

UMS: Kernel Module

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Chapter 1

Data Structure Index

1.1 Data Structures

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Chapter 2

File Index

2.1 File List

Here is a list of all documented files with brief descriptions:

const.h	Set of data structures and other constant variables used by UMS kernel module	23
ums_api.c	Contains implementations of the UMS kernel module API	27
ums_api.h	The header that contains essential functions, data structures and proc filesystem of the UMS kernel module	44
ums_dev.c	Contains implementations of the UMS miscdevice	63
ums_dev.h	The header that is responsible for UMS miscdevice and includes other headers required by UMS device to function properly	64

Chapter 3

Data Structure Documentation

3.1 completion_list Struct Reference

The list of the completion lists created by the specific process

```
#include <ums_api.h>
```

Data Fields

- struct list_head **list**
- unsigned int [list_count](#)

3.1.1 Detailed Description

The list of the completion lists created by the specific process

3.1.2 Field Documentation

3.1.2.1 list_count

```
unsigned int completion_list::list_count
```

Number of completion lists created by the process

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

- [ums_api.h](#)

3.2 completion_list_node Struct Reference

Represents a node in the [completion_list](#)

```
#include <ums_api.h>
```

Data Fields

- [ums_clid_t](#) `clid`
- struct list_head `list`
- unsigned int [worker_count](#)
- unsigned int [finished_count](#)
- [state_t](#) `state`
- [worker_list_t](#) * `idle_list`
- [worker_list_t](#) * `busy_list`

3.2.1 Detailed Description

Represents a node in the [completion_list](#)

3.2.2 Field Documentation

3.2.2.1 busy_list

```
worker\_list\_t* completion_list_node::busy_list
```

List of worker threads that has been completed or currently running

3.2.2.2 clid

```
ums\_clid\_t completion_list_node::clid
```

Completion list ID

3.2.2.3 finished_count

```
unsigned int completion_list_node::finished_count
```

Number of worker threads that has completed their work

3.2.2.4 idle_list

```
worker_list_t* completion_list_node::idle_list
```

List of worker threads that are ready and waiting to be scheduled

3.2.2.5 state

```
state_t completion_list_node::state
```

State of the completion list

3.2.2.6 worker_count

```
unsigned int completion_list_node::worker_count
```

Number of worker threads assigned to the completion list

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

- [ums_api.h](#)

3.3 list_params Struct Reference

Parameters that are created by the scheduler and passed to dequeue the completion list items

```
#include <const.h>
```

Data Fields

- unsigned int [size](#)
- unsigned int [worker_count](#)
- [state_t](#) [state](#)
- [ums_wid_t](#) [workers](#) []

3.3.1 Detailed Description

Parameters that are created by the scheduler and passed to dequeue the completion list items

3.3.2 Field Documentation

3.3.2.1 size

```
unsigned int list_params::size
```

Size of the worker thread array

3.3.2.2 state

```
state_t list_params::state
```

Tracks the state of the completion list which is set by the kernel module after a dequeue call

3.3.2.3 worker_count

```
unsigned int list_params::worker_count
```

Tracks the quantity of the available workers and used as state indicator for scheduler to perform a new dequeue call

3.3.2.4 workers

```
ums_wid_t list_params::workers[]
```

Array of worker threads. Stores ID of worker threads in case they are available to be scheduled (when worker thread is finished, scheduler replaces ID with -1 value)

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

- [const.h](#)

3.4 process Struct Reference

Represents a node in the [process_list](#)

```
#include <ums_api.h>
```

Data Fields

- [pid_t](#) [pid](#)
- struct [list_head](#) [list](#)
- [state_t](#) [state](#)
- [completion_list_t](#) * [completion_lists](#)
- [worker_list_t](#) * [worker_list](#)
- [scheduler_list_t](#) * [scheduler_list](#)
- [process_proc_entry_t](#) * [proc_entry](#)

3.4.1 Detailed Description

Represents a node in the [process_list](#)

3.4.2 Field Documentation

3.4.2.1 completion_lists

`completion_list_t*` process::completion_lists

List of completions lists created by the process

3.4.2.2 pid

`pid_t` process::pid

pid of the process or tgid of the process threads

3.4.2.3 proc_entry

`process_proc_entry_t*` process::proc_entry

Proc entries of the process

3.4.2.4 scheduler_list

`scheduler_list_t*` process::scheduler_list

List of schedulers created by the process

3.4.2.5 state

`state_t` process::state

State of the process

3.4.2.6 worker_list

`worker_list_t*` process::worker_list

List of worker threads created by the process

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

- [ums_api.h](#)

3.5 process_list Struct Reference

The list of the processes handled by the UMS kernel module

```
#include <ums_api.h>
```

Data Fields

- struct list_head **list**
- unsigned int [process_count](#)

3.5.1 Detailed Description

The list of the processes handled by the UMS kernel module

3.5.2 Field Documentation

3.5.2.1 process_count

```
unsigned int process_list::process_count
```

Number of processes handled by the UMS kernel module

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

- [ums_api.h](#)

3.6 process_proc_entry Struct Reference

Responsible for tracking proc_dir_entries of the process

```
#include <ums_api.h>
```

Data Fields

- struct proc_dir_entry * [pde](#)
- struct proc_dir_entry * [parent](#)
- struct proc_dir_entry * [child](#)

3.6.1 Detailed Description

Responsible for tracking proc_dir_entries of the process

3.6.2 Field Documentation

3.6.2.1 child

```
struct proc_dir_entry* process_proc_entry::child
```

Child folder of the process' folder (/proc/ums/<PID>/schedulers/)

3.6.2.2 parent

```
struct proc_dir_entry* process_proc_entry::parent
```

Parent folder of the process' folder (/proc/ums/)

3.6.2.3 pde

```
struct proc_dir_entry* process_proc_entry::pde
```

proc_dir_entry of the process (/proc/ums/<PID>/)

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

- [ums_api.h](#)

3.7 scheduler Struct Reference

Represents a node in the [scheduler_list](#)

```
#include <ums_api.h>
```

Data Fields

- [ums_sid_t](#) sid
- [pid_t](#) pid
- [pid_t](#) tid
- [ums_wid_t](#) wid
- unsigned long [entry_point](#)
- unsigned long [return_addr](#)
- unsigned long [stack_ptr](#)
- unsigned long [base_ptr](#)
- [state_t](#) state
- struct pt_regs [regs](#)
- struct fpu [fpu_regs](#)
- [completion_list_node_t](#) * comp_list
- struct list_head [list](#)
- [scheduler_proc_entry_t](#) * proc_entry
- unsigned int [switch_count](#)
- unsigned long [avg_switch_time](#)
- unsigned long [time_needed_for_the_last_switch](#)
- unsigned long [total_time_needed_for_the_switch](#)
- struct timespec64 [time_of_the_last_switch](#)

3.7.1 Detailed Description

Represents a node in the [scheduler_list](#)

3.7.2 Field Documentation

3.7.2.1 avg_switch_time

```
unsigned long scheduler::avg_switch_time
```

Average time needed for context switch

3.7.2.2 base_ptr

```
unsigned long scheduler::base_ptr
```

Snapshot of the base pointer that is restored when exiting scheduling mode

3.7.2.3 comp_list

```
completion_list_node_t* scheduler::comp_list
```

Pointer of the completion list that is associated with the scheduler

3.7.2.4 entry_point

```
unsigned long scheduler::entry_point
```

Function pointer and an entry point set by a user, that serves as a starting point of the scheduler. It is a scheduling function that determines the next thread to be scheduled

3.7.2.5 fpu_regs

```
struct fpu scheduler::fpu_regs
```

Snapshot of FPU registers

3.7.2.6 pid

```
pid_t scheduler::pid
```

pid of the process thread that is currently running the scheduler

3.7.2.7 proc_entry

```
scheduler_proc_entry_t* scheduler::proc_entry
```

Proc entry of the scheduler

3.7.2.8 regs

```
struct pt_regs scheduler::regs
```

Snapshot of CPU registers

3.7.2.9 return_addr

```
unsigned long scheduler::return_addr
```

Snapshot of the instruction pointer that is restored when exiting scheduling mode

3.7.2.10 sid

```
ums_sid_t scheduler::sid
```

Scheduler ID

3.7.2.11 stack_ptr

```
unsigned long scheduler::stack_ptr
```

Snapshot of the stack pointer that is restored when exiting scheduling mode

3.7.2.12 state

```
state_t scheduler::state
```

State of the scheduler

3.7.2.13 switch_count

```
unsigned int scheduler::switch_count
```

Number of context switches

3.7.2.14 tid

```
pid_t scheduler::tid
```

pid of the process that created the scheduler

3.7.2.15 time_needed_for_the_last_switch

```
unsigned long scheduler::time_needed_for_the_last_switch
```

Time needed for the last context switch

3.7.2.16 time_of_the_last_switch

```
struct timespec64 scheduler::time_of_the_last_switch
```

Time when the last switch occurred

3.7.2.17 total_time_needed_for_the_switch

```
unsigned long scheduler::total_time_needed_for_the_switch
```

Total time needed for the context switches

3.7.2.18 wid

```
ums_wid_t scheduler::wid
```

ID of the worker that is managed by the scheduler

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

- [ums_api.h](#)

3.8 scheduler_list Struct Reference

The list of the schedulers created by the specific process

```
#include <ums_api.h>
```

Data Fields

- struct list_head **list**
- unsigned int [scheduler_count](#)

3.8.1 Detailed Description

The list of the schedulers created by the specific process

3.8.2 Field Documentation

3.8.2.1 scheduler_count

```
unsigned int scheduler_list::scheduler_count
```

Number of schedulers created by the process

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

- [ums_api.h](#)

3.9 scheduler_params Struct Reference

Parameters that are passed in order to create a scheduler

```
#include <const.h>
```

Data Fields

- unsigned long [entry_point](#)
- [ums_clid_t](#) clid
- [ums_sid_t](#) sid
- int [core_id](#)

3.9.1 Detailed Description

Parameters that are passed in order to create a scheduler

3.9.2 Field Documentation

3.9.2.1 clid

```
ums\_clid\_t scheduler_params::clid
```

ID of the completion list that is assigned to the scheduler

3.9.2.2 core_id

```
int scheduler_params::core_id
```

ID of the CPU core that is assigned to the scheduler (It is handled automatically by the library, no user input required)

3.9.2.3 entry_point

```
unsigned long scheduler_params::entry_point
```

Function pointer and an entry point set by a user, that serves as a starting point of the scheduler. It is a scheduling function that determines the next thread to be scheduled

