

FOSA Reference Manual

0.2

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1 FOSA Module Index

1.1 FOSA Modules

Here is a list of all modules:

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2 FOSA Hierarchical Index

2.1 FOSA Class Hierarchy

This inheritance list is sorted roughly, but not completely, alphabetically:

fosa_ads_scheduler_ops_t	19
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3 FOSA Data Structure Index

3.1 FOSA Data Structures

Here are the data structures with brief descriptions:

fosa_ads_scheduler_ops_t	19
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4 FOSA Module Documentation

4.1 FOSA Private Interfaces

Modules

- [Application Defined Scheduling](#)
- [Clocks and Timers](#)
- [FOSA Errors](#)
- [Mutexes and Condvars](#)
- [Thread and Signals](#)

4.1.1 Detailed Description

FOSA is an OS adaption layer that encapsulates all POSIX types and functions into neutral names so that FRSH can compile and be used in non-POSIX operating systems such as OSE.

It is divided in two parts:

- FRSH_FOSA: Types visible to the application via FRSH_API and the functions to manage them (thread, signals).
- FOSA: Types and functions only used within FRSH.

The former reside in the FRSH subversion directory and the latter have their own. They need to be separated because the application must not see FOSA itself.

For simplicity, we have chosen to hide the operation function on signals and mutexes with the assumption that a direct mapping exists for frsh_signal_t, frsh_signal_info_t and frsh_mutex_t in the native OS.

Since there are some parts which are platform dependent a define has been introduced for each platform. Currently the supported defines are:

`-DRT_LINUX -DOSE -DMARTE_OS`

This module contains all other modules that are internal to the FRSH implementation.

Note that to compile FOSA objects an include path towards FRSH is needed: `-I<frsh_include_directory>`.

4.2 Application Defined Scheduling

Data Structures

- struct [fosa_ads_scheduler_ops_t](#)

Typedefs

- typedef FOSA_ADS_ACTIONS_T_OPAQUE [fosa_ads_actions_t](#)
- typedef int [fosa_ads_urgency_t](#)

Enumerations

- enum [fosa_ads_error_cause_t](#) { **FOSA_ADS_THREAD_NOT_ATTACHED**, **FOSA_ADS_INVALID_ACTION** }

Functions

- `int fosa_ads_scheduler_create` (const `fosa_ads_scheduler_ops_t` *scheduler_ops, size_t scheduler_data_size, void *init_args, size_t init_args_size)
- `int fosa_thread_attr_set_appscheduled` (frsh_thread_attr_t *attr, bool appscheduled)
- `int fosa_thread_attr_get_appscheduled` (const frsh_thread_attr_t *attr, bool *appscheduled)
- `int fosa_thread_attr_set_appsched_params` (frsh_thread_attr_t *attr, const void *param, size_t paramsize)
- `int fosa_thread_attr_get_appsched_params` (const frsh_thread_attr_t *attr, void *param, size_t *paramsize)
- `int fosa_ads_set_appscheduled` (frsh_thread_id_t thread, bool appscheduled)
- `int fosa_ads_get_appscheduled` (frsh_thread_id_t thread, bool *appscheduled)
- `int fosa_ads_set_appschedparam` (frsh_thread_id_t thread, const void *param, size_t paramsize)
- `int fosa_ads_get_appsched_params` (frsh_thread_id_t thread, void *param, size_t *paramsize)
- `int fosa_adsactions_add_reject` (`fosa_ads_actions_t` *sched_actions, frsh_thread_id_t thread)
- `int fosa_adsactions_add_activate` (`fosa_ads_actions_t` *sched_actions, frsh_thread_id_t thread, `fosa_ads_urgency_t` urgency)
- `int fosa_adsactions_add_suspend` (`fosa_ads_actions_t` *sched_actions, frsh_thread_id_t thread)
- `int fosa_adsactions_add_timeout` (`fosa_ads_actions_t` *sched_actions, `fosa_clock_id_t` clock_id, const struct timespec *at_time)
- `int fosa_adsactions_add_thread_notification` (`fosa_ads_actions_t` *sched_actions, frsh_thread_id_t thread, `fosa_clock_id_t` clock_id, const struct timespec *at_time)
- `int fosa_ads_set_handled_signal_set` (frsh_signal_t set[])
- `int fosa_ads_invoke_withdata` (const void *msg, size_t msg_size, void *reply, size_t *reply_size)

4.2.1 Detailed Description

This module defines the function and types for an abstraction of the Application Defined Scheduling.

4.2.2 Typedef Documentation

4.2.2.1 typedef FOSA_ADS_ACTIONS_T_OPAQUE `fosa_ads_actions_t`

ADS actions

This type is used to represent a list of scheduling actions that the scheduler will later request to be executed by the system. The possible actions are of the following kinds:

- reject a thread that has requested attachment to this scheduler
- activate an application-scheduled thread with the desired value of urgency
- suspend an application-scheduled thread
- program a timeout
- program a timed notification associated to a particular application-scheduled thread.

No comparison or assignment operators are defined for this type

4.2.2.2 typedef int `fosa_ads_urgency_t`

The urgency used to order the threads of the same priority in the underlying scheduler. Support for urgency scheduling is required for supporting the hierarchical scheduling module

4.2.3 Enumeration Type Documentation

4.2.3.1 enum `fosa_ads_error_cause_t`

Causes of error in the `appsched_error` primitive operation

4.2.4 Function Documentation

4.2.4.1 int `fosa_ads_scheduler_create` (const `fosa_ads_scheduler_ops_t` * `scheduler_ops`, `size_t scheduler_data_size`, void * `init_args`, `size_t init_args_size`)

`fosa_ads_scheduler_create()`

Create the application defined scheduler

The application defined scheduler is created with the primitive operations specified in the object pointed to by `scheduler_ops`.

The clock used to read the time immediately before the invocation of each primitive operation, to be reported to the scheduler via the `current_time` parameter of each primitive operation is the `FOSA_CLOCK_REALTIME` clock.

The `scheduler_data_size` parameter is used to request that a memory area of this size must be created and reserved for the scheduler to store its state. A pointer to this area is passed to the scheduler operations in the `sched_data` parameter.

Parameter `init_arg` points to an area that contains configuration information for the scheduler. The function creates a memory area of `init_arg_size` bytes and copies into it the area pointed by `arg`. A pointer to this new created area will be passed to the primitive operation `init()` in its `arg` parameter.

