Penn OS

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Chapter 1

PennOS Group 15 - Spring 2025

1.1 Names, PennKeys

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1.2 Submitted Source Files

- `src/fat/` - PennFAT filesystem implementation
  - `pennfat.c`, `pennfat.h` - Main PennFAT program
  - `fat_core.c`, `fat_core.h` - Core filesystem functions
  - `fat_kernel.c`, `fat_kernel.h` - Kernel-level filesystem functions
  - `fd_table.c`, `fd_table.h` - File descriptor table implementation
  - `err.c`, `err.h` - Error handling for filesystem
- `src/kernel/` - PennOS kernel implementation
  - `kernel.c`, `kernel.h` - Core kernel functionality
  - `pcb.c`, `pcb.h` - Process Control Block implementation
  - `p_errno.h`, `u_perror.c` - Error handling for the OS
  - `calls/` - System and user-level calls
    - `kernel-call.c`, `kernel-call.h` - Kernel-level calls
    - `sys-call.c`, `sys-call.h` - System calls
    - `user-call.c`, `user-call.h` - User-level commands
- `src/penn-shell/` - PennOS shell implementation
  - `penn-shell.c`, `penn-shell.h` - Shell implementation
  - `parser.c`, `parser.h` - Command line parser
  - `execute_command.c`, `execute_command.h` - Command execution
  - `stress.c`, `stress.h` - Shell commands for testing

- `src/util/` - Utility functions and data structures
  - `Vec.c`, `Vec.h` - Vector implementation
  - `deque.c`, `deque.h` - Deque implementation
  - `spthread.c`, `spthread.h` - Special thread library
  - `logger/` - Logging functionality
  - `types/` - Type definitions
- `src/pennos.c` - Main PennOS entry point

1.3 Extra Credit

We did not implement any of the extra credit options.

1.4 Compilation Instructions

1.4.1 For the standalone PennFAT:

1. Change to the fat directory: `cd src/fat`
2. Build the PennFAT executable: `make`
3. Run the standalone PennFAT: `./bin/pennfat`
4. Create a filesystem: `mkfs <filesystem_name> <blocks_in_fat> <block_size_config>`
   - Example: `mkfs fs.img 10 4` (creates a filesystem with 10 blocks in FAT and 4096-byte blocks)

1.4.2 For the full PennOS:

1. Create a filesystem using the standalone PennFAT (see instructions above)
2. Move the created filesystem file to the root directory
3. From the root directory, compile PennOS: `make`
4. Run PennOS with: `./bin/pennos fatfs <filesystem_file> [log_fname]`
   - Example: `./bin/pennos fatfs test_fs pennos.log`

1.5 Overview of Work Accomplished

We've implemented PennOS, a complete UNIX-like operating system. It runs as a user-level program on a host OS. Some noteworthy components are:

1. **PennFAT Filesystem**: A FAT-based filesystem implementation that supports file creation, deletion, reading, writing, permission management. Note that this filesystem is stored as a single file on the host OS.
2. **Kernel and Scheduler**: A round-robin scheduler with priority support. Manages processes as 'spthreads' and handles create, block, terminate, and scheduling.
3. **Process Management**: Full process lifecycle support, including zombies, orphans, and cleanup. Also supports parent-child relationships.
4. **Shell**: A command-line shell that supports built-in commands, I/O redirection, job control, and shell scripts.
5. **Error Handling**: Error handling was done similar to UNIX's errno and perror.

1.6 Description of Code and Code Layout

See the Submitted Source Files section for information on what each file contains.

As for the overall layout, we structured the OS into four key layers:

- **Core Infrastructure**: Basic utilities like `Vec`, `deque`, and the custom `spthread` library for lightweight threading.
- **Kernel Layer**: Handles core OS responsibilities—process management, scheduling, and kernel-level calls.
- **System Call Interface**: Bridges user programs and the kernel, isolating privilege boundaries and internal logic.
- **User-Level Applications**: Includes the shell, command parsing, and user-facing built-ins.

Some implementation decisions that we made were:

- **Abstraction**: we used consistent prefixes (`k_`, `s_`, `u_`) to denote kernel, system, and user-level functions.
- **Process Control Block (PCB)**: Stores process metadata—PID, state, priority, file descriptors—used across scheduling and management.
- **Scheduler**: Priority-based with multiple queues for different process states (running, blocked, zombie, etc.).
- **Filesystem Integration**: Kernel interfaces cleanly with the FAT filesystem, maintaining a strict separation.
- **Error Handling**: Unified error system modeled after `errno`/`perror` for consistent diagnostics.

1.7 General Comments

No other comments.

Chapter 2

Class Index

2.1 Class List

Here are the classes, structs, unions and interfaces with brief descriptions:

Chapter 3

File Index

3.1 File List

Here is a list of all files with brief descriptions:

Chapter 4

Class Documentation

4.1 buffer Struct Reference

`#include <fat_core.h>`

Public Attributes

- uint8_t * arr
- int size

4.1.1 Detailed Description

buffer structure for holding data

Parameters

arr	pointer to data array
size	size of buffer in bytes

4.1.2 Member Data Documentation

4.1.2.1 arr

`uint8_t* buffer::arr`

4.1.2.2 size

`int buffer::size`

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

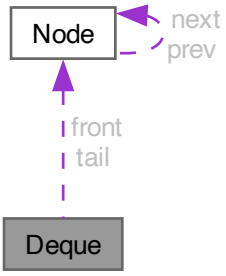
- src/fat/fat_core.h

4.2 Deque Struct Reference

Double-ended queue (deque) structure.

`#include <deque.h>`

Collaboration diagram for Deque:



Public Attributes

- Node * front
- Node * tail
- int size
- void(* delete_mem)(void *)

4.2.1 Detailed Description

Double-ended queue (deque) structure.

The Deque supports insertion and removal of elements from both ends. It uses a doubly-linked list of Node structures. The delete_mem function pointer is used to free memory for stored data.

4.2.2 Member Data Documentation

4.2.2.1 delete_mem

```
void(* Deque::delete_mem) (void *)
```

Function pointer to free element memory.

4.2.2.2 front

```
Node* Deque::front
```

Pointer to the front node.

4.2.2.3 size

```
int Deque::size
```

Number of elements in the deque.

4.2.2.4 tail

```
Node* Deque::tail
```

Pointer to the tail node.

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

- src/util/deque.h

4.3 dir_entry Struct Reference

```
#include <fat_core.h>
```

Public Attributes

- char name [32]
- uint32_t size
- uint16_t first_block
- uint8_t type
- uint8_t perm
- time_t mtime
- long double reserved

4.3.1 Detailed Description

directory entry structure representing a file in the filesystem

Parameters

name	file name name[0] is a special marker • 0: end of directory • 1: deleted entry; the file is also deleted • 2: deleted entry; the file is still being used
size	number of bytes in file
first_block	first block number of file (undefined if 0 size)

Parameters

type	type of file • 0: unknown • 1: regular file • 2: directory file • 3: symbolic link
perm	file permissions • 0: none • 2: write only • 4: read only • 5: read and executable (shell scripts) • 6: read and write • 7: read, write, and executable
mtime	creation/modification time
reserved	reserved bytes (last 16)

4.3.2 Member Data Documentation

4.3.2.1 first_block

```
uint16_t dir_entry::first_block
```

4.3.2.2 mtime

```
time_t dir_entry::mtime
```

4.3.2.3 name

```
char dir_entry::name[32]
```

4.3.2.4 perm

```
uint8_t dir_entry::perm
```

4.3.2.5 reserved

```
long double dir_entry::reserved
```

4.3.2.6 size

```
uint32_t dir_entry::size
```

4.3.2.7 type

```
uint8_t dir_entry::type
```

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

- src/fat/fat_core.h

4.4 fd_node Struct Reference

```
#include <fd_table.h>
```

Collaboration diagram for fd_node:

Public Attributes

- char * name
- int fd
- int offset
- int size
- int mode
- struct fd_node * next

4.4.1 Detailed Description

node struct to represent each file in the fd table

Parameters

name	file name
fd	fd number
offset	pointer offset
size	file size
mode	mode of file (0: read, 1: write, 2: append)
next	pointer to next node in list

4.4.2 Member Data Documentation

4.4.2.1 fd

```
int fd_node::fd
```

4.4.2.2 mode

```
int fd_node::mode
```

4.4.2.3 name

```
char* fd_node::name
```

4.4.2.4 next

```
struct fd_node* fd_node::next
```

4.4.2.5 offset

```
int fd_node::offset
```

4.4.2.6 size

```
int fd_node::size
```

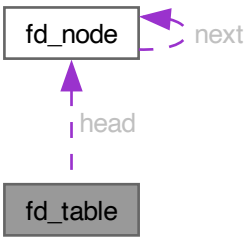
The documentation for this struct was generated from the following file:

- src/fat/fd_table.h

4.5 fd_table Struct Reference

```
#include <fd_table.h>
```

Collaboration diagram for fd_table:



Public Attributes

- FD_Node * head

4.5.1 Detailed Description

fd table struct

Parameters

head	head of the fd_table which is a linkedlist of fd_nodes

4.5.2 Member Data Documentation

4.5.2.1 head

```
FD_Node* fd_table::head
```

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

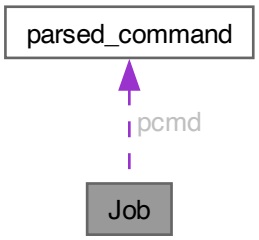
- src/fat/fd_table.h

4.6 Job Struct Reference

struct for job

```
#include <penn-shell.h>
```

«««< HEAD Collaboration diagram for Job: ======= Collaboration diagram for Job:»»»> 1bee6ba39be93d5183b34551923906b3a4d3



Public Attributes

- int job_id
- pid_t pid
- char * command
- JobStatus status
- struct parsed_command * pcmd

4.6.1 Detailed Description

struct for job

4.6.2 Member Data Documentation

4.6.2.1 command

```
char* Job::command
```

4.6.2.2 job_id

```
int Job::job_id
```

4.6.2.3 pcmd

```
struct parsed_command* Job::pcmd
```

4.6.2.4 pid

```
pid_t Job::pid
```

4.6.2.5 status

```
JobStatus Job::status
```

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

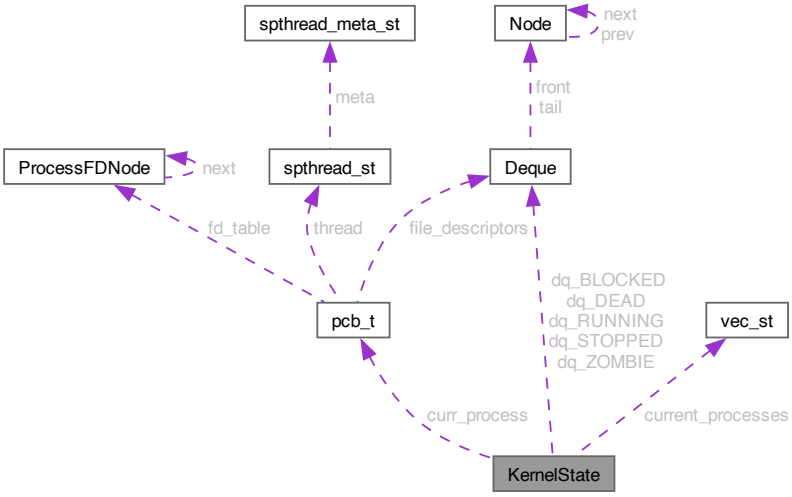
- src/penn-shell/penn-shell.h

4.7 KernelState Struct Reference

The kernel state.

`#include <kernel.h>`

Collaboration diagram for KernelState:



Public Attributes

- Deque * dq_RUNNING [3]
- Deque * dq_ZOMBIE
- Deque * dq_DEAD
- Deque * dq_BLOCKED
- Deque * dq_STOPPED
- int curr_thread_num
- int process_quanta
- pcb_t * curr_process
- Vec current_processes
- pid_t terminal_owner_pid

4.7.1 Detailed Description

The kernel state.

This structure contains all the state information for the kernel.

4.7.2 Member Data Documentation

4.7.2.1 curr_process

`pcb_t* KernelState::curr_process`

4.7.2.2 curr_thread_num

```
int KernelState::curr_thread_num
```

4.7.2.3 current_processes

```
Vec KernelState::current_processes
```

4.7.2.4 dq_BLOCKED

```
Deque* KernelState::dq_BLOCKED
```

4.7.2.5 dq_DEAD

```
Deque* KernelState::dq_DEAD
```

4.7.2.6 dq_RUNNING

```
Deque* KernelState::dq_RUNNING[3]
```

4.7.2.7 dq_STOPPED

```
Deque* KernelState::dq_STOPPED
```

4.7.2.8 dq_ZOMBIE

```
Deque* KernelState::dq_ZOMBIE
```

4.7.2.9 process_quanta

```
int KernelState::process_quanta
```

4.7.2.10 terminal_owner_pid

```
pid_t KernelState::terminal_owner_pid
```

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

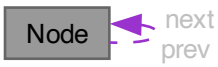
- src/kernel/kernel.h

4.8 Node Struct Reference

Node structure for doubly-linked list used in Deque.

```
#include <deque.h>
```

Collaboration diagram for Node:



Public Attributes

- void * data
- struct Node * next
- struct Node * prev

4.8.1 Detailed Description

Node structure for doubly-linked list used in Deque.

This structure represents a node in the deque, holding a pointer to data and pointers to the next and previous nodes in the list.

4.8.2 Member Data Documentation

4.8.2.1 data

```
void* Node::data
```

Pointer to the data stored in the node.

4.8.2.2 next

```
struct Node* Node::next
```

Pointer to the next node in the deque.

4.8.2.3 prev

```
struct Node* Node::prev
```

Pointer to the previous node in the deque.

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

- src/util/deque.h

4.9 parsed_command Struct Reference

struct parsed_command stored all necessary information needed for penn-shell.

```
#include <parser.h>
```

Public Attributes

- bool is_background
- bool is_file_append
- const char * stdin_file
- const char * stdout_file
- size_t num_commands
- char ** commands [ ]

4.9.1 Detailed Description

struct parsed_command stored all necessary information needed for penn-shell.

4.9.2 Member Data Documentation

4.9.2.1 commands

```
char** parsed_command::commands[ ]
```

4.9.2.2 is_background

```
bool parsed_command::is_background
```

4.9.2.3 is_file_append

```
bool parsed_command::is_file_append
```

4.9.2.4 num_commands

```
size_t parsed_command::num_commands
```

4.9.2.5 stdin_file

```
const char* parsed_command::stdin_file
```

4.9.2.6 stdout_file

```
const char* parsed_command::stdout_file
```

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

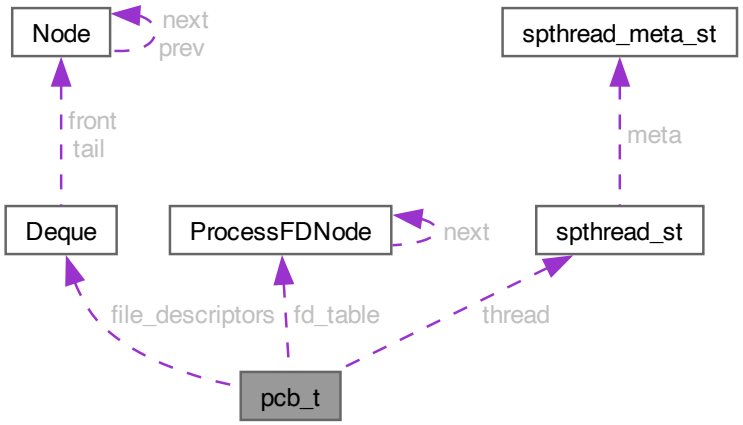
- src/penn-shell/parser.h

4.10 pcb_t Struct Reference

The Process Control Block (PCB) structure.

```
#include <pcb.h>
```

Collaboration diagram for pcb_t:



Public Attributes

- pid_t pid
- pid_t ppid
- int priority_level
- int term_signal
- int stop_signal
- ProcessStatus status
- bool status_changed
- unsigned long wake_up_tick
- Deque * file_descriptors
- ProcessFDNode * fd_table
- spthread_t * thread
- char * name
- bool foreground

4.10.1 Detailed Description

The Process Control Block (PCB) structure.

This structure represents a process control block (PCB) in the kernel.

4.10.2 Member Data Documentation

4.10.2.1 fd_table

```
ProcessFDNode* pcb_t::fd_table
```

4.10.2.2 file_descriptors

```
Deque* pcb_t::file_descriptors
```

4.10.2.3 foreground

```
bool pcb_t::foreground
```

4.10.2.4 name

```
char* pcb_t::name
```

4.10.2.5 pid

```
pid_t pcb_t::pid
```

4.10.2.6 ppid

```
pid_t pcb_t::ppid
```

4.10.2.7 priority_level

```
int pcb_t::priority_level
```

4.10.2.8 status

```
ProcessStatus pcb_t::status
```

4.10.2.9 status_changed

```
bool pcb_t::status_changed
```

4.10.2.10 stop_signal

```
int pcb_t::stop_signal
```

4.10.2.11 term_signal

```
int pcb_t::term_signal
```

4.10.2.12 thread

```
spthread_t* pcb_t::thread
```

4.10.2.13 wake_up_tick

```
unsigned long pcb_t::wake_up_tick
```

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

- src/kernel/pcb.h

4.11 ProcessFDNode Struct Reference

The Process File Descriptor Node structure.

`#include <pcb.h>`

«««< HEAD Collaboration diagram for ProcessFDNode: ======= Collaboration diagram for ProcessFDNode:»»»> 1bee6ba39be93d5183b34551923906b3a4d38e38

Public Attributes

- int fd_num
- char fname [32]
- int mode
- int offset
- struct ProcessFDNode * next

4.11.1 Detailed Description

The Process File Descriptor Node structure.

This structure represents a file descriptor node in the process's file descriptor table.

4.11.2 Member Data Documentation

4.11.2.1 fd_num

`int ProcessFDNode::fd_num`

4.11.2.2 fname

`char ProcessFDNode::fname[32]`

4.11.2.3 mode

`int ProcessFDNode::mode`

4.11.2.4 next

```
struct ProcessFDNode* ProcessFDNode::next
```

4.11.2.5 offset

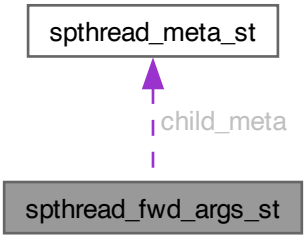
```
int ProcessFDNode::offset
```

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

- src/kernel/pcb.h

4.12 spthread_fwd_args_st Struct Reference

Collaboration diagram for spthread_fwd_args_st:



Public Attributes

- pthread_fn actual_routine
- void * actual_arg
- bool setup_done
- pthread_mutex_t setup_mutex
- pthread_cond_t setup_cond
- spthread_meta_t * child_meta

4.12.1 Member Data Documentation

4.12.1.1 actual_arg

```
void* spthread_fwd_args_st::actual_arg
```

4.12.1.2 actual_routine

```
pthread_fn spthread_fwd_args_st::actual_routine
```

4.12.1.3 child_meta

```
spthread_meta_t* spthread_fwd_args_st::child_meta
```

4.12.1.4 setup_cond

```
pthread_cond_t spthread_fwd_args_st::setup_cond
```

4.12.1.5 setup_done

```
bool spthread_fwd_args_st::setup_done
```

4.12.1.6 setup_mutex

```
pthread_mutex_t spthread_fwd_args_st::setup_mutex
```

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

- src/util/spthread.c

4.13 spthread_meta_st Struct Reference

Public Attributes

- sigset_t suspend_set
- volatile sig_atomic_t state
- pthread_mutex_t meta_mutex

4.13.1 Member Data Documentation

4.13.1.1 meta_mutex

```
pthread_mutex_t spthread_meta_st::meta_mutex
```

4.13.1.2 state

```
volatile sig_atomic_t spthread_meta_st::state
```

4.13.1.3 suspend_set

```
sigset_t spthread_meta_st::suspend_set
```

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

- src/util/spthread.c

4.14 spthread_signal_args_st Struct Reference

Public Attributes

- const int signal
- volatile sig_atomic_t ack
- pthread_mutex_t shutup_mutex

4.14.1 Member Data Documentation

4.14.1.1 ack

```
volatile sig_atomic_t spthread_signal_args_st::ack
```

4.14.1.2 shutup_mutex

```
pthread_mutex_t spthread_signal_args_st::shutup_mutex
```

4.14.1.3 signal

```
const int spthread_signal_args_st::signal
```

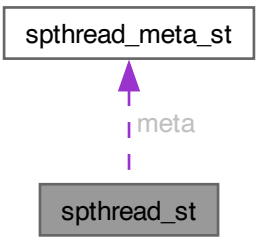
The documentation for this struct was generated from the following file:

- src/util/spthread.c

4.15 spthread_st Struct Reference

```
#include <spthread.h>
```

Collaboration diagram for spthread_st:



Public Attributes

- pthread_t thread
- spthread_meta_t * meta

4.15.1 Member Data Documentation

4.15.1.1 meta

```
spthread_meta_t* spthread_st::meta
```

4.15.1.2 thread

```
pthread_t spthread_st::thread
```

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

- src/util/spthread.h

4.16 vec_st Struct Reference

```
#include <Vec.h>
```

Public Attributes

- ptr_t * data
- size_t length
- size_t capacity
- ptr_dtor_fn ele_dtor_fn

4.16.1 Member Data Documentation

4.16.1.1 capacity

```
size_t vec_st::capacity
```

4.16.1.2 data

```
ptr_t* vec_st::data
```

4.16.1.3 ele_dtor_fn

```
ptr_dtor_fn vec_st::ele_dtor_fn
```

4.16.1.4 length

```
size_t vec_st::length
```

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

- src/util/Vec.h

Chapter 5

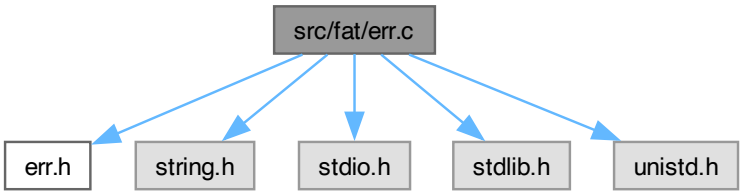
File Documentation

5.1 README.md File Reference

5.2 src/fat/err.c File Reference

```
#include "err.h"
#include <string.h>
#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>
```

Include dependency graph for err.c:



Functions

- char * error_case (void)

  Returns a string description of the current error.
- void f_perror (char *message)

  Prints an error message to the standard error stream.

Variables

- int ERRNO = 0

5.2.1 Function Documentation

5.2.1.1 error_case()

```
char * error_case (
            void )
```

Returns a string description of the current error.

Returns

A string description of the current error.

5.2.1.2 f_perror()

```
void f_perror (
            char * message)
```

Prints an error message to the standard error stream.

Parameters

message	The message to print.