3.9.2.4 sid

```
ums_sid_t scheduler_params::sid
```

ID of the scheduler which is set by the kernel module

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

- [const.h](#)

3.10 scheduler_proc_entry Struct Reference

Responsible for tracking proc_dir_entries of the schedulers of the specific process

```
#include <ums_api.h>
```

Data Fields

- struct proc_dir_entry * [pde](#)
- struct proc_dir_entry * [parent](#)
- struct proc_dir_entry * [child](#)
- struct proc_dir_entry * [info](#)

3.10.1 Detailed Description

Responsible for tracking proc_dir_entries of the schedulers of the specific process

3.10.2 Field Documentation

3.10.2.1 child

```
struct proc_dir_entry* scheduler_proc_entry::child
```

Child folder of the scheduler's folder (/proc/ums/<PID>/schedulers/<Scheduler ID>/workers/)

3.10.2.2 info

```
struct proc_dir_entry* scheduler_proc_entry::info
```

File that contains information and statistics of the scheduler performance (/proc/ums/<PID>/schedulers/<Scheduler ID>/info)

3.10.2.3 parent

```
struct proc_dir_entry* scheduler_proc_entry::parent
```

Parent folder of the scheduler's folder (/proc/ums/<PID>/schedulers/)

3.10.2.4 pde

```
struct proc_dir_entry* scheduler_proc_entry::pde
```

proc_dir_entry of the scheduler of the specific process (/proc/ums/<PID>/schedulers/<Scheduler ID>/)

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

- [ums_api.h](#)

3.11 worker Struct Reference

Represents a node in the [worker_list](#)

```
#include <ums_api.h>
```

Data Fields

- [ums_wid_t](#) wid
- [pid_t](#) pid
- [pid_t](#) tid
- [ums_sid_t](#) sid
- [ums_clid_t](#) clid
- unsigned long [entry_point](#)
- unsigned long [stack_addr](#)
- struct pt_regs [regs](#)
- struct fpu [fpu_regs](#)
- struct list_head [global_list](#)
- struct list_head [local_list](#)
- [state_t](#) state
- [worker_proc_entry_t](#) * [proc_entry](#)
- unsigned int [switch_count](#)
- unsigned long [total_exec_time](#)
- struct timespec64 [time_of_the_last_switch](#)

3.11.1 Detailed Description

Represents a node in the [worker_list](#)

3.11.2 Field Documentation

3.11.2.1 clid

```
ums_clid_t worker::clid
```

ID of the completion list where worker thread is assigned to

3.11.2.2 entry_point

```
unsigned long worker::entry_point
```

Function pointer and an entry point set by a user, that serves as a starting point of the worker thread *

3.11.2.3 fpu_regs

```
struct fpu worker::fpu_regs
```

Snapshot of FPU registers

3.11.2.4 global_list

```
struct list_head worker::global_list
```

List of the worker threads created by the process

3.11.2.5 local_list

```
struct list_head worker::local_list
```

List of the worker threads of the completion list

3.11.2.6 pid

```
pid_t worker::pid
```

pid of the process thread that is currently running the worker thread

3.11.2.7 proc_entry

```
worker_proc_entry_t* worker::proc_entry
```

Proc entry of the worker thread

3.11.2.8 regs

```
struct pt_regs worker::regs
```

Snapshot of CPU registers

3.11.2.9 sid

```
ums_sid_t worker::sid
```

ID of the scheduler which manages the current worker thread

3.11.2.10 stack_addr

```
unsigned long worker::stack_addr
```

Address of the stack allocated by the UMS library

3.11.2.11 state

```
state_t worker::state
```

State of worker thread's progress

3.11.2.12 switch_count

```
unsigned int worker::switch_count
```

Number of context switches

3.11.2.13 tid

```
pid_t worker::tid
```

pid of the process that created the worker thread

3.11.2.14 time_of_the_last_switch

```
struct timespec64 worker::time_of_the_last_switch
```

Time when the last switch occurred

3.11.2.15 total_exec_time

```
unsigned long worker::total_exec_time
```

Total execution time of the worker thread

3.11.2.16 wid

```
ums_wid_t worker::wid
```

Worker thread ID

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

- [ums_api.h](#)

3.12 worker_list Struct Reference

The list of the worker threads

```
#include <ums_api.h>
```

Data Fields

- struct list_head **list**
- unsigned int [worker_count](#)

3.12.1 Detailed Description

The list of the worker threads

3.12.2 Field Documentation

3.12.2.1 worker_count

```
unsigned int worker_list::worker_count
```

Number of worker threads created by the process

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

- [ums_api.h](#)

3.13 worker_params Struct Reference

Parameters that are passed in order to create a worker thread

```
#include <const.h>
```

Data Fields

- unsigned long [entry_point](#)
- unsigned long [function_args](#)
- unsigned long [stack_size](#)
- unsigned long [stack_addr](#)
- [ums_clid_t](#) [clid](#)

3.13.1 Detailed Description

Parameters that are passed in order to create a worker thread

3.13.2 Field Documentation

3.13.2.1 clid

```
ums_clid_t worker_params::clid
```

ID of the completion list where worker thread is assigned to

3.13.2.2 entry_point

```
unsigned long worker_params::entry_point
```

Function pointer and an entry point set by a user, that serves as a starting point of the worker thread

3.13.2.3 function_args

```
unsigned long worker_params::function_args
```

Pointer of the function arguments that are passed to the entry point/function

3.13.2.4 stack_addr

```
unsigned long worker_params::stack_addr
```

Address of the stack allocated by the UMS library

3.13.2.5 `stack_size`

```
unsigned long worker_params::stack_size
```

Stack size of the worker thread set by a user

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

- [const.h](#)

3.14 `worker_proc_entry` Struct Reference

Responsible for tracking `proc_dir_entries` of the worker of the specific process

```
#include <ums_api.h>
```

Data Fields

- `struct proc_dir_entry *` [pde](#)
- `struct proc_dir_entry *` [parent](#)

3.14.1 Detailed Description

Responsible for tracking `proc_dir_entries` of the worker of the specific process

3.14.2 Field Documentation

3.14.2.1 `parent`

```
struct proc_dir_entry* worker_proc_entry::parent
```

Parent folder of the worker thread's file (`/proc/ums/<PID>/schedulers/<Scheduler ID>/workers/`)

3.14.2.2 `pde`

```
struct proc_dir_entry* worker_proc_entry::pde
```

`proc_dir_entry` of the worker thread of the completion list that is assigned to a specific scheduler and contains information/statistics regarding worker thread's performance (`/proc/ums/<PID>/schedulers/<Scheduler ID>/workers/<Worker ID>`)

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

- [ums_api.h](#)

Chapter 4

File Documentation

4.1 const.h File Reference

Set of data structures and other constant variables used by UMS kernel module.

```
#include <linux/ioctl.h>
```

Data Structures

- struct [list_params](#)
Parameters that are created by the scheduler and passed to dequeue the completion list items
- struct [worker_params](#)
Parameters that are passed in order to create a worker thread
- struct [scheduler_params](#)
Parameters that are passed in order to create a scheduler

Macros

- `#define UMS_NAME "ums"`
- `#define UMS_DEVICE "/dev/ums"`
- `#define UMS_IOC_MAGIC 'R'`
- `#define UMS_IOC_DEVICE_NAME "ums_sched"`
- `#define UMS_MODULE_NAME_LOG "ums_sched: "`
- `#define UMS_PROC_NAME_LOG "/proc/ums: "`
- `#define UMS_MINOR MISC_DYNAMIC_MINOR`
- `#define UMS_BUFFER_LEN 64`
- `#define UMS_ENTER_IO(UMS_IOC_MAGIC, 1)`
- `#define UMS_EXIT_IO(UMS_IOC_MAGIC, 2)`
- `#define UMS_CREATE_LIST_IO(UMS_IOC_MAGIC, 3)`
- `#define UMS_CREATE_WORKER_IOW(UMS_IOC_MAGIC, 4, unsigned long)`
- `#define UMS_ENTER_SCHEDULING_MODE_IOWR(UMS_IOC_MAGIC, 5, unsigned long)`
- `#define UMS_EXIT_SCHEDULING_MODE_IO(UMS_IOC_MAGIC, 6)`
- `#define UMS_EXECUTE_THREAD_IOW(UMS_IOC_MAGIC, 7, unsigned long)`
- `#define UMS_THREAD_YIELD_IOW(UMS_IOC_MAGIC, 8, unsigned long)`
- `#define UMS_DEQUEUE_COMPLETION_LIST_ITEMS_IOWR(UMS_IOC_MAGIC, 9, unsigned long)`

- **#define UMS_SUCCESS 0**
Successful execution.
- **#define UMS_ERROR 1**
Error.
- **#define UMS_ERROR_PROCESS_NOT_FOUND 1000**
Process is not managed by UMS kernel module.
- **#define UMS_ERROR_PROCESS_ALREADY_EXISTS 1001**
Process is already managed by UMS kernel module.
- **#define UMS_ERROR_COMPLETION_LIST_NOT_FOUND 1002**
Completion list cannot be found.
- **#define UMS_ERROR_SCHEDULER_NOT_FOUND 1003**
Scheduler cannot be found.
- **#define UMS_ERROR_WORKER_NOT_FOUND 1004**
Worker thread cannot be found.
- **#define UMS_ERROR_STATE_RUNNING 1005**
The object is still running, thus cannot be modified, updated, deleted.
- **#define UMS_ERROR_CMD_IS_NOT_ISSUED_BY_MAIN_THREAD 1006**
The command is not issued by the main process thread, e.g. ums_exit()
- **#define UMS_ERROR_WORKER_ALREADY_RUNNING 1007**
The worker thread is already running.
- **#define UMS_ERROR_WRONG_INPUT 1008**
Wrong input.
- **#define UMS_ERROR_CMD_IS_NOT_ISSUED_BY_SCHEDULER 1009**
The command is not issued by the scheduler.
- **#define UMS_ERROR_CMD_IS_NOT_ISSUED_BY_WORKER 1010**
The command is not issued by the worker.
- **#define UMS_ERROR_WORKER_ALREADY_FINISHED 1011**
The worker thread has already finished execution.
- **#define UMS_ERROR_NO_AVAILABLE_WORKERS 1012**
No worker threads are available.
- **#define UMS_ERROR_COMPLETION_LIST_ALREADY_FINISHED 1013**
All worker threads in the completion list have finished execution.
- **#define UMS_ERROR_FAILED_TO_CREATE_PROC_ENTRY 1014**
Failed to create proc entry.
- **#define UMS_ERROR_FAILED_TO_PROC_OPEN 1015**
Failed to open proc entry.
- **#define UMS_ERROR_COMPLETION_LIST_IS_USED_AND_CANNOT_BE_MODIFIED 1016**
The completion list is being used, thus cannot be modified.