Returns 0 if successful; otherwise it returns an error code: `EINVAL`: The value of `scheduler_ops` was invalid `EAGAIN`: The system lacks enough resources to create the scheduler

Alternatively, in case of error the implementation is allowed to notify it to the system console and then terminate the `FRSH` implementation and dependant applications

4.2.4.2 int `fosa_thread_attr_set_appscheduled` (`frsh_thread_attr_t` * `attr`, bool `appscheduled`)

`fosa_thread_attr_set_appscheduled()`

Set the `appscheduled` attribute of a thread attributes object

This function is used to set the `appscheduled` attribute in the object pointed to by `attr`. This attribute controls the kind of scheduling used for threads created with it. If true, the thread is scheduled by the application scheduler. If not, it is scheduled by the system under a fixed priority scheduler

Returns 0 if successful; otherwise it returns an error code: `EINVAL`: The value of `attr` is invalid

Alternatively, in case of error the implementation is allowed to notify it to the system console and then terminate the `FRSH` implementation and dependant applications

4.2.4.3 int `fosa_thread_attr_get_appscheduled` (const `frsh_thread_attr_t` * `attr`, bool * `appscheduled`)

`fosa_thread_attr_get_appscheduled()`

Get the `appscheduled` attribute of a thread attributes object

This function is used to get the `appscheduled` attribute in the object pointed to by `attr`. This attribute controls the kind of scheduling used for threads created with it. If true, the thread is scheduled by the application scheduler. If not, it is scheduled by the system under a fixed priority scheduler.

Returns 0 if successful; otherwise it returns an error code: EINVAL: The value of attr is invalid

Alternatively, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSH implementation and dependant applications

4.2.4.4 `int fosa_thread_attr_set_appsched_params (frsh_thread_attr_t * attr, const void * param, size_t paramsize)`

[fosa_thread_attr_set_appsched_params\(\)](#)

Set the appsched_param attribute of a thread attributes object

This function is used to set the appsched_param attribute in the object pointed to by attr. For those threads with appscheduled set to true, this attribute represents the application-specific scheduling parameters. If successful, the function shall set the size of the appsched_param attribute to the value specified by paramsize, and shall copy the scheduling parameters occupying paramsize bytes and pointed to by param into that attribute

Returns 0 if successful; otherwise it returns an error code: EINVAL: The value of attr is invalid, or paramsize is less than zero or larger than FOSA_ADS_SCHEDPARAM_MAX

Alternatively, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSH implementation and dependant applications

4.2.4.5 `int fosa_thread_attr_get_appsched_params (const frsh_thread_attr_t * attr, void * param, size_t * paramsize)`

[fosa_thread_attr_get_appsched_params\(\)](#)

Get the appsched_param attribute of a thread attributes object

This function is used to get the appsched_param attribute from the object pointed to by attr. For those threads with appscheduled set to true, this attribute represents the application-specific scheduling parameters. If successful, the function shall set the value pointed to by paramsize to the size of the appsched_param attribute, and shall copy the scheduling parameters occupying paramsize bytes into the variable pointed to by param. This variable should be capable of storing a number of bytes equal to paramsize.

Returns 0 if successful; otherwise it returns an error code: EINVAL: The value of attr is invalid

Alternatively, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSH implementation and dependant applications

4.2.4.6 `int fosa_ads_set_appscheduled (frsh_thread_id_t thread, bool appscheduled)`

[fosa_ads_set_appscheduled\(\)](#)

Dynamically set the appscheduled attribute of a thread

This function is used to dynamically set the appscheduled attribute of the thread identified by thread. This attribute controls the kind of scheduling used for threads created with it. If true, the thread is scheduled by the application scheduler. If not, it is scheduled by the system under a fixed priority scheduler.

Returns 0 if successful; otherwise it returns an error code: EINVAL: The value of thread is invalid

EREJECT: the attachment of the thread to the frsh scheduler was rejected by the frsh scheduler possibly because of incorrect attributes, or because the requested minimum capacity cannot be guaranteed

Alternatively, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSH implementation and dependant applications

4.2.4.7 int fosa_ads_get_appscheduled (frsh_thread_id_t thread, bool * appscheduled)

fosa_ads_getappscheduled()

Dynamically get the appscheduled attribute of a thread

This function is used to dynamically get the appscheduled attribute of the thread identified by thread. This attribute controls the kind of scheduling used for threads created with it. If true, the thread is scheduled by the application scheduler. If not, it is scheduled by the system under a fixed priority scheduler

Returns 0 if successful; otherwise it returns an error code: EINVAL: The value of thread is invalid

Alternatively, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSH implementation and dependant applications

4.2.4.8 int fosa_ads_set_appschedparam (frsh_thread_id_t thread, const void * param, size_t paramsize)

fosa_ads_setappschedparam()

Dynamically set the appsched_param attribute of a thread

This function is used to dynamically set the appsched_param attribute of the thread identified by thread. For those threads with appscheduled set to true, this attribute represents the application-specific scheduling parameters. If successful, the function shall set the size of the appsched_param attribute to the value specified by paramsize, and shall copy the scheduling parameters occupying paramsize bytes and pointed to by param into that attribute

Returns 0 if successful; otherwise it returns an error code: EINVAL: The value of thread is invalid, or paramsize is less than zero or larger than FOSA_ADS_SCHEDPARAM_MAX

Alternatively, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSH implementation and dependant applications

4.2.4.9 int fosa_ads_get_appsched_params (frsh_thread_id_t thread, void * param, size_t * paramsize)

[fosa_ads_get_appsched_params\(\)](#)

Dynamically get the appsched_param attribute of a thread

This function is used to dynamically get the appsched_param attribute of the thread identified by thread. For those threads with appscheduled set to true, this attribute represents the application-specific scheduling parameters. If successful, the function shall set the variable pointed to by paramsize to the size of the appsched_param attribute, and shall copy the scheduling parameters occupying paramsize bytes into the variable pointed to by param. This variable should be capable of storing a number of bytes equal to paramsize.

Returns 0 if successful; otherwise it returns an error code: EINVAL: The value of thread is invalid, or paramsize is less than zero or larger than FOSA_ADS_SCHEDPARAM_MAX

Alternatively, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSH implementation and dependant applications.