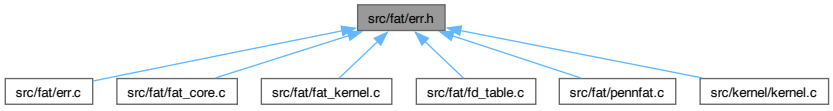
5.2.2 Variable Documentation

5.2.2.1 ERRNO

```
int ERRNO = 0
```

5.3 src/fat/err.h File Reference

This graph shows which files directly or indirectly include this file:



Macros

- #define FS_SUCCESS 0
- #define MKFS 1
- #define MOUNT 2
- #define UNMOUNT 3
- #define FILE_NOT_FOUND 4
- #define FILE_SYSTEM 5
- #define MEMORY_ERROR 6
- #define INVALID_FD 7
- #define PERMISSION_DENIED 8
- #define INVALID_ARGS 9
- #define INVALID_PATH 10
- #define INVALID_OFFSET 11
- #define INVALID_WHENCE 12
- #define INVALID_OPERATION 13
- #define FS_NOT_MOUNTED 14
- #define FS_ALREADY_MOUNTED 15
- #define NOT_A_DIRECTORY 16
- #define NO_SPACE 17

Functions

- char * error_case (void)

  Returns a string description of the current error.
- void f_perror (char *message)

  Prints an error message to the standard error stream.

Variables

- int ERRNO

5.3.1 Macro Definition Documentation

5.3.1.1 FILE_NOT_FOUND

```
#define FILE_NOT_FOUND 4
```

5.3.1.2 FILE_SYSTEM

```
#define FILE_SYSTEM 5
```

5.3.1.3 FS_ALREADY_MOUNTED

```
#define FS_ALREADY_MOUNTED 15
```

5.3.1.4 FS_NOT_MOUNTED

```
#define FS_NOT_MOUNTED 14
```

5.3.1.5 FS_SUCCESS

```
#define FS_SUCCESS 0
```

5.3.1.6 INVALID_ARGS

```
#define INVALID_ARGS 9
```

5.3.1.7 INVALID_FD

```
#define INVALID_FD 7
```

5.3.1.8 INVALID_OFFSET

```
#define INVALID_OFFSET 11
```

5.3.1.9 INVALID_OPERATION

```
#define INVALID_OPERATION 13
```

5.3.1.10 INVALID_PATH

```
#define INVALID_PATH 10
```

5.3.1.11 INVALID_WHENCE

```
#define INVALID_WHENCE 12
```

5.3.1.12 MEMORY_ERROR

```
#define MEMORY_ERROR 6
```

5.3.1.13 MKFS

```
#define MKFS 1
```

5.3.1.14 MOUNT

```
#define MOUNT 2
```

5.3.1.15 NO_SPACE

```
#define NO_SPACE 17
```

5.3.1.16 NOT_A_DIRECTORY

```
#define NOT_A_DIRECTORY 16
```

5.3.1.17 PERMISSION_DENIED

```
#define PERMISSION_DENIED 8
```

5.3.1.18 UNMOUNT

```
#define UNMOUNT 3
```

5.3.2 Function Documentation

5.3.2.1 error_case()

```
char * error_case (
            void )
```

Returns a string description of the current error.

Returns

A string description of the current error.

5.3.2.2 f_perror()

```
void f_perror (
            char * message)
```

Prints an error message to the standard error stream.

Parameters

message	The message to print.

5.3.3 Variable Documentation

5.3.3.1 ERRNO

```
int ERRNO  [extern]
```

5.4 err.h

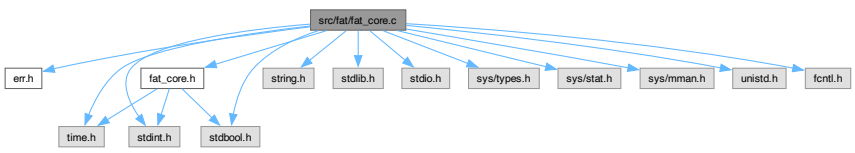
Go to the documentation of this file.

```
00001 #ifndef ERR_H
00002 #define ERR_H
00003
00004 #define FS_SUCCESS 0
00005 #define MKFS 1
00006 #define MOUNT 2
00007 #define UNMOUNT 3
00008 #define FILE_NOT_FOUND 4
00009 #define FILE_SYSTEM 5
00010 #define MEMORY_ERROR 6
00011 #define INVALID_FD 7
00012 #define PERMISSION_DENIED 8
00013 #define INVALID_ARGS 9
00014 #define INVALID_PATH 10
00015 #define INVALID_OFFSET 11
00016 #define INVALID_WHENCE 12
00017 #define INVALID_OPERATION 13
00018 #define FS_NOT_MOUNTED 14
00019 #define FS_ALREADY_MOUNTED 15
00020 #define NOT_A_DIRECTORY 16
00021 #define NO_SPACE 17
00022
00023 extern int ERRNO;
00024
00030 char *error_case(void);
00031
00037 void f_perror(char *message);
00038
00039 #endif
```

5.5 src/fat/fat_core.c File Reference

```
#include "err.h"
#include "fat_core.h"
#include <time.h>
#include <string.h>
#include <stdlib.h>
#include <stdio.h>
#include <stdint.h>
#include <stdbool.h>
#include <sys/types.h>
#include <sys/stat.h>
#include <sys/mman.h>
#include <unistd.h>
#include <fcntl.h>
```

Include dependency graph for fat_core.c:



Functions

- int convert_block_size (int input)
- int fs_create (char *fs_name, int new_fat_block_count, int block_config)
- int fs_mount (char *fs_name)
- int fs_unmount ()
- Dir_entry get_directory (void)
- int lookup_directory_offset (char *name, int block)
- Dir_entry offset_to_directory (int offset)
- int update_directory (Dir_entry ent, int offset)
- Dir_entry name_to_directory (char *name)
- Dir_entry index_to_directory (int index)
- int get_file_permission (char *name)
- void perm_to_rwx (int perm, char *permission_str)
- void format_file_info (Dir_entry entry, char *buffer)
- void fs_list_files (const char *filename, file_info_callback_t callback, void *user_data)

  List files in the filesystem, invoking a callback for each entry.
- int create_file (char *filename, uint8_t type)
- int fs_touch (char *file_name)
- int fs_rm (char *file_name)
- int fs_mv (char *source, char *dest)
- int read_file (Dir_entry ent, uint8_t *arr, int num_bytes, int buff_pos, int file_pos)
- int write_file (Dir_entry ent, uint8_t *arr, int num_bytes, int start)
- int k_read_at (Dir_entry ent, char *buf, int n, int offset)
- int k_write_at (Dir_entry ent, const char *str, int n, int offset)
- int fs_chmod (char *filename, uint8_t new_perm)

5.5.1 Function Documentation

5.5.1.1 convert_block_size()

```
int convert_block_size (
            int input)
```

maps block size configuration to actual byte size

Parameters

input	block size configuration (0-4)

Returns

size in bytes or -1 if invalid input

5.5.1.2 create_file()

```
int create_file (
            char * filename,
            uint8_t type)
```

creates a new file with specified type

Parameters

filename	name of the file to create
type	file type (regular, directory, etc.)

Returns

1 on success, -1 on failure

5.5.1.3 format_file_info()

```
void format_file_info (
            Dir_entry entry,
            char * buffer)
```

5.5.1.4 fs_chmod()

```
int fs_chmod (
            char * filename,
            uint8_t new_perm)
```

changes permissions of a file

Parameters

filename	name of the file
new_perm	new permission value

Returns

1 on success, -1 on failure

5.5.1.5 fs_create()

```
int fs_create (
            char * fs_name,
            int new_fat_block_count,
            int block_config)
```

creates a new pennfat filesystem

Parameters

fs_name	name of the filesystem file
new_fat_block_count	number of blocks in FAT region
block_config	block size configuration (0-4)

Returns

1 on success, -1 on failure

5.5.1.6 fs_list_files()

```
void fs_list_files (
            const char * filename,
            file_info_callback_t callback,
            void * user_data)
```

List files in the filesystem, invoking a callback for each entry.

Parameters

filename	If not NULL, only list that file; else list all files.
callback	Function called for each file entry found.
user_data	Opaque pointer passed to callback.

5.5.1.7 fs_mount()

```
int fs_mount (
            char * fs_name)
```

mounts a pennfat filesystem into memory

Parameters

fs_name	name of the filesystem file to mount

Returns

0 on success, -1 on failure

5.5.1.8 fs_mv()

```
int fs_mv (
            char * source,
            char * dest)
```

renames a file in the filesystem

Parameters

source	original filename
dest	new filename

Returns

1 on success, -1 on failure

5.5.1.9 fs_rm()

```
int fs_rm (
            char * file_name)
```

removes a file from the filesystem

Parameters

file_name	name of the file to remove

Returns

1 on success, -1 on failure

5.5.1.10 fs_touch()

```
int fs_touch (
            char * file_name)
```

creates a file or updates its timestamp if it exists

Parameters

file_name	name of the file to touch

Returns

1 on success, -1 on failure

5.5.1.11 fs_unmount()

```
int fs_unmount (
            void )
```

unmounts the currently mounted filesystem

Returns

0 on success, -1 on failure

5.5.1.12 get_directory()

```
Dir_entry get_directory (
            void )
```

gets the root directory entry

Returns

root directory entry

5.5.1.13 get_file_permission()

```
int get_file_permission (
            char * name)
```

gets permission value for a file

Parameters

name	filename

Returns

permission value or -1 if file not found

5.5.1.14 index_to_directory()

```
Dir_entry index_to_directory (
            int index)
```

gets directory entry by index

Parameters

index	index of directory entry

Returns

directory entry at specified index or empty entry if not found

5.5.1.15 k_read_at()

```
int k_read_at (
            Dir_entry ent,
            char * buf,
            int n,
            int offset)
```

reads data from a file with explicit offset

Parameters

ent	directory entry for the file
arr	buffer to store read data
num_bytes	number of bytes to read
file_pos	position in file to start reading from

Returns

number of bytes read or -1 on error

5.5.1.16 k_write_at()

```
int k_write_at (
            Dir_entry ent,
            const char * str,
            int n,
            int offset)
```

writes data to a file with explicit offset

Parameters

ent	directory entry for the file
str	buffer containing data to write
n	number of bytes to write
offset	position in file to start writing at

Returns

number of bytes written or -1 on error

5.5.1.17 lookup_directory_offset()

```
int lookup_directory_offset (
            char * name,
            int block)
```

finds the location of a directory entry by name

Parameters

name	filename to find
block	block to start search from

Returns

offset of directory entry or -1 if not found

5.5.1.18 name_to_directory()

```
Dir_entry name_to_directory (
            char * name)
```

gets directory entry by filename

Parameters

name	filename to find

Returns

directory entry for specified file or empty entry if not found

5.5.1.19 offset_to_directory()

```
Dir_entry offset_to_directory (
            int offset)
```

gets directory entry at specified offset

Parameters

offset	file offset of directory entry

Returns

directory entry at specified offset

5.5.1.20 perm_to_rwx()

```
void perm_to_rwx (
            int perm,
            char * permission_str)
```

converts permission value to string representation

Parameters

perm	permission value
permission_str	output string buffer (should be at least 4 bytes)

5.5.1.21 read_file()

```
int read_file (
            Dir_entry ent,
            uint8_t * arr,
            int num_bytes,
            int buff_pos,
            int file_pos)
```

reads data from a file

Parameters

ent	directory entry for the file
arr	buffer to store read data
num_bytes	number of bytes to read
buff_pos	starting position in buffer
file_pos	starting position in file

Returns

number of bytes read or -1 on error

5.5.1.22 update_directory()

```
int update_directory (
            Dir_entry ent,
            int offset)
```

updates a directory entry

Parameters

ent	updated directory entry
offset	offset of entry to update

Returns

1 on success, -1 on failure

5.5.1.23 write_file()

```
int write_file (
            Dir_entry ent,
            uint8_t * arr,
            int num_bytes,
            int start)
```

writes data to a file

Parameters

ent	directory entry for the file
arr	buffer containing data to write
num_bytes	number of bytes to write
start	starting position in file

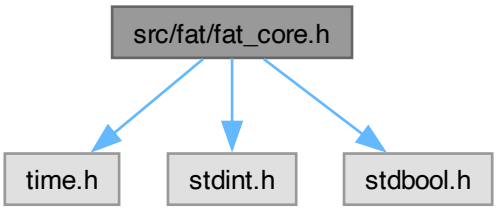
Returns

number of bytes written or -1 on error

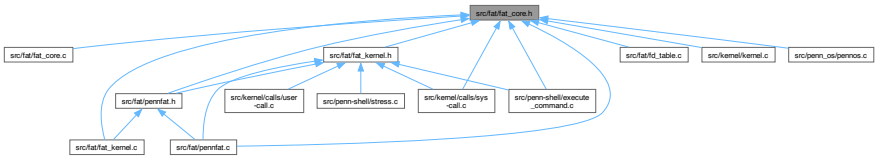
5.6 src/fat/fat_core.h File Reference

```
#include <time.h>
#include <stdint.h>
#include <stdbool.h>
```

Include dependency graph for fat_core.h:



This graph shows which files directly or indirectly include this file:



Classes

- struct dir_entry
- struct buffer

Macros

- #define UNKNOWN_FILE 0
- #define REGULAR_FILE 1
- #define DIRECTORY_FILE 2
- #define LINK_FILE 4
- #define EOD_FLAG 0x00
- #define LAST_BLOCK 0xFFFF
- #define FREE_BLOCK 0x0000
- #define SEEK_SET 0
- #define SEEK_CUR 1
- #define SEEK_END 2

Typedefs

- typedef struct dir_entry Dir_entry
- typedef struct buffer Buffer
- typedef void(∗ file_info_callback_t) (const Dir_entry ∗, void ∗)

Functions

- int convert_block_size (int input)
- int fs_create (char ∗fs_name, int new_fat_block_count, int block_config)
- int fs_mount (char ∗fs_name)
- int fs_unmount (void)
- int fs_touch (char ∗file_name)
- int fs_rm (char ∗file_name)
- int fs_mv (char ∗source, char ∗dest)
- int create_file (char ∗filename, uint8_t type)
- int read_file (Dir_entry ent, uint8_t ∗arr, int num_bytes, int buff_pos, int file_pos)
- int write_file (Dir_entry ent, uint8_t ∗arr, int num_bytes, int start)
- int k_read_at (Dir_entry ent, char ∗buf, int n, int offset)
- int k_write_at (Dir_entry ent, const char ∗str, int n, int offset)
- Dir_entry get_directory (void)
- int lookup_directory_offset (char ∗name, int block)
- Dir_entry offset_to_directory (int offset)

- Dir_entry name_to_directory (char *name)
- Dir_entry index_to_directory (int index)
- void fs_list_files (const char *filename, file_info_callback_t callback, void *user_data)

  List files in the filesystem, invoking a callback for each entry.
- void format_file_info (Dir_entry entry, char *buffer)
- int update_directory (Dir_entry ent, int offset)
- void perm_to_rwx (int perm, char *permission_str)
- int get_file_permission (char *name)
- int fs_chmod (char *filename, uint8_t new_perm)

5.6.1 Macro Definition Documentation

5.6.1.1 DIRECTORY_FILE

```
#define DIRECTORY_FILE 2
```

5.6.1.2 EOD_FLAG

```
#define EOD_FLAG 0x00
```

5.6.1.3 FREE_BLOCK

```
#define FREE_BLOCK 0x0000
```

5.6.1.4 LAST_BLOCK

```
#define LAST_BLOCK 0xFFFF
```

5.6.1.5 LINK_FILE

```
#define LINK_FILE 4
```

5.6.1.6 REGULAR_FILE

```
#define REGULAR_FILE 1
```

5.6.1.7 SEEK_CUR

```
#define SEEK_CUR 1
```

5.6.1.8 SEEK_END

```
#define SEEK_END 2
```

5.6.1.9 SEEK_SET

```
#define SEEK_SET 0
```

5.6.1.10 UNKNOWN_FILE

```
#define UNKNOWN_FILE 0
```

5.6.2 Typedef Documentation

5.6.2.1 Buffer

```
typedef struct buffer Buffer
```

buffer structure for holding data

Parameters

arr	pointer to data array
size	size of buffer in bytes

5.6.2.2 Dir_entry

```
typedef struct dir_entry Dir_entry
```

directory entry structure representing a file in the filesystem

Parameters

name	file name name[0] is a special marker • 0: end of directory • 1: deleted entry; the file is also deleted • 2: deleted entry; the file is still being used
size	number of bytes in file
first_block	first block number of file (undefined if 0 size)
type	type of file • 0: unknown • 1: regular file • 2: directory file • 3: symbolic link

Parameters

perm	file permissions • 0: none • 2: write only • 4: read only • 5: read and executable (shell scripts) • 6: read and write • 7: read, write, and executable
mtime	creation/modification time
reserved	reserved bytes (last 16)

5.6.2.3 file_info_callback_t

```
typedef void(* file_info_callback_t) (const Dir_entry *, void *)
```

5.6.3 Function Documentation

5.6.3.1 convert_block_size()

```
int convert_block_size (
            int input)
```

maps block size configuration to actual byte size

Parameters

input	block size configuration (0-4)

Returns

size in bytes or -1 if invalid input

5.6.3.2 create_file()

```
int create_file (
            char * filename,
            uint8_t type)
```

creates a new file with specified type

Parameters

filename	name of the file to create
type	file type (regular, directory, etc.)

Returns

1 on success, -1 on failure

5.6.3.3 format_file_info()

```
void format_file_info (
            Dir_entry entry,
            char * buffer)
```

5.6.3.4 fs_chmod()

```
int fs_chmod (
            char * filename,
            uint8_t new_perm)
```

changes permissions of a file

Parameters

filename	name of the file
new_perm	new permission value

Returns

1 on success, -1 on failure

5.6.3.5 fs_create()

```
int fs_create (
            char * fs_name,
            int new_fat_block_count,
            int block_config)
```

creates a new pennfat filesystem

Parameters

fs_name	name of the filesystem file
new_fat_block_count	number of blocks in FAT region
block_config	block size configuration (0-4)

Returns

1 on success, -1 on failure

5.6.3.6 fs_list_files()

```
void fs_list_files (
            const char * filename,
            file_info_callback_t callback,
            void * user_data)
```

List files in the filesystem, invoking a callback for each entry.

Parameters

filename	If not NULL, only list that file; else list all files.
callback	Function called for each file entry found.
user_data	Opaque pointer passed to callback.

5.6.3.7 fs_mount()

```
int fs_mount (
            char * fs_name)
```

mounts a pennfat filesystem into memory

Parameters

fs_name	name of the filesystem file to mount

Returns

0 on success, -1 on failure

5.6.3.8 fs_mv()

```
int fs_mv (
            char * source,
            char * dest)
```

renames a file in the filesystem

Parameters

source	original filename
dest	new filename

Returns

1 on success, -1 on failure

5.6.3.9 fs_rm()

```
int fs_rm (
            char * file_name)
```

removes a file from the filesystem

Parameters

file_name	name of the file to remove

Returns

1 on success, -1 on failure

5.6.3.10 fs_touch()

```
int fs_touch (
            char * file_name)
```

creates a file or updates its timestamp if it exists

Parameters

file_name	name of the file to touch

Returns

1 on success, -1 on failure

5.6.3.11 fs_unmount()

```
int fs_unmount (
            void )
```

unmounts the currently mounted filesystem

Returns

0 on success, -1 on failure

5.6.3.12 get_directory()

```
Dir_entry get_directory (
            void )
```

gets the root directory entry

Returns

root directory entry

5.6.3.13 get_file_permission()

```
int get_file_permission (
            char * name)
```

gets permission value for a file

Parameters

name	filename

Returns

permission value or -1 if file not found

5.6.3.14 index_to_directory()

```
Dir_entry index_to_directory (
            int index)
```

gets directory entry by index

Parameters

index	index of directory entry

Returns

directory entry at specified index or empty entry if not found

5.6.3.15 k_read_at()

```
int k_read_at (
            Dir_entry ent,
            char * buf,
            int n,
            int offset)
```

reads data from a file with explicit offset

Parameters

ent	directory entry for the file
arr	buffer to store read data
num_bytes	number of bytes to read
file_pos	position in file to start reading from

Returns

number of bytes read or -1 on error

5.6.3.16 k_write_at()

```
int k_write_at (
            Dir_entry ent,
            const char * str,
            int n,
            int offset)
```

writes data to a file with explicit offset

Parameters

ent	directory entry for the file
str	buffer containing data to write
n	number of bytes to write
offset	position in file to start writing at

Returns

number of bytes written or -1 on error

5.6.3.17 lookup_directory_offset()

```
int lookup_directory_offset (
            char * name,
            int block)
```

finds the location of a directory entry by name

Parameters

name	filename to find
block	block to start search from

Returns

offset of directory entry or -1 if not found

5.6.3.18 name_to_directory()

```
Dir_entry name_to_directory (
            char * name)
```

gets directory entry by filename

Parameters

name	filename to find

Returns

directory entry for specified file or empty entry if not found

5.6.3.19 offset_to_directory()

```
Dir_entry offset_to_directory (
            int offset)
```

gets directory entry at specified offset

Parameters

offset	file offset of directory entry

Returns

directory entry at specified offset

5.6.3.20 perm_to_rwx()

```
void perm_to_rwx (
            int perm,
            char * permission_str)
```

converts permission value to string representation

Parameters

perm	permission value
permission_str	output string buffer (should be at least 4 bytes)

5.6.3.21 read_file()

```
int read_file (
            Dir_entry ent,
            uint8_t * arr,
            int num_bytes,
            int buff_pos,
            int file_pos)
```

reads data from a file

Parameters

ent	directory entry for the file
arr	buffer to store read data
num_bytes	number of bytes to read
buff_pos	starting position in buffer
file_pos	starting position in file

Returns

number of bytes read or -1 on error

5.6.3.22 update_directory()

```
int update_directory (
            Dir_entry ent,
            int offset)
```

updates a directory entry

Parameters

ent	updated directory entry
offset	offset of entry to update

Returns

1 on success, -1 on failure

5.6.3.23 write_file()

```
int write_file (
            Dir_entry ent,
            uint8_t * arr,
            int num_bytes,
            int start)
```

writes data to a file

Parameters

ent	directory entry for the file
arr	buffer containing data to write
num_bytes	number of bytes to write
start	starting position in file

Returns

number of bytes written or -1 on error

5.7 fat_core.h

Go to the documentation of this file.

```
00001 #ifndef FAT_CORE_H
00002 #define FAT_CORE_H
00003
00004 #include <time.h>
00005 #include <stdint.h>
00006 #include <stdbool.h>
00007
00008 /* File types */
00009 #define UNKNOWN_FILE 0
00010 #define REGULAR_FILE 1
00011 #define DIRECTORY_FILE 2
00012 #define LINK_FILE 4
00013
00014 /* Special flags */
00015 #define EOD_FLAG 0x00
00016
00017 /* Block status values */
00018 #define LAST_BLOCK 0xFFFF
00019 #define FREE_BLOCK 0x0000
00020
00021 /* File positioning constants */
00022 #define SEEK_SET 0
00023 #define SEEK_CUR 1
00024 #define SEEK_END 2
00025
```