Typedefs

- typedef enum [state](#) **state_t**
States of processes, completion lists and threads (schedulers, worker threads)
- typedef enum [worker_status](#) **worker_status_t**
Status of the worker thread Used as a parameter that is passed for pausing or completing the worker thread.
- typedef unsigned int **ums_sid_t**
Scheduler ID
- typedef unsigned int **ums_wid_t**
Worker thread ID
- typedef unsigned int **ums_clid_t**

Completion list ID

- typedef struct [list_params](#) **list_params_t**

Parameters that are created by the scheduler and passed to dequeue the completion list items

- typedef struct [worker_params](#) **worker_params_t**

Parameters that are passed in order to create a worker thread

- typedef struct [scheduler_params](#) **scheduler_params_t**

Parameters that are passed in order to create a scheduler

Enumerations

- enum [state](#) { [IDLE](#) , [RUNNING](#) , [FINISHED](#) }

States of processes, completion lists and threads (schedulers, worker threads)

- enum [worker_status](#) { [PAUSE](#) , [FINISH](#) }

Status of the worker thread Used as a parameter that is passed for pausing or completing the worker thread.

4.1.1 Detailed Description

Set of data structures and other constant variables used by UMS kernel module.

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Author

Bektur Umarbaev hrafnulf13@gmail.com

Date

4.1.2 Enumeration Type Documentation

4.1.2.1 state

enum [state](#)

States of processes, completion lists and threads (schedulers, worker threads)

Enumerator

IDLE	Represents the state when worker thread is waiting to be scheduled; When scheduler waits or searches for available worker threads to run; Completion list has available worker threads to be scheduled
RUNNING	Represents the state when worker thread is scheduled and ran by the scheduler; When scheduler handles worker thread; Completion list is currently used and can't be modified
FINISHED	Represents the state when worker thread has been completed; When scheduler has completed all scheduling work with a completion list; All completion list's worker threads has been completed

4.1.2.2 worker_status

```
enum worker_status
```

Status of the worker thread Used as a parameter that is passed for pausing or completing the worker thread.

Enumerator

PAUSE	Used for pausing a worker thread: ums_thread_pause() == ums_thread_yield(PAUSE)
FINISH	Used for completing a worker thread: ums_thread_exit() == ums_thread_yield(FINISH)

4.2 const.h

[Go to the documentation of this file.](#)

```

1
28 #pragma once
29
30 #include <linux/ioctl.h>
31
32 /*
33  * Definitions
34  */
35 #define UMS_NAME "ums"
36 #define UMS_DEVICE "/dev/ums"
37 #define UMS_IOC_MAGIC 'R'
38 #define UMS_IOC_DEVICE_NAME "ums_sched"
39 #define UMS_MODULE_NAME_LOG "ums_sched: "
40 #define UMS_PROC_NAME_LOG "/proc/ums: "
41 #define UMS_MINOR MISC_DYNAMIC_MINOR
42 #define UMS_BUFFER_LEN 64
43
44 /*
45  * IOCTL definitions
46  */
47 #define UMS_ENTER _IO(UMS_IOC_MAGIC, 1)
48 #define UMS_EXIT _IO(UMS_IOC_MAGIC, 2)
49 #define UMS_CREATE_LIST _IO(UMS_IOC_MAGIC, 3)
50 #define UMS_CREATE_WORKER _IOW(UMS_IOC_MAGIC, 4, unsigned long)
51 #define UMS_ENTER_SCHEDULING_MODE _IOWR(UMS_IOC_MAGIC, 5, unsigned long)
52 #define UMS_EXIT_SCHEDULING_MODE _IO(UMS_IOC_MAGIC, 6)
53 #define UMS_EXECUTE_THREAD _IOW(UMS_IOC_MAGIC, 7, unsigned long)
54 #define UMS_THREAD_YIELD _IOW(UMS_IOC_MAGIC, 8, unsigned long)
55 #define UMS_DEQUEUE_COMPLETION_LIST_ITEMS _IOWR(UMS_IOC_MAGIC, 9, unsigned long)
56
57 /*
58  * Errors and return values
59  */
60 #define UMS_SUCCESS 0
61 #define UMS_ERROR 1

```

```

62 #define UMS_ERROR_PROCESS_NOT_FOUND 1000
63 #define UMS_ERROR_PROCESS_ALREADY_EXISTS 1001
64 #define UMS_ERROR_COMPLETION_LIST_NOT_FOUND 1002
65 #define UMS_ERROR_SCHEDULER_NOT_FOUND 1003
66 #define UMS_ERROR_WORKER_NOT_FOUND 1004
67 #define UMS_ERROR_STATE_RUNNING 1005
68 #define UMS_ERROR_CMD_IS_NOT_ISSUED_BY_MAIN_THREAD 1006
69 #define UMS_ERROR_WORKER_ALREADY_RUNNING 1007
70 #define UMS_ERROR_WRONG_INPUT 1008
71 #define UMS_ERROR_CMD_IS_NOT_ISSUED_BY_SCHEDULER 1009
72 #define UMS_ERROR_CMD_IS_NOT_ISSUED_BY_WORKER 1010
73 #define UMS_ERROR_WORKER_ALREADY_FINISHED 1011
74 #define UMS_ERROR_NO_AVAILABLE_WORKERS 1012
75 #define UMS_ERROR_COMPLETION_LIST_ALREADY_FINISHED 1013
76 #define UMS_ERROR_FAILED_TO_CREATE_PROC_ENTRY 1014
77 #define UMS_ERROR_FAILED_TO_PROC_OPEN 1015
78 #define UMS_ERROR_COMPLETION_LIST_IS_USED_AND_CANNOT_BE_MODIFIED 1016
79
84 typedef enum state {
85     IDLE,
86     RUNNING,
87     FINISHED
88 } state_t;
89
94 typedef enum worker_status {
95     PAUSE,
96     FINISH
97 } worker_status_t;
98
103 typedef unsigned int ums_sid_t;
104
109 typedef unsigned int ums_wid_t;
110
115 typedef unsigned int ums_clid_t;
116
121 typedef struct list_params {
122     unsigned int size;
123     unsigned int worker_count;
124     state_t state;
125     ums_wid_t workers[];
126 } list_params_t;
127
132 typedef struct worker_params {
133     unsigned long entry_point;
134     unsigned long function_args;
135     unsigned long stack_size;
136     unsigned long stack_addr;
137     ums_clid_t clid;
138 } worker_params_t;
139
144 typedef struct scheduler_params {
145     unsigned long entry_point;
146     ums_clid_t clid;
147     ums_sid_t sid;
148     int core_id;
149 } scheduler_params_t;

```

4.3 ums_api.c File Reference

Contains implementations of the UMS kernel module API.

```
#include "ums_api.h"
```

Functions

- `int enter_ums (void)`
Called by a process to request a scheduling management Checks if the process is already managed or not, if not:
- `int exit_ums (void)`
Called by a process to request a completion of the scheduling management Checks if the process is already managed or not, if not:
- `process_t * create_process_node (pid_t pid)`
Creates a `process` data structure to handle the specified process To create a `process` data structure, UMS kernel module:
- `ums_clid_t create_completion_list ()`
Creates a `completion_list_node` for the process To create a `completion_list_node`, UMS kernel module:
- `ums_wid_t create_worker_thread (worker_params_t *params)`
Creates a `worker` thread for the process To create a `worker`, UMS kernel module:
- `ums_sid_t enter_scheduling_mode (scheduler_params_t *params)`
Converts a `pthread` to the `scheduler`.
- `int exit_scheduling_mode (void)`
Converts `scheduler` back to the `pthread`.
- `int execute_thread (ums_wid_t worker_id)`
Executes a worker thread with a `worker_id` To execute the worker thread:
- `int thread_yield (worker_status_t status)`
Pauses or completes the execution of the worker thread To pause or complete the execution of the worker thread:
- `int dequeue_completion_list_items (list_params_t *params)`
Provides a list of available worker threads of the completion list that can be scheduled To retrieve the list of available worker threads:
- `process_t * check_if_process_exists (pid_t pid)`
Checks if `process` with `pid` is managed by the UMS kernel module
- `completion_list_node_t * check_if_completion_list_exists (process_t *process, ums_clid_t clid)`
Checks if completion list with `clid` was created by a `process`
- `scheduler_t * check_if_scheduler_exists (process_t *process, ums_sid_t sid)`
Checks if scheduler with `sid` was created by a `process`
- `scheduler_t * check_if_scheduler_exists_run_by (process_t *process, pid_t pid)`
Checks if scheduler with `pid` was created by a `process`
- `worker_t * check_if_worker_exists (worker_list_t *worker_list, ums_wid_t wid)`
Checks if worker thread with `wid` exists in `worker_list` of the completion list Search is performed using `local_list` member of `worker`.
- `worker_t * check_if_worker_exists_global (worker_list_t *worker_list, ums_wid_t wid)`
Checks if worker thread with `wid` exists in `worker_list` of the process Search is performed using `global_list` member of `worker`.
- `state_t check_schedulers_state (process_t *process)`
Checks if schedulers of the process have finished their work
- `int delete_process (process_t *process)`
Deletes `process` from the global `process_list` The function was used during early phases of development and later was left unused, since `proc` entries of the process are linked to `process` (in case user wants to see statistics, the data should be available for read), it was decided that only kernel module can delete data structures allocated for the process Therefore `delete_process_safe()` is used to delete `process` Still the function performs a check to see if all schedulers have finished their job and then performs series of deletions of all data structures used by the process.
- `int delete_process_safe (process_t *process)`
Called by UMS kernel module when module exits to delete `process` from the global `process_list` The function does not perform a check to see if all schedulers have finished their job to delete data structures used by the process It is assumed that all work has been done, therefore user issued a command to UMS kernel module to exit.
- `int delete_completion_lists_and_worker_threads (process_t *process)`
Deletes completion lists and worker threads created by the process Calls `delete_workers_from_completion_list()` and frees allocated memory that was used by the completion lists.