4.2.4.10 int fosa_adsactions_add_reject (fosa_ads_actions_t * sched_actions, frsh_thread_id_t thread)

[fosa_adsactions_add_reject\(\)](#)

Add a reject-thread action

This function adds a thread-reject action to the object referenced by `sched_actions`, that will serve to notify that the thread identified by `thread` has not been accepted by the scheduler to be scheduled by it, possibly because the thread contained invalid application scheduling attributes, or because there are not enough resources for the new thread. At the end of the `new_thread()` scheduler primitive operation, the parent of the rejected thread waiting on a `fosa_thread_create()` or the rejected thread itself waiting on a `fosa_ads_set_appscheduled()` function shall complete the function with an error code of `EREJECT`. If no reject-thread action is added during the `new_thread()` scheduler primitive operation, the thread is accepted to be scheduled by the scheduler and the associated `fosa_thread_create()` or the `fosa_ads_set_appscheduled()` function shall be completed without error. For the function to succeed, it has to be called from the `new_thread()` primitive operation and for the thread that is requesting attachment to the scheduler.

Returns 0 if successful; otherwise it returns an error code: `ENOMEM`: There is insufficient memory to add this action `EPOLICY`: The thread specified by `thread` is not the one requesting attachment to the scheduler, or the function is not being called from the `new_thread` primitive operation `EINVAL`: The value specified by `sched_actions` is invalid

Alternatively, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSH implementation and dependant applications

4.2.4.11 `int fosa_adsactions_add_activate (fosa_ads_actions_t * sched_actions, frsh_thread_id_t thread, fosa_ads_urgency_t urgency)`

`fosa_adsactions_add_activate()`

Add a thread-activate action

This function adds a thread-activate action to the object referenced by `sched_actions`. In case the thread had been previously suspended via `posix_appsched_actions_addsuspend()`, it will be activated at the end of the primitive operation.

In those implementations that do not support urgency scheduling, the `urgencu` value is ignored. These implementations cannot support the frsh hierarchical scheduling module.

In those implementations supporting urgency-scheduling, the action will cause the change of the urgency of the thread to the value specified in the `urgency` argument. Besides, if the thread was already active at the time the thread-activate action is executed, the change of urgency will imply a reordering of the thread in its priority queue, so that for threads of the same priority, those with more urgency will be scheduled before those of less urgency.

Returns 0 if successful; otherwise it returns an error code: `ENOMEM`: There is insufficient memory to add this action `EPOLICY`: The thread specified by `thread` has its `appscheduled` attribute set to false, `EINVAL`: The value specified by `sched_actions` is invalid

Alternatively, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSH implementation and dependant applications

4.2.4.12 `int fosa_adsactions_add_suspend (fosa_ads_actions_t * sched_actions, frsh_thread_id_t thread)`

`fosa_adsactions_add_suspend()`

Add a thread-suspend action

This function adds a thread-suspend action to the object referenced by `sched_actions`, that will cause the thread identified by `thread` to be suspended waiting for a thread-activate action at the end of the scheduler operation. If the thread was already waiting for a thread-activate action the thread-suspend action has no effect. It is an error trying to suspend a thread that is blocked by the operating system.

Returns 0 if successful; otherwise it returns an error code: `ENOMEM`: There is insufficient memory to add

this action EPOLICY: The thread specified by thread has its appscheduled attribute set to false, EINVAL: The value specified by sched_actions is invalid

Alternatively, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSH implementation and dependant applications

4.2.4.13 `int fosa_adsactions_add_timeout (fosa_ads_actions_t * sched_actions, fosa_clock_id_t clock_id, const struct timespec * at_time)`

[fosa_adsactions_add_timeout\(\)](#)

Add a timeout action

This function adds a timeout action to the object referenced by sched_actions, that will cause the timeout() scheduler operation to be invoked if no other scheduler operation is invoked before timeout expires. The timeout shall expire when the clock specified by clock_id reaches the absolute time specified by the at_time argument.

Returns 0 if successful; otherwise it returns an error code: ENOMEM: There is insufficient memory to add this action EPOLICY: The thread specified by thread has its appscheduled attribute set to false, EINVAL: The value specified by sched_actions is invalid

Alternatively, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSH implementation and dependant applications

4.2.4.14 `int fosa_adsactions_add_thread_notification (fosa_ads_actions_t * sched_actions, frsh_thread_id_t thread, fosa_clock_id_t clock_id, const struct timespec * at_time)`

[fosa_adsactions_add_thread_notification\(\)](#)

Add a timed-thread-notification action

This function adds a thread-notification action associated with the thread specified in the thread argument that will cause the notification_for_thread() scheduler operation to be invoked at the time specified by at_time. This operation shall be invoked when the clock specified by clock_id reaches the absolute time specified by the at_time argument. In particular, a cpu-time clock may be used for parameter clock_id. Only one thread-notification can be active for each thread and clock. Calling the function shall remove the former thread-notification, if any, that had been programmed for the same thread and clock. A value of NULL for parameter at_time is used to cancel a previous thread-notification, if any, for the thread specified by thread and the clock specified by clock_id.

Returns 0 if successful; otherwise it returns an error code: ENOMEM: There is insufficient memory to add this action EPOLICY: The thread specified by thread has its appscheduled attribute set to false, EINVAL: The value specified by sched_actions is invalid

Alternatively, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSH implementation and dependant applications

4.2.4.15 `int fosa_ads_set_handled_signal_set (frsh_signal_t set[])`

[fosa_ads_set_handled_signal_set\(\)](#)

Specify the set of signals that will be handled by the application scheduler

This function is used to dynamically set the set of signals that are handled by the application scheduler. When a signal included in this set is generated, the signal() primitive operation of the application scheduler shall be executed. When a signal in tis set is generated, it shall always imply the execution of the signal() primitive operation, regardless of whether that signal could be accepted by some other thread. Once the signal() primitive operation is executed the signal is consumed, so no signal handlers shall be executed and

no threads using a sigwait operation shall return for that particular signal instance. For this function to succeed, it has to be called from a primitive operation of a scheduler.

Returns 0 if successful; otherwise it returns an error code: EPOLICY: The function has not been called from a scheduler primitive operation EINVAL: The value specified by set is invalid

Alternatively, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSH implementation and dependant applications

4.2.4.16 `int fosa_ads_invoke_withdata (const void * msg, size_t msg_size, void * reply, size_t * reply_size)`

[fosa_ads_invoke_withdata\(\)](#)

Explicitly invoke the scheduler, with data

This function can be used by any thread in the process to invoke the ads scheduler or to share data with it.