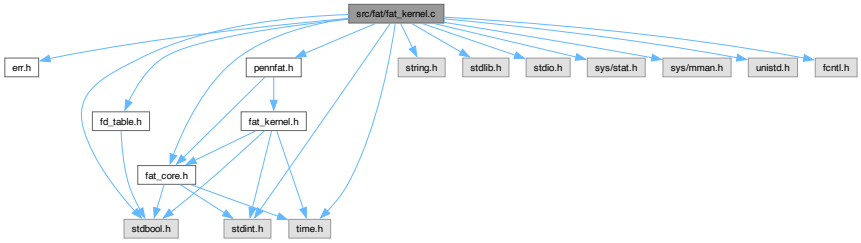
```
00050 typedef struct dir_entry
00051 {
00052     char name[32];
00053     uint32_t size;
00054     uint16_t first_block;
00055     uint8_t type;
00056     uint8_t perm;
00057     time_t mtime;
00058     long double reserved;
00059 } Dir_entry;
00060
00066 typedef struct buffer
00067 {
00068     uint8_t *arr;
00069     int size;
00070 } Buffer;
00071
00072 /*
00073  * Filesystem core management functions
00074  */
00075
00081 int convert_block_size(int input);
00082
00090 int fs_create(char *fs_name, int new_fat_block_count, int block_config);
00091
00097 int fs_mount(char *fs_name);
00098
00103 int fs_unmount(void);
00104
00105 /*
00106  * File operation functions
00107  */
00108
00114 int fs_touch(char *file_name);
00115
00121 int fs_rm(char *file_name);
00122
00129 int fs_mv(char *source, char *dest);
00130
00137 int create_file(char *filename, uint8_t type);
00138
00139 /*
00140  * File data read/write functions
00141  */
00142
00152 int read_file(Dir_entry ent, uint8_t *arr, int num_bytes, int buff_pos, int file_pos);
00153
00162 int write_file(Dir_entry ent, uint8_t *arr, int num_bytes, int start);
00163
00172 int k_read_at(Dir_entry ent, char *buf, int n, int offset);
00173
00182 int k_write_at(Dir_entry ent, const char *str, int n, int offset);
00183
00184 /*
00185  * Directory entry management functions
00186  */
00187
00192 Dir_entry get_directory(void);
00193
00200 int lookup_directory_offset(char *name, int block);
00201
00207 Dir_entry offset_to_directory(int offset);
00208
00214 Dir_entry name_to_directory(char *name);
00215
00221 Dir_entry index_to_directory(int index);
00222
00223 // Callback type for file listing
00224 typedef void (*file_info_callback_t)(const Dir_entry *, void *);
00225
00232 void fs_list_files(const char *filename, file_info_callback_t callback, void *user_data);
00233
00234 // Formats a Dir_entry into a printable string for ls output
00235 void format_file_info(Dir_entry entry, char *buffer);
00236
00243 int update_directory(Dir_entry ent, int offset);
00244
00245 /*
00246  * Utility functions
00247  */
00248
00254 void perm_to_rwx(int perm, char *permission_str);
00255
00261 int get_file_permission(char *name);
00262
00269 int fs_chmod(char *filename, uint8_t new_perm);
00270
```

```
00271 #endif
```

5.8 src/fat/fat_kernel.c File Reference

```
#include "err.h"
#include "fd_table.h"
#include "pennfat.h"
#include "fat_core.h"
#include <time.h>
#include <string.h>
#include <stdlib.h>
#include <stdio.h>
#include <stdint.h>
#include <stdbool.h>
#include <sys/stat.h>
#include <sys/mman.h>
#include <unistd.h>
#include <fcntl.h>
```

Include dependency graph for fat_kernel.c:



Macros

- #define MAX_LINE_LENGTH 4096

Functions

- void init ()
- int k_open (const char *fname, int mode)
- int kf_read (int fd, int n, char *buf)
- int kf_write (int fd, const char *str, int n)
- int k_read_at_offset (int fd, int n, char *buf, int offset)
- int k_write_at_offset (int fd, const char *str, int n, int offset)
- int k_close (int fd)
- void k_unlink (const char *fname)
- void k_lseek (int fd, int offset, int whence)
- void k_ls (const char *filename)
- void f_touch (char *args[])
- void f_rm (char *args[])
- void f_mv (char *args[])
- void f_cat (char *args[], int fd_in, int fd_out)
- void f_cp (char *args[])
- int f_get_permission (char *file_name)
- int k_chmod (const char *fname, uint8_t new_perm)
- void f_chmod (char *args[])
- int k_get_permission (const char *fname)

5.8.1 Macro Definition Documentation

5.8.1.1 MAX_LINE_LENGTH

```
#define MAX_LINE_LENGTH 4096
```

5.8.2 Function Documentation

5.8.2.1 f_cat()

```
void f_cat (
            char * args[],
            int fd_in,
            int fd_out)
```

concatenates files or displays input

Parameters

args	command arguments array (args[0] is command name)
fd_in	input file descriptor
fd_out	output file descriptor

5.8.2.2 f_chmod()

```
void f_chmod (
            char * args[])
```

changes file permissions

Parameters

args	command arguments array (args[0] is command name)

5.8.2.3 f_cp()

```
void f_cp (
            char * args[])
```

copies a file

Parameters

args	command arguments array (args[0] is command name)

5.8.2.4 f_get_permission()

```
int f_get_permission (
            char * file_name)
```

gets permission value for a file

Parameters

file_name	name of the file

Returns

permission value or -1 if file not found

5.8.2.5 f_mv()

```
void f_mv (
            char * args[])
```

renames a file

Parameters

args	command arguments array (args[0] is command name)

5.8.2.6 f_rm()

```
void f_rm (
            char * args[])
```

removes files from the filesystem

Parameters

args	command arguments array (args[0] is command name)

5.8.2.7 f_touch()

```
void f_touch (
            char * args[])
```

creates empty files or updates timestamps of existing files

Parameters

args	command arguments array (args[0] is command name)

5.8.2.8 init()

```
void init (
            void )
```

initializes the pennfat system

5.8.2.9 k_chmod()

```
int k_chmod (
            const char * fname,
            uint8_t new_perm)
```

changes permissions of a file

Parameters

fname	name of the file
new_perm	new permission value

Returns

1 on success, -1 on failure

5.8.2.10 k_close()

```
int k_close (
            int fd)
```

closes a file descriptor

Parameters

fd	file descriptor to close

Returns

0 on success, negative value on failure

5.8.2.11 k_get_permission()

```
int k_get_permission (
            const char * fname)
```

gets permission value for a file

Parameters

fname	name of the file

Returns

permission value or -1 if file not found

5.8.2.12 k_ls()

```
void k_ls (
            const char * filename)
```

lists file(s) in the filesystem

Parameters

filename	specific file to list, or NULL for all files

5.8.2.13 k_lseek()

```
void k_lseek (
            int fd,
            int offset,
            int whence)
```

repositions the file offset

Parameters

fd	file descriptor
offset	offset value
whence	reference position (SEEK_SET, SEEK_CUR, SEEK_END)

5.8.2.14 k_open()

```
int k_open (
            const char * fname,
            int mode)
```

opens a file with specified mode

Parameters

fname	name of the file to open
mode	access mode (F_READ, F_WRITE, F_APPEND)

Returns

file descriptor on success, negative value on failure

5.8.2.15 k_read_at_offset()

```
int k_read_at_offset (
            int fd,
            int n,
            char * buf,
            int offset)
```

reads data from a file at specified offset

Parameters

fd	file descriptor
n	maximum number of bytes to read
buf	buffer to store read data
offset	position in file to start reading from

Returns

number of bytes read, 0 on EOF, negative value on error

5.8.2.16 k_unlink()

```
void k_unlink (
            const char * fname)
```

removes a file from the filesystem

Parameters

fname	name of the file to remove

5.8.2.17 k_write_at_offset()

```
int k_write_at_offset (
            int fd,
            const char * str,
            int n,
            int offset)
```

writes data to a file at specified offset

Parameters

fd	file descriptor
str	buffer containing data to write
n	number of bytes to write
offset	position in file to start writing at

Returns

number of bytes written, negative value on error

5.8.2.18 kf_read()

```
int kf_read (
            int fd,
            int n,
            char * buf)
```

reads data from a file

Parameters

fd	file descriptor
n	maximum number of bytes to read
buf	buffer to store read data

Returns

number of bytes read, 0 on EOF, negative value on error

5.8.2.19 kf_write()

```
int kf_write (
            int fd,
            const char * str,
            int n)
```

writes data to a file

Parameters

fd	file descriptor
str	buffer containing data to write
n	number of bytes to write

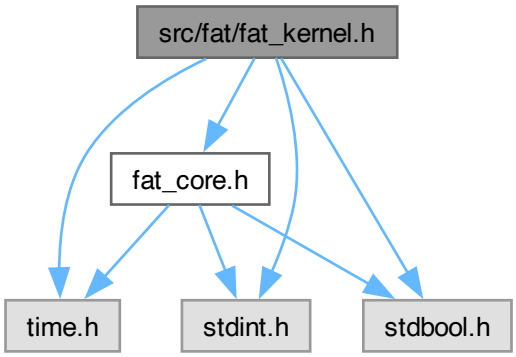
Returns

number of bytes written, negative value on error

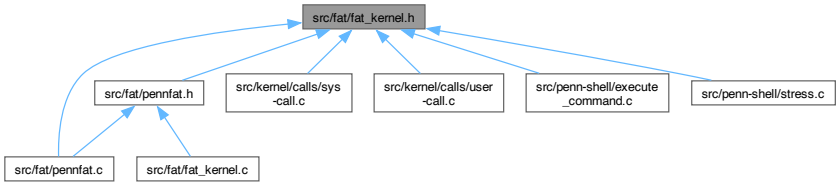
5.9 src/fat/fat_kernel.h File Reference

```
#include "fat_core.h"
#include <time.h>
#include <stdint.h>
#include <stdbool.h>
```

Include dependency graph for fat_kernel.h:



This graph shows which files directly or indirectly include this file:



Macros

- #define F_READ 0
- #define F_WRITE 1
- #define F_APPEND 2
- #define STDIN_FILENO 0
- #define STDOUT_FILENO 1
- #define STDERR_FILENO 2
- #define SEEK_SET 0
- #define SEEK_CUR 1
- #define SEEK_END 2

Functions

- void init (void)
- int k_open (const char ∗fname, int mode)
- int kf_read (int fd, int n, char ∗buf)
- int kf_write (int fd, const char ∗str, int n)
- int k_read_at_offset (int fd, int n, char ∗buf, int offset)
- int k_write_at_offset (int fd, const char ∗str, int n, int offset)
- int k_close (int fd)
- void k_unlink (const char ∗fname)
- void k_lseek (int fd, int offset, int whence)
- void k_ls (const char ∗filename)
- void f_touch (char ∗args[ ])
- void f_rm (char ∗args[ ])
- void f_mv (char ∗args[ ])
- void f_cat (char ∗args[ ], int fd_in, int fd_out)
- void f_cp (char ∗args[ ])
- void f_chmod (char ∗args[ ])
- int f_get_permission (char ∗file_name)
- int k_chmod (const char ∗fname, uint8_t new_perm)
- int k_get_permission (const char ∗fname)

5.9.1 Macro Definition Documentation

5.9.1.1 F_APPEND

```
#define F_APPEND 2
```

5.9.1.2 F_READ

```
#define F_READ 0
```

5.9.1.3 F_WRITE

```
#define F_WRITE 1
```

5.9.1.4 SEEK_CUR

```
#define SEEK_CUR 1
```

5.9.1.5 SEEK_END

```
#define SEEK_END 2
```

5.9.1.6 SEEK_SET

```
#define SEEK_SET 0
```

5.9.1.7 STDERR_FILENO

```
#define STDERR_FILENO 2
```

5.9.1.8 STDIN_FILENO

```
#define STDIN_FILENO 0
```

5.9.1.9 STDOUT_FILENO

```
#define STDOUT_FILENO 1
```

5.9.2 Function Documentation

5.9.2.1 f_cat()

```
void f_cat (
            char * args[],
            int fd_in,
            int fd_out)
```

concatenates files or displays input

Parameters

args	command arguments array (args[0] is command name)
fd_in	input file descriptor
fd_out	output file descriptor

5.9.2.2 f_chmod()

```
void f_chmod (
            char * args[])
```

changes file permissions

Parameters

args	command arguments array (args[0] is command name)

5.9.2.3 f_cp()

```
void f_cp (
            char * args[])
```

copies a file

Parameters

args	command arguments array (args[0] is command name)

5.9.2.4 f_get_permission()

```
int f_get_permission (
            char * file_name)
```

gets permission value for a file

Parameters

file_name	name of the file

Returns

permission value or -1 if file not found

5.9.2.5 f_mv()

```
void f_mv (
            char * args[])
```

renames a file

Parameters

args	command arguments array (args[0] is command name)

5.9.2.6 f_rm()

```
void f_rm (
            char * args[])
```

removes files from the filesystem

Parameters

args	command arguments array (args[0] is command name)

5.9.2.7 f_touch()

```
void f_touch (
            char * args[])
```

creates empty files or updates timestamps of existing files

Parameters

args	command arguments array (args[0] is command name)

5.9.2.8 init()

```
void init (
            void )
```

initializes the pennfat system

5.9.2.9 k_chmod()

```
int k_chmod (
            const char * fname,
            uint8_t new_perm)
```

changes permissions of a file

Parameters

fname	name of the file
new_perm	new permission value

Returns

1 on success, -1 on failure

5.9.2.10 k_close()

```
int k_close (
            int fd)
```

closes a file descriptor

Parameters

fd	file descriptor to close

Returns

0 on success, negative value on failure

5.9.2.11 k_get_permission()

```
int k_get_permission (
            const char * fname)
```

gets permission value for a file

Parameters

fname	name of the file

Returns

permission value or -1 if file not found

5.9.2.12 k_ls()

```
void k_ls (
            const char * filename)
```

lists file(s) in the filesystem

Parameters

filename	specific file to list, or NULL for all files

5.9.2.13 k_lseek()

```
void k_lseek (
            int fd,
            int offset,
            int whence)
```

repositions the file offset

Parameters

fd	file descriptor
offset	offset value
whence	reference position (SEEK_SET, SEEK_CUR, SEEK_END)

5.9.2.14 k_open()

```
int k_open (
            const char * fname,
            int mode)
```

opens a file with specified mode

Parameters

fname	name of the file to open
mode	access mode (F_READ, F_WRITE, F_APPEND)

Returns

file descriptor on success, negative value on failure

5.9.2.15 k_read_at_offset()

```
int k_read_at_offset (
            int fd,
            int n,
            char * buf,
            int offset)
```

reads data from a file at specified offset

Parameters

fd	file descriptor
n	maximum number of bytes to read
buf	buffer to store read data
offset	position in file to start reading from

Returns

number of bytes read, 0 on EOF, negative value on error

5.9.2.16 k_unlink()

```
void k_unlink (
            const char * fname)
```

removes a file from the filesystem

Parameters

fname	name of the file to remove

5.9.2.17 k_write_at_offset()

```
int k_write_at_offset (
            int fd,
            const char * str,
            int n,
            int offset)
```

writes data to a file at specified offset

Parameters

fd	file descriptor
str	buffer containing data to write
n	number of bytes to write
offset	position in file to start writing at

Returns

number of bytes written, negative value on error

5.9.2.18 kf_read()

```
int kf_read (
            int fd,
            int n,
            char * buf)
```

reads data from a file

Parameters

fd	file descriptor
n	maximum number of bytes to read
buf	buffer to store read data

Returns

number of bytes read, 0 on EOF, negative value on error

5.9.2.19 kf_write()

```
int kf_write (
            int fd,
            const char * str,
            int n)
```

writes data to a file

Parameters

fd	file descriptor
str	buffer containing data to write
n	number of bytes to write

Returns

number of bytes written, negative value on error

5.10 fat_kernel.h

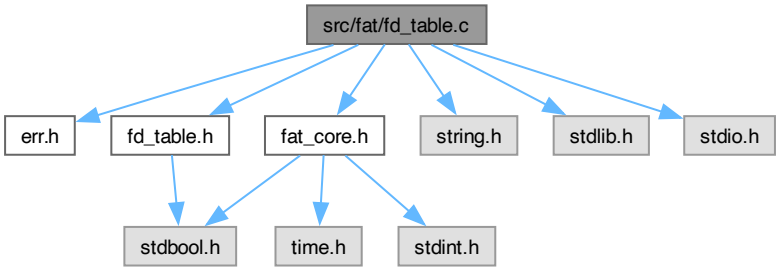
Go to the documentation of this file.

```
00001 #ifndef FAT_KERNEL_H
00002 #define FAT_KERNEL_H
00003
00004 #include "fat_core.h"
00005 #include <time.h>
00006 #include <stdint.h>
00007 #include <stdbool.h>
00008
00009 /* File opening modes */
00010 #define F_READ 0
00011 #define F_WRITE 1
00012 #define F_APPEND 2
00013
00014 /* Standard file descriptors */
00015 #define STDIN_FILENO 0
00016 #define STDOUT_FILENO 1
00017 #define STDERR_FILENO 2
00018
00019 /* File positioning constants */
00020 #define SEEK_SET 0
00021 #define SEEK_CUR 1
00022 #define SEEK_END 2
00023
00027 void init(void);
00028
00029 /*
00030  * File descriptor management functions
00031  */
00032
00039 int k_open(const char *fname, int mode);
00040
00048 int kf_read(int fd, int n, char *buf);
00049
00057 int kf_write(int fd, const char *str, int n);
00058
00067 int k_read_at_offset(int fd, int n, char *buf, int offset);
00068
00077 int k_write_at_offset(int fd, const char *str, int n, int offset);
00078
00084 int k_close(int fd);
00085
00090 void k_unlink(const char *fname);
00091
00098 void k_lseek(int fd, int offset, int whence);
00099
00100 /*
00101  * File listing functions
00102  */
00103
00108 void k_ls(const char *filename);
00109
00110 /*
00111  * File manipulation command functions
00112  */
00113
00118 void f_touch(char *args[]);
00119
00124 void f_rm(char *args[]);
00125
00130 void f_mv(char *args[]);
00131
00138 void f_cat(char *args[], int fd_in, int fd_out);
00139
00144 void f_cp(char *args[]);
00145
00150 void f_chmod(char *args[]);
00151
00157 int f_get_permission(char *file_name);
00158
00165 int k_chmod(const char *fname, uint8_t new_perm);
00166
00172 int k_get_permission(const char *fname);
00173
00174 #endif
```

5.11 src/fat/fd_table.c File Reference

```
#include "err.h"
#include "fd_table.h"
#include "fat_core.h"
#include <string.h>
#include <stdlib.h>
#include <stdio.h>
```

Include dependency graph for fd_table.c:



Functions

- void initialize_fd_table (FD_Table *fd_table)
- FD_Node * lookup_add_position (FD_Table *fd_table)
- FD_Node * add_fd (FD_Table *fd_table, char *name, int mode)
- FD_Node * remove_fd (FD_Table *fd_table, int fd)
- FD_Node * lookup_fd (FD_Table *fd_table, int fd)

5.11.1 Function Documentation

5.11.1.1 add_fd()

```
FD_Node * add_fd (
            FD_Table * fd_table,
            char * name,
            int mode)
```

add new fd_node to fd_table

Parameters

fd_table	pointer to fd_table linked list
name	name of file being added
mode	mode of file being added

Returns

fd_node that was added (or NULL on error)

5.11.1.2 initialize_fd_table()

```
void initialize_fd_table (
            FD_Table * fd_table)
```

initialize a fd table for a process

Parameters

fd_table	pointer to fd_table

5.11.1.3 lookup_add_position()

```
FD_Node * lookup_add_position (
            FD_Table * fd_table)
```

finds correct position in the linked list to insert a new fd_node done in order to maintain sequential FD numbers with no gaps

Parameters

fd_table	Pointer to the file descriptor table

Returns

pointer to the node after which to insert, or NULL to insert at head

5.11.1.4 lookup_fd()

```
FD_Node * lookup_fd (
            FD_Table * fd_table,
            int fd)
```

find the fd_node with the fd number supplied as argument

Parameters

fd_table	fd_table
fd	fd number that is being searched for

Returns

fd_node being searched for (or NULL if it's not present)

5.11.1.5 remove_fd()

```
FD_Node * remove_fd (
            FD_Table * fd_table,
            int fd)
```

remove fd_node with given fd number from fd_table linked list

Parameters

fd_table	fd_table
fd	fd number being removed

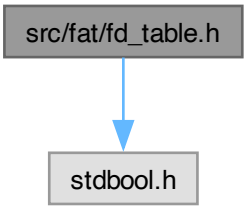
Returns

fd_node that was removed (or NULL on error)

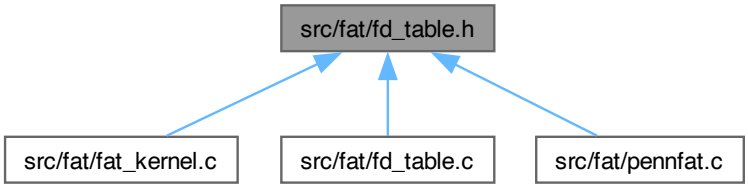
5.12 src/fat/fd_table.h File Reference

```
#include <stdbool.h>
```

Include dependency graph for fd_table.h:



This graph shows which files directly or indirectly include this file:



Classes

- struct fd_node
- struct fd_table

Macros

- #define F_READ 0
- #define F_WRITE 1
- #define F_APPEND 2

Typedefs

- typedef struct fd_node FD_Node
- typedef struct fd_table FD_Table

Functions

- void initialize_fd_table (FD_Table *fd_table)
- FD_Node * lookup_add_position (FD_Table *fd_table)
- FD_Node * add_fd (FD_Table *fd_table, char *name, int mode)
- FD_Node * remove_fd (FD_Table *fd_table, int fd)
- FD_Node * lookup_fd (FD_Table *fd_table, int fd)

5.12.1 Macro Definition Documentation

5.12.1.1 F_APPEND

```
#define F_APPEND 2
```

5.12.1.2 F_READ

```
#define F_READ 0
```

5.12.1.3 F_WRITE

```
#define F_WRITE 1
```

5.12.2 Typedef Documentation

5.12.2.1 FD_Node

```
typedef struct fd_node FD_Node
```

node struct to represent each file in the fd table

Parameters

name	file name
fd	fd number
offset	pointer offset
size	file size
mode	mode of file (0: read, 1: write, 2: append)
next	pointer to next node in list

5.12.2.2 FD_Table

```
typedef struct fd_table FD_Table
```

fd table struct

Parameters

head	head of the fd_table which is a linkedlist of fd_nodes

5.12.3 Function Documentation

5.12.3.1 add_fd()

```
FD_Node * add_fd (
            FD_Table * fd_table,
            char * name,
            int mode)
```

add new fd_node to fd_table

Parameters

fd_table	pointer to fd_table linked list
name	name of file being added
mode	mode of file being added

Returns

fd_node that was added (or NULL on error)

5.12.3.2 initialize_fd_table()

```
void initialize_fd_table (
            FD_Table * fd_table)
```

initialize a fd table for a process

Parameters

fd_table	pointer to fd_table

5.12.3.3 lookup_add_position()

```
FD_Node * lookup_add_position (
            FD_Table * fd_table)
```

finds correct position in the linked list to insert a new fd_node done in order to maintain sequential FD numbers with no gaps

Parameters

fd_table	Pointer to the file descriptor table

Returns

pointer to the node after which to insert, or NULL to insert at head

5.12.3.4 lookup_fd()

```
FD_Node * lookup_fd (
            FD_Table * fd_table,
            int fd)
```

find the fd_node with the fd number supplied as argument

Parameters

fd_table	fd_table
fd	fd number that is being searched for

Returns

fd_node being searched for (or NULL if it's not present)

5.12.3.5 remove_fd()

```
FD_Node * remove_fd (
            FD_Table * fd_table,
            int fd)
```

remove fd_node with given fd number from fd_table linked list

Parameters

fd_table	fd_table
fd	fd number being removed

Returns

fd_node that was removed (or NULL on error)

5.13 fd_table.h

Go to the documentation of this file.