- int [delete_workers_from_completion_list](#) ([worker_list_t](#) *[worker_list](#))
Deletes worker threads assigned to the completion list
- int [delete_workers_from_process_list](#) ([worker_list_t](#) *[worker_list](#))
Deletes worker threads created by the process Frees allocated memory that was used by the worker threads.
- int [delete_schedulers](#) ([process_t](#) *[process](#))
Deletes schedulers created by the process Frees allocated memory that was used by the schedulers.
- int [cleanup](#) ()
Performs a cleanup by deleting all the allocated data structures for all processes that were managed by the UMS kernel module
- unsigned long [get_exec_time](#) ([struct timespec64](#) *[prev_time](#))
Computes time difference between passed [prev_time](#) and current time, which is used in this case as an indicator of execution time for [worker](#) and [scheduler](#)
- int [init_proc](#) (void)
Initializes the core proc directory for UMS kernel module
- int [delete_proc](#) (void)
Deletes all proc files of the UMS kernel module
- int [create_process_proc_entry](#) ([process_t](#) *[process](#))
Dynamically creates essential proc entries for the process Allocates a memory for [process_proc_entry](#) and initializes it:
- int [create_scheduler_proc_entry](#) ([process_t](#) *[process](#), [scheduler_t](#) *[scheduler](#))
Dynamically creates essential proc entries for the scheduler of the process Allocates a memory for [scheduler_proc_entry](#) and initializes it:
- int [create_worker_proc_entry](#) ([process_t](#) *[process](#), [scheduler_t](#) *[scheduler](#), [worker_t](#) *[worker](#))
Dynamically creates essential proc entries for the worker of the process Allocates a memory for [worker_proc_entry](#) and initializes it:

Variables

- [process_list_t](#) [process_list](#)

4.3.1 Detailed Description

Contains implementations of the UMS kernel module API.

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Author

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Date

4.3.2 Function Documentation

4.3.2.1 `check_if_completion_list_exists()`

```
completion_list_node_t * check_if_completion_list_exists (
    process_t * process,
    ums_clid_t clid )
```

Checks if completion list with `clid` was created by a process

Parameters

<i>process</i>	pointer to process
<i>clid</i>	Completion list ID

Returns

returns pointer to [completion_list_node](#), or `NULL` if no completion list was found

4.3.2.2 `check_if_process_exists()`

```
process_t * check_if_process_exists (
    pid_t pid )
```

Checks if `process` with `pid` is managed by the UMS kernel module

Parameters

<i>pid</i>	pid of the process
------------	--------------------

Returns

returns pointer to [process](#), or `NULL` if no process was found

4.3.2.3 `check_if_scheduler_exists()`

```
scheduler_t * check_if_scheduler_exists (
    process_t * process,
    ums_sid_t sid )
```

Checks if scheduler with `sid` was created by a process

Parameters

<i>process</i>	pointer to process
<i>sid</i>	Scheduler ID

Returns

returns pointer to [scheduler](#), or NULL if no scheduler was found

4.3.2.4 check_if_scheduler_exists_run_by()

```
scheduler\_t * check_if_scheduler_exists_run_by (
    process\_t * process,
    pid_t pid )
```

Checks if scheduler with `pid` was created by a process

Parameters

<i>process</i>	pointer to process
<i>pid</i>	pid of the pthread which is associated with scheduler

Returns

returns pointer to [scheduler](#), or NULL if no scheduler was found

4.3.2.5 check_if_worker_exists()

```
worker\_t * check_if_worker_exists (
    worker\_list\_t * worker_list,
    ums_wid_t wid )
```

Checks if worker thread with `wid` exists in `worker_list` of the completion list Search is performed using local↵
_list member of [worker](#).

Parameters

<i>worker_list</i>	pointer to worker_list
<i>wid</i>	Worker ID

Returns

returns pointer to [worker](#), or NULL if no worker was found

4.3.2.6 check_if_worker_exists_global()

```
worker_t * check_if_worker_exists_global (
    worker_list_t * worker_list,
    ums_wid_t wid )
```

Checks if worker thread with `wid` exists in `worker_list` of the process Search is performed using `global_list` member of `worker`.

Parameters

<code>worker_list</code>	pointer to <code>worker_list</code>
<code>wid</code>	Worker ID

Returns

returns pointer to `worker`, or NULL if no worker was found

4.3.2.7 check_schedulers_state()

```
state_t check_schedulers_state (
    process_t * process )
```

Checks if schedulers of the process have finished their work

Parameters

<code>process</code>	pointer to <code>process</code>
----------------------	---------------------------------

Returns

returns `state`

4.3.2.8 cleanup()

```
int cleanup (
    void )
```

Performs a cleanup by deleting all the allocated data structures for all processes that were managed by the UMS kernel module

Returns

returns `UMS_SUCCESS` if succesful

4.3.2.9 create_completion_list()

```
ums_clid_t create_completion_list (
    void )
```

Creates a [completion_list_node](#) for the process To create a [completion_list_node](#), UMS kernel module:

- Checks if the process is already managed, if not returns UMS_ERROR_PROCESS_NOT_FOUND
- Allocates and initializes completion_list_node:
 - Adds the completion list to the list of completion lists created by the process
 - [completion_list_node::clid](#) is set to process::completion_lists::list_count value (which is incremented after)
 - [completion_list_node::worker_count](#) is set to 0
 - [completion_list_node::finished_count](#) is set to 0
 - [completion_list_node::state](#) is set to IDLE
 - Allocates and initializes idle_list member of the [process](#) to track idle worker threads created by the process
 - Allocates and initializes busy_list member of the [process](#) to track finished and running worker threads created by the process

Returns

returns completion list ID

4.3.2.10 create_process_node()

```
process_t * create_process_node (
    pid_t pid )
```

Creates a [process](#) data structure to handle the specified process To create a [process](#) data structure, UMS kernel module:

- Allocates and initializes process:
 - [process::pid](#) is set to pid
 - [process::state](#) is set to RUNNING
 - Allocates and initializes [completion_list](#) member of the [process](#) to track completion lists created by the process
 - Allocates and initializes [worker_list](#) member of the [process](#) to track worker threads created by the process
 - Allocates and initializes [scheduler_list](#) member of the [process](#) to track schedulers created by the process

Parameters

<i>pid</i>	pid of the process
------------	--------------------

Returns

returns a pointer to [process](#) data structure of the specified process

4.3.2.11 create_process_proc_entry()

```
int create_process_proc_entry (
    process\_t * process )
```

Dinamically creates essential proc entries for the process Allocates a memory for [process_proc_entry](#) and initializes it:

- Creates a folder to represent the process
- Creates schedulers folder

Parameters

<i>process</i>	pointer to process
----------------	------------------------------------

Returns

returns UMS_SUCCESS when succesful or error constant if there are any errors

4.3.2.12 create_scheduler_proc_entry()

```
int create_scheduler_proc_entry (
    process\_t * process,
    scheduler\_t * scheduler )
```

Dinamically creates essential proc entries for the scheduler of the process Allocates a memory for [scheduler_proc_entry](#) and initializes it:

- Creates a folder to represent the scheduler
- Creates info file that provides statistics about the scheduler
- Creates workers folder of the completion list that is assigned to the scheduler
- Creates proc entries for each worker thread by calling [create_worker_proc_entry\(\)](#)

Parameters

<i>process</i>	pointer to process
<i>scheduler</i>	pointer to scheduler

Returns

returns UMS_SUCCESS when succesful or error constant if there are any errors

4.3.2.13 create_worker_proc_entry()

```
int create_worker_proc_entry (
    process_t * process,
    scheduler_t * scheduler,
    worker_t * worker )
```

Dinamically creates essential proc entries for the worker of the process Allocates a memory for [worker_proc_entry](#) and initializes it:

- Creates a file that provides statistics about the worker

Parameters

<i>process</i>	pointer to process
<i>scheduler</i>	pointer to scheduler
<i>worker</i>	pointer to worker

Returns

returns UMS_SUCCESS when succesful or error constant if there are any errors

4.3.2.14 create_worker_thread()

```
ums_wid_t create_worker_thread (
    worker_params_t * params )
```

Creates a [worker](#) thread for the process To create a [worker](#), UMS kernel module:

- Checks if the process is already managed, if not returns UMS_ERROR_PROCESS_NOT_FOUND
- Checks if completion list exists based on the passed parameters *params*, if not returns UMS_ERROR_↔COMPLETION_LIST_NOT_FOUND
- Checks if completion list is used currently, thus cannot be modified and returns UMS_ERROR_↔COMPLETION_LIST_IS_USED_AND_CANNOT_BE_MODIFIED
- Allocates and initializes worker:
 - Adds the worker to the list of workers created by the process
 - [worker::wid](#) is set to `process::worker_list::worker_count` value (which is incremented after)

- `worker::pid` is set to -1
- `worker::tid` is set to `current->tgid`
- `worker::clid` is set to `worker_params::clid`
- `worker::state` is set to IDLE
- `worker::entry_point` is set to `worker_params::entry_point`
- `worker::stack_addr` is set to `worker_params::stack_addr`
- `worker::switch_count` is set to 0;
- `worker::total_exec_time` is set to 0;
- `worker::regs` is a `pt_regs` data structure and set to a snapshot of current CPU registers of the process
 - * `regs::ip` is set to `worker_params::entry_point`
 - * `regs::di` is set to `worker_params::function_args`
 - * `regs::sp` is set to `worker_params::stack_addr`
 - * `regs::bp` is set to `worker_params::stack_addr`
- `worker::fpu_regs` is a `fpu` data structure and set to a snapshot of current FPU registers of the process
- Adds worker to the idle list of the completion list

Parameters

<code>params</code>	pointer to <code>worker_params</code>
---------------------	---------------------------------------

Returns

returns worker ID

4.3.2.15 delete_completion_lists_and_worker_threads()

```
int delete_completion_lists_and_worker_threads (
    process_t * process )
```

Deletes completion lists and worker threads created by the process Calls `delete_workers_from_completion_list()` and frees allocated memory that was used by the completion lists.

Parameters

<code>process</code>	pointer to <code>process</code>
----------------------	---------------------------------

Returns

returns `UMS_SUCCESS` if succesful

4.3.2.16 delete_proc()

```
int delete_proc (
    void )
```

Deletes all proc files of the UMS kernel module

Returns

returns UMS_SUCCESS when succesful or error constant if there are any errors

4.3.2.17 delete_process()

```
int delete_process (
    process_t * process )
```

Deletes [process](#) from the global [process_list](#) The function was used during early phases of development and later was left unused, since proc entries of the process are linked to [process](#) (in case user wants to see statistics, the data should be available for read), it was decided that only kernel module can delete data structures allocated for the process Therefore [delete_process_safe\(\)](#) is used to delete [process](#) Still the function performs a check to see if all schedulers have finished their job and then performs series of deletions of all data structures used by the process.