If successful, the function shall cause the execution of the primitive operation `explicit_call_with_data()` of the ads scheduler with its thread parameter equal to the thread ID of the calling thread, and its `msg_size` parameter equal to `msg_size`. In addition, if `msg_size` is larger than zero, the function shall make available to the scheduler a memory area whose contents are identical to the memory area pointed to by `msg` in the `msg` parameter of the `explicit_call_with_data()` primitive operation (note that copying the information is not needed).

The function shall not return until the system has finished execution of the `explicit_call_with_data()` primitive operation. If the `reply` argument is non NULL, the memory area pointed to by the `reply` parameter of `explicit_call_with_data()` primitive operation is copied into the memory area pointed to by `reply`, and its size is copied into the variable pointed to by `reply_size`. The size of the reply information is limited to the value `FOSA_ADS_SCHEDINFO_MAX`.

The function shall fail if the size specified by `msg_size` is larger than `FOSA_ADS_SCHEDINFO_MAX`. The function shall fail if primitive operation `explicit_call_with_data()` is set to NULL for the ads scheduler.

Returns 0 if successful; otherwise it returns an error code: EPOLICY: The function been called from inside a scheduler primitive operation EINVAL: The value of `msg_size` is less than zero or larger than `FOSA_ADS_SCHEDINFO_MAX` EMASKED: The operation cannot be executed because the primitive operation `explicit_call_with_data()` is set to NULL

Alternatively, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSH implementation and dependant applications

4.3 Clocks and Timers

Typedefs

- typedef `FOSA_CLOCK_ID_T_OPAQUE` `fosa_clock_id_t`
- typedef `FOSA_TIMER_ID_T_OPAQUE` `fosa_timer_id_t`

Functions

- int [fosa_clock_get_time](#) (`fosa_clock_id_t` clockid, struct timespec current_time)
- int [fosa_thread_get_cputime_clock](#) (`frsh_thread_id_t` tid, `fosa_clock_id_t` *clockid)
- int [fosa_timer_create](#) (`fosa_clock_id_t` clockid, `frsh_signal_t` signal, `frsh_signal_info_t` info, `fosa_timer_id_t` *timerid)
- int [fosa_timer_delete](#) (`fosa_timer_id_t` timerid)
- int [fosa_timer_arm](#) (`fosa_timer_id_t` timerid, bool abstime, const struct timespec *value)

- int [fosa_timer_disarm](#) (fosa_timer_id_t timerid)

4.3.1 Detailed Description

This module defines the types and functions to abstract clocks and timers for the FRSH implementation.

4.3.2 Function Documentation

4.3.2.1 int [fosa_clock_get_time](#) (fosa_clock_id_t *clockid*, struct timespec *current_time*)

[fosa_get_time](#)()

Get the time from a clock

This function sets the variable pointed to by *current_time* to the current value of the clock specified by *clockid*, which may be the `FOSA_CLOCK_REALTIME` constant or a value obtained with [fosa_get_cputime_clock](#)()

Returns 0 if successful; otherwise it returns an error code: `EINVAL`: the value of *clockid* is invalid

Alternatively, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSH implementation and dependant applications

4.3.2.2 int [fosa_thread_get_cputime_clock](#) (frsh_thread_id_t *tid*, fosa_clock_id_t * *clockid*)

[fosa_get_cputime_clock](#)()

Get the identifier of a cpu-time clock

This function stores in the variable pointed to by *clockid* the identifier of a cpu-time clock for the thread specified by *tid*.

Returns 0 if successful; otherwise it returns an error code: `EINVAL`: the value of *tid* is invalid

Alternatively, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSH implementation and dependant applications

4.3.2.3 int [fosa_timer_create](#) (fosa_clock_id_t *clockid*, frsh_signal_t *signal*, frsh_signal_info_t *info*, fosa_timer_id_t * *timerid*)

[fosa_create_timer](#)()

Create a one-shot timer

This function creates a timer based on the clock specified by *clock*, and associates to this timer a notification mechanism consisting of a signal and associated information. Initially, the timer is in the disarmed state, i.e., not counting time. It can be armed to start counting time with [fosa_timer_arm](#)()

The function stores the identifier of the newly created timer in the variable pointed to by *timerid*.

When the timer expires, the signal number specified by *signal* will be sent together with the information specified by *info*, to the thread that armed the timer (

See also:

[fosa_timer_arm](#)()

In those implementations that do not support queueing a signal with information to a thread (such as POSIX), the signal may be sent to any thread that is waiting for this signal via [fosa_signal_wait](#)(). Portability can be ensured by having the receiver thread be the one who is waiting for the signal.

Returns 0 if successful; otherwise it returns an error code: EINVAL: the value of clockid or signal is invalid
EAGAIN: the system lacks enough resources to create the timer

Alternatively, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSH implementation and dependant applications

4.3.2.4 `int fosa_timer_delete (fosa_timer_id_t timerid)`

Delete a timer

The function deletes the timer specified by timerid, which becomes unusable. If the timer was armed, it is automatically disarmed before deletion.

Returns 0 if successful; otherwise it returns an error code: EINVAL: the value of timerid is not valid

Alternatively, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSH implementation and dependant applications

4.3.2.5 `int fosa_timer_arm (fosa_timer_id_t timerid, bool abstime, const struct timespec * value)`

[fosa_timer_arm\(\)](#)

Arm a timer

The timer specified by timer is armed and starts counting time.

If abstime is true, the value pointed to by value is the absolute time at which the timer will expire. If value specifies a time instant in the past, the timer expires immediately.

If abstime is false, the value pointed to by value is the relative interval that must elapse for the timer to expire.

In both cases, absolute or relative, the time is measured with the clock associated with the timer when it was created.

If the timer was already armed, the previous time or interval is discarded and the timer is rearmed with the new value.

When the timer expires, it is disarmed.

Returns 0 if successful; otherwise it returns an error code: EINVAL: the value of timerid or value is invalid

Alternatively, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSH implementation and dependant applications

4.3.2.6 `int fosa_timer_disarm (fosa_timer_id_t timerid)`

[fosa_timer_disarm\(\)](#)

Disarm a timer

The timer specified by timer is disarmed, and will not expire unless it is rearmed. If the timer was already disarmed, the function has no effect.