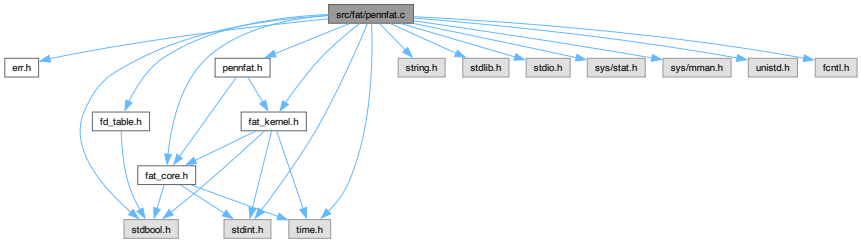
```
00001 #ifndef FD_TABLE_H
00002 #define FD_TABLE_H
00003
00004 #include <stdbool.h>
00005
00006 struct dir_entry;
00007
00008 #define F_READ 0
00009 #define F_WRITE 1
00010 #define F_APPEND 2
00011
00012
00023 typedef struct fd_node {
00024     char* name;
00025     int fd;
00026     int offset;
00027     int size;
00028     int mode;
00029     struct fd_node* next;
```

```
00030 } FD_Node;
00031
00036 typedef struct fd_table {
00037     FD_Node* head;
00038 } FD_Table;
00039
00044 void initialize_fd_table(FD_Table* fd_table);
00045
00052 FD_Node* lookup_add_position(FD_Table* fd_table);
00053
00061 FD_Node* add_fd(FD_Table* fd_table, char* name, int mode);
00062
00069 FD_Node* remove_fd(FD_Table* fd_table, int fd);
00070
00077 FD_Node* lookup_fd(FD_Table* fd_table, int fd);
00078
00079 #endif
```

5.14 src/fat/pennfat.c File Reference

```
#include "err.h"
#include "fd_table.h"
#include "pennfat.h"
#include "fat_core.h"
#include <time.h>
#include <string.h>
#include <stdlib.h>
#include <stdio.h>
#include <stdint.h>
#include <stdbool.h>
#include <sys/stat.h>
#include <sys/mman.h>
#include <unistd.h>
#include <fcntl.h>
#include "fat_kernel.h"
```

Include dependency graph for pennfat.c:



Functions

- int main (int argc, char **argv)

5.14.1 Function Documentation

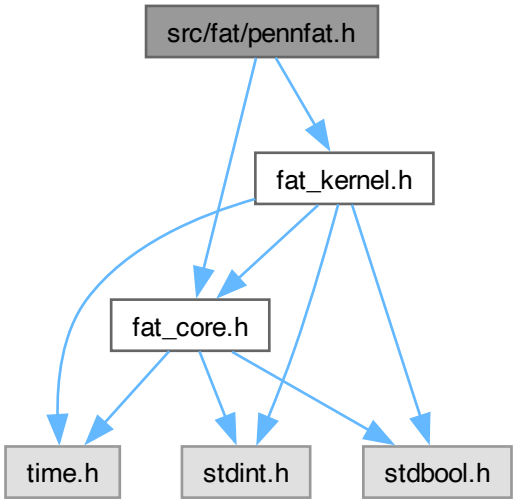
5.14.1.1 main()

```
int main (
            int argc,
            char ** argv)
```

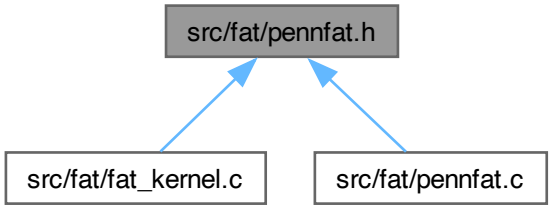
5.15 src/fat/pennfat.h File Reference

```
#include "fat_core.h"
#include "fat_kernel.h"
```

Include dependency graph for pennfat.h:



This graph shows which files directly or indirectly include this file:



Macros

- #define MAX_LINE_LENGTH 4096

5.15.1 Macro Definition Documentation

5.15.1.1 MAX_LINE_LENGTH

```
#define MAX_LINE_LENGTH 4096
```

5.16 pennfat.h

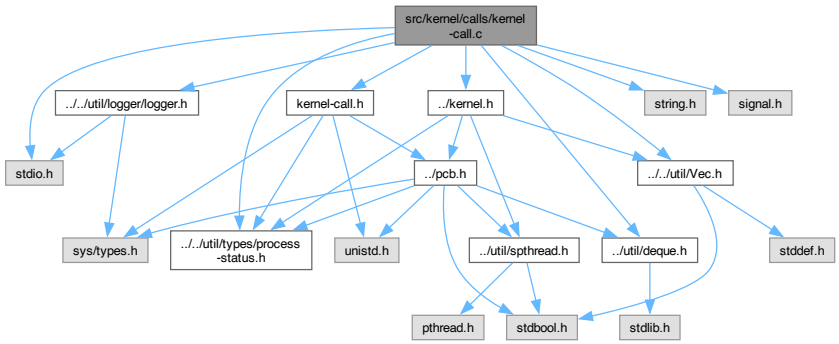
Go to the documentation of this file.

```
00001 #ifndef PENNFAT_H
00002 #define PENNFAT_H
00003
00004 #include "fat_core.h"
00005 #include "fat_kernel.h"
00006
00007 #define MAX_LINE_LENGTH 4096
00008
00009 #endif
```

5.17 src/kernel/calls/kernel-call.c File Reference

```
#include "kernel-call.h"
#include <stdio.h>
#include <string.h>
#include "../../util/Vec.h"
#include "../../util/deque.h"
#include "../../util/logger/logger.h"
#include "../../util/types/process-status.h"
#include "../kernel.h"
#include "signal.h"
```

Include dependency graph for kernel-call.c:



Functions

- pid_t k_get_current_process_pid ()

  Get the pid of the current process.
- pcb_t * k_get_current_process ()

  Get the current process running in the kernel.
- int k_get_lowest_pid ()
- pcb_t * k_proc_create (pcb_t *parent)

  Create a new child process, inheriting applicable properties from the parent.
- void k_proc_cleanup (pcb_t *proc)

  Clean up a terminated/finished thread's resources. This may include freeing the PCB, handling children, etc.
- int k_release_fd (pcb_t *proc, int local_fd)

Releases a process's hold on a file descriptor. This involves finding the corresponding global file table entry, decrementing its reference count, and potentially closing the underlying file/resource if the count reaches zero. It also updates the process's local FD table to mark the descriptor as closed.

- pcb_t * k_get_proc (pid_t pid)

  Get a process by its PID.
- int k_write (int fd, const char *buf, int n)

  Write a message to the standard output.
- int k_read (char *store_result, int len, int fd)

  Read form standard input.
- pcb_t * k_get_process_by_pid (pid_t pid)

  Get the current process running in the kernel.

5.17.1 Function Documentation

5.17.1.1 k_get_current_process()

```
pcb_t * k_get_current_process ()
```

Get the current process running in the kernel.

Returns

Reference to the current PCB.

5.17.1.2 k_get_current_process_pid()

```
pid_t k_get_current_process_pid ()
```

Get the pid of the current process.

Returns

The PID of the current process.

5.17.1.3 k_get_lowest_pid()

```
int k_get_lowest_pid ()
```

5.17.1.4 k_get_proc()

```
pcb_t * k_get_proc (
            pid_t pid)
```

Get a process by its PID.

Parameters

pid	The PID of the process to retrieve.

Returns

A pointer to the process control block (PCB) of the process, or NULL if not found.

A pointer to the process control block (PCB) of the process, or NULL if not found.

5.17.1.5 k_get_process_by_pid()

```
pcb_t * k_get_process_by_pid (
            pid_t pid)
```

Get the current process running in the kernel.

Returns

Reference to the current PCB.

5.17.1.6 k_proc_cleanup()

```
void k_proc_cleanup (
            pcb_t * proc)
```

Clean up a terminated/finished thread's resources. This may include freeing the PCB, handling children, etc.

5.17.1.7 k_proc_create()

```
pcb_t * k_proc_create (
            pcb_t * parent)
```

Create a new child process, inheriting applicable properties from the parent.

Returns

Reference to the child PCB.

5.17.1.8 k_read()

```
int k_read (
            char * store_result,
            int len,
            int fd)
```

Read form standard input.

Parameters

store_result	The buffer to store the read result.
len	The length of the buffer.
fd	The file descriptor to read from (not used in this implementation).

Returns

The number of bytes read.

5.17.1.9 k_release_fd()

```
int k_release_fd (
            pcb_t * proc,
            int local_fd)
```

Releases a process's hold on a file descriptor. This involves finding the corresponding global file table entry, decrementing its reference count, and potentially closing the underlying file/resource if the count reaches zero. It also updates the process's local FD table to mark the descriptor as closed.

Parameters

proc	The process control block (PCB) of the process closing the FD.
local_fd	The file descriptor number *local* to the given process.

Returns

0 on success, -1 on error (e.g., invalid local_fd, FD not open by this process).

0 on success, -1 on error (e.g., invalid local_fd, FD not open by this process).

5.17.1.10 k_write()

```
int k_write (
            int fd,
            const char * buf,
            int n)
```

Write a message to the standard output.

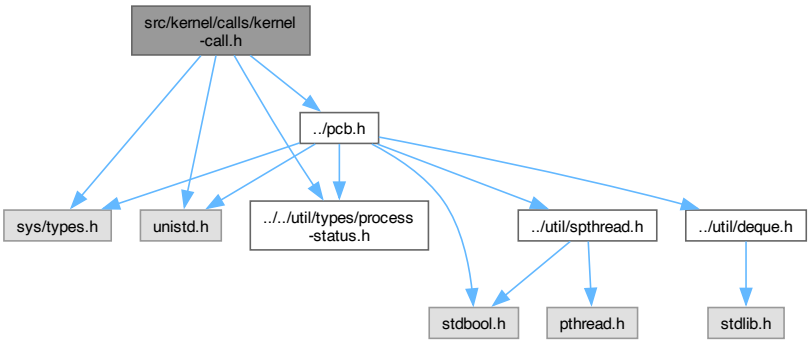
Parameters

msg	The message to write.
fd	The file descriptor to write to (not used in this implementation).

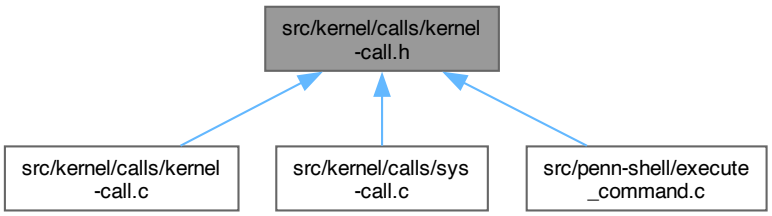
5.18 src/kernel/calls/kernel-call.h File Reference

```
#include <sys/types.h>
#include <unistd.h>
#include "../../util/types/process-status.h"
#include "../pcb.h"
```

Include dependency graph for kernel-call.h:



This graph shows which files directly or indirectly include this file:



Functions

- pid_t k_get_current_process_pid ()

  Get the pid of the current process.
- pcb_t * k_get_current_process ()

  Get the current process running in the kernel.
- pcb_t * k_get_process_by_pid (pid_t pid)

  Get the current process running in the kernel.
- pcb_t * k_proc_create (pcb_t *parent)

  Create a new child process, inheriting applicable properties from the parent.
- void k_proc_cleanup (pcb_t *proc)

  Clean up a terminated/finished thread's resources. This may include freeing the PCB, handling children, etc.
- int k_release_fd (pcb_t *proc, int local_fd)

Releases a process's hold on a file descriptor. This involves finding the corresponding global file table entry, decrementing its reference count, and potentially closing the underlying file/resource if the count reaches zero. It also updates the process's local FD table to mark the descriptor as closed.

- pcb_t * k_get_proc (pid_t pid)

  Get a process by its PID.
- int k_read (char *store_result, int len, int fd)

  Read form standard input.
- int k_write (int fd, const char *buf, int n)

  Write a message to the standard output.

5.18.1 Function Documentation

5.18.1.1 k_get_current_process()

```
pcb_t * k_get_current_process ()
```

Get the current process running in the kernel.

Returns

Reference to the current PCB.

5.18.1.2 k_get_current_process_pid()

```
pid_t k_get_current_process_pid ()
```

Get the pid of the current process.

Returns

The PID of the current process.

5.18.1.3 k_get_proc()

```
pcb_t * k_get_proc (
            pid_t pid)
```

Get a process by its PID.

Parameters

pid	The PID of the process to retrieve.

Returns

A pointer to the process control block (PCB) of the process, or NULL if not found.

A pointer to the process control block (PCB) of the process, or NULL if not found.

5.18.1.4 k_get_process_by_pid()

```
pcb_t * k_get_process_by_pid (
            pid_t pid)
```

Get the current process running in the kernel.

Returns

Reference to the current PCB.

5.18.1.5 k_proc_cleanup()

```
void k_proc_cleanup (
            pcb_t * proc)
```

Clean up a terminated/finished thread's resources. This may include freeing the PCB, handling children, etc.

5.18.1.6 k_proc_create()

```
pcb_t * k_proc_create (
            pcb_t * parent)
```

Create a new child process, inheriting applicable properties from the parent.

Returns

Reference to the child PCB.

5.18.1.7 k_read()

```
int k_read (
            char * store_result,
            int len,
            int fd)
```

Read form standard input.

Parameters

store_result	The buffer to store the read result.
len	The length of the buffer.
fd	The file descriptor to read from (not used in this implementation).

Returns

The number of bytes read.

5.18.1.8 k_release_fd()

```
int k_release_fd (
            pcb_t * proc,
            int local_fd)
```

Releases a process's hold on a file descriptor. This involves finding the corresponding global file table entry, decrementing its reference count, and potentially closing the underlying file/resource if the count reaches zero. It also updates the process's local FD table to mark the descriptor as closed.

Parameters

proc	The process control block (PCB) of the process closing the FD.
local_fd	The file descriptor number *local* to the given process.

Returns

0 on success, -1 on error (e.g., invalid local_fd, FD not open by this process).

0 on success, -1 on error (e.g., invalid local_fd, FD not open by this process).

5.18.1.9 k_write()

```
int k_write (
            int fd,
            const char * buf,
            int n)
```

Write a message to the standard output.

Parameters

msg	The message to write.
fd	The file descriptor to write to (not used in this implementation).

5.19 kernel-call.h

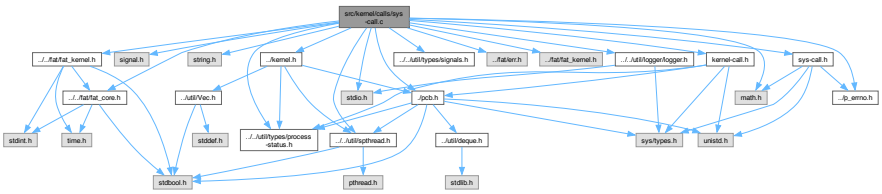
Go to the documentation of this file.

```
00001 #include <sys/types.h>
00002 #include <unistd.h>
00003 #include "../../util/types/process-status.h"
00004 #include "../pcb.h"
00005
00010 pid_t k_get_current_process_pid();
00011
00017 pcb_t *k_get_current_process();
00018
00024
00025 pcb_t *k_get_process_by_pid(pid_t pid);
00032 pcb_t *k_proc_create(pcb_t *parent);
00033
00038 void k_proc_cleanup(pcb_t *proc);
00039
00054 int k_release_fd(pcb_t *proc, int local_fd);
00055 int k_release_fd(pcb_t *proc, int local_fd);
00056
00065 pcb_t *k_get_proc(pid_t pid);
00066
00075 int k_read(char *store_result, int len, int fd);
00076
00083
00084 int k_write(int fd, const char *buf, int n);
```

5.20 src/kernel/calls/sys-call.c File Reference

```
#include <math.h>
#include <signal.h>
#include <stdio.h>
#include <string.h>
#include "../../fat/fat_core.h"
#include "../../fat/fat_kernel.h"
#include "../../util/logger/logger.h"
#include "../../util/spthread.h"
#include "../../util/types/process-status.h"
#include "../../util/types/signals.h"
#include "../fat/err.h"
#include "../fat/fat_kernel.h"
#include "../kernel.h"
#include "../p_errno.h"
#include "../pcb.h"
#include "kernel-call.h"
#include "sys-call.h"
```

Include dependency graph for sys-call.c:



Functions

- int map_fat_error_to_p_errno (int fat_errno)
- int s_open (const char ∗fname, int mode)
- int s_read (int fd, char ∗buf, int n)
- int s_write (int fd, const char ∗str, int n)
- int s_close (int fd)
- int s_lseek (int fd, int offset, int whence)
- int s_unlink (const char ∗fname)
- void s_ls (const char ∗filename)
- pid_t s_spawn (void ∗(∗func)(void ∗), char ∗argv[ ], int fd0, int fd1, int foreground)
- pid_t s_waitpid_helper (pid_t curr_proc_pid, pid_t pid, int ∗wstatus)
- pid_t s_waitpid (pid_t pid, int ∗wstatus, int nohang)
- void s_sleep (unsigned int ticks)
- int s_kill (pid_t pid, int signal)
- int s_set_terminal_owner (pid_t pid)
- void s_nice_pid (int prio, int pid)
- void s_exit (void)
- int s_nice (pid_t pid, int priority)
- char ∗ s_itos (int n)
- void s_ps ()
- void s_register_end ()
- int s_chmod (const char ∗fname, const char ∗mode_str)
- int s_get_permission (const char ∗fname)
- pid_t s_getpid (void)

5.20.1 Function Documentation

5.20.1.1 map_fat_error_to_p_errno()

```
int map_fat_error_to_p_errno (
            int fat_errno)
```

5.20.1.2 s_chmod()

```
int s_chmod (
            const char * fname,
            const char * mode_str)
```

changes permissions of a file

Parameters

fname	name of the file
mode_str	mode string (e.g., "+r", "-wx")

Returns

0 on success, -1 on failure

5.20.1.3 s_close()

```
int s_close (
            int fd)
```

closes a file descriptor

Parameters

fd	file descriptor to close

Returns

0 on success, negative value on failure

5.20.1.4 s_exit()

```
void s_exit (
            void )
```

terminates calling process

5.20.1.5 s_get_permission()

```
int s_get_permission (
            const char * fname)
```

gets the permission bits for a file.

Parameters

fname	name of the file.

Returns

permission value (int) on success, -1 on failure (sets P_ERRNO).

5.20.1.6 s_getpid()

```
pid_t s_getpid (
            void )
```

gets the process ID of the calling process

Returns

process ID of calling process

5.20.1.7 s_itos()

```
char * s_itos (
            int n)
```

5.20.1.8 s_kill()

```
int s_kill (
            pid_t pid,
            int signal)
```

sends a signal to a process

Parameters

pid	process ID of target process
signal	signal number (P_SIGTERM, P_SIGSTOP, P_SIGCONT)

Returns

0 on success, -1 on error

5.20.1.9 s_ls()

```
void s_ls (
            const char * filename)
```

lists file(s) in filesystem

Parameters

filename	specific file to list, or NULL for all files

5.20.1.10 s_lseek()

```
int s_lseek (
            int fd,
            int offset,
            int whence)
```

repositions file offset of open file descriptor

Parameters

fd	file descriptor
offset	offset value
whence	reference position (SEEK_SET, SEEK_CUR, SEEK_END)

Returns

new offset on success, negative value on error

5.20.1.11 s_nice()

```
int s_nice (
            pid_t pid,
            int priority)
```

sets scheduling priority of a process

Parameters

pid	process ID of target
priority	new priority value (0, 1, or 2)

Returns

0 on success, -1 on failure

5.20.1.12 s_nice_pid()

```
void s_nice_pid (
            int prio,
            int pid)
```

Sets the priority of a process

Parameters

prio	new priority value (0, 1, or 2)
pid	process ID of target process

5.20.1.13 s_open()

```
int s_open (
            const char * fname,
            int mode)
```

opens a file with specified mode

Parameters

fname	name of file to open
mode	access mode (F_READ, F_WRITE, or F_APPEND)

Returns

file descriptor on success, negative value on error

5.20.1.14 s_ps()

```
void s_ps (
            void )
```

displays information about all processes

5.20.1.15 s_read()

```
int s_read (
            int fd,
            char * buf,
            int n)
```

reads data from a file descriptor

Parameters

fd	file descriptor to read from
buf	buffer to store read data
n	maximum number of bytes to read

Returns

number of bytes read, 0 on EOF, negative value on error

5.20.1.16 s_register_end()

```
void s_register_end (
            void )
```

registers calling process as finished

5.20.1.17 s_set_terminal_owner()

```
int s_set_terminal_owner (
            pid_t pid)
```

sets the terminal owner

Parameters

pid	process ID of target

5.20.1.18 s_sleep()

```
void s_sleep (
            unsigned int ticks)
```

suspends calling process for specified clock ticks

Parameters

ticks	duration of sleep in clock ticks (must be $>$ 0)

5.20.1.19 s_spawn()

```
pid_t s_spawn (
            void *(* func )(void *),
            char * argv[],
            int fd0,
            int fd1,
            int foreground)
```

creates a child process executing specified function

Parameters

func	function to execute
argv	null-terminated array of args (command name as argv[0])
fd0	input file descriptor
fd1	output file descriptor
foreground	true for foreground execution, false for background

Returns

process ID of child, -1 on error

5.20.1.20 s_unlink()

```
int s_unlink (
            const char * fname)
```

removes a file from filesystem if not in use

Parameters

fname	name of file to remove

Returns

0 on success, -1 on error

5.20.1.21 s_waitpid()

```
pid_t s_waitpid (
            pid_t pid,
            int * wstatus,
            int nohang)
```

waits for a child process to change state

Parameters

pid	process ID of child to wait for (-1 for any child)
wstatus	pointer to store exit status information
nohang	if true, return immediately if no child has exited

Returns

process ID of state-changed child, 0 if nohang and no change, -1 on error

5.20.1.22 s_waitpid_helper()

```
pid_t s_waitpid_helper (
            pid_t curr_proc_pid,
            pid_t pid,
            int * wstatus)
```

5.20.1.23 s_write()

```
int s_write (
            int fd,
            const char * str,
            int n)
```

writes data to a file descriptor

Parameters

fd	file descriptor to write to
str	buffer containing data to write
n	number of bytes to write

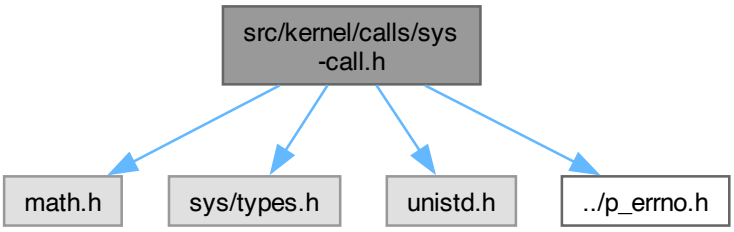
Returns

number of bytes written, negative value on error

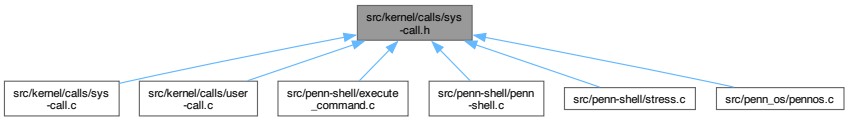
5.21 src/kernel/calls/sys-call.h File Reference

```
#include <math.h>
#include <sys/types.h>
#include <unistd.h>
#include "../p_errno.h"
```

Include dependency graph for sys-call.h:



This graph shows which files directly or indirectly include this file:



Macros

- #define P_WAIT_STATUS_MACROS_H
- #define P_WAIT_FLAG_STOPPED 0x100
- #define P_WAIT_FLAG_SIGNALED 0x200
- #define P_WAIT_SIG_MASK 0xFF
- #define P_WIFEXITED(status)

  Returns true if the child terminated normally (via s_exit or return).

