zstream()
- PrevCRC = integer()
- Binary = binary()
- CRC = integer()

Update a running CRC checksum for Binary. If Binary is the empty binary, this function returns the required initial value for the crc.

```
Crc = lists:foldl(fun(Bin,Crc0) ->
                  zlib:crc32(Z, Crc0, Bin),
                  end, zlib:crc32(Z,<< >>), Bins)
```

```
crc32_combine(Z, CRC1, CRC2, Size2) -> CRC
```

Types:

- Z = zstream()
- CRC = integer()
- CRC1 = integer()
- CRC2 = integer()
- Size2 = integer()

Combine two CRC checksums into one. For two binaries, Bin1 and Bin2 with sizes of Size1 and Size2, with CRC checksums CRC1 and CRC2. `crc32_combine/4` returns the CRC checksum of <<Bin1/binary,Bin2/binary>>, requiring only CRC1, CRC2, and Size2.

```
adler32(Z, Binary) -> Checksum
```

Types:

- Z = zstream()
- Binary = binary()
- Checksum = integer()

Calculate the Adler-32 checksum for Binary.

```
adler32(Z, PrevAdler, Binary) -> Checksum
```

Types:

- Z = zstream()
- PrevAdler = integer()
- Binary = binary()
- Checksum = integer()

Update a running Adler-32 checksum for Binary. If Binary is the empty binary, this function returns the required initial value for the checksum.

```
Crc = lists:foldl(fun(Bin,Crc0) ->
                  zlib:adler32(Z, Crc0, Bin),
                  end, zlib:adler32(Z,<< >>), Bins)
```

adler32\_combine(Z, Adler1, Adler2, Size2) -> Adler

Types:

- Z = zstream()
- Adler = integer()
- Adler1 = integer()
- Adler2 = integer()
- Size2 = integer()

Combine two Adler-32 checksums into one. For two binaries, Bin1 and Bin2 with sizes of Size1 and Size2, with Adler-32 checksums Adler1 and Adler2.

adler32\_combine/4 returns the Adler checksum of <<Bin1/binary,Bin2/binary>>, requiring only Adler1, Adler2, and Size2.

compress(Binary) -> Compressed

Types:

- Binary = Compressed = binary()

Compress a binary (with zlib headers and checksum).

uncompress(Binary) -> Decompressed

Types:

- Binary = Decompressed = binary()

Uncompress a binary (with zlib headers and checksum).

zip(Binary) -> Compressed

Types:

- Binary = Compressed = binary()

Compress a binary (without zlib headers and checksum).

unzip(Binary) -> Decompressed

Types:

- Binary = Decompressed = binary()

Uncompress a binary (without zlib headers and checksum).

gzip(Data) -> Compressed

Types:

- Binary = Compressed = binary()

Compress a binary (with gz headers and checksum).

gunzip(Bin) -> Decompressed

Types:



- Binary = Decompressed = binary()

Uncompress a binary (with gz headers and checksum).

# app

File

The *application resource file* specifies the resources an application uses, and how the application is started. There must always be one application resource file called `Application.app` for each application `Application` in the system.

The file is read by the application controller when an application is loaded/started. It is also used by the functions in `systools`, for example when generating start scripts.

## FILE SYNTAX

The application resource file should be called `Application.app` where `Application` is the name of the application. The file should be located in the `ebin` directory for the application.

It must contain one single Erlang term, which is called an *application specification*:

```
{application, Application,
  [{description, Description},
   {id,          Id},
   {vsns,       Vsn},
   {modules,    Modules},
   {maxP,       MaxP},
   {maxT,       MaxT},
   {registered, Names},
   {included_applications, Apps},
   {applications, Apps},
   {env,        Env},
   {mod,        Start},
   {start_phases, Phases}]}
```

|             | Value                | Default   |
|-------------|----------------------|-----------|
|             | -----                | -----     |
| Application | atom()               | -         |
| Description | string()             | ""        |
| Id          | string()             | ""        |
| Vsn         | string()             | ""        |
| Modules     | [Module]             | []        |
| MaxP        | int()                | infinity  |
| MaxT        | int()                | infinity  |
| Names       | [Name]               | []        |
| Apps        | [App]                | []        |
| Env         | [{Par, Val}]         | []        |
| Start       | {Module, StartArgs}  | undefined |
| Phases      | [{Phase, PhaseArgs}] | undefined |

```
Module = Name = App = Par = Phase = atom()
Val = StartArgs = PhaseArgs = term()
```

`Application` is the name of the application.

For the application controller, all keys are optional. The respective default values are used for any omitted keys.

The functions in `systools` require more information. If they are used, the following keys are mandatory: `description`, `vsn`, `modules`, `registered` and `applications`. The other keys are ignored by `systools`.

`description` A one-line description of the application.