Returns 0 if successful; otherwise it returns an error code: EINVAL: the value of timerid or value is invalid

Alternatively, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSH implementation and dependant applications

4.4 FOSA Errors

We define return error values.

4.5 Mutexes and Condvars

Functions

- [int fosa_mutex_init](#) (frsh_mutex_t *mutex, int prioceiling)
- [int fosa_mutex_destroy](#) (frsh_mutex_t *mutex)
- [int fosa_mutex_set_prioceiling](#) (frsh_mutex_t *mutex, int new_ceiling, int *old_ceiling)
- [int fosa_mutex_get_prioceiling](#) (const frsh_mutex_t *mutex, int *ceiling)
- [int fosa_mutex_lock](#) (frsh_mutex_t *mutex)
- [int fosa_mutex_trylock](#) (frsh_mutex_t *mutex)
- [int fosa_mutex_unlock](#) (frsh_mutex_t *mutex)
- [int fosa_cond_init](#) (fosa_cond_t *cond)
- [int fosa_cond_destroy](#) (fosa_cond_t *cond)
- [int fosa_cond_signal](#) (fosa_cond_t *cond)
- [int fosa_cond_broadcast](#) (fosa_cond_t *cond)
- [int fosa_cond_wait](#) (fosa_cond_t *cond, frsh_mutex_t *mutex)
- [int fosa_cond_timedwait](#) (fosa_cond_t *cond, frsh_mutex_t *mutex, const struct timespec abstime)

4.5.1 Detailed Description

This module defines the types and functions to abstract mutexes and conditional variables for the FRSB implementation.

4.5.2 Function Documentation

4.5.2.1 [int fosa_mutex_init](#) (frsh_mutex_t * *mutex*, int *prioceiling*)

[fosa_mutex_init\(\)](#)

Initialize a frsh mutex

The mutex pointed to by *mutex* is initialized as a mutex using the priority ceiling protocol. A priority ceiling of *prioceiling* is assigned to this mutex.

Returns 0 if successful; otherwise it returns an error code: EINVAL: the value of *prioceiling* is invalid EAGAIN: the system lacked the necessary resources to create the mutex ENOMEM: Insufficient memory exists to initialize the mutex EBUSY: The system has detected an attempt to reinitialize the mutex

Alternatively, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSB implementation and dependant applications

4.5.2.2 [int fosa_mutex_destroy](#) (frsh_mutex_t * *mutex*)

[fosa_mutex_destroy\(\)](#)

Destroy a frsh mutex

The mutex pointed to by *mutex* is destroyed

Returns 0 if successful; otherwise it returns an error code: EINVAL: the value of *mutex* is invalid EBUSY: The mutex is in use (is locked)

Alternatively, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSH implementation and dependant applications

4.5.2.3 `int fosa_mutex_set_prioceiling (frsh_mutex_t * mutex, int new_ceiling, int * old_ceiling)`

[fosa_mutex_set_prioceiling\(\)](#)

Dynamically set the priority ceiling of a mutex

This function locks the mutex (blocking the calling thread if necessary) and after it is locked it changes its priority ceiling to the value specified by `new_ceiling`, and then it unlocks the mutex. The previous value of the ceiling is returned in `old_ceiling`.

Returns 0 if successful; otherwise it returns an error code: EINVAL: the value of mutex or prioceiling is invalid

Alternatively, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSH implementation and dependant applications

4.5.2.4 `int fosa_mutex_get_prioceiling (const frsh_mutex_t * mutex, int * ceiling)`

[fosa_mutex_get_prioceiling\(\)](#)

Dynamically get the priority ceiling of a mutex

This function copies into the variable pointed to by `ceiling` the current priority ceiling of the mutex referenced by `mutex`

Returns 0 if successful; otherwise it returns an error code: EINVAL: the value of mutex is invalid

Alternatively, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSH implementation and dependant applications

4.5.2.5 `int fosa_mutex_lock (frsh_mutex_t * mutex)`

[fosa_mutex_lock\(\)](#)

Lock a mutex

This function locks the mutex specified by `mutex`. If it is already locked, the calling thread blocks until the mutex becomes available. The operation returns with the mutex in the locked state, with the calling thread as its owner.

Returns 0 if successful; otherwise it returns an error code: EINVAL: the value of mutex is invalid, or the priority of the calling thread is higher than the priority ceiling of the mutex EDEADLK: the current thread already owns this mutex

Alternatively, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSH implementation and dependant applications

4.5.2.6 `int fosa_mutex_trylock (frsh_mutex_t * mutex)`

[fosa_mutex_trylock\(\)](#)

Try locking a mutex

This function is identical to [fosa_mutex_lock\(\)](#) except that if the mutex is already locked the call returns immediately with an error indication.

Returns 0 if successful; otherwise it returns an error code: EINVAL: the value of mutex is invalid, or the priority of the calling thread is higher than the priority ceiling of the mutex EBUSY: the mutex was already

locked

Alternatively, except for EBUSY, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSH implementation and dependant applications

4.5.2.7 `int fosa_mutex_unlock (frsh_mutex_t * mutex)`

[fosa_mutex_unlock\(\)](#)

Unlock a mutex

This function must be called by the owner of the mutex referenced by `mutex`, to unlock it. If there are threads blocked on the mutex the mutex becomes available and the highest priority thread is awakened to acquire the mutex.

Returns 0 if successful; otherwise it returns an error code: EINVAL: the value of `mutex` is invalid EPERM: the calling thread is not the owner of the mutex

Alternatively, except for EBUSY, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSH implementation and dependant applications

4.5.2.8 `int fosa_cond_init (fosa_cond_t * cond)`

[fosa_cond_init\(\)](#)

Initiatize a condition variable

The condition variable referenced by `cond` is initialized with the attributes required by the FOSA implementation.