- #define P_WIFSIGNALED(status)

  Returns true if the child process was terminated by a signal.
- #define P_WTERMSIG(status)

  Returns the number of the signal that caused the child to terminate. (Only valid if P_WIFSIGNALED(status) is true).
- #define P_WIFSTOPPED(status)

  Returns true if the child process was stopped by delivery of a signal.
- #define P_WSTOPSIG(status)

  Returns the number of the signal which caused the child to stop. (Only valid if P_WIFSTOPPED(status) is true).

Functions

- int s_open (const char *fname, int mode)
- int s_close (int fd)
- int s_read (int fd, char *buf, int n)
- int s_write (int fd, const char *str, int n)
- int s_lseek (int fd, int offset, int whence)
- int s_unlink (const char *fname)
- void s_ls (const char *filename)
- pid_t s_spawn (void *(*func)(void *), char *argv[], int fd0, int fd1, int foreground)
- pid_t s_waitpid (pid_t pid, int *wstatus, int nohang)
- int s_kill (pid_t pid, int signal)
- void s_exit (void)
- int s_nice (pid_t pid, int priority)
- void s_sleep (unsigned int ticks)
- void s_ps (void)
- void s_register_end (void)
- void s_nice_pid (int prio, int pid)
- pid_t s_getpid (void)
- int s_chmod (const char *fname, const char *mode_str)
- int s_get_permission (const char *fname)
- int s_set_terminal_owner (pid_t pid)

Variables

- int P_ERRNO

  Error number for the last system call.

5.21.1 Macro Definition Documentation

5.21.1.1 P_WAIT_FLAG_SIGNALED

```
#define P_WAIT_FLAG_SIGNALED 0x200
```

5.21.1.2 P_WAIT_FLAG_STOPPED

```
#define P_WAIT_FLAG_STOPPED 0x100
```

5.21.1.3 P_WAIT_SIG_MASK

```
#define P_WAIT_SIG_MASK 0xFF
```

5.21.1.4 P_WAIT_STATUS_MACROS_H

```
#define P_WAIT_STATUS_MACROS_H
```

5.21.1.5 P_WIFEXITED

```
#define P_WIFEXITED(
              status)
```

Value:

```
(((status) & (P_WAIT_FLAG_STOPPED | P_WAIT_FLAG_SIGNALED)) == 0)
```

Returns true if the child terminated normally (via s_exit or return).

5.21.1.6 P_WIFSIGNALED

```
#define P_WIFSIGNALED(
              status)
```

Value:

```
(((status) & P_WAIT_FLAG_SIGNALED) != 0)
```

Returns true if the child process was terminated by a signal.

5.21.1.7 P_WIFSTOPPED

```
#define P_WIFSTOPPED(
              status)
```

Value:

```
(((status) & P_WAIT_FLAG_STOPPED) != 0)
```

Returns true if the child process was stopped by delivery of a signal.

5.21.1.8 P_WSTOPSIG

```
#define P_WSTOPSIG(
              status)
```

Value:

```
((status) & P_WAIT_SIG_MASK)
```

Returns the number of the signal which caused the child to stop. (Only valid if P_WIFSTOPPED(status) is true).

5.21.1.9 P_WTERMSIG

```
#define P_WTERMSIG(
              status)
```

Value:

```
((status) & P_WAIT_SIG_MASK)
```

Returns the number of the signal that caused the child to terminate. (Only valid if P_WIFSIGNALED(status) is true).

5.21.2 Function Documentation

5.21.2.1 s_chmod()

```
int s_chmod (
             const char * fname,
             const char * mode_str)
```

changes permissions of a file

Parameters

fname	name of the file
mode_str	mode string (e.g., "+r", "-wx")

Returns

0 on success, -1 on failure

5.21.2.2 s_close()

```
int s_close (
             int fd)
```

closes a file descriptor

Parameters

fd	file descriptor to close

Returns

0 on success, negative value on failure

5.21.2.3 s_exit()

```
void s_exit (
             void )
```

terminates calling process

5.21.2.4 s_get_permission()

```
int s_get_permission (
             const char * fname)
```

gets the permission bits for a file.

Parameters

fname	name of the file.

Returns

permission value (int) on success, -1 on failure (sets P_ERRNO).

5.21.2.5 s_getpid()

```
pid_t s_getpid (
            void )
```

gets the process ID of the calling process

Returns

process ID of calling process

5.21.2.6 s_kill()

```
int s_kill (
            pid_t pid,
            int signal)
```

sends a signal to a process

Parameters

pid	process ID of target process
signal	signal number (P_SIGTERM, P_SIGSTOP, P_SIGCONT)

Returns

0 on success, -1 on error

5.21.2.7 s_ls()

```
void s_ls (
            const char * filename)
```

lists file(s) in filesystem

Parameters

filename	specific file to list, or NULL for all files

5.21.2.8 s_lseek()

```
int s_lseek (
            int fd,
            int offset,
            int whence)
```

repositions file offset of open file descriptor

Parameters

fd	file descriptor
offset	offset value
whence	reference position (SEEK_SET, SEEK_CUR, SEEK_END)

Returns

new offset on success, negative value on error

5.21.2.9 s_nice()

```
int s_nice (
            pid_t pid,
            int priority)
```

sets scheduling priority of a process

Parameters

pid	process ID of target
priority	new priority value (0, 1, or 2)

Returns

0 on success, -1 on failure

5.21.2.10 s_nice_pid()

```
void s_nice_pid (
            int prio,
            int pid)
```

Sets the priority of a process

Parameters

prio	new priority value (0, 1, or 2)
pid	process ID of target process

5.21.2.11 s_open()

```
int s_open (
            const char * fname,
            int mode)
```

opens a file with specified mode

Parameters

fname	name of file to open
mode	access mode (F_READ, F_WRITE, or F_APPEND)

Returns

file descriptor on success, negative value on error

5.21.2.12 s_ps()

```
void s_ps (
            void )
```

displays information about all processes

5.21.2.13 s_read()

```
int s_read (
            int fd,
            char * buf,
            int n)
```

reads data from a file descriptor

Parameters

fd	file descriptor to read from
buf	buffer to store read data
n	maximum number of bytes to read

Returns

number of bytes read, 0 on EOF, negative value on error

5.21.2.14 s_register_end()

```
void s_register_end (
            void )
```

registers calling process as finished

5.21.2.15 s_set_terminal_owner()

```
int s_set_terminal_owner (
            pid_t pid)
```

sets the terminal owner

Parameters

pid	process ID of target

5.21.2.16 s_sleep()

```
void s_sleep (
            unsigned int ticks)
```

suspends calling process for specified clock ticks

Parameters

ticks	duration of sleep in clock ticks (must be $>$ 0)

5.21.2.17 s_spawn()

```
pid_t s_spawn (
            void *(* func )(void *),
            char * argv[],
            int fd0,
            int fd1,
            int foreground)
```

creates a child process executing specified function

Parameters

func	function to execute
argv	null-terminated array of args (command name as argv[0])
fd0	input file descriptor
fd1	output file descriptor
foreground	true for foreground execution, false for background

Returns

process ID of child, -1 on error

5.21.2.18 s_unlink()

```
int s_unlink (
            const char * fname)
```

removes a file from filesystem if not in use

Parameters

fname	name of file to remove

Returns

0 on success, -1 on error

5.21.2.19 s_waitpid()

```
pid_t s_waitpid (
            pid_t pid,
            int * wstatus,
            int nohang)
```

waits for a child process to change state

Parameters

pid	process ID of child to wait for (-1 for any child)
wstatus	pointer to store exit status information
nohang	if true, return immediately if no child has exited

Returns

process ID of state-changed child, 0 if nohang and no change, -1 on error

5.21.2.20 s_write()

```
int s_write (
            int fd,
            const char * str,
            int n)
```

writes data to a file descriptor

Parameters

fd	file descriptor to write to
str	buffer containing data to write
n	number of bytes to write

Returns

number of bytes written, negative value on error

5.21.3 Variable Documentation

5.21.3.1 P_ERRNO

```
int P_ERRNO  [extern]
```

Error number for the last system call.

5.22 sys-call.h

Go to the documentation of this file.

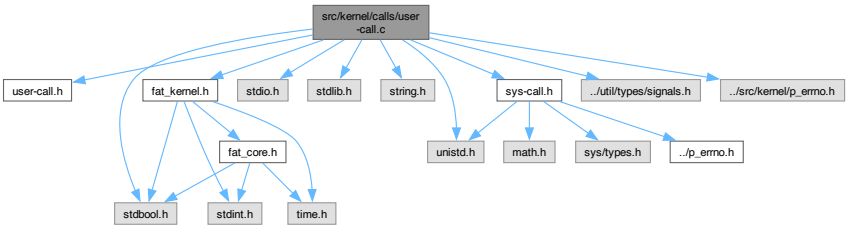
```
00001 #ifndef SYS_CALL_H
00002 #define SYS_CALL_H
00003
00004 #include <math.h>
00005 #include <sys/types.h>
00006 #include <unistd.h>
00007 #include "../p_errno.h"
00008
00009 // File system call
00013 extern int P_ERRNO;
00014
00021 int s_open(const char *fname, int mode);
00022
00028 int s_close(int fd);
00029
00037 int s_read(int fd, char *buf, int n);
00038
00046 int s_write(int fd, const char *str, int n);
00047
00055 int s_lseek(int fd, int offset, int whence);
00056
00062 int s_unlink(const char *fname);
00063
00068 void s_ls(const char *filename);
00069
00079 pid_t s_spawn(void *(*func)(void *),
00080               char *argv[],
00081               int fd0,
00082               int fd1,
00083               int foreground);
00084
00093 pid_t s_waitpid(pid_t pid, int *wstatus, int nohang);
00094
00101 int s_kill(pid_t pid, int signal);
00102
00106 void s_exit(void);
00107
00114 int s_nice(pid_t pid, int priority);
00115
00120 void s_sleep(unsigned int ticks);
00121
00125 void s_ps(void);
00126
00130 void s_register_end(void);
00131
00138 void s_nice_pid(int prio, int pid);
00139
00144 pid_t s_getpid(void);
00145
00152 int s_chmod(const char *fname, const char *mode_str); // Pass mode string
00153
00159 int s_get_permission(const char *fname);
00160
00165 int s_set_terminal_owner(pid_t pid);
00166
00167 #ifndef P_WAIT_STATUS_MACROS_H // Include guard for these macros
00168 #define P_WAIT_STATUS_MACROS_H
00169
00170 #define P_WAIT_FLAG_STOPPED 0x100  // Bit 8 indicates stopped by a signal
00171 #define P_WAIT_FLAG_SIGNALED 0x200 // Bit 9 indicates terminated by a signal
00172 #define P_WAIT_SIG_MASK 0xFF       // Lower 8 bits for signal number
00173
00177 #define P_WIFEXITED(status) (((status) & (P_WAIT_FLAG_STOPPED | P_WAIT_FLAG_SIGNALED)) == 0)
00178
00182 #define P_WIFSIGNALED(status) (((status) & P_WAIT_FLAG_SIGNALED) != 0)
```

```
00183
00188 #define P_WTERMSIG(status) ((status) & P_WAIT_SIG_MASK)
00189
00193 #define P_WIFSTOPPED(status) (((status) & P_WAIT_FLAG_STOPPED) != 0)
00194
00199 #define P_WSTOPSIG(status) ((status) & P_WAIT_SIG_MASK)
00200
00201 #endif // P_WAIT_STATUS_MACROS_H
00202
00203 #endif /* SYS_CALL_H */
```

5.23 src/kernel/calls/user-call.c File Reference

```
#include "user-call.h"
#include <stdbool.h>
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <unistd.h>
#include "../util/types/signals.h"
#include "fat_kernel.h"
#include "sys-call.h"
#include "../src/kernel/p_errno.h"
```

Include dependency graph for user-call.c:



Functions

- void * u_cat (void *arg)

  The ususal `cat` program.
- void * u_ps (void *arg)

  List all processes on PennOS, displaying PID, PPID, priority, status, and command name.
- void * u_kill (void *arg)

  Sends a specified signal to a list of processes. If a signal name is not specified, default to "term". Valid signals are -term, -stop, and -cont.
- void * u_zombify (void *arg)

  Used to test zombifying functionality of your kernel.
- void * zombie_child (void *arg)

  Helper for zombify.
- void * u_nice (void *arg)

  Spawn a new process for `command` and set its priority to `priority`.
- void * u_nice_pid (void *arg)

  Adjust the priority level of an existing process.
- void * u_orphanify (void *arg)

Used to test orphanifying functionality of your kernel.

- void * u_orphan_child (void *arg)

  Helper for orphanify.
- int stoi (char *str)

  Converts a string to an integer.
- void * u_sleep (void *arg)

  Sleep for `n` seconds.
- void * u_busy (void *arg)

  Busy wait indefinitely. It can only be interrupted via signals.
- void * u_echo (void *arg)

  Echo back an input string.
- void * u_ls (void *arg)

  Lists all files in the working directory. For extra credit, it should support relative and absolute file paths.
- void * u_touch (void *arg)

  For each file, create an empty file if it doesn't exist, else update its timestamp.
- void * u_mv (void *arg)

  Rename a file. If the `dst_file` file already exists, overwrite it.
- void * u_cp (void *arg)
- void * u_rm (void *arg)

  Remove a list of files. Treat each file in the list as a separate transaction. (i.e. if removing file1 fails, still attempt to remove file2, file3, etc.)
- void * u_bg (void *arg)

  Resumes the most recently stopped job in the background, or the job specified by job_id.
- void * u_fg (void *arg)

  Brings the most recently stopped or background job to the foreground, or the job specified by job_id.
- void * u_man (void *arg)

  Lists all available commands.
- void * u_jobs (void *arg)

  Lists all jobs.
- void * u_logout (void *arg)

  Exits the shell and shutsdown PennOS.
- void * u_chmod (void *arg)

  Change permissions of a file. There's no need to error if a permission being added already exists, or if a permission being removed is already not granted.

5.23.1 Function Documentation

5.23.1.1 stoi()

```
int stoi (
            char * str)
```

Converts a string to an integer.

5.23.1.2 u_bg()

```
void * u_bg (
            void * arg)
```

Resumes the most recently stopped job in the background, or the job specified by job_id.

Example Usage: bg Example Usage: bg 2 (job_id is 2)

5.23.1.3 u_busy()

```
void * u_busy (
            void * arg)
```

Busy wait indefinitely. It can only be interrupted via signals.

Example Usage: busy

5.23.1.4 u_cat()

```
void * u_cat (
            void * arg)
```

The ususal `cat` program.

If `files` arg is provided, concatenate these files and print to stdout If `files` arg is *not* provided, read from stdin and print back to stdout

Example Usage: cat f1 f2 (concatenates f1 and f2 and print to stdout) Example Usage: cat f1 f2 $<$ f3 (concatenates f1 and f2 and prints to stdout, ignores f3) Example Usage: cat $<$ f3 (concatenates f3, prints to stdout)

5.23.1.5 u_chmod()

```
void * u_chmod (
            void * arg)
```

Change permissions of a file. There's no need to error if a permission being added already exists, or if a permission being removed is already not granted.

Print appropriate error message if:

- `file` is not a file that exists
- `perms` is invalid

Example Usage: chmod +x file (adds executable permission to file) Example Usage: chmod +rw file (adds read + write permissions to file) Example Usage: chmod -wx file (removes write + executable permissions from file)

5.23.1.6 u_cp()

```
void * u_cp (
            void * arg)
```

Copy a file. If the `dst_file` file already exists, overwrite it.

Print appropriate error message if:

- `src_file` is not a file that exists
- `src_file` does not have read permissions
- `dst_file` file already exists but does not have write permissions

Example Usage: cp src_file dst_file

5.23.1.7 u_echo()

```
void * u_echo (
            void * arg)
```

Echo back an input string.

Example Usage: echo Hello World

5.23.1.8 u_fg()

```
void * u_fg (
            void * arg)
```

Brings the most recently stopped or background job to the foreground, or the job specified by job_id.

Example Usage: fg Example Usage: fg 2 (job_id is 2)

5.23.1.9 u_jobs()

```
void * u_jobs (
            void * arg)
```

Lists all jobs.

Example Usage: jobs

5.23.1.10 u_kill()

```
void * u_kill (
            void * arg)
```

Sends a specified signal to a list of processes. If a signal name is not specified, default to "term". Valid signals are -term, -stop, and -cont.

Example Usage: kill 1 2 3 (sends term to processes 1, 2, and 3) Example Usage: kill -term 1 2 (sends term to processes 1 and 2) Example Usage: kill -stop 1 2 (sends stop to processes 1 and 2) Example Usage: kill -cont 1 (sends cont to process 1)

5.23.1.11 u_logout()

```
void * u_logout (
            void * arg)
```

Exits the shell and shutsdown PennOS.

Example Usage: logout

5.23.1.12 u_ls()

```
void * u_ls (
            void * arg)
```

Lists all files in the working directory. For extra credit, it should support relative and absolute file paths.

Example Usage: ls (regular credit) Example Usage: ls ../../foo/./bar/sample (only for EC)

5.23.1.13 u_man()

```
void * u_man (
            void * arg)
```

Lists all available commands.

Example Usage: man

5.23.1.14 u_mv()

```
void * u_mv (
            void * arg)
```

Rename a file. If the `dst_file` file already exists, overwrite it.

Print appropriate error message if:

- `src_file` is not a file that exists
- `src_file` does not have read permissions
- `dst_file` file already exists but does not have write permissions

Example Usage: mv src_file dst_file

5.23.1.15 u_nice()

```
void * u_nice (
            void * arg)
```

Spawn a new process for `command` and set its priority to `priority`.

1. Adjust the priority level of an existing process.

Example Usage: nice 2 cat f1 f2 f3 (spawns cat with priority 2)

5.23.1.16 u_nice_pid()

```
void * u_nice_pid (
            void * arg)
```

Adjust the priority level of an existing process.

Parameters

prio	The new priority level (0, 1, or 2).
pid	The PID of the target process.

5.23.1.17 u_orphan_child()

```
void * u_orphan_child (
            void * arg)
```

Helper for orphanify.

5.23.1.18 u_orphanify()

```
void * u_orphanify (
            void * arg)
```

Used to test orphanifying functionality of your kernel.

Example Usage: orphanify

5.23.1.19 u_ps()

```
void * u_ps (
            void * arg)
```

List all processes on PennOS, displaying PID, PPID, priority, status, and command name.

Example Usage: ps

5.23.1.20 u_rm()

```
void * u_rm (
            void * arg)
```

Remove a list of files. Treat each file in the list as a separate transaction. (i.e. if removing file1 fails, still attempt to remove file2, file3, etc.)

Print appropriate error message if:

- `file` is not a file that exists

Example Usage: rm f1 f2 f3 f4 f5

5.23.1.21 u_sleep()

```
void * u_sleep (
            void * arg)
```

Sleep for `n` seconds.

Note that you'll have to convert the number of seconds to the correct number of ticks.

Example Usage: sleep 10

5.23.1.22 u_touch()

```
void * u_touch (
            void * arg)
```

For each file, create an empty file if it doesn't exist, else update its timestamp.

Example Usage: touch f1 f2 f3 f4 f5

5.23.1.23 u_zombify()

```
void * u_zombify (
            void * arg)
```

Used to test zombifying functionality of your kernel.

Example Usage: zombify

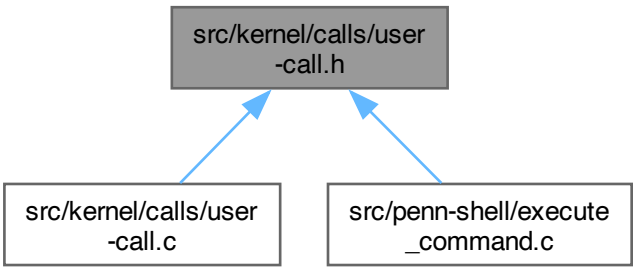
5.23.1.24 zombie_child()

```
void * zombie_child (
            void * arg)
```

Helper for zombify.

5.24 src/kernel/calls/user-call.h File Reference

This graph shows which files directly or indirectly include this file:



Macros

- #define MAX_MESSAGE_SIZE 4096

Functions

- void * u_cat (void *arg)

  The ususal `cat` program.
- void * u_sleep (void *arg)

  Sleep for `n` seconds.
- void * u_busy (void *arg)

  Busy wait indefinitely. It can only be interrupted via signals.
- void * u_echo (void *arg)

  Echo back an input string.
- void * u_ls (void *arg)

  Lists all files in the working directory. For extra credit, it should support relative and absolute file paths.
- void * u_touch (void *arg)

  For each file, create an empty file if it doesn't exist, else update its timestamp.
- void * u_mv (void *arg)

  Rename a file. If the `dst_file` file already exists, overwrite it.
- void * u_cp (void *arg)
- void * u_rm (void *arg)

  Remove a list of files. Treat each file in the list as a separate transaction. (i.e. if removing file1 fails, still attempt to remove file2, file3, etc.)
- void * u_chmod (void *arg)

  Change permissions of a file. There's no need to error if a permission being added already exists, or if a permission being removed is already not granted.
- void * u_ps (void *arg)

  List all processes on PennOS, displaying PID, PPID, priority, status, and command name.
- void * u_kill (void *arg)

  Sends a specified signal to a list of processes. If a signal name is not specified, default to "term". Valid signals are -term, -stop, and -cont.
- void * zombie_child (void *arg)

  Helper for zombify.
- void * u_zombify (void *arg)

  Used to test zombifying functionality of your kernel.
- void * u_orphan_child (void *arg)

  Helper for orphanify.
- void * u_orphanify (void *arg)

  Used to test orphanifying functionality of your kernel.
- void * u_nice (void *arg)

  Spawn a new process for `command` and set its priority to `priority`.
- void * u_nice_pid (void *arg)

  Adjust the priority level of an existing process.
- void * u_man (void *arg)

  Lists all available commands.
- void * u_bg (void *arg)

  Resumes the most recently stopped job in the background, or the job specified by job_id.
- void * u_fg (void *arg)

  Brings the most recently stopped or background job to the foreground, or the job specified by job_id.
- void * u_jobs (void *arg)

Lists all jobs.