Parameters

<i>process</i>	pointer to process
----------------	------------------------------------

Returns

returns UMS_SUCCESS if succesful

4.3.2.18 delete_process_safe()

```
int delete_process_safe (
    process_t * process )
```

Called by UMS kernel module when module exits to delete [process](#) from the global [process_list](#) The function does not perform a check to see if all schedulers have finished their job to delete data structures used by the process It is assumed that all work has been done, therefore user issued a command to UMS kernel module to exit.

Parameters

<i>process</i>	pointer to process
----------------	------------------------------------

Returns

returns UMS_SUCCESS if succesful

4.3.2.19 delete_schedulers()

```
int delete_schedulers (
    process_t * process )
```

Deletes schedulers created by the process Frees allocated memory that was used by the schedulers.

Parameters

<i>process</i>	pointer to process
----------------	------------------------------------

Returns

returns UMS_SUCCESS if succesful

4.3.2.20 delete_workers_from_completion_list()

```
int delete_workers_from_completion_list (
    worker_list_t * worker_list )
```

Deletes worker threads assigned to the completion list

Parameters

<i>worker_list</i>	pointer to worker_list of the completion_list_node
--------------------	--

Returns

returns UMS_SUCCESS if succesful

4.3.2.21 delete_workers_from_process_list()

```
int delete_workers_from_process_list (
    worker_list_t * worker_list )
```

Deletes worker threads created by the process Frees allocated memory that was used by the worker threads.

Parameters

<i>worker_list</i>	pointer to worker_list of the process
--------------------	---

Returns

returns UMS_SUCCESS if succesful

4.3.2.22 dequeue_completion_list_items()

```
int dequeue_completion_list_items (
    list_params_t * params )
```

Provides a list of available worker threads of the completion list that can be scheduled To retrieve the list of available worker threads:

- Checks if the process is already managed, if not returns `UMS_ERROR_PROCESS_NOT_FOUND`
- Checks if scheduler associated by the pthread already exists, if not returns `UMS_ERROR_SCHEDULER_NOT_FOUND`
- Checks if there are any available workers, if not modifies `params` state value to `FINISHED` to indicate the completion of the work
- Retrieves the list of idle worker threads from the completion list and copies them back to the `params`

Parameters

<code>params</code>	pointer to <code>list_params</code>
---------------------	-------------------------------------

Returns

returns `UMS_SUCCESS` when succesful or error constant if there are any errors

4.3.2.23 enter_scheduling_mode()

```
ums_sid_t enter_scheduling_mode (
    scheduler_params_t * params )
```

Converts a pthread to the `scheduler`.

To create a `scheduler`, UMS kernel module:

- Checks if the process is already managed, if not returns `UMS_ERROR_PROCESS_NOT_FOUND`
- Checks if completion list exists based on the passed parameters `params`, if not returns `UMS_ERROR_COMPLETION_LIST_NOT_FOUND`
- Allocates and initializes scheduler:
 - Adds the scheduler to the list of schedulers created by the process
 - `scheduler::sid` is set to `process::scheduler_list::scheduler_count`; value (which is incremented after)
 - `scheduler::pid` is set to `current->pid`
 - `scheduler::tid` is set to `current->tgid`

- `scheduler::wid` is set to -1
- `scheduler::state` is set to IDLE
- `scheduler::entry_point` is set to `scheduler_params::entry_point`
- `scheduler::avg_switch_time` is set to 0;
- `scheduler::time_needed_for_the_last_switch` is set to 0;
- `scheduler::total_time_needed_for_the_switch` is set to 0;
- `scheduler::comp_list` is set to the pointer of the completion list retrieved using `check_if_completion_list_exists` by passing `scheduler_params::clid`
- `scheduler::regs` is a `pt_regs` data structure and set to a snapshot of current CPU registers of the pthread
 - * `scheduler::return_addr` is set to `regs::ip`
 - * `scheduler::stack_ptr` is set to `regs::sp`
 - * `scheduler::base_ptr` is set to `regs::bp`
 - * `regs::ip` is set to `scheduler_params::entry_point`
- `scheduler::fpu_regs` is a `fpu` data structure and set to a snapshot of current FPU registers of the pthread
- Sets the state of the completion list assigned to that scheduler to RUNNING, since the scheduling starts after the completion of `ioctl` call
- Creates `scheduler_proc_entry` for the scheduler by calling `create_scheduler_proc_entry()`
- Performs a context switch by copying previously saved and modified `scheduler::regs` data structure to `task_pt_regs(current)`

Parameters

<i>params</i>	pointer to <code>scheduler_params</code>
---------------	--

Returns

returns scheduler ID

4.3.2.24 enter_ums()

```
int enter_ums (
    void )
```

Called by a process to request a scheduling management Checks if the process is already managed or not, if not:

- Creates a `process` data structure by calling `create_process_node()`
- Creates the proc entries by calling `create_process_proc_entry()`

Returns

returns `UMS_SUCCESS` when succesful or error constant if there are any errors

4.3.2.25 execute_thread()

```
int execute_thread (
    ums_wid_t worker_id )
```

Executes a worker thread with a `worker_id` To execute the worker thread:

- Checks if the process is already managed, if not returns `UMS_ERROR_PROCESS_NOT_FOUND`
- Checks if scheduler associated by the pthread already exists, if not returns `UMS_ERROR_SCHEDULER_NOT_FOUND`
- Checks if the worker thread exists, currently running, completed its' work
- Updates the worker and scheduler data structures
- Records the statistics related to the scheduler and worker, such as number of switches and the time the switch happened
- Saves the register values of the scheduler
- Performs a context switch

Parameters

<code>worker_id</code>	Worker thread ID
------------------------	------------------

Returns

returns `UMS_SUCCESS` when succesful or error constant if there are any errors

4.3.2.26 exit_scheduling_mode()

```
int exit_scheduling_mode (
    void )
```

Converts `scheduler` back to the pthread.

To create a `scheduler`, UMS kernel module:

- Checks if the process is already managed, if not returns `UMS_ERROR_PROCESS_NOT_FOUND`
- Checks if scheduler associated by the pthread already exists, if not returns `UMS_ERROR_SCHEDULER_NOT_FOUND`
- Modifies scheduler:
 - `scheduler::wid` is set to -1
 - `scheduler::state` is set to FINISHED
 - `scheduler::regs` is modified:

- * regs::ip is set to [scheduler::return_addr](#)
- * regs::sp is set to [scheduler::stack_ptr](#)
- * regs::bp is set to [scheduler::base_ptr](#)
- * regs::ip is set to [scheduler_params::entry_point](#)
- Performs a context switch by copying previously saved and modified [scheduler::regs](#) data structure to `task_pt_regs(current)`
- Changes current FPU registers to previously saved `scheduler::fpu_regs` via `copy_kernel_to_fxregs()`

Returns

returns `UMS_SUCCESS` when succesful or error constant if there are any errors

4.3.2.27 `exit_ums()`

```
int exit_ums (
    void )
```

Called by a process to request a completion of the scheduling management Checks if the process is already managed or not, if not:

- Sets the [state](#) of the process to `FINISHED`, but does not delete related data structures of the process (which are deleted when UMS kernel module exits)

Returns

returns `UMS_SUCCESS` when succesful or error constant if there are any errors

4.3.2.28 `get_exec_time()`

```
unsigned long get_exec_time (
    struct timespec64 * prev_time )
```

Computes time difference between passed `prev_time` and current time, which is used in this case as an indicator of execution time for [worker](#) and [scheduler](#)

Parameters

<code>prev_time</code>	member of worker and scheduler
------------------------	--

Returns

returns unsigned long

4.3.2.29 init_proc()

```
int init_proc (
    void )
```

Initializes the core proc directory for UMS kernel module

Returns

returns UMS_SUCCESS when succesful or error constant if there are any errors

4.3.2.30 thread_yield()

```
int thread_yield (
    worker_status_t status )
```

Pauses or completes the execution of the worker thread To pause or complete the execution of the worker thread:

- Checks if the process is already managed, if not returns UMS_ERROR_PROCESS_NOT_FOUND
- Checks if scheduler associated by the pthread already exists, if not returns UMS_ERROR_SCHEDULER_↔NOT_FOUND
- Checks if the worker thread exists, currently running, completed its' work
- Updates the worker, scheduler and completion list data structures:
 - if status is set to PAUSE:
 - * worker::state is set to IDLE, so that it can be scheduled later
 - * worker is added back to the completion list
 - if status is set to FINISH:
 - * worker::state is set to FINISHED
 - * completion list increments the value of finished workers
- Records the statistics related to the scheduler and worker, such as number of switches and the time the switch happened
- Saves the register values of the worker thread
- Performs a context switch

Parameters

<i>status</i>	value of <code>worker_status</code> , which is the status of the worker thread
---------------	--

Returns

returns UMS_SUCCESS when succesful or error constant if there are any errors

4.3.3 Variable Documentation**4.3.3.1 process_list**

```
process_list_t process_list
```

Initial value:

```
= {
    .list = LIST_HEAD_INIT(process_list.list),
}
```

4.4 ums_api.h File Reference

The header that contains essential functions, data structures and proc filesystem of the UMS kernel module.

```
#include "const.h"
#include <asm/current.h>
#include <asm/fpu/internal.h>
#include <asm/fpu/types.h>
#include <linux/kernel.h>
#include <linux/module.h>
#include <linux/list.h>
#include <linux/slab.h>
#include <linux/types.h>
#include <linux/time.h>
#include <linux/proc_fs.h>
#include <linux/seq_file.h>
```

Data Structures

- struct [process_list](#)
The list of the processes handled by the UMS kernel module
- struct [process](#)
Represents a node in the [process_list](#)
- struct [completion_list](#)
The list of the completion lists created by the specific process
- struct [completion_list_node](#)
Represents a node in the [completion_list](#)
- struct [worker_list](#)
The list of the worker threads
- struct [worker](#)
Represents a node in the [worker_list](#)
- struct [scheduler_list](#)

- The list of the schedulers created by the specific process*

 - struct [scheduler](#)

Represents a node in the [scheduler_list](#)
- struct [process_proc_entry](#)