`id` Product identification, or similar.

`vsn` The version of the application.

`modules` All modules introduced by this application. `systools` uses this list when generating start scripts and tar files. A module can only be defined in one application.

`maxP` *Deprecated - will be ignored*

The maximum number of processes allowed in the application.

`maxT` The maximum time in milliseconds that the application is allowed to run. After the specified time the application will automatically terminate.

`registered` All names of registered processes started in this application. `systools` uses this list to detect name clashes between different applications.

`included_applications` All applications which are included by this application. When this application is started, all included application will automatically be loaded, but not started, by the application controller. It is assumed that the topmost supervisor of the included application is started by a supervisor of this application.

`applications` All applications which must be started before this application is allowed to be started. `systools` uses this list to generate correct start scripts. Defaults to the empty list, but note that all applications have dependencies to (at least) `kernel` and `stdlib`.

`env` Configuration parameters used by the application. The value of a configuration parameter is retrieved by calling `application:get_env/1,2`. The values in the application resource file can be overridden by values in a configuration file (see `config(4)`) or by command line flags (see `erl(1)`).

`mod` Specifies the application callback module and a start argument, see `application(3)`.

The `mod` key is necessary for an application implemented as a supervision tree, or the application controller will not know how to start it. The `mod` key can be omitted for applications without processes, typically code libraries such as the application `STDLIB`.

`start_phases` A list of start phases and corresponding start arguments for the application. If this key is present, the application master will - in addition to the usual call to `Module:start/2` - also call

```
Module:start_phase(Phase, Type, PhaseArgs) for each start phase defined by
the start_phases key, and only after this extended start procedure will
application:start(Application) return.
```

Start phases may be used to synchronize startup of an application and its included applications. In this case, the `mod` key must be specified as:

```
{mod, {application_starter, [Module, StartArgs]}}
```

The application master will then call `Module:start/2` for the primary application, followed by calls to `Module:start_phase/3` for each start phase (as defined for the primary application) both for the primary application and for each of its included application, for which the start phase is defined.

This implies that for an included application, the set of start phases must be a subset of the set of phases defined for the primary application. Refer to *OTP Design Principles* for more information.

## SEE ALSO

`application(3)` [page 36], `systools(3)`

# config

## File

A *configuration file* contains values for configuration parameters for the applications in the system. The `erl` command line argument `-config Name` tells the system to use data in the system configuration file `Name.config`.

Configuration parameter values in the configuration file will override the values in the application resource files (see `app(4)`). The values in the configuration file can be overridden by command line flags (see `erl(1)`).

The value of a configuration parameter is retrieved by calling `application:get_env/1,2`.

## FILE SYNTAX

The configuration file should be called `Name.config` where `Name` is an arbitrary name.

The `.config` file contains one single Erlang term. The file has the following syntax:

```
[{Application1, [{Par11, Val11}, ..]},
 ..
 {ApplicationN, [{ParN1, ValN1}, ..]}].
```

- `Application` = `atom()` is the name of the application.
- `Par` = `atom()` is the name of a configuration parameter.
- `Val` = `term()` is the value of a configuration parameter.

## sys.config

When starting Erlang in embedded mode, it is assumed that exactly one system configuration file is used, named `sys.config`. This file should be located in `$ROOT/releases/Vsn`, where `$ROOT` is the Erlang/OTP root installation directory and `Vsn` is the release version.

Release handling relies on this assumption. When installing a new release version, the new `sys.config` is read and used to update the application configurations.

This means that specifying another, or additional, `.config` files would lead to inconsistent update of application configurations. Therefore, in Erlang 5.4/OTP R10B, the syntax of `sys.config` was extended to allow pointing out other `.config` files:

```
[{Application, [{Par, Val}]} | File].
```

- `File` = `string()` is the name of another `.config` file. The extension `.config` may be omitted. It is recommended to use absolute paths. A relative path is relative the current working directory of the emulator.

When traversing the contents of `sys.config` and a filename is encountered, its contents are read and merged with the result so far. When an application configuration tuple `{Application, Env}` is found, it is merged with the result so far. Merging means that new parameters are added and existing parameter values overwritten. Example:

```
sys.config:
```

```
[{myapp, [{par1, val1}, {par2, val2}]},  
 "/home/user/myconfig"].
```

```
myconfig.config:
```

```
[{myapp, [{par2, val3}, {par3, val4}]}].
```

This will yield the following environment for `myapp`:

```
[{par1, val1}, {par2, val3}, {par3, val4}]
```

The behaviour if a file specified in `sys.config` does not exist or is erroneous in some other way, is backwards compatible. Starting the runtime system will fail. Installing a new release version will not fail, but an error message is given and the erroneous file is ignored.

## SEE ALSO

`app(4)`, `erl(1)`, *OTP Design Principles*

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