- void * u_logout (void *arg)

  Exits the shell and shutsdown PennOS.

- int stoi (char *str)

  Converts a string to an integer.

- void * u_hang (void *arg)

  Test command that spawns 10 child processes and waits on them (blocking). Useful for testing the scheduler and wait functionality.

- void * u_nohang (void *arg)

  Test command that spawns 10 child processes and waits on them (non-blocking). Useful for testing the scheduler with non-blocking waits.

- void * u_recur (void *arg)

  Test command that recursively spawns 26 processes (Gen_A through Gen_Z). Useful for testing recursive spawning and deep process hierarchies.

- void * u_crash (void *arg)

  Test command that writes a large pattern to a file and then crashes. Useful for testing file system durability and crash recovery. Requires the filesystem to be able to hold at least 5480 bytes in a file.

5.24.1 Macro Definition Documentation

5.24.1.1 MAX_MESSAGE_SIZE

```
#define MAX_MESSAGE_SIZE 4096
```

5.24.2 Function Documentation

5.24.2.1 stoi()

```
int stoi (
            char * str)
```

Converts a string to an integer.

5.24.2.2 u_bg()

```
void * u_bg (
            void * arg)
```

Resumes the most recently stopped job in the background, or the job specified by job_id.

Example Usage: bg Example Usage: bg 2 (job_id is 2)

5.24.2.3 u_busy()

```
void * u_busy (
            void * arg)
```

Busy wait indefinitely. It can only be interrupted via signals.

Example Usage: busy

5.24.2.4 u_cat()

```
void * u_cat (
            void * arg)
```

The ususal `cat` program.

If `files` arg is provided, concatenate these files and print to stdout If `files` arg is *not* provided, read from stdin and print back to stdout

Example Usage: cat f1 f2 (concatenates f1 and f2 and print to stdout) Example Usage: cat f1 f2 < f3 (concatenates f1 and f2 and prints to stdout, ignores f3) Example Usage: cat < f3 (concatenates f3, prints to stdout)

5.24.2.5 u_chmod()

```
void * u_chmod (
            void * arg)
```

Change permissions of a file. There's no need to error if a permission being added already exists, or if a permission being removed is already not granted.

Print appropriate error message if:

- `file` is not a file that exists
- `perms` is invalid

Example Usage: chmod +x file (adds executable permission to file) Example Usage: chmod +rw file (adds read + write permissions to file) Example Usage: chmod -wx file (removes write + executable permissions from file)

5.24.2.6 u_cp()

```
void * u_cp (
            void * arg)
```

Copy a file. If the `dst_file` file already exists, overwrite it.

Print appropriate error message if:

- `src_file` is not a file that exists
- `src_file` does not have read permissions
- `dst_file` file already exists but does not have write permissions

Example Usage: cp src_file dst_file

5.24.2.7 u_crash()

```
void * u_crash (
            void * arg)
```

Test command that writes a large pattern to a file and then crashes. Useful for testing file system durability and crash recovery. Requires the filesystem to be able to hold at least 5480 bytes in a file.

Example Usage: crash

5.24.2.8 u_echo()

```
void * u_echo (
            void * arg)
```

Echo back an input string.

Example Usage: echo Hello World

5.24.2.9 u_fg()

```
void * u_fg (
            void * arg)
```

Brings the most recently stopped or background job to the foreground, or the job specified by job_id.

Example Usage: fg Example Usage: fg 2 (job_id is 2)

5.24.2.10 u_hang()

```
void * u_hang (
            void * arg)
```

Test command that spawns 10 child processes and waits on them (blocking). Useful for testing the scheduler and wait functionality.

Example Usage: hang

5.24.2.11 u_jobs()

```
void * u_jobs (
            void * arg)
```

Lists all jobs.

Example Usage: jobs

5.24.2.12 u_kill()

```
void * u_kill (
            void * arg)
```

Sends a specified signal to a list of processes. If a signal name is not specified, default to "term". Valid signals are -term, -stop, and -cont.

Example Usage: kill 1 2 3 (sends term to processes 1, 2, and 3) Example Usage: kill -term 1 2 (sends term to processes 1 and 2) Example Usage: kill -stop 1 2 (sends stop to processes 1 and 2) Example Usage: kill -cont 1 (sends cont to process 1)

5.24.2.13 u_logout()

```
void * u_logout (
            void * arg)
```

Exits the shell and shutsdown PennOS.

Example Usage: logout

5.24.2.14 u_ls()

```
void * u_ls (
            void * arg)
```

Lists all files in the working directory. For extra credit, it should support relative and absolute file paths.

Example Usage: ls (regular credit) Example Usage: ls ../../foo/./bar/sample (only for EC)

5.24.2.15 u_man()

```
void * u_man (
            void * arg)
```

Lists all available commands.

Example Usage: man

5.24.2.16 u_mv()

```
void * u_mv (
            void * arg)
```

Rename a file. If the `dst_file` file already exists, overwrite it.

Print appropriate error message if:

- `src_file` is not a file that exists
- `src_file` does not have read permissions
- `dst_file` file already exists but does not have write permissions

Example Usage: mv src_file dst_file

5.24.2.17 u_nice()

```
void * u_nice (
            void * arg)
```

Spawn a new process for `command` and set its priority to `priority`.

1. Adjust the priority level of an existing process.

Example Usage: nice 2 cat f1 f2 f3 (spawns cat with priority 2)

5.24.2.18 u_nice_pid()

```
void * u_nice_pid (
            void * arg)
```

Adjust the priority level of an existing process.

Example Usage: nice_pid 0 123 (sets priority 0 to PID 123)

Parameters

prio	The new priority level (0, 1, or 2).
pid	The PID of the target process.

5.24.2.19 u_nohang()

```
void * u_nohang (
            void * arg)
```

Test command that spawns 10 child processes and waits on them (non-blocking). Useful for testing the scheduler with non-blocking waits.

Example Usage: nohang

5.24.2.20 u_orphan_child()

```
void * u_orphan_child (
            void * arg)
```

Helper for orphanify.

5.24.2.21 u_orphanify()

```
void * u_orphanify (
            void * arg)
```

Used to test orphanifying functionality of your kernel.

Example Usage: orphanify

5.24.2.22 u_ps()

```
void * u_ps (
            void * arg)
```

List all processes on PennOS, displaying PID, PPID, priority, status, and command name.

Example Usage: ps

5.24.2.23 u_recur()

```
void * u_recur (
            void * arg)
```

Test command that recursively spawns 26 processes (Gen_A through Gen_Z). Useful for testing recursive spawning and deep process hierarchies.

Example Usage: recur

5.24.2.24 u_rm()

```
void * u_rm (
            void * arg)
```

Remove a list of files. Treat each file in the list as a separate transaction. (i.e. if removing file1 fails, still attempt to remove file2, file3, etc.)

Print appropriate error message if:

- `file` is not a file that exists

Example Usage: rm f1 f2 f3 f4 f5

5.24.2.25 u_sleep()

```
void * u_sleep (
            void * arg)
```

Sleep for `n` seconds.

Note that you'll have to convert the number of seconds to the correct number of ticks.

Example Usage: sleep 10

5.24.2.26 u_touch()

```
void * u_touch (
            void * arg)
```

For each file, create an empty file if it doesn't exist, else update its timestamp.

Example Usage: touch f1 f2 f3 f4 f5

5.24.2.27 u_zombify()

```
void * u_zombify (
            void * arg)
```

Used to test zombifying functionality of your kernel.

Example Usage: zombify

5.24.2.28 zombie_child()

```
void * zombie_child (
            void * arg)
```

Helper for zombify.

5.25 user-call.h

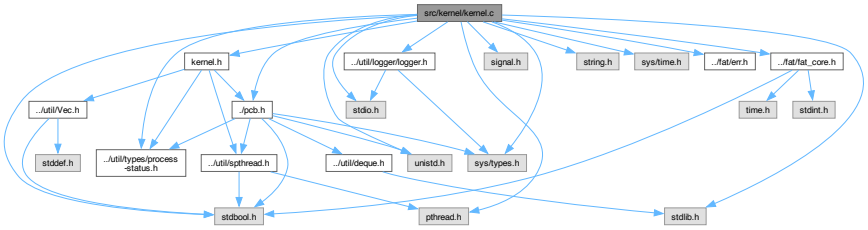
Go to the documentation of this file.

```
00001 #ifndef MAX_MESSAGE_SIZE
00002 #define MAX_MESSAGE_SIZE 4096
00003 #endif
00014 void* u_cat(void* arg);
00015
00024 void* u_sleep(void* arg);
00025
00032 void* u_busy(void* arg);
00033
00039 void* u_echo(void* arg);
00040
00048 void* u_ls(void* arg);
00049
00056 void* u_touch(void* arg);
00057
00068 void* u_mv(void* arg);
00069
00080 void* u_cp(void* arg);
00081
00092 void* u_rm(void* arg);
00093
00108 void* u_chmod(void* arg);
00109
00116 void* u_ps(void* arg);
00117
00128 void* u_kill(void* arg);
00129
00133 void* zombie_child(void* arg);
00134
00140 void* u_zombify(void* arg);
00141
00145 void* u_orphan_child(void* arg);
00146
00152 void* u_orphanify(void* arg);
00153
00160 void* u_nice(void* arg);
00161
00167 void* u_nice_pid(void* arg);
00168
00174 void* u_man(void* arg);
00175
00183 void* u_bg(void* arg);
00184
00192 void* u_fg(void* arg);
00193
00199 void* u_jobs(void* arg);
00200
00206 void* u_logout(void* arg);
00207
00212 int stoi(char* str);
00213
00220 void* u_hang(void* arg);
00221
00228 void* u_nohang(void* arg);
00229
00236 void* u_recur(void* arg);
00237
00245 void* u_crash(void* arg);
```

5.26 src/kernel/kernel.c File Reference

```
#include "kernel.h"
#include <pthread.h>
#include <signal.h>
#include <stdbool.h>
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <sys/time.h>
#include <sys/types.h>
#include <unistd.h>
#include "../fat/err.h"
#include "../fat/fat_core.h"
#include "../util/logger/logger.h"
#include "../util/types/process-status.h"
#include "pcb.h"
```

Include dependency graph for kernel.c:



Macros

- #define _POSIX_C_SOURCE 200809L

Functions

- unsigned long get_kernel_ticks ()

  Get the kernel ticks.
- void alarm_handler (int signum)
- KernelState * getKernelState ()

  Get the kernel state.
- void stop_handler (int signum)
- void int_handler (int signum)
- void kernel_set_up ()

  Initialize the kernel.
- void start_kernel ()

  Start the kernel.
- void check_blocked_processes ()

  Check if a process is blocked by sleep and wake it up if the time has come.
- void add_process_to_scheduler (pcb_t *proc)

  Add a process to the appropriate run queue based on its priority. Also set its place in the pid pool.
- void add_process_to_run_queue (pcb_t *proc)

  Add a process to the appropriate run queue based on its priority.

- void remove_process_from_run_queue (pcb_t *proc)
  Remove a process from its current run queue.
- void add_process_to_zombie_queue (pcb_t *proc)
  Add a process to the zombie queue.
- void remove_process_from_zombie_queue (pcb_t *proc)
  Remove a process from the zombie queue.

Variables

- volatile unsigned long kernel_ticks = 0
- volatile bool g_shutdown_requested = false
  Global variable to track if a shutdown has been requested.
- struct KernelState k

5.26.1 Macro Definition Documentation

5.26.1.1 _POSIX_C_SOURCE

```
#define _POSIX_C_SOURCE 200809L
```

5.26.2 Function Documentation

5.26.2.1 add_process_to_run_queue()

```
void add_process_to_run_queue (
            pcb_t * proc)
```

Add a process to the appropriate run queue based on its priority.

Parameters

proc	The process to enqueue. Must not be NULL.

5.26.2.2 add_process_to_scheduler()

```
void add_process_to_scheduler (
            pcb_t * proc)
```

Add a process to the appropriate run queue based on its priority. Also set its place in the pid pool.

This schedules the process to be picked up by the kernel scheduler during its round-robin cycle. Must only be called on RUNNING processes.

Parameters

proc	The process to enqueue. Must not be NULL.

5.26.2.3 add_process_to_zombie_queue()

```
void add_process_to_zombie_queue (
            pcb_t * proc)
```

Add a process to the zombie queue.

Zombie processes have terminated but are waiting to be reaped by their parent. This function registers such processes into the dq_ZOMBIE queue.

Parameters

proc	The process to mark as zombie. Must not be NULL.

Add a process to the zombie queue.

Zombie processes have terminated but are waiting to be reaped by their parent. This function registers such processes into the dq_ZOMBIE queue.

Parameters

proc	The process to mark as zombie. Must not be NULL.

5.26.2.4 alarm_handler()

```
void alarm_handler (
            int signum)
```

5.26.2.5 check_blocked_processes()

```
void check_blocked_processes ()
```

Check if a process is blocked by sleep and wake it up if the time has come.

5.26.2.6 get_kernel_ticks()

```
unsigned long get_kernel_ticks ()
```

Get the kernel ticks.

Returns

unsigned long The number of ticks since the kernel started.

5.26.2.7 getKernelState()

```
KernelState * getKernelState ()
```

Get the kernel state.

Returns

KernelState* The kernel state.

5.26.2.8 int_handler()

```
void int_handler (
            int signum)
```

5.26.2.9 kernel_set_up()

```
void kernel_set_up ()
```

Initialize the kernel.

This function is called once at kernel startup and should perform any necessary initialization tasks.

5.26.2.10 remove_process_from_run_queue()

```
void remove_process_from_run_queue (
            pcb_t * proc)
```

Remove a process from its current run queue.

This is typically used when a process blocks, is killed, exits, or is reprioritized. The function will look for the process by PID within its current priority-level queue and remove it if found.

Parameters

proc	The process to remove. Must not be NULL.

Remove a process from its current run queue.

This is typically used when a process blocks, is killed, exits, or is reprioritized. The function will look for the process by PID within its current priority-level queue and remove it if found.

Parameters

proc	The process to remove. Must not be NULL.

5.26.2.11 remove_process_from_zombie_queue()

```
void remove_process_from_zombie_queue (
            pcb_t * proc)
```

Remove a process from the zombie queue.

This is typically done when the parent reaps a zombie child via s_waitpid. The function matches by PID and removes the process.

Parameters

proc	The zombie process to remove. Must not be NULL.

Remove a process from the zombie queue.

This is typically done when the parent reaps a zombie child via s_waitpid. The function matches by PID and removes the process.

Parameters

proc	The zombie process to remove. Must not be NULL.

5.26.2.12 start_kernel()

```
void start_kernel ()
```

Start the kernel.

This function is called once at kernel startup and should perform any necessary initialization tasks.

5.26.2.13 stop_handler()

```
void stop_handler (
            int signum)
```

5.26.3 Variable Documentation

5.26.3.1 g_shutdown_requested

```
volatile bool g_shutdown_requested = false
```

Global variable to track if a shutdown has been requested.

5.26.3.2 k

```
struct KernelState k
```

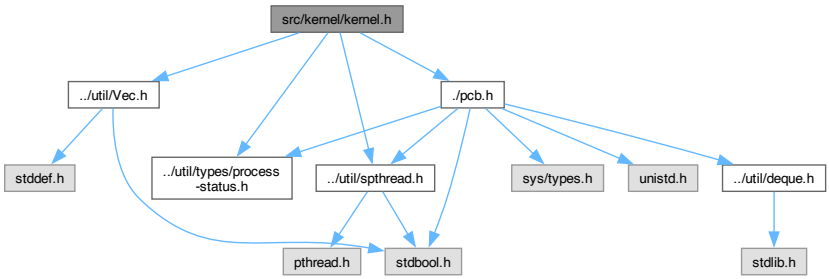
5.26.3.3 kernel_ticks

```
volatile unsigned long kernel_ticks = 0
```

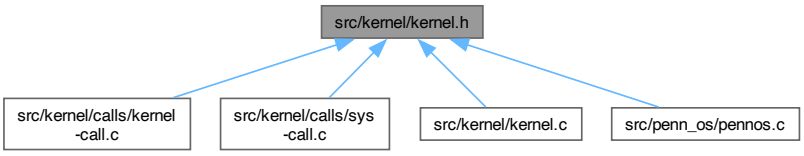
5.27 src/kernel/kernel.h File Reference

```
#include "../util/Vec.h"
#include "../util/spthread.h"
#include "../util/types/process-status.h"
#include "./pcb.h"
```

Include dependency graph for kernel.h:



This graph shows which files directly or indirectly include this file:



Classes

- struct KernelState

  The kernel state.

Macros

- #define PROCESS_QUANTA 19
- #define MAX_PROC 100

Typedefs

- typedef struct KernelState KernelState

  The kernel state.

Functions

- KernelState * getKernelState ()
  Get the kernel state.
- void start_kernel ()
  Start the kernel.
- void kernel_set_up ()
  Initialize the kernel.
- void add_process_to_scheduler (pcb_t *proc)
  Add a process to the appropriate run queue based on its priority. Also set its place in the pid pool.
- void add_process_to_run_queue (pcb_t *proc)
  Add a process to the appropriate run queue based on its priority.
- void remove_process_from_run_queue (pcb_t *proc)
  Remove a process from its current run queue.
- void add_process_to_zombie_queue (pcb_t *proc)
  Add a process to the zombie queue.
- void remove_process_from_zombie_queue (pcb_t *proc)
  Remove a process from the zombie queue.
- void check_blocked_processes ()
  Check if a process is blocked by sleep and wake it up if the time has come.
- unsigned long get_kernel_ticks ()
  Get the kernel ticks.

Variables

- volatile bool g_shutdown_requested
  Global variable to track if a shutdown has been requested.

5.27.1 Macro Definition Documentation

5.27.1.1 MAX_PROC

```
#define MAX_PROC 100
```

5.27.1.2 PROCESS_QUANTA

```
#define PROCESS_QUANTA 19
```

5.27.2 Typedef Documentation

5.27.2.1 KernelState

```
typedef struct KernelState KernelState
```

The kernel state.

This structure contains all the state information for the kernel.

5.27.3 Function Documentation

5.27.3.1 add_process_to_run_queue()

```
void add_process_to_run_queue (
            pcb_t * proc)
```

Add a process to the appropriate run queue based on its priority.

Parameters

proc	The process to enqueue. Must not be NULL.

5.27.3.2 add_process_to_scheduler()

```
void add_process_to_scheduler (
            pcb_t * proc)
```

Add a process to the appropriate run queue based on its priority. Also set its place in the pid pool.

This schedules the process to be picked up by the kernel scheduler during its round-robin cycle. Must only be called on RUNNING processes.

Parameters

proc	The process to enqueue. Must not be NULL.

5.27.3.3 add_process_to_zombie_queue()

```
void add_process_to_zombie_queue (
            pcb_t * proc)
```

Add a process to the zombie queue.

Zombie processes have terminated but are waiting to be reaped by their parent. This function registers such processes into the dq_ZOMBIE queue.

Parameters

proc	The process to mark as zombie. Must not be NULL.

Add a process to the zombie queue.

Zombie processes have terminated but are waiting to be reaped by their parent. This function registers such processes into the dq_ZOMBIE queue.

Parameters

proc	The process to mark as zombie. Must not be NULL.

5.27.3.4 check_blocked_processes()

```
void check_blocked_processes ()
```

Check if a process is blocked by sleep and wake it up if the time has come.

5.27.3.5 get_kernel_ticks()

```
unsigned long get_kernel_ticks ()
```

Get the kernel ticks.

Returns

unsigned long The number of ticks since the kernel started.

5.27.3.6 getKernelState()

```
KernelState * getKernelState ()
```

Get the kernel state.

Returns

KernelState* The kernel state.

5.27.3.7 kernel_set_up()

```
void kernel_set_up ()
```

Initialize the kernel.

This function is called once at kernel startup and should perform any necessary initialization tasks.

5.27.3.8 remove_process_from_run_queue()

```
void remove_process_from_run_queue (
            pcb_t * proc)
```

Remove a process from its current run queue.

This is typically used when a process blocks, is killed, exits, or is reprioritized. The function will look for the process by PID within its current priority-level queue and remove it if found.

Parameters

proc	The process to remove. Must not be NULL.

Remove a process from its current run queue.

This is typically used when a process blocks, is killed, exits, or is reprioritized. The function will look for the process by PID within its current priority-level queue and remove it if found.

Parameters

proc	The process to remove. Must not be NULL.

5.27.3.9 remove_process_from_zombie_queue()

```
void remove_process_from_zombie_queue (
            pcb_t * proc)
```

Remove a process from the zombie queue.

This is typically done when the parent reaps a zombie child via s_waitpid. The function matches by PID and removes the process.

Parameters

proc	The zombie process to remove. Must not be NULL.

Remove a process from the zombie queue.

This is typically done when the parent reaps a zombie child via s_waitpid. The function matches by PID and removes the process.

Parameters

proc	The zombie process to remove. Must not be NULL.

5.27.3.10 start_kernel()

```
void start_kernel ()
```

Start the kernel.

This function is called once at kernel startup and should perform any necessary initialization tasks.

5.27.4 Variable Documentation

5.27.4.1 g_shutdown_requested

```
volatile bool g_shutdown_requested  [extern]
```

Global variable to track if a shutdown has been requested.

5.28 kernel.h

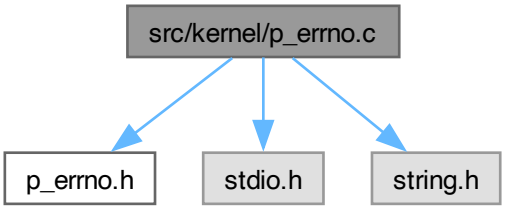
Go to the documentation of this file.

```
00001 #include "../util/Vec.h"
00002 #include "../util/spthread.h"
00003 #include "../util/types/process-status.h"
00004 #include "./pcb.h"
00005 #ifndef PROCESS_QUANTA
00006 #define PROCESS_QUANTA 19
00007 #endif
00008
00009 #ifndef MAX_PROC
00010 #define MAX_PROC 100
00011 #endif
00012
00018 typedef struct KernelState
00019 {
00020   Deque *dq_RUNNING[3];
00021   Deque *dq_ZOMBIE;
00022   Deque *dq_DEAD; // Ensure this exists if used, otherwise remove
00023   Deque *dq_BLOCKED;
00024   Deque *dq_STOPPED; // Make sure this is uncommented/added
00025   int curr_thread_num;
00026   int process_quanta;
00027   pcb_t *curr_process;
00028   Vec current_processes;
00029   pid_t terminal_owner_pid; // Add terminal owner tracking
00030 } KernelState;
00031
00035 extern volatile bool g_shutdown_requested;
00036
00042 KernelState *getKernelState();
00043
00050 void start_kernel();
00051
00058 void kernel_set_up();
00059
00069 void add_process_to_scheduler(pcb_t *proc);
00070
00077
00078 void add_process_to_run_queue(pcb_t *proc);
00079
00089
00099 void remove_process_from_run_queue(pcb_t *proc);
00100
00110
00120 void add_process_to_zombie_queue(pcb_t *proc);
00121
00130
00139 void remove_process_from_zombie_queue(pcb_t *proc);
00140
00146 void check_blocked_processes();
00147
00153 unsigned long get_kernel_ticks();
```

5.29 src/kernel/p_errno.c File Reference

```
#include "p_errno.h"
#include <stdio.h>
#include <string.h>
```

Include dependency graph for p_errno.c:



Functions

- void u_perror (const char *msg)

  Print an error message to the standard error stream.