Responsible for tracking [proc_dir_entries](#) of the process
- struct [scheduler_proc_entry](#)

Responsible for tracking [proc_dir_entries](#) of the schedulers of the specific process
- struct [worker_proc_entry](#)

Responsible for tracking [proc_dir_entries](#) of the worker of the specific process

Typedefs

- typedef struct [process_list](#) **process_list_t**

The list of the processes handled by the UMS kernel module
- typedef struct [process](#) **process_t**

Represents a node in the [process_list](#)
- typedef struct [completion_list](#) **completion_list_t**

The list of the completion lists created by the specific process
- typedef struct [completion_list_node](#) **completion_list_node_t**

Represents a node in the [completion_list](#)
- typedef struct [worker_list](#) **worker_list_t**

The list of the worker threads
- typedef struct [worker](#) **worker_t**

Represents a node in the [worker_list](#)
- typedef struct [scheduler_list](#) **scheduler_list_t**

The list of the schedulers created by the specific process
- typedef struct [scheduler](#) **scheduler_t**

Represents a node in the [scheduler_list](#)
- typedef struct [process_proc_entry](#) **process_proc_entry_t**

Responsible for tracking [proc_dir_entries](#) of the process
- typedef struct [scheduler_proc_entry](#) **scheduler_proc_entry_t**

Responsible for tracking [proc_dir_entries](#) of the schedulers of the specific process
- typedef struct [worker_proc_entry](#) **worker_proc_entry_t**

Responsible for tracking [proc_dir_entries](#) of the worker of the specific process

Functions

- int [enter_ums](#) (void)

Called by a process to request a scheduling management Checks if the process is already managed or not, if not:
- int [exit_ums](#) (void)

Called by a process to request a completion of the scheduling management Checks if the process is already managed or not, if not:
- [ums_clid_t](#) [create_completion_list](#) (void)

Creates a [completion_list_node](#) for the process To create a [completion_list_node](#), UMS kernel module:
- [ums_wid_t](#) [create_worker_thread](#) ([worker_params_t](#) *params)

Creates a [worker](#) thread for the process To create a [worker](#), UMS kernel module:
- [ums_sid_t](#) [enter_scheduling_mode](#) ([scheduler_params_t](#) *params)

Converts a pthread to the [scheduler](#).
- int [exit_scheduling_mode](#) (void)

- Converts [scheduler](#) back to the pthread.
- int [execute_thread](#) ([ums_wid_t](#) worker_id)

Executes a worker thread with a *worker_id* To execute the worker thread:
- int [thread_yield](#) ([worker_status_t](#) status)

Pauses or completes the execution of the worker thread To pause or complete the execution of the worker thread:
- int [dequeue_completion_list_items](#) ([list_params_t](#) *params)

Provides a list of available worker threads of the completion list that can be scheduled To retrieve the list of available worker threads:
- int [delete_process](#) ([process_t](#) *process)

Deletes [process](#) from the global [process_list](#) The function was used during early phases of development and later was left unused, since proc entries of the process are linked to [process](#) (in case user wants to see statistics, the data should be available for read), it was decided that only kernel module can delete data structures allocated for the process Therefore [delete_process_safe\(\)](#) is used to delete [process](#) Still the function performs a check to see if all schedulers have finished their job and then performs series of deletions of all data structures used by the process.
- int [delete_completion_lists_and_worker_threads](#) ([process_t](#) *process)

Deletes completion lists and worker threads created by the process Calls [delete_workers_from_completion_list\(\)](#) and frees allocated memory that was used by the completion lists.
- int [delete_workers_from_completion_list](#) ([worker_list_t](#) *worker_list)

Deletes worker threads assigned to the completion list
- int [delete_workers_from_process_list](#) ([worker_list_t](#) *worker_list)

Deletes worker threads created by the process Frees allocated memory that was used by the worker threads.
- int [delete_schedulers](#) ([process_t](#) *process)

Deletes schedulers created by the process Frees allocated memory that was used by the schedulers.
- [process_t](#) * [create_process_node](#) ([pid_t](#) pid)

Creates a [process](#) data structure to handle the specified process To create a [process](#) data structure, UMS kernel module:
- [process_t](#) * [check_if_process_exists](#) ([pid_t](#) pid)

Checks if *process* with *pid* is managed by the UMS kernel module
- [completion_list_node_t](#) * [check_if_completion_list_exists](#) ([process_t](#) *proc, [ums_clid_t](#) clid)

Checks if completion list with *clid* was created by a *process*
- [scheduler_t](#) * [check_if_scheduler_exists](#) ([process_t](#) *proc, [ums_sid_t](#) sid)

Checks if scheduler with *sid* was created by a *process*
- [scheduler_t](#) * [check_if_scheduler_exists_run_by](#) ([process_t](#) *process, [pid_t](#) pid)

Checks if scheduler with *pid* was created by a *process*
- [worker_t](#) * [check_if_worker_exists](#) ([worker_list_t](#) *worker_list, [ums_wid_t](#) wid)

Checks if worker thread with *wid* exists in [worker_list](#) of the completion list Search is performed using *local_list* member of *worker*.
- [worker_t](#) * [check_if_worker_exists_global](#) ([worker_list_t](#) *worker_list, [ums_wid_t](#) wid)

Checks if worker thread with *wid* exists in [worker_list](#) of the process Search is performed using *global_list* member of *worker*.
- [state_t](#) [check_if_schedulers_state](#) ([process_t](#) *proc)
- unsigned long [get_exec_time](#) ([struct timespec64](#) *prev_time)

Computes time difference between passed *prev_time* and current time, which is used in this case as an indicator of execution time for *worker* and *scheduler*
- int [cleanup](#) (void)

Performs a cleanup by deleting all the allocated data structures for all processes that were managed by the UMS kernel module
- int [init_proc](#) (void)

Initializes the core proc directory for UMS kernel module
- int [delete_proc](#) (void)

Deletes all proc files of the UMS kernel module
- int [create_process_proc_entry](#) ([process_t](#) *process)

Dynamically creates essential proc entries for the process Allocates a memory for `process_proc_entry` and initializes it:

- int `create_scheduler_proc_entry` (`process_t` *`process`, `scheduler_t` *`scheduler`)

Dynamically creates essential proc entries for the scheduler of the process Allocates a memory for `scheduler_proc_entry` and initializes it:

- int `create_worker_proc_entry` (`process_t` *`process`, `scheduler_t` *`scheduler`, `worker_t` *`worker`)

Dynamically creates essential proc entries for the worker of the process Allocates a memory for `worker_proc_entry` and initializes it:

- int `delete_process_proc_entry` (`process_t` *`process`)

4.4.1 Detailed Description

The header that contains essential functions, data structures and proc filesystem of the UMS kernel module.

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Author

Bektur Umarbaev hrafnulf13@gmail.com

Date

4.4.2 Function Documentation

4.4.2.1 `check_if_completion_list_exists()`

```
completion_list_node_t * check_if_completion_list_exists (
    process_t * process,
    ums_clid_t clid )
```

Checks if completion list with `clid` was created by a `process`

Parameters

<i>process</i>	pointer to process
<i>clid</i>	Completion list ID

Returns

returns pointer to [completion_list_node](#), or `NULL` if no completion list was found

4.4.2.2 check_if_process_exists()

```
process\_t * check_if_process_exists (
    pid_t pid )
```

Checks if `process` with `pid` is managed by the UMS kernel module

Parameters

<i>pid</i>	pid of the process
------------	--------------------

Returns

returns pointer to [process](#), or `NULL` if no process was found

4.4.2.3 check_if_scheduler_exists()

```
scheduler\_t * check_if_scheduler_exists (
    process\_t * process,
    ums\_sid\_t sid )
```

Checks if scheduler with `sid` was created by a `process`

Parameters

<i>process</i>	pointer to process
<i>sid</i>	Scheduler ID

Returns

returns pointer to [scheduler](#), or `NULL` if no scheduler was found

4.4.2.4 check_if_scheduler_exists_run_by()

```
scheduler_t * check_if_scheduler_exists_run_by (
    process_t * process,
    pid_t pid )
```

Checks if scheduler with `pid` was created by a `process`

Parameters

<code>process</code>	pointer to <code>process</code>
<code>pid</code>	pid of the pthread which is associated with scheduler

Returns

returns pointer to `scheduler`, or `NULL` if no scheduler was found

4.4.2.5 check_if_worker_exists()

```
worker_t * check_if_worker_exists (
    worker_list_t * worker_list,
    ums_wid_t wid )
```

Checks if worker thread with `wid` exists in `worker_list` of the completion list Search is performed using local `_list` member of `worker`.

Parameters

<code>worker_list</code>	pointer to <code>worker_list</code>
<code>wid</code>	Worker ID

Returns

returns pointer to `worker`, or `NULL` if no worker was found

4.4.2.6 check_if_worker_exists_global()

```
worker_t * check_if_worker_exists_global (
    worker_list_t * worker_list,
    ums_wid_t wid )
```

Checks if worker thread with `wid` exists in `worker_list` of the process Search is performed using `global_list` member of `worker`.