Returns 0 if successful; otherwise it returns an error code: EAGAIN: the system lacked the necessary resources to create the condition variable ENOMEM: Insufficient memory exists to initialize the condition variable EBUSY: The system has detected an attempt to reinitialize the condition variable

Alternatively, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSH implementation and dependant applications

4.5.2.9 `int fosa_cond_destroy (fosa_cond_t * cond)`

[fosa_cond_destroy\(\)](#)

Destroy a condition variable

The condition variable pointed to by `cond` is destroyed

Returns 0 if successful; otherwise it returns an error code: EINVAL: the value of `cond` is invalid EBUSY: The condition variable is in use (a thread is waiting on it)

Alternatively, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSH implementation and dependant applications

4.5.2.10 `int fosa_cond_signal (fosa_cond_t * cond)`

[fosa_cond_signal\(\)](#)

Signal a condition variable

This call unblocks at least one of the threads that are waiting on the condition variable referenced by `cond`. If there are no threads waiting, the function has no effect

Returns 0 if successful; otherwise it returns an error code: EINVAL: the value of `cond` is invalid

Alternatively, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSH implementation and dependant applications

4.5.2.11 `int fosa_cond_broadcast (fosa_cond_t * cond)`

[fosa_cond_broadcast\(\)](#)

Broadcast a condition variable

This call unblocks all of the threads that are waiting on the condition variable referenced by cond. If there are no threads waiting, the function has no effect.

Returns 0 if successful; otherwise it returns an error code: EINVAL: the value of cond is invalid

Alternatively, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSH implementation and dependant applications

4.5.2.12 `int fosa_cond_wait (fosa_cond_t * cond, frsh_mutex_t * mutex)`

[fosa_cond_wait\(\)](#)

Wait at a condition variable

This call is used to block on the condition variable referenced by cond. It shall be called with the mutex referenced by mutex locked. The function releases the mutex and blocks the calling thread until the condition is signalled by some other thread and the calling thread is awakened. Then it locks the mutex and returns with the mutex locked by the calling thread.

Returns 0 if successful; otherwise it returns an error code: EINVAL: the value of cond or mutex is invalid, or different mutexes were used for concurrent wait operations on cond, or the mutex was not owned by the calling thread

Alternatively, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSH implementation and dependant applications

4.5.2.13 `int fosa_cond_timedwait (fosa_cond_t * cond, frsh_mutex_t * mutex, const struct timespec abstime)`

[fosa_cond_timedwait\(\)](#)

Wait at a condition variable, with a timeout

This function is equal to [fosa_cond_wait\(\)](#), except that the maximum wait time is limited to the absolute time referenced by abstime, as measured by the FOSA_CLOCK_REALTIME clock.

Returns 0 if successful; otherwise it returns an error code: EINVAL: the value of cond or mutex or abstime is invalid, or different mutexes were used for concurrent wait operations on cond, or the mutex was not owned by the calling thread ETIMEDOUT: the timeout expired

Alternatively, except for ETIMEDOUT, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSH implementation and dependant applications

4.6 Thread and Signals

Functions

- bool [fosa_thread_equal](#) (frsh_thread_id_t t1, frsh_thread_id_t t2)
- frsh_thread_id_t [fosa_thread_self](#) ()

- `int fosa_thread_create` (`frsh_thread_id_t *tid`, `const frsh_thread_attr_t *attr`, `frsh_thread_code_t code`, `void *arg`)
- `int fosa_thread_set_specific_data` (`int key`, `frsh_thread_id_t tid`, `const void *value`)
- `int fosa_thread_get_specific_data` (`int key`, `frsh_thread_id_t tid`, `void **value`)
- `int fosa_get_priority_max` ()
- `int fosa_get_priority_min` ()
- `int fosa_thread_attr_set_prio` (`frsh_thread_attr_t *attr`, `int prio`)
- `int frsh_thread_attr_get_prio` (`const frsh_thread_attr_t *attr`, `size_t *prio`)
- `int fosa_thread_set_prio` (`frsh_thread_id_t tid`, `int prio`)
- `int fosa_thread_get_prio` (`frsh_thread_id_t tid`, `int *prio`)
- `int frsh_set_accepted_signals` (`frsh_signal_t set[]`, `int size`)
- `int fosa_signal_queue` (`frsh_signal_t signal`, `frsh_signal_info_t info`, `frsh_thread_id_t receiver`)
- `int fosa_signal_wait` (`frsh_signal_t set[]`, `int size`, `frsh_signal_t *signal_received`, `frsh_signal_info_t *info`)
- `int fosa_signal_timedwait` (`frsh_signal_t set[]`, `int size`, `frsh_signal_t *signal_received`, `frsh_signal_info_t *info`, `const struct timespec *timeout`)

4.6.1 Detailed Description

This module defines the functions that manipulate `frsh_threads` and `frsh_signals` inside FRSB implementation.

Applications can refer to FRSB threads but they cannot create them directly, instead they must use `frsh_thread_create*`() which in turn use `fosa_thread_create`() .

For signals, we assume that the OS provides a direct mapping for `frsh_signal_t` and `frsh_signal_info_t` in the native interface.

4.6.2 Function Documentation

4.6.2.1 `bool fosa_thread_equal` (`frsh_thread_id_t t1`, `frsh_thread_id_t t2`)

`fosa_thread_equal`()

Compare two thread identifiers to determine if they refer to the same thread

4.6.2.2 `frsh_thread_id_t fosa_thread_self` ()

`fosa_thread_self`()

Return the thread id of the calling thread

4.6.2.3 `int fosa_thread_create` (`frsh_thread_id_t *tid`, `const frsh_thread_attr_t *attr`, `frsh_thread_code_t code`, `void * arg`)

`fosa_thread_create`()

This function creates a new thread using the attributes specified in `attr`. If `attr` is `NULL`, default attributes are used. The new thread starts running immediately, executing the function specified by `code`, with an argument equal to `arg`. Upon successful return, the variable pointed to by `tid` will contain the identifier of the newly created thread. The set of signals that may be synchronously accepted is inherited from the parent thread.