Variables

- int P_ERRNO = 0

  Error number for the last system call.

5.29.1 Function Documentation

5.29.1.1 u_perror()

```
void u_perror (
            const char * msg)
```

Print an error message to the standard error stream.

Parameters

msg	The message to print.

5.29.2 Variable Documentation

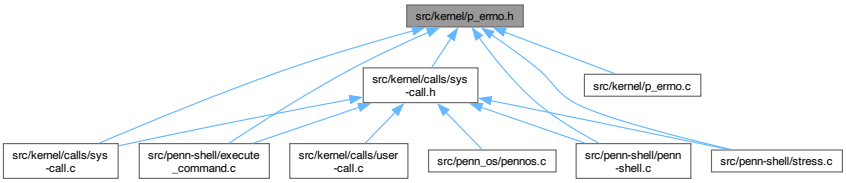
5.29.2.1 P_ERRNO

```
int P_ERRNO = 0
```

Error number for the last system call.

5.30 src/kernel/p_errno.h File Reference

This graph shows which files directly or indirectly include this file:



Macros

- #define P_ERRNO_SUCCESS 0
- #define P_ERRNO_FILE_NOT_FOUND 1
- #define P_ERRNO_PERMISSION 2
- #define P_ERRNO_WRITE_CONFLICT 3
- #define P_ERRNO_INTERNAL 4
- #define P_ERRNO_INVALID_ARG 5
- #define P_ERRNO_NO_SPACE 6
- #define P_ERRNO_NOT_MOUNTED 7
- #define P_ERRNO_ALREADY_MOUNTED 8
- #define P_ERRNO_INVALID_FD 9
- #define P_ERRNO_NOT_A_DIRECTORY 10
- #define P_ERRNO_INVALID_OPERATION 11
- #define P_ERRNO_INVALID_WHENCE 12
- #define P_ERRNO_INVALID_OFFSET 13
- #define P_ERRNO_ESRCH 14
- #define P_ERRNO_EINVAL 15
- #define P_ERRNO_ECHILD 16
- #define P_ERRNO_UNKNOWN 255

Functions

- void u_perror (const char *msg)

  Print an error message to the standard error stream.

Variables

- int P_ERRNO

  Error number for the last system call.

5.30.1 Macro Definition Documentation

5.30.1.1 P_ERRNO_ALREADY_MOUNTED

```
#define P_ERRNO_ALREADY_MOUNTED 8
```

5.30.1.2 P_ERRNO_ECHILD

```
#define P_ERRNO_ECHILD 16
```

5.30.1.3 P_ERRNO_EINVAL

```
#define P_ERRNO_EINVAL 15
```

5.30.1.4 P_ERRNO_ESRCH

```
#define P_ERRNO_ESRCH 14
```

5.30.1.5 P_ERRNO_FILE_NOT_FOUND

```
#define P_ERRNO_FILE_NOT_FOUND 1
```

5.30.1.6 P_ERRNO_INTERNAL

```
#define P_ERRNO_INTERNAL 4
```

5.30.1.7 P_ERRNO_INVALID_ARG

```
#define P_ERRNO_INVALID_ARG 5
```

5.30.1.8 P_ERRNO_INVALID_FD

```
#define P_ERRNO_INVALID_FD 9
```

5.30.1.9 P_ERRNO_INVALID_OFFSET

```
#define P_ERRNO_INVALID_OFFSET 13
```

5.30.1.10 P_ERRNO_INVALID_OPERATION

```
#define P_ERRNO_INVALID_OPERATION 11
```

5.30.1.11 P_ERRNO_INVALID_WHENCE

```
#define P_ERRNO_INVALID_WHENCE 12
```

5.30.1.12 P_ERRNO_NO_SPACE

```
#define P_ERRNO_NO_SPACE 6
```

5.30.1.13 P_ERRNO_NOT_A_DIRECTORY

```
#define P_ERRNO_NOT_A_DIRECTORY 10
```

5.30.1.14 P_ERRNO_NOT_MOUNTED

```
#define P_ERRNO_NOT_MOUNTED 7
```

5.30.1.15 P_ERRNO_PERMISSION

```
#define P_ERRNO_PERMISSION 2
```

5.30.1.16 P_ERRNO_SUCCESS

```
#define P_ERRNO_SUCCESS 0
```

5.30.1.17 P_ERRNO_UNKNOWN

```
#define P_ERRNO_UNKNOWN 255
```

5.30.1.18 P_ERRNO_WRITE_CONFLICT

```
#define P_ERRNO_WRITE_CONFLICT 3
```

5.30.2 Function Documentation

5.30.2.1 u_perror()

```
void u_perror (
            const char * msg)
```

Print an error message to the standard error stream.

Parameters

msg	The message to print.

5.30.3 Variable Documentation

5.30.3.1 P_ERRNO

```
int P_ERRNO  [extern]
```

Error number for the last system call.

5.31 p_errno.h

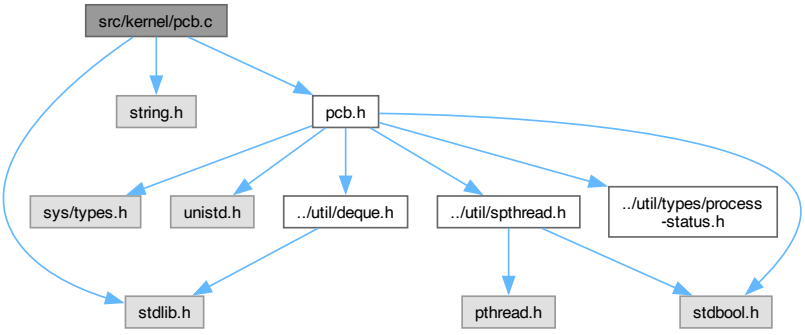
Go to the documentation of this file.

```
00001 #ifndef P_ERRNO_H
00002 #define P_ERRNO_H
00003
00004 #define P_ERRNO_SUCCESS 0            // No error
00005 #define P_ERRNO_FILE_NOT_FOUND 1     // File not found (maps from FAT: FILE_NOT_FOUND)
00006 #define P_ERRNO_PERMISSION 2         // Permission denied (maps from FAT: PERMISSION_DENIED)
00007 #define P_ERRNO_WRITE_CONFLICT 3     // File open for writing elsewhere
00008 #define P_ERRNO_INTERNAL 4           // General internal kernel/OS error (maps from FAT: MEMORY_ERROR,
      FILE_SYSTEM)
00009 #define P_ERRNO_INVALID_ARG 5        // Invalid argument provided to syscall (e.g., bad priority)
      (maps from FAT: INVALID_ARGS)
00010 #define P_ERRNO_NO_SPACE 6           // No space left on device (maps from FAT: NO_SPACE)
00011 #define P_ERRNO_NOT_MOUNTED 7        // Filesystem not mounted (maps from FAT: FS_NOT_MOUNTED)
00012 #define P_ERRNO_ALREADY_MOUNTED 8    // Filesystem already mounted (maps from FAT: FS_ALREADY_MOUNTED)
00013 #define P_ERRNO_INVALID_FD 9         // Invalid file descriptor (maps from FAT: INVALID_FD)
00014 #define P_ERRNO_NOT_A_DIRECTORY 10   // Path is not a directory (maps from FAT: NOT_A_DIRECTORY)
00015 #define P_ERRNO_INVALID_OPERATION 11 // Operation not permitted (e.g., closing stdin, bad mode) (maps
      from FAT: INVALID_OPERATION)
00016 #define P_ERRNO_INVALID_WHENCE 12    // Invalid 'whence' argument for lseek (maps from FAT:
      INVALID_WHENCE)
00017 #define P_ERRNO_INVALID_OFFSET 13    // Invalid 'offset' argument for lseek (maps from FAT:
      INVALID_OFFSET)
00018 #define P_ERRNO_ESRCH 14             // No such process
00019 #define P_ERRNO_EINVAL 15            // Invalid argument (general, e.g., bad signal)
00020 #define P_ERRNO_ECHILD 16            // No child processes (for waitpid)
00021 #define P_ERRNO_UNKNOWN 255          // Unknown error
00022
00023 extern int P_ERRNO; // Make sure this is declared extern @Nikita pls
00024
00030 void u_perror(const char *msg);
00031
00032 #endif // P_ERRNO_H
```

5.32 src/kernel/pcb.c File Reference

```
#include <stdlib.h>
#include <string.h>
#include "pcb.h"
```

Include dependency graph for pcb.c:



Functions

- void pcb_initialize_fd_table (pcb_t *pcb)

  Initialize the file descriptor table for a process.
- int pcb_add_fd (pcb_t *pcb, int fd, const char *fname, int mode, int offset)

  Add a file descriptor to the process's file descriptor table.
- int pcb_remove_fd (pcb_t *pcb, int fd)

  Remove a file descriptor from the process's file descriptor table.
- ProcessFDNode * pcb_get_fd (pcb_t *pcb, int fd_num)

  Get a file descriptor from the process's file descriptor table.
- pcb_t * pcb_create (pid_t pid, pid_t ppid, int priority_level, char *name, bool foreground)
- void pcb_destroy (pcb_t *pcb)
- int pcb_set_fd (pcb_t *pcb, int fd_num, const char *fname, int mode, int offset)

  Set a file descriptor in the process's file descriptor table.

5.32.1 Function Documentation

5.32.1.1 pcb_add_fd()

```
int pcb_add_fd (
            pcb_t * pcb,
            int kernel_fd,
            const char * fname,
            int mode,
            int offset)
```

Add a file descriptor to the process's file descriptor table.

Parameters

pcb	The process control block to add the file descriptor to.
kernel_fd	The kernel file descriptor number.
fname	The name of the file.
mode	The mode of the file.
offset	The offset of the file.

Returns

int The file descriptor number.

5.32.1.2 pcb_create()

```
pcb_t * pcb_create (
            pid_t pid,
            pid_t ppid,
            int priority_level,
            char * name,
            bool foreground)
```

5.32.1.3 pcb_destroy()

```
void pcb_destroy (
            pcb_t * pcb)
```

5.32.1.4 pcb_get_fd()

```
ProcessFDNode * pcb_get_fd (
            pcb_t * pcb,
            int fd_num)
```

Get a file descriptor from the process's file descriptor table.

Parameters

pcb	The process control block to get the file descriptor from.
fd_num	The file descriptor number.

Returns

ProcessFDNode∗ The file descriptor node.

5.32.1.5 pcb_initialize_fd_table()

```
void pcb_initialize_fd_table (
            pcb_t * pcb)
```

Initialize the file descriptor table for a process.

Parameters

pcb	The process control block to initialize.

5.32.1.6 pcb_remove_fd()

```
int pcb_remove_fd (
            pcb_t * pcb,
            int fd_num)
```

Remove a file descriptor from the process's file descriptor table.

Parameters

pcb	The process control block to remove the file descriptor from.
fd_num	The file descriptor number.

Returns

int The file descriptor number.

5.32.1.7 pcb_set_fd()

```
int pcb_set_fd (
            pcb_t * pcb,
            int fd_num,
            const char * fname,
            int mode,
            int offset)
```

Set a file descriptor in the process's file descriptor table.

Parameters

pcb	The process control block to set the file descriptor in.
fd_num	The file descriptor number.
fname	The name of the file.
mode	The mode of the file.
offset	The offset of the file.

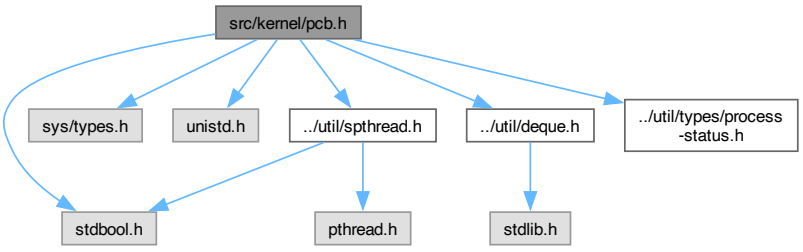
Returns

int The file descriptor number.

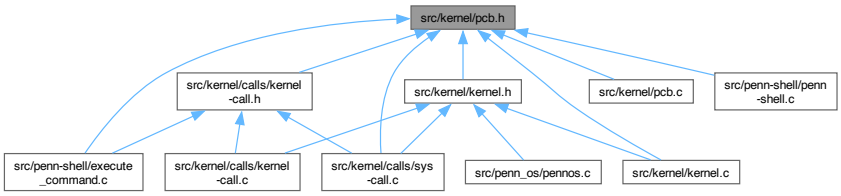
5.33 src/kernel/pcb.h File Reference

```
#include <stdbool.h>
#include <sys/types.h>
#include <unistd.h>
#include "../util/deque.h"
#include "../util/spthread.h"
#include "../util/types/process-status.h"
```

Include dependency graph for pcb.h:



This graph shows which files directly or indirectly include this file:



Classes

- struct ProcessFDNode

  The Process File Descriptor Node structure.
- struct pcb_t

  The Process Control Block (PCB) structure.

Typedefs

- typedef struct ProcessFDNode ProcessFDNode

  The Process File Descriptor Node structure.
- typedef struct pcb_t pcb_t

  The Process Control Block (PCB) structure.

Functions

- void pcb_initialize_fd_table (pcb_t ∗pcb)

  Initialize the file descriptor table for a process.
- int pcb_add_fd (pcb_t ∗pcb, int kernel_fd, const char ∗fname, int mode, int offset)

  Add a file descriptor to the process's file descriptor table.
- ProcessFDNode ∗ pcb_get_fd (pcb_t ∗pcb, int fd_num)

  Get a file descriptor from the process's file descriptor table.
- int pcb_remove_fd (pcb_t ∗pcb, int fd_num)

  Remove a file descriptor from the process's file descriptor table.
- int pcb_set_fd (pcb_t ∗pcb, int fd_num, const char ∗fname, int mode, int offset)

  Set a file descriptor in the process's file descriptor table.

5.33.1 Typedef Documentation

5.33.1.1 pcb_t

```
typedef struct pcb_t pcb_t
```

The Process Control Block (PCB) structure.

This structure represents a process control block (PCB) in the kernel.

5.33.1.2 ProcessFDNode

```
typedef struct ProcessFDNode ProcessFDNode
```

The Process File Descriptor Node structure.

This structure represents a file descriptor node in the process's file descriptor table.

5.33.2 Function Documentation

5.33.2.1 pcb_add_fd()

```
int pcb_add_fd (
            pcb_t * pcb,
            int kernel_fd,
            const char * fname,
            int mode,
            int offset)
```

Add a file descriptor to the process's file descriptor table.

Parameters

pcb	The process control block to add the file descriptor to.
kernel↩ _fd	The kernel file descriptor number.
fname	The name of the file.
mode	The mode of the file.
offset	The offset of the file.

Returns

int The file descriptor number.

5.33.2.2 pcb_get_fd()

```
ProcessFDNode * pcb_get_fd (
            pcb_t * pcb,
            int fd_num)
```

Get a file descriptor from the process's file descriptor table.

Parameters

pcb	The process control block to get the file descriptor from.
fd_num	The file descriptor number.

Returns

ProcessFDNode∗ The file descriptor node.

5.33.2.3 pcb_initialize_fd_table()

```
void pcb_initialize_fd_table (
            pcb_t * pcb)
```

Initialize the file descriptor table for a process.

Parameters

pcb	The process control block to initialize.

5.33.2.4 pcb_remove_fd()

```
int pcb_remove_fd (
            pcb_t * pcb,
            int fd_num)
```

Remove a file descriptor from the process's file descriptor table.

Parameters

pcb	The process control block to remove the file descriptor from.
fd_num	The file descriptor number.

Returns

int The file descriptor number.

5.33.2.5 pcb_set_fd()

```
int pcb_set_fd (
            pcb_t * pcb,
            int fd_num,
            const char * fname,
            int mode,
            int offset)
```

Set a file descriptor in the process's file descriptor table.

Parameters

pcb	The process control block to set the file descriptor in.
fd_num	The file descriptor number.
fname	The name of the file.
mode	The mode of the file.
offset	The offset of the file.

Returns

int The file descriptor number.

5.34 pcb.h

Go to the documentation of this file.

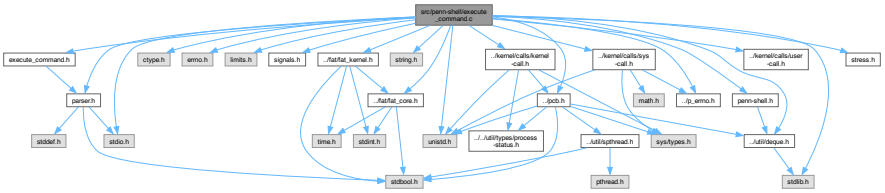
```
00001 #ifndef PCB_H
00002 #define PCB_H
00003
00004 #include <stdbool.h>
00005 #include <sys/types.h>
00006 #include <unistd.h>
00007 #include "../util/deque.h"
00008 #include "../util/spthread.h"
00009 #include "../util/types/process-status.h"
00010
00011 // The Process Control Block (PCB) structure for kernel processes
00012 // This should match the current implementation as used in sys-call.c and
00013 // kernel-call.c
00014
00021 typedef struct ProcessFDNode
00022 {
00023   int fd_num; // process-level FD
00024   char fname[32];
00025   int mode;
00026   int offset;
00027   struct ProcessFDNode *next;
00028 } ProcessFDNode;
00029
00035 typedef struct pcb_t
00036 {
00037   pid_t pid;                  // Process ID
00038   pid_t ppid;                 // Parent Process ID
00039   int priority_level;         // Priority level (0, 1, 2)
00040   int term_signal;            // Signal that terminated the process
00041   int stop_signal;            // Signal that stopped the process
00042   ProcessStatus status;       // Process status (enum)
00043   bool status_changed;        // Flag to indicate status change
00044   unsigned long wake_up_tick; // Tick count when sleep should end
00045   Deque *file_descriptors;    // Set of file descriptors
00046   ProcessFDNode *fd_table;    // Linked list of file descriptor nodes
00047   spthread_t *thread;         // Pointer to the thread of execution
00048   char *name;                 // Process name
00049   bool foreground;            // Foreground/background process
00050 } pcb_t;
00051
00057 void pcb_initialize_fd_table(pcb_t *pcb);
00058
00069 int pcb_add_fd(pcb_t *pcb, int kernel_fd, const char *fname, int mode, int offset);
00070
00078 ProcessFDNode *pcb_get_fd(pcb_t *pcb, int fd_num);
00079
00087 int pcb_remove_fd(pcb_t *pcb, int fd_num);
00088
00099 int pcb_set_fd(pcb_t *pcb, int fd_num, const char *fname, int mode, int offset);
00100
00101 #endif // PCB_H
```

5.35 src/penn-shell/execute_command.c File Reference

```
#include "execute_command.h"
#include <ctype.h>
#include <errno.h>
#include <limits.h>
#include <signals.h>
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <unistd.h>
#include "../fat/fat_core.h"
#include "../fat/fat_kernel.h"
#include "../kernel/calls/kernel-call.h"
#include "../kernel/calls/sys-call.h"
#include "../kernel/calls/user-call.h"
#include "../kernel/pcb.h"
```

```
#include "../kernel/p_errno.h"
#include "../util/deque.h"
#include "parser.h"
#include "penn-shell.h"
#include "stress.h"
```

Include dependency graph for execute_command.c:



Functions

- int execute_script_file (const char ∗script_path, int inherit_fd0, int inherit_fd1)
- pid_t execute_single_command (struct parsed_command ∗cmd, int cmd_index, int input_fd, int output_fd, const char ∗full_command_line)
- int handle_shell_builtin (struct parsed_command ∗cmd)
- int execute_command (struct parsed_command ∗cmd)

  Execute a parsed command via Penn-Shell.

5.35.1 Function Documentation

5.35.1.1 execute_command()

```
int execute_command (
            struct parsed_command * cmd)
```

Execute a parsed command via Penn-Shell.

Parameters

cmd	The parsed command to execute.

Returns

int The exit status of the command.

5.35.1.2 execute_script_file()

```
int execute_script_file (
            const char * script_path,
            int inherit_fd0,
            int inherit_fd1)
```

5.35.1.3 execute_single_command()

```
pid_t execute_single_command (
            struct parsed_command * cmd,
            int cmd_index,
            int input_fd,
            int output_fd,
            const char * full_command_line)
```

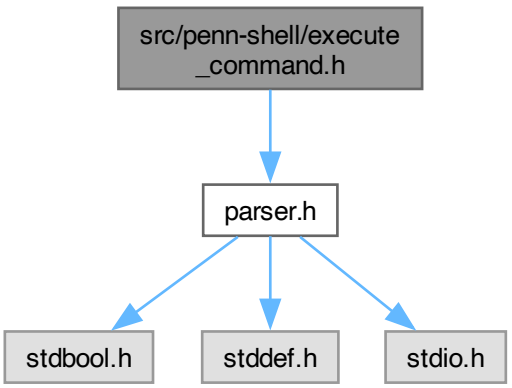
5.35.1.4 handle_shell_builtin()

```
int handle_shell_builtin (
            struct parsed_command * cmd)
```

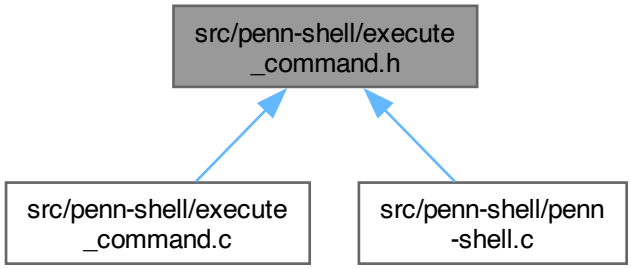
5.36 src/penn-shell/execute_command.h File Reference

```
#include "parser.h"
```

Include dependency graph for execute_command.h:



This graph shows which files directly or indirectly include this file:



Functions

- int execute_command (struct parsed_command *cmd)

  Execute a parsed command via Penn-Shell.

5.36.1 Function Documentation

5.36.1.1 execute_command()

```
int execute_command (
            struct parsed_command * cmd)
```

Execute a parsed command via Penn-Shell.

Parameters

cmd	The parsed command to execute.

Returns

int The exit status of the command.