Parameters

worker_list	pointer to worker_list
<i>wid</i>	Worker ID

Returns

returns pointer to [worker](#), or NULL if no worker was found

4.4.2.7 cleanup()

```
int cleanup (  
    void )
```

Performs a cleanup by deleting all the allocated data structures for all processes that were managed by the UMS kernel module

Returns

returns UMS_SUCCESS if succesful

4.4.2.8 create_completion_list()

```
ums_clid_t create_completion_list (  
    void )
```

Creates a [completion_list_node](#) for the process To create a [completion_list_node](#), UMS kernel module:

- Checks if the process is already managed, if not returns UMS_ERROR_PROCESS_NOT_FOUND
- Allocates and initializes completion_list_node:
 - Adds the completion list to the list of completion lists created by the process
 - [completion_list_node::clid](#) is set to process::completion_lists::list_count value (which is incremented after)
 - [completion_list_node::worker_count](#) is set to 0
 - [completion_list_node::finished_count](#) is set to 0
 - [completion_list_node::state](#) is set to IDLE
 - Allocates and initializes idle_list member of the [process](#) to track idle worker threads created by the process
 - Allocates and initializes busy_list member of the [process](#) to track finished and running worker threads created by the process

Returns

returns completion list ID

4.4.2.9 create_process_node()

```
process_t * create_process_node (
    pid_t pid )
```

Creates a [process](#) data structure to handle the specified process To create a [process](#) data structure, UMS kernel module:

- Allocates and initializes process:
 - [process::pid](#) is set to `pid`
 - [process::state](#) is set to `RUNNING`
 - Allocates and initializes [completion_list](#) member of the [process](#) to track completion lists created by the process
 - Allocates and initializes [worker_list](#) member of the [process](#) to track worker threads created by the process
 - Allocates and initializes [scheduler_list](#) member of the [process](#) to track schedulers created by the process

Parameters

<code>pid</code>	pid of the process
------------------	--------------------

Returns

returns a pointer to [process](#) data structure of the specified process

4.4.2.10 create_process_proc_entry()

```
int create_process_proc_entry (
    process_t * process )
```

Dynamically creates essential proc entries for the process Allocates a memory for [process_proc_entry](#) and initializes it:

- Creates a folder to represent the process
- Creates schedulers folder

Parameters

<code>process</code>	pointer to process
----------------------	------------------------------------

Returns

returns `UMS_SUCCESS` when succesful or error constant if there are any errors

4.4.2.11 create_scheduler_proc_entry()

```
int create_scheduler_proc_entry (
    process_t * process,
    scheduler_t * scheduler )
```

Dinamically creates essential proc entries for the scheduler of the process Allocates a memory for [scheduler_proc_entry](#) and initializes it:

- Creates a folder to represent the scheduler
- Creates info file that provides statistics about the scheduler
- Creates workers folder of the completion list that is assigned to the scheduler
- Creates proc entries for each worker thread by calling [create_worker_proc_entry\(\)](#)

Parameters

<i>process</i>	pointer to process
<i>scheduler</i>	pointer to scheduler

Returns

returns UMS_SUCCESS when succesful or error constant if there are any errors

4.4.2.12 create_worker_proc_entry()

```
int create_worker_proc_entry (
    process_t * process,
    scheduler_t * scheduler,
    worker_t * worker )
```

Dinamically creates essential proc entries for the worker of the process Allocates a memory for [worker_proc_entry](#) and initializes it:

- Creates a file that provides statistics about the worker

Parameters

<i>process</i>	pointer to process
<i>scheduler</i>	pointer to scheduler
<i>worker</i>	pointer to worker

Returns

returns UMS_SUCCESS when succesful or error constant if there are any errors

4.4.2.13 create_worker_thread()

```
ums_wid_t create_worker_thread (
    worker_params_t * params )
```

Creates a [worker](#) thread for the process To create a [worker](#), UMS kernel module:

- Checks if the process is already managed, if not returns UMS_ERROR_PROCESS_NOT_FOUND
- Checks if completion list exists based on the passed parameters `params`, if not returns UMS_ERROR_COMPLETION_LIST_NOT_FOUND
- Checks if completion list is used currently, thus cannot be modified and returns UMS_ERROR_COMPLETION_LIST_IS_USED_AND_CANNOT_BE_MODIFIED
- Allocates and initializes worker:
 - Adds the worker to the list of workers created by the process
 - `worker::wid` is set to `process::worker_list::worker_count` value (which is incremented after)
 - `worker::pid` is set to -1
 - `worker::tid` is set to `current->tgid`
 - `worker::clid` is set to `worker_params::clid`
 - `worker::state` is set to IDLE
 - `worker::entry_point` is set to `worker_params::entry_point`
 - `worker::stack_addr` is set to `worker_params::stack_addr`
 - `worker::switch_count` is set to 0;
 - `worker::total_exec_time` is set to 0;
 - `worker::regs` is a `pt_regs` data structure and set to a snapshot of current CPU registers of the process
 - * `regs::ip` is set to `worker_params::entry_point`
 - * `regs::di` is set to `worker_params::function_args`
 - * `regs::sp` is set to `worker_params::stack_addr`
 - * `regs::bp` is set to `worker_params::stack_addr`
 - `worker::fpu_regs` is a `fpu` data structure and set to a snapshot of current FPU registers of the process
 - Adds worker to the idle list of the completion list

Parameters

<code>params</code>	pointer to worker_params
---------------------	--

Returns

returns worker ID

4.4.2.14 delete_completion_lists_and_worker_threads()

```
int delete_completion_lists_and_worker_threads (
    process_t * process )
```

Deletes completion lists and worker threads created by the process. Calls [delete_workers_from_completion_list\(\)](#) and frees allocated memory that was used by the completion lists.

Parameters

<i>process</i>	pointer to process
----------------	------------------------------------

Returns

returns UMS_SUCCESS if succesful

4.4.2.15 delete_proc()

```
int delete_proc (
    void )
```

Deletes all proc files of the UMS kernel module

Returns

returns UMS_SUCCESS when succesful or error constant if there are any errors

4.4.2.16 delete_process()

```
int delete_process (
    process_t * process )
```

Deletes [process](#) from the global [process_list](#). The function was used during early phases of development and later was left unused, since proc entries of the process are linked to [process](#) (in case user wants to see statistics, the data should be available for read), it was decided that only kernel module can delete data structures allocated for the process. Therefore [delete_process_safe\(\)](#) is used to delete [process](#). Still the function performs a check to see if all schedulers have finished their job and then performs series of deletions of all data structures used by the process.

Parameters

<i>process</i>	pointer to process
----------------	------------------------------------

Returns

returns UMS_SUCCESS if succesful

4.4.2.17 delete_schedulers()

```
int delete_schedulers (
    process_t * process )
```

Deletes schedulers created by the process Frees allocated memory that was used by the schedulers.

Parameters

<i>process</i>	pointer to process
----------------	------------------------------------

Returns

returns UMS_SUCCESS if succesful

4.4.2.18 delete_workers_from_completion_list()

```
int delete_workers_from_completion_list (
    worker_list_t * worker_list )
```

Deletes worker threads assigned to the completion list

Parameters

<i>worker_list</i>	pointer to worker_list of the completion_list_node
--------------------	--

Returns

returns UMS_SUCCESS if succesful

4.4.2.19 delete_workers_from_process_list()

```
int delete_workers_from_process_list (
    worker_list_t * worker_list )
```

Deletes worker threads created by the process Frees allocated memory that was used by the worker threads.

Parameters

<code>worker_list</code>	pointer to <code>worker_list</code> of the <code>process</code>
--------------------------	---

Returns

returns `UMS_SUCCESS` if succesful

4.4.2.20 dequeue_completion_list_items()

```
int dequeue_completion_list_items (
    list_params_t * params )
```

Provides a list of available worker threads of the completion list that can be scheduled To retrieve the list of available worker threads:

- Checks if the process is already managed, if not returns `UMS_ERROR_PROCESS_NOT_FOUND`
- Checks if scheduler associated by the pthread already exists, if not returns `UMS_ERROR_SCHEDULER_↔NOT_FOUND`
- Checks if there are any available workers, if not modifies `params` state value to `FINISHED` to indicate the completion of the work
- Retrieves the list of idle worker threads from the completion list and copies them back to the `params`

Parameters

<code>params</code>	pointer to <code>list_params</code>
---------------------	-------------------------------------

Returns

returns `UMS_SUCCESS` when succesful or error constant if there are any errors

4.4.2.21 enter_scheduling_mode()

```
ums_sid_t enter_scheduling_mode (
    scheduler_params_t * params )
```

Converts a pthread to the `scheduler`.

To create a `scheduler`, UMS kernel module:

- Checks if the process is already managed, if not returns `UMS_ERROR_PROCESS_NOT_FOUND`

- Checks if completion list exists based on the passed parameters `params`, if not returns `UMS_ERROR_COMPLETION_LIST_NOT_FOUND`
- Allocates and initializes scheduler:
 - Adds the scheduler to the list of schedulers created by the process
 - `scheduler::sid` is set to `process::scheduler_list::scheduler_count`; value (which is incremented after)
 - `scheduler::pid` is set to `current->pid`
 - `scheduler::tid` is set to `current->tgid`
 - `scheduler::wid` is set to -1
 - `scheduler::state` is set to IDLE
 - `scheduler::entry_point` is set to `scheduler_params::entry_point`
 - `scheduler::avg_switch_time` is set to 0;
 - `scheduler::time_needed_for_the_last_switch` is set to 0;
 - `scheduler::total_time_needed_for_the_switch` is set to 0;
 - `scheduler::comp_list` is set to the pointer of the completion list retrieved using `check_if_completion_list_exists` by passing `scheduler_params::clid`
 - `scheduler::regs` is a `pt_regs` data structure and set to a snapshot of current CPU registers of the pthread
 - * `scheduler::return_addr` is set to `regs::ip`
 - * `scheduler::stack_ptr` is set to `regs::sp`
 - * `scheduler::base_ptr` is set to `regs::bp`
 - * `regs::ip` is set to `scheduler_params::entry_point`
 - `scheduler::fpu_regs` is a `fpu` data structure and set to a snapshot of current FPU registers of the pthread
 - Sets the state of the completion list assigned to that scheduler to RUNNING, since the scheduling starts after the completion of `ioctl` call
 - Creates `scheduler_proc_entry` for the scheduler by calling `create_scheduler_proc_entry()`
 - Performs a context switch by copying previously saved and modified `scheduler::regs` data structure to `task_pt_regs(current)`

Parameters

<code>params</code>	pointer to <code>scheduler_params</code>
---------------------	--

Returns

returns scheduler ID

4.4.2.22 enter_ums()

```
int enter_ums (
    void )
```

Called by a process to request a scheduling management Checks if the process is already managed or not, if not:

- Creates a `process` data structure by calling `create_process_node()`
- Creates the proc entries by calling `create_process_proc_entry()`

Returns

returns `UMS_SUCCESS` when succesful or error constant if there are any errors

4.4.2.23 execute_thread()

```
int execute_thread (
    ums_wid_t worker_id )
```

Executes a worker thread with a `worker_id` To execute the worker thread:

- Checks if the process is already managed, if not returns `UMS_ERROR_PROCESS_NOT_FOUND`
- Checks if scheduler associated by the pthread already exists, if not returns `UMS_ERROR_SCHEDULER_NOT_FOUND`
- Checks if the worker thread exists, currently running, completed its' work
- Updates the worker and scheduler data structures
- Records the statistics related to the scheduler and worker, such as number of switches and the time the switch happened
- Saves the register values of the scheduler
- Performs a context switch

Parameters

<i>worker_id</i>	Worker thread ID
------------------	------------------

Returns

returns `UMS_SUCCESS` when succesful or error constant if there are any errors

4.4.2.24 exit_scheduling_mode()

```
int exit_scheduling_mode (
    void )
```

Converts `scheduler` back to the pthread.