Returns 0 if successful; otherwise it returns a code error:

EAGAIN: the system lacks the necessary resources to create a new thread or the maximum number of threads has been reached

EINVAL: the value specified by attr is invalid (for instance, it has not been correctly initialized)

EREJECT: the creation of the thread was rejected by the frsh scheduler possibly because of incorrect attributes, or because the requested minimum capacity cannot be guaranteed

4.6.2.4 `int fosa_thread_set_specific_data (int key, frsh_thread_id_t tid, const void * value)`

[fosa_thread_set_specific_data\(\)](#)

Set thread-specific data

For the thread identified by tid, the thread-specific data field identified by key will be set to the value specified by value

Returns 0 if successful; otherwise, an error code is returned EINVAL: the value of key is not between 0 and FOSA_MAX_KEYS-1

Alternatively, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSB implementation and dependant applications

4.6.2.5 `int fosa_thread_get_specific_data (int key, frsh_thread_id_t tid, void ** value)`

[fosa_thread_get_specific_data\(\)](#)

Get thread-specific data

For the thread identified by tid, the thread-specific data field identified by key will be copied to the variable pointed to by value

Returns 0 if successful; otherwise, an error code is returned EINVAL: the value of key is not between 0 and FOSA_MAX_KEYS-1

Alternatively, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSB implementation and dependant applications

4.6.2.6 `int fosa_get_priority_max ()`

[fosa_get_priority_max\(\)](#)

Return the maximum priority value used in this implementation

4.6.2.7 `int fosa_get_priority_min ()`

[fosa_get_priority_min\(\)](#)

Return the minimum priority value used in this implementation

4.6.2.8 `int fosa_thread_attr_set_prio (frsh_thread_attr_t * attr, int prio)`

[fosa_thread_attr_set_prio\(\)](#)

Change the priority of a thread attributes object

The priority of the thread attributes object specified by attr is set to the value specified by prio. This function has no runtime effect on the priority, except when the attributes object is used to create a thread, when it will be created with the specified priority

Returns 0 if successful, or the following error code: EINVAL: the specified priority value is not between the minimum and the maximum priorities defined in this FRSH implementation Alternatively, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSH implementation and dependant applications

4.6.2.9 `int frsh_thread_attr_get_prio (const frsh_thread_attr_t * attr, size_t * prio)`

[frsh_thread_attr_get_prio\(\)](#)

Get the priority from a thread attributes object

This function sets the variable pointed to by prio to the priority stored in the thread attributes object attr.

Returns 0

4.6.2.10 `int fosa_thread_set_prio (frsh_thread_id_t tid, int prio)`

[fosa_thread_set_prio\(\)](#)

Dynamically change the priority of a thread

The priority of the thread identified by tid is set to the value specified by prio.

Returns 0 if successful, or the following error code: EINVAL: the specified priority value is not between the minimum and the maximum priorities defined in this FRSH implementation Alternatively, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSH implementation and dependant applications

4.6.2.11 `int fosa_thread_get_prio (frsh_thread_id_t tid, int * prio)`

[fosa_thread_get_prio\(\)](#)

Dynamically get the priority of a thread

This function sets the variable pointed to by prio to the priority of the thread identified by tid

Returns 0

4.6.2.12 `int frsh_set_accepted_signals (frsh_signal_t set[], int size)`

[fosa_set_accepted_signals\(\)](#)

Establish the set of signals that may be synchronously accepted by the calling thread

The function uses the array of signal numbers specified by set, which must be of size equal to size

Returns 0 if successful; otherwise it returns an error code: EINVAL: the array contains one or more values which are not between FOSA_SIGNAL_MIN and FOSA_SIGNAL_MAX, or size is less than 0

Alternatively, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSH implementation and dependant applications

4.6.2.13 `int fosa_signal_queue (frsh_signal_t signal, frsh_signal_info_t info, frsh_thread_id_t receiver)`

[fosa_signal_queue\(\)](#)

Queue a signal

This function is used to explicitly send a signal with a specified value

The signal number specified by `signal` is sent together with the information specified by `info`, to the thread identified by `receiver`. In those implementations that do not support queuing a signal with information to a thread (such as POSIX), the signal may be sent to any thread that is waiting for this signal via `fosa_signal_wait()`. Portability can be ensured by having the receiver thread be the one who is waiting for the signal.

Returns 0 if successful; otherwise it returns an error code: EINVAL: the signal specified by `signal` is not between FOSA_SIGNAL_MIN and FOSA_SIGNAL_MAX

EAGAIN: no resources are available to queue the signal; the maximum number of queued signals has been reached, or a systemwide resource limit has been exceeded

Alternatively, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSH implementation and dependant applications

4.6.2.14 `int fosa_signal_wait (frsh_signal_t set[], int size, frsh_signal_t * signal_received, frsh_signal_info_t * info)`

`fosa_signal_wait()`

Wait for a signal

The function waits for the arrival of one of the signals in the array of signal numbers specified by `set`, which must be of size equal to `size`. If there is a signal already queued, the function returns immediately. If there is no signal of the specified set queued, the calling thread is suspended until a signal from that set arrives. Upon return, if `signal_received` is not NULL the number of the signal received is stored in the variable pointed to by `signal_received`; and if `info` is not NULL the associated information is stored in the variable pointed to by `info`.

Returns 0 if successful; otherwise it returns an error code: EINVAL: the array contains one or more values which are not between FOSA_SIGNAL_MIN and FOSA_SIGNAL_MAX, or `size` is less than 0

Alternatively, in case of error the implementation is allowed to notify it to the system console and then terminate the FRSH implementation and dependant applications

4.6.2.15 `int fosa_signal_timedwait (frsh_signal_t set[], int size, frsh_signal_t * signal_received, frsh_signal_info_t * info, const struct timespec * timeout)`

`fosa_signal_timedwait()`

Timed wait for a signal

This function behaves the same as `fosa_signal_wait()`, except that the suspension time is limited to the time interval specified in the `timespec` structure referenced by `timeout`.

Returns 0 if successful; otherwise it returns an error code: EINVAL: the array contains one or more values which are not between FOSA_SIGNAL_MIN and FOSA_SIGNAL_MAX, or `size` is less than 0, or `timeout` is invalid EAGAIN: The timeout expired

Alternatively, in case of the EINVAL error the implementation is allowed to notify it to the system console and then terminate the FRSH implementation and dependant applications