5.37 execute_command.h

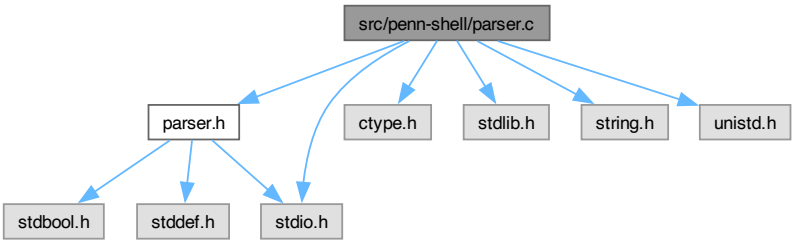
Go to the documentation of this file.

```
00001 #include "parser.h"
00002
00009 int execute_command(struct parsed_command *cmd);
```

5.38 src/penn-shell/parser.c File Reference

```
#include "parser.h"
#include <ctype.h>
#include <stdlib.h>
#include <string.h>
#include <unistd.h>
#include <stdio.h>
```

Include dependency graph for parser.c:



Macros

- #define JUMP_OUT(code)

Functions

- int parse_command (const char *const cmd_line, struct parsed_command **const result)

  Parse a command line into a parsed_command structure.
- void print_parsed_command (const struct parsed_command *const cmd)

  Print a parsed command line.
- void print_parsed_command_without_end (struct parsed_command *const cmd)

  Print a parsed command line without the trailing newline.
- void print_parser_errcode (FILE *output, int err_code)

  Print a debugging message for a parser error code.

5.38.1 Macro Definition Documentation

5.38.1.1 JUMP_OUT

```
#define JUMP_OUT(
                code)
```

Value:

```
do {                    \
  ret_code = code;      \
  goto PROCESS_ERROR; \
} while (0)
```

5.38.2 Function Documentation

5.38.2.1 parse_command()

```
int parse_command (
            const char * cmd_line,
            struct parsed_command ** result)
```

Parse a command line into a parsed_command structure.

Parameters

cmd_line	The command line to parse.
result	A pointer to a pointer to a parsed_command structure.

Returns

int 0 on success, -1 on failure.

layout of memory for `struct parsed_command` bool is_background; bool is_file_append;

const char *stdin_file; const char *stdout_file;

size_t num_commands;

commands are pointers to `arguments` char **commands[num_commands];

below are hidden in memory **

arguments are pointers to `original_string + num_commands` because all argv are null-terminated char *arguments[total_strings + num_commands];

original_string is a copy of the cmdline but with each token null-terminated char *original_string;

5.38.2.2 print_parsed_command()

```
void print_parsed_command (
            const struct parsed_command * cmd)
```

Print a parsed command line.

Parameters

cmd	The parsed command to print.

5.38.2.3 print_parsed_command_without_end()

```
void print_parsed_command_without_end (
            struct parsed_command * cmd)
```

Print a parsed command line without the trailing newline.

Parameters

cmd	The parsed command to print.

5.38.2.4 print_parser_errcode()

```
void print_parser_errcode (
            FILE * output,
            int err_code)
```

Print a debugging message for a parser error code.

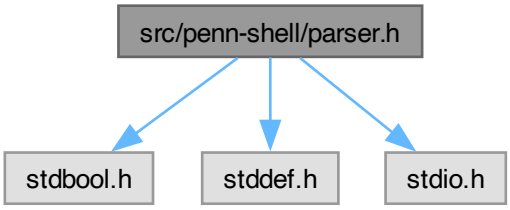
Parameters

output	The output stream to print to.
err_code	The error code to print.

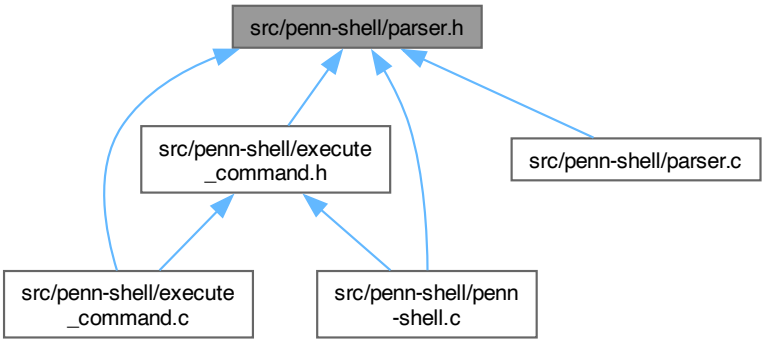
5.39 src/penn-shell/parser.h File Reference

```
#include <stdbool.h>
#include <stddef.h>
#include <stdio.h>
```

Include dependency graph for parser.h:



This graph shows which files directly or indirectly include this file:



Classes

- struct parsed_command

  struct parsed_command stored all necessary information needed for penn-shell.

Macros

- #define UNEXPECTED_FILE_INPUT 1
- #define UNEXPECTED_FILE_OUTPUT 2
- #define UNEXPECTED_PIPELINE 3
- #define UNEXPECTED_AMPERSAND 4
- #define EXPECT_INPUT_FILENAME 5
- #define EXPECT_OUTPUT_FILENAME 6
- #define EXPECT_COMMANDS 7

Functions

- int parse_command (const char ∗cmd_line, struct parsed_command ∗∗result)

  Parse a command line into a parsed_command structure.
- void print_parsed_command (const struct parsed_command ∗cmd)

  Print a parsed command line.
- void print_parser_errcode (FILE ∗output, int err_code)

  Print a debugging message for a parser error code.
- void print_parsed_command_without_end (struct parsed_command ∗cmd)

  Print a parsed command line without the trailing newline.

5.39.1 Macro Definition Documentation

5.39.1.1 EXPECT_COMMANDS

```
#define EXPECT_COMMANDS 7
```

5.39.1.2 EXPECT_INPUT_FILENAME

```
#define EXPECT_INPUT_FILENAME 5
```

5.39.1.3 EXPECT_OUTPUT_FILENAME

```
#define EXPECT_OUTPUT_FILENAME 6
```

5.39.1.4 UNEXPECTED_AMPERSAND

```
#define UNEXPECTED_AMPERSAND 4
```

5.39.1.5 UNEXPECTED_FILE_INPUT

```
#define UNEXPECTED_FILE_INPUT 1
```

5.39.1.6 UNEXPECTED_FILE_OUTPUT

```
#define UNEXPECTED_FILE_OUTPUT 2
```

5.39.1.7 UNEXPECTED_PIPELINE

```
#define UNEXPECTED_PIPELINE 3
```

5.39.2 Function Documentation

5.39.2.1 parse_command()

```
int parse_command (
            const char * cmd_line,
            struct parsed_command ** result)
```

Parse a command line into a parsed_command structure.

Parameters

cmd_line	The command line to parse.
result	A pointer to a pointer to a parsed_command structure.

Returns

int 0 on success, -1 on failure.

layout of memory for `struct parsed_command` bool is_background; bool is_file_append;

const char *stdin_file; const char *stdout_file;

size_t num_commands;

commands are pointers to `arguments` char **commands[num_commands];

below are hidden in memory **

arguments are pointers to `original_string + num_commands` because all argv are null-terminated char *arguments[total_strings + num_commands];

original_string is a copy of the cmdline but with each token null-terminated char *original_string;

5.39.2.2 print_parsed_command()

```
void print_parsed_command (
            const struct parsed_command * cmd)
```

Print a parsed command line.

Parameters

cmd	The parsed command to print.

5.39.2.3 print_parsed_command_without_end()

```
void print_parsed_command_without_end (
            struct parsed_command * cmd)
```

Print a parsed command line without the trailing newline.

Parameters

cmd	The parsed command to print.

5.39.2.4 print_parser_errcode()

```
void print_parser_errcode (
            FILE * output,
            int err_code)
```

Print a debugging message for a parser error code.

Parameters

output	The output stream to print to.
err_code	The error code to print.

5.40 parser.h

Go to the documentation of this file.

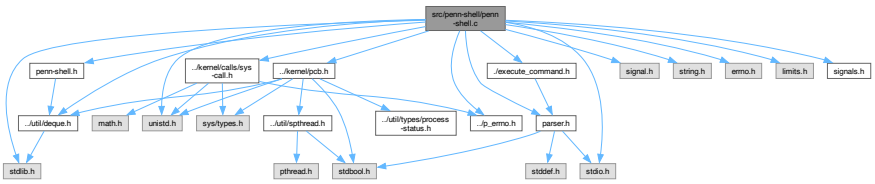
```
00001 /* Penn-Shell Parser
00002    hanbangw, 21fa    */
00003
00004 #pragma once
00005
00006 #include <stdbool.h>
00007 #include <stddef.h>
00008 #include <stdio.h>
00009
00010 #define UNEXPECTED_FILE_INPUT 1
00011 #define UNEXPECTED_FILE_OUTPUT 2
00012 #define UNEXPECTED_PIPELINE 3
00013 #define UNEXPECTED_AMPERSAND 4
00014 #define EXPECT_INPUT_FILENAME 5
```

```
00015 #define EXPECT_OUTPUT_FILENAME 6
00016 #define EXPECT_COMMANDS 7
00017
00023 struct parsed_command
00024 {
00025   // indicates the command shall be executed in background
00026   // (ends with an ampersand '&')
00027   bool is_background;
00028
00029   // indicates if the stdout_file shall be opened in append mode
00030   // ignore this value when stdout_file is NULL
00031   bool is_file_append;
00032
00033   // filename for redirecting input from
00034   const char *stdin_file;
00035
00036   // filename for redirecting output to
00037   const char *stdout_file;
00038
00039   // number of commands (pipeline stages)
00040   size_t num_commands;
00041
00042   // an array to a list of arguments
00043   // size of `commands' is `num_commands'
00044   char **commands[];
00045 };
00046
00054 int parse_command(const char *cmd_line, struct parsed_command **result);
00055
00061 void print_parsed_command(const struct parsed_command *cmd);
00062
00069 void print_parser_errcode(FILE *output, int err_code);
00070
00076 void print_parsed_command_without_end(struct parsed_command *cmd);
```

5.41 src/penn-shell/penn-shell.c File Reference

```
#include "penn-shell.h"
#include <signal.h>
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <unistd.h>
#include "../kernel/calls/sys-call.h"
#include "../kernel/p_errno.h"
#include "./execute_command.h"
#include "parser.h"
#include "../kernel/pcb.h"
#include "../util/deque.h"
#include <errno.h>
#include <limits.h>
#include <signals.h>
```

Include dependency graph for penn-shell.c:



Macros

- #define _POSIX_C_SOURCE 200809L
- #define LINE_BUFFER_CHUNK_SIZE 128

Functions

- void free_job (void *data)
  Frees memory associated with a job.
- void initialize_job_control ()
  Initializes job control mechanisms.
- Job * find_job_by_pid (pid_t pid)
  Finds a job by its process ID.
- Job * find_job_by_id (int job_id)
  Finds a job by its job ID.
- Job * find_last_job ()
  Finds the most recently added job.
- Job * find_last_stopped_job ()
  Finds the most recently stopped job.
- char * reconstruct_command (char *argv[])
  Reconstructs a command string from an argument vector.
- void add_job (pid_t pid, struct parsed_command *cmd, JobStatus status)
  Adds a new job to the job list.
- void remove_job_by_pid (pid_t pid)
  Removes a job from the job list by its process ID.
- int read_line_from_fd (int fd, char **line_buffer, size_t *buffer_size, size_t *line_len)
- void * shell (void *args)
  Main shell function to be run as a thread.

Variables

- Deque * job_list
  Global job list.
- int next_job_id
  Next available job ID.
- pid_t shell_pid
  Process ID of the shell.
- pid_t terminal_controller_pid = -1
  Process ID of the terminal controller.

5.41.1 Macro Definition Documentation

5.41.1.1 _POSIX_C_SOURCE

```
#define _POSIX_C_SOURCE 200809L
```

5.41.1.2 LINE_BUFFER_CHUNK_SIZE

```
#define LINE_BUFFER_CHUNK_SIZE 128
```

5.41.2 Function Documentation

5.41.2.1 add_job()

```
void add_job (
            pid_t pid,
            struct parsed_command * cmd,
            JobStatus status)
```

Adds a new job to the job list.

Parameters

pid	Process ID of the new job.
cmd	Parsed command structure for the job.
status	Initial status of the job.

5.41.2.2 find_job_by_id()

```
Job * find_job_by_id (
            int job_id)
```

Finds a job by its job ID.

Parameters

job↩ _id	Job ID to search for.

Returns

Job* Pointer to the found job, or NULL if not found.

5.41.2.3 find_job_by_pid()

```
Job * find_job_by_pid (
            pid_t pid)
```

Finds a job by its process ID.

Parameters

pid	Process ID to search for.

Returns

Job* Pointer to the found job, or NULL if not found.

5.41.2.4 find_last_job()

```
Job * find_last_job ()
```

Finds the most recently added job.

Returns

Job* Pointer to the last job, or NULL if no jobs exist.

5.41.2.5 find_last_stopped_job()

```
Job * find_last_stopped_job ()
```

Finds the most recently stopped job.

Returns

Job* Pointer to the last stopped job, or NULL if no stopped jobs exist.

5.41.2.6 free_job()

```
void free_job (
            void * data)
```

Frees memory associated with a job.

Parameters

data	Pointer to the job to be freed.

5.41.2.7 initialize_job_control()

```
void initialize_job_control ()
```

Initializes job control mechanisms.

5.41.2.8 read_line_from_fd()

```
int read_line_from_fd (
            int fd,
            char ** line_buffer,
            size_t * buffer_size,
            size_t * line_len)
```

5.41.2.9 reconstruct_command()

```
char * reconstruct_command (
            char * argv[])
```

Reconstructs a command string from an argument vector.

Parameters

argv	Array of command arguments.

Returns

char* Reconstructed command string.

5.41.2.10 remove_job_by_pid()

```
void remove_job_by_pid (
            pid_t pid)
```

Removes a job from the job list by its process ID.

Parameters

pid	Process ID of the job to remove.

5.41.2.11 shell()

```
void * shell (
            void * args)
```

Main shell function to be run as a thread.

Parameters

args	Arguments passed to the shell thread.

Returns

void* Return value of the thread.

5.41.3 Variable Documentation

5.41.3.1 job_list

```
Deque* job_list
```

Global job list.

5.41.3.2 next_job_id

```
int next_job_id
```

Next available job ID.

5.41.3.3 shell_pid

```
pid_t shell_pid
```

Process ID of the shell.

5.41.3.4 terminal_controller_pid

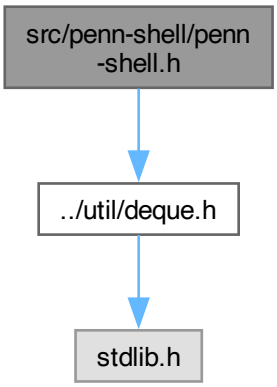
```
pid_t terminal_controller_pid = -1
```

Process ID of the terminal controller.

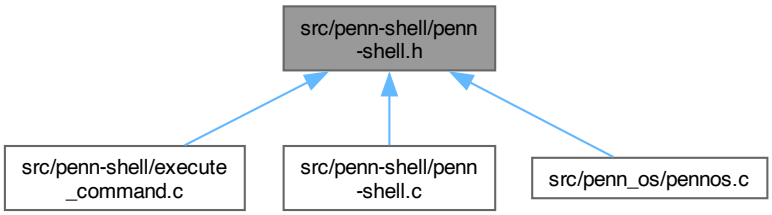
5.42 src/penn-shell/penn-shell.h File Reference

```
#include "../util/deque.h"
```

Include dependency graph for penn-shell.h:



This graph shows which files directly or indirectly include this file:



Classes

- struct Job

  struct for job

Macros

- #define PENSHELL_H
- #define MAX_MESSAGE_SIZE 4096
- #define SHELL_PROMPT "$"

Typedefs

- typedef int pid_t
- typedef struct Job Job

  struct for job

Enumerations

- enum JobStatus { JOB_STATUS_RUNNING , JOB_STATUS_STOPPED , JOB_STATUS_DONE }

  enum for job status

Functions

- void * shell (void *args)

  Main shell function to be run as a thread.
- void free_job (void *data)

  Frees memory associated with a job.
- void initialize_job_control ()

  Initializes job control mechanisms.
- Job * find_job_by_pid (pid_t pid)

  Finds a job by its process ID.
- Job * find_job_by_id (int job_id)

  Finds a job by its job ID.
- Job * find_last_job ()

  Finds the most recently added job.
- Job * find_last_stopped_job ()

  Finds the most recently stopped job.
- void add_job (pid_t pid, struct parsed_command *cmd, JobStatus status)

  Adds a new job to the job list.
- void remove_job_by_pid (pid_t pid)

  Removes a job from the job list by its process ID.
- char * reconstruct_command (char *argv[ ])

  Reconstructs a command string from an argument vector.

Variables

- Deque * job_list

  Global job list.
- int next_job_id

  Next available job ID.
- pid_t shell_pid

  Process ID of the shell.
- pid_t terminal_controller_pid

  Process ID of the terminal controller.

5.42.1 Macro Definition Documentation

5.42.1.1 MAX_MESSAGE_SIZE

```
#define MAX_MESSAGE_SIZE 4096
```

5.42.1.2 PENSHELL_H

```
#define PENSHELL_H
```

5.42.1.3 SHELL_PROMPT

```
#define SHELL_PROMPT "$"
```

5.42.2 Typedef Documentation

5.42.2.1 Job

```
typedef struct Job Job
```

struct for job

5.42.2.2 pid_t

```
typedef int pid_t
```

5.42.3 Enumeration Type Documentation

5.42.3.1 JobStatus

```
enum JobStatus
```

enum for job status

Enumerator

JOB_STATUS_RUNNING	
JOB_STATUS_STOPPED	
JOB_STATUS_DONE	

5.42.4 Function Documentation

5.42.4.1 add_job()

```
void add_job (
            pid_t pid,
            struct parsed_command * cmd,
            JobStatus status)
```

Adds a new job to the job list.

Parameters

pid	Process ID of the new job.
cmd	Parsed command structure for the job.
status	Initial status of the job.

5.42.4.2 find_job_by_id()

```
Job * find_job_by_id (
            int job_id)
```

Finds a job by its job ID.

Parameters

job_id	Job ID to search for.

Returns

Job* Pointer to the found job, or NULL if not found.

5.42.4.3 find_job_by_pid()

```
Job * find_job_by_pid (
            pid_t pid)
```

Finds a job by its process ID.

Parameters

pid	Process ID to search for.

Returns

Job* Pointer to the found job, or NULL if not found.

5.42.4.4 find_last_job()

```
Job * find_last_job ()
```

Finds the most recently added job.

Returns

Job* Pointer to the last job, or NULL if no jobs exist.

5.42.4.5 find_last_stopped_job()

```
Job * find_last_stopped_job ()
```

Finds the most recently stopped job.

Returns

Job* Pointer to the last stopped job, or NULL if no stopped jobs exist.

5.42.4.6 free_job()

```
void free_job (
            void * data)
```

Frees memory associated with a job.

Parameters

data	Pointer to the job to be freed.

5.42.4.7 initialize_job_control()

```
void initialize_job_control ()
```

Initializes job control mechanisms.

5.42.4.8 reconstruct_command()

```
char * reconstruct_command (
            char * argv[])
```

Reconstructs a command string from an argument vector.

Parameters

argv	Array of command arguments.

Returns

char* Reconstructed command string.

5.42.4.9 remove_job_by_pid()

```
void remove_job_by_pid (
            pid_t pid)
```

Removes a job from the job list by its process ID.

Parameters

pid	Process ID of the job to remove.

5.42.4.10 shell()

```
void * shell (
            void * args)
```

Main shell function to be run as a thread.

Parameters

args	Arguments passed to the shell thread.

Returns

void* Return value of the thread.

5.42.5 Variable Documentation

5.42.5.1 job_list

```
Deque* job_list  [extern]
```

Global job list.

5.42.5.2 next_job_id

```
int next_job_id  [extern]
```

Next available job ID.

5.42.5.3 shell_pid

```
pid_t shell_pid  [extern]
```

Process ID of the shell.

5.42.5.4 terminal_controller_pid

```
pid_t terminal_controller_pid  [extern]
```

Process ID of the terminal controller.

5.43 penn-shell.h

Go to the documentation of this file.

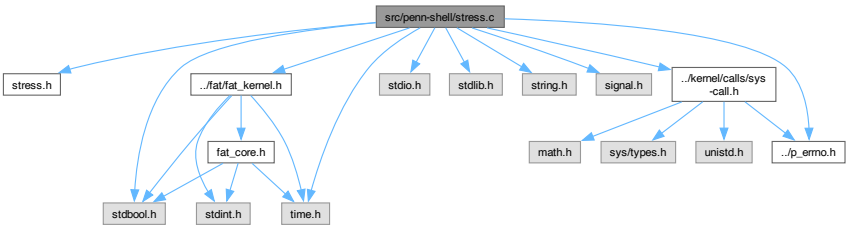
```
00001 #include "../util/deque.h" // Include deque if using it for job list
00002
00003 #ifndef PENSHELL_H
00004 #define PENSHELL_H
00005 // #include "../util/types/process-status.h"
00006 #ifndef MAX_MESSAGE_SIZE
00007 #define MAX_MESSAGE_SIZE 4096
00008 #endif
00009
00010 #ifndef SHELL_PROMPT
00011 #define SHELL_PROMPT "$"
00012 #endif
00013
00014 #ifndef pid_t
00015 typedef int pid_t;
00016 #endif
00017
00018 #ifndef JobStatus
00019
00024 typedef enum
00025 {
00026     JOB_STATUS_RUNNING,
00027     JOB_STATUS_STOPPED,
00028     JOB_STATUS_DONE // Transient state before removal
00029 } JobStatus;
00030 #endif
00031
00032 #ifndef Job
00033
00038 typedef struct Job
00039 {
00040     int job_id;
00041     pid_t pid;
00042     char *command; // Store a copy of the command line
00043     JobStatus status;
00044     struct parsed_command *pcmd; // Store the parsed command for potential restart/display
00045 } Job;
00046 #endif
00047
00053 void *shell(void *args);
00054
00059 void free_job(void *data);
00060
00064 void initialize_job_control();
00065
00071 Job *find_job_by_pid(pid_t pid);
00072
00078 Job *find_job_by_id(int job_id);
00079
00084 Job *find_last_job();
00085
00090 Job *find_last_stopped_job();
00091
00098 void add_job(pid_t pid, struct parsed_command *cmd, JobStatus status);
00099
00104 void remove_job_by_pid(pid_t pid);
00105
00111 char *reconstruct_command(char *argv[]);
00112
00114 extern Deque *job_list;
00115
00117 extern int next_job_id;
00118
00120 extern pid_t shell_pid;
00121
00123 extern pid_t terminal_controller_pid;
00124
00125 #endif
```

5.44 src/penn-shell/stress.c File Reference

```
#include "stress.h"
#include <stdbool.h>
#include <stdio.h>
```

```
#include <stdlib.h>
#include <string.h>
#include <signal.h>
#include <time.h>
#include "../kernel/calls/sys-call.h"
#include "../kernel/p_errno.h"
#include "../fat/fat_kernel.h"
```

Include dependency graph for stress.c:



Functions

- void * u_hang (void *arg)

  Test command that spawns 10 child processes and waits on them (blocking). Useful for testing the scheduler and wait functionality.
- void * u_nohang (void *arg)

  Test command that spawns 10 child processes and waits on them (non-blocking). Useful for testing the scheduler with non-blocking waits.
- void * u_recur (void *arg)

  Test command that recursively spawns 26 processes (Gen_A