To create a `scheduler`, UMS kernel module:

- Checks if the process is already managed, if not returns `UMS_ERROR_PROCESS_NOT_FOUND`

- Checks if scheduler associated by the pthread already exists, if not returns `UMS_ERROR_SCHEDULER_NOT_FOUND`
- Modifies scheduler:
 - `scheduler::wid` is set to -1
 - `scheduler::state` is set to `FINISHED`
 - `scheduler::regs` is modified:
 - * `regs::ip` is set to `scheduler::return_addr`
 - * `regs::sp` is set to `scheduler::stack_ptr`
 - * `regs::bp` is set to `scheduler::base_ptr`
 - * `regs::ip` is set to `scheduler_params::entry_point`
 - Performs a context switch by copying previously saved and modified `scheduler::regs` data structure to `task_pt_regs(current)`
 - Changes current FPU registers to previously saved `scheduler::fpu_regs` via `copy_kernel_to_fxregs()`

Returns

returns `UMS_SUCCESS` when succesful or error constant if there are any errors

4.4.2.25 exit_ums()

```
int exit_ums (
    void )
```

Called by a process to request a completion of the scheduling management Checks if the process is already managed or not, if not:

- Sets the `state` of the process to `FINISHED`, but does not delete related data structures of the process (which are deleted when UMS kernel module exits)

Returns

returns `UMS_SUCCESS` when succesful or error constant if there are any errors

4.4.2.26 get_exec_time()

```
unsigned long get_exec_time (
    struct timespec64 * prev_time )
```

Computes time difference between passed `prev_time` and current time, which is used in this case as an indicator of execution time for `worker` and `scheduler`

Parameters

<code>prev_time</code>	member of <code>worker</code> and <code>scheduler</code>
------------------------	--

Returns

returns unsigned long

4.4.2.27 init_proc()

```
int init_proc (
    void )
```

Initializes the core proc directory for UMS kernel module

Returns

returns `UMS_SUCCESS` when succesful or error constant if there are any errors

4.4.2.28 thread_yield()

```
int thread_yield (
    worker_status_t status )
```

Pauses or completes the execution of the worker thread To pause or complete the execution of the worker thread:

- Checks if the process is already managed, if not returns `UMS_ERROR_PROCESS_NOT_FOUND`
- Checks if scheduler associated by the pthread already exists, if not returns `UMS_ERROR_SCHEDULER_NOT_FOUND`
- Checks if the worker thread exists, currently running, completed its' work
- Updates the worker, scheduler and completion list data structures:
 - if `status` is set to `PAUSE`:
 - * `worker::state` is set to `IDLE`, so that it can be scheduled later
 - * worker is added back to the completion list
 - if `status` is set to `FINISH`:
 - * `worker::state` is set to `FINISHED`
 - * completion list increments the value of finished workers
- Records the statistics related to the scheduler and worker, such as number of switches and the time the switch happened
- Saves the register values of the worker thread
- Performs a context switch

Parameters

<i>status</i>	value of worker_status , which is the status of the worker thread
---------------	---

Returns

returns UMS_SUCCESS when succesful or error constant if there are any errors

4.5 ums_api.h

[Go to the documentation of this file.](#)

```

1
28 #pragma once
29
30 #include "const.h"
31
32 #include <asm/current.h>
33 #include <asm/fpu/internal.h>
34 #include <asm/fpu/types.h>
35 #include <linux/kernel.h>
36 #include <linux/module.h>
37 #include <linux/list.h>
38 #include <linux/slab.h>
39 #include <linux/types.h>
40 #include <linux/time.h>
41 #include <linux/proc_fs.h>
42 #include <linux/seq_file.h>
43
44 typedef struct process_list process_list_t;
45 typedef struct process process_t;
46 typedef struct completion_list completion_list_t;
47 typedef struct completion_list_node completion_list_node_t;
48 typedef struct worker_list worker_list_t;
49 typedef struct worker worker_t;
50 typedef struct scheduler_list scheduler_list_t;
51 typedef struct scheduler scheduler_t;
52
53 typedef struct process_proc_entry process_proc_entry_t;
54 typedef struct scheduler_proc_entry scheduler_proc_entry_t;
55 typedef struct worker_proc_entry worker_proc_entry_t;
56
57 int enter_ums(void);
58 int exit_ums(void);
59 ums_clid_t create_completion_list(void);
60 ums_wid_t create_worker_thread(worker_params_t *params);
61 ums_sid_t enter_scheduling_mode(scheduler_params_t *params);
62 int exit_scheduling_mode(void);
63 int execute_thread(ums_wid_t worker_id);
64 int thread_yield(worker_status_t status);
65 int dequeue_completion_list_items(list_params_t *params);
66 int delete_process(process_t *process);
67 int delete_completion_lists_and_worker_threads(process_t *process);
68 int delete_workers_from_completion_list(worker_list_t *worker_list);
69 int delete_workers_from_process_list(worker_list_t *worker_list);
70 int delete_schedulers(process_t *process);
71 process_t *create_process_node(pid_t pid);
72 process_t *check_if_process_exists(pid_t pid);
73 completion_list_node_t *check_if_completion_list_exists(process_t *proc, ums_clid_t clid);
74 scheduler_t *check_if_scheduler_exists(process_t *proc, ums_sid_t sid);
75 scheduler_t *check_if_scheduler_exists_run_by(process_t *process, pid_t pid);
76 worker_t *check_if_worker_exists(worker_list_t *worker_list, ums_wid_t wid);
77 worker_t *check_if_worker_exists_global(worker_list_t *worker_list, ums_wid_t wid);
78 state_t check_if_schedulers_state(process_t *proc);
79 unsigned long get_exec_time(struct timespec64 *prev_time);
80 int cleanup(void);
81
82 int init_proc(void);
83 int delete_proc(void);
84 int create_process_proc_entry(process_t *process);
85 int create_scheduler_proc_entry(process_t *process, scheduler_t *scheduler);
86 int create_worker_proc_entry(process_t *process, scheduler_t *scheduler, worker_t *worker);
87 int delete_process_proc_entry(process_t *process);
88
89 typedef struct process_list {
90     struct list_head list;

```

```

95     unsigned int process_count;
96 } process_list_t;
97
102 typedef struct process {
103     pid_t pid;
104     struct list_head list;
105     state_t state;
106     completion_list_t *completion_lists;
107     worker_list_t *worker_list;
108     scheduler_list_t *scheduler_list;
109     process_proc_entry_t *proc_entry;
110 } process_t;
111
116 typedef struct completion_list {
117     struct list_head list;
118     unsigned int list_count;
119 } completion_list_t;
120
125 typedef struct completion_list_node {
126     ums_clid_t clid;
127     struct list_head list;
128     unsigned int worker_count;
129     unsigned int finished_count;
130     state_t state;
131     worker_list_t *idle_list;
132     worker_list_t *busy_list;
133 } completion_list_node_t;
134
139 typedef struct worker_list {
140     struct list_head list;
141     unsigned int worker_count;
142 } worker_list_t;
143
148 typedef struct worker {
149     ums_wid_t wid;
150     pid_t pid;
151     pid_t tid;
152     ums_sid_t sid;
153     ums_clid_t clid;
154     unsigned long entry_point;
155     unsigned long stack_addr;
156     struct pt_regs regs;
157     struct fpu fpu_regs;
158     struct list_head global_list;
159     struct list_head local_list;
160     state_t state;
161     worker_proc_entry_t *proc_entry;
162     unsigned int switch_count;
163     unsigned long total_exec_time;
164     struct timespec64 time_of_the_last_switch;
165 } worker_t;
166
171 typedef struct scheduler_list {
172     struct list_head list;
173     unsigned int scheduler_count;
174 } scheduler_list_t;
175
180 typedef struct scheduler {
181     ums_sid_t sid;
182     pid_t pid;
183     pid_t tid;
184     ums_wid_t wid;
185     unsigned long entry_point;
186     unsigned long return_addr;
187     unsigned long stack_ptr;
188     unsigned long base_ptr;
189     state_t state;
190     struct pt_regs regs;
191     struct fpu fpu_regs;
192     completion_list_node_t *comp_list;
193     struct list_head list;
194     scheduler_proc_entry_t *proc_entry;
195     unsigned int switch_count;
196     unsigned long avg_switch_time;
197     unsigned long time_needed_for_the_last_switch;
198     unsigned long total_time_needed_for_the_switch;
199     struct timespec64 time_of_the_last_switch;
200 } scheduler_t;
201
206 typedef struct process_proc_entry {
207     struct proc_dir_entry *pde;
208     struct proc_dir_entry *parent;
209     struct proc_dir_entry *child;
210 } process_proc_entry_t;
211
216 typedef struct scheduler_proc_entry {
217     struct proc_dir_entry *pde;

```

```

218     struct proc_dir_entry *parent;
219     struct proc_dir_entry *child;
220     struct proc_dir_entry *info;
221 } scheduler_proc_entry_t;
222
227 typedef struct worker_proc_entry {
228     struct proc_dir_entry *pde;
229     struct proc_dir_entry *parent;
230 } worker_proc_entry_t;

```

4.6 ums_dev.c File Reference

Contains implementations of the UMS miscdevice.

```

#include "ums_dev.h"
#include <linux/kernel.h>
#include <linux/module.h>
#include <linux/miscdevice.h>
#include <linux/spinlock.h>
#include <linux/fs.h>

```

Functions

- **MODULE_AUTHOR** ("Bektur Umarbaev")
- **MODULE_DESCRIPTION** ("User Mode thread Scheduling (UMS)")
- **MODULE_LICENSE** ("GPL")
- **DEFINE_SPINLOCK** (spinlock_ums)
- **module_init** (init_dev)
- **module_exit** (exit_dev)

Variables

- unsigned long **spinlock_flags_ums**

4.6.1 Detailed Description

Contains implementations of the UMS miscdevice.

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Author

Bektur Umarbaev hrafnulf13@gmail.com

Date

4.7 ums_dev.h File Reference

The header that is responsible for UMS miscdevice and includes other headers required by UMS device to function properly.

```
#include "const.h"
#include "ums_api.h"
```

4.7.1 Detailed Description

The header that is responsible for UMS miscdevice and includes other headers required by UMS device to function properly.

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Author

Bektur Umarbaev hrafnulf13@gmail.com

Date

4.8 ums_dev.h

[Go to the documentation of this file.](#)

```
1
28 #pragma once
29
30 #include "const.h"
31 #include "ums_api.h"
```


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