5 FOSA Data Structure Documentation

5.1 `fosa_ads_scheduler_ops_t` Struct Reference

```
#include <fosa_types.h>
```

Data Fields

- void(* **init**)(void *sched_data, void *arg)
- void(* **new_thread**)(void *sched_data, frsh_thread_id_t thread, [fosa_ads_actions_t](#) *actions, struct timespec *current_time)
- void(* **thread_terminate**)(void *sched_data, frsh_thread_id_t thread, [fosa_ads_actions_t](#) *actions, struct timespec *current_time)
- void(* **thread_ready**)(void *sched_data, frsh_thread_id_t thread, [fosa_ads_actions_t](#) *actions, struct timespec *current_time)
- void(* **thread_block**)(void *sched_data, frsh_thread_id_t thread, [fosa_ads_actions_t](#) *actions, struct timespec *current_time)
- void(* **change_sched_param_thread**)(void *sched_data, frsh_thread_id_t thread, [fosa_ads_actions_t](#) *actions, struct timespec *current_time)
- void(* **explicit_call_with_data**)(void *sched_data, frsh_thread_id_t thread, const void *msg, size_t msg_size, void **reply, size_t *reply_size, [fosa_ads_actions_t](#) *actions, struct timespec *current_time)
- void(* **notification_for_thread**)(void *sched_data, frsh_thread_id_t thread, fosa_clock_id_t clock, [fosa_ads_actions_t](#) *actions, struct timespec *current_time)
- void(* **timeout**)(void *sched_data, [fosa_ads_actions_t](#) *actions, struct timespec *current_time)
- void(* **signal**)(void *sched_data, frsh_signal_t signal, frsh_signal_info_t siginfo, [fosa_ads_actions_t](#) *actions, struct timespec *current_time)
- void(* **appshed_error**)(void *sched_data, frsh_thread_id_t thread, [fosa_ads_error_cause_t](#) cause, [fosa_ads_actions_t](#) *actions)

5.1.1 Detailed Description

Scheduler primitive operations

This structure is used to create application schedulers. It contains pointers to the primitive operations that are invoked by the system when a scheduling event occurs:

- The **init()** primitive operation is invoked by the system just after the scheduler has been created using [fosa_ads_scheduler_create\(\)](#).
- The **new_thread()** primitive operation is invoked by the system when a thread has requested attachment to this scheduler; this can be a newly created thread (via [fosa_thread_create\(\)](#)), or an existing thread that was not running under ads scheduler (via [fosa_ads_set_appscheduled\(\)](#)).

The thread can be rejected by the scheduler adding a reject-thread action to the actions parameter using [fosa_ads_actions_add_reject\(\)](#). If no reject-thread action is added, the thread is accepted.

Newly created threads shall be activated by the system after the execution of the **new_thread()** primitive operation. The urgency of an accepted thread (either newly created or existing) shall be set to a value of zero, unless an activate-thread action with a different value of urgency is added via [fosa_ads_actions_add_activate\(\)](#).

If a request to attach a thread to this scheduler was made via [fosa_ads_set_appscheduled\(\)](#), at the finalization of the **new_thread()** primitive operation if the newly attached thread is blocked by the system (not by the scheduler itself via a suspend scheduling action), a thread-block event shall be generated for the scheduler immediately and, consequently, the **thread_block()** primitive operation shall be invoked by the system.

- The **thread_terminate()** primitive operation is invoked by the system when a thread attached to this scheduler is terminating (via an explicit or implicit thread termination, or cancellation, or when it is no longer scheduled by the ads scheduler (via [fosa_ads_setappscheduled\(\)](#))).

Before the `thread_terminate()` primitive operation is invoked by the system, all the thread-notification events programmed for that thread are cancelled.

In the case of a thread that is terminating, the `thread_terminate()` primitive operation is executed before the execution of the cleanup handlers and of the thread-specific data destructor functions. In that way, the `thread` parameter corresponds to a valid thread Id and the thread-specific data is valid and can be accessed from the `thread_terminate()` primitive operation.

Also for terminating threads, after the `thread_terminate()` primitive operation finishes, the system shall lower the urgency of the thread identified by `thread` to a value of zero, and shall deattach it from the ads scheduler. Then, the thread shall execute the cleanup handlers and the thread-specific data destructor functions outside the management of its former scheduler. Notice that in a multiprocessor system this may imply the suspension of the thread identified by parameter `thread` during the execution of the `thread_terminate()` primitive operation.

- The **`thread_ready()`** primitive operation is invoked by the system when a thread attached to this scheduler that was blocked has become unblocked by the system.
- The **`thread_block()`** primitive operation is invoked by the system when a thread attached to this scheduler has blocked.
- The **`change_sched_param_thread()`** primitive operation is invoked by the system when the scheduling parameters of a thread attached to this scheduler have been changed, but the thread continues to run under this scheduler. The change includes either the regular scheduling parameters (`fosa_thread_set_prio()`) or the application- defined scheduling parameters, via `fosa_ads_set_appsched_param()`.
- The **`explicit_call_with_data()`** primitive operation is invoked by the system when a thread (identified by the `thread` parameter) has explicitly invoked the scheduler with a message containing scheduling information, and possibly requesting a reply message, via `fosa_ads_invoke_withdata()`.
- The **`notification_for_thread()`** primitive operation is invoked by the system when the time for a thread-notification previously programmed by the scheduler via `fosa_ads_actions_add_thread_notification()` is reached. Parameter `clock` identifies the clock for which the thread-notification was programmed.
- The **`timeout()`** primitive operation is invoked by the system when a timeout requested by the scheduler (via `fosa_ads_actions_add_timeout()`) has expired.
- The **`signal()`** primitive operation is invoked by the system when a signal belonging to the set of signals for which the scheduler is waiting (via `fosa_ads_set_handled_signal_set()`) has been generated. The signal number and its associated information (if any) are passed in the arguments `signal` and `siginfo`.
The signal is consumed with the invocation of this primitive operation, which implies that it will not cause the execution of any signal handler, nor it may be accepted by any thread waiting for this signal number.
- The **`appsched_error()`** primitive operation is invoked by the system when an error in the scheduling actions list specified in a previous primitive operation is detected. The cause of the error is notified in the parameter `cause`. The defined causes of error are described `fosa_ads_error_cause_t`

Every primitive operation receives the argument `sched_data`. It is a pointer to a memory area containing information shared by all the scheduler operations. It can be used to store the data structures required by

the scheduler (for example, a ready queue and a delay queue). Scheduler operations should not use any other global data out of this memory area.

The actions argument is used by the scheduler to request the operating system to execute a set of scheduling actions at the end of the primitive operation. It is passed empty by the system, and the scheduler may add multiple scheduling actions.

The current_time argument contains the system time measured immediately before the invocation of the primitive operation using the FOSA_CLOCK_REALTIME clock

In addition to these common parameters, most of the primitive operations receive a thread argument. This argument allows the primitive operations to know which is the thread that has produced or is related to the event.

The documentation for this struct was generated from the following file:

- include/fosa_types.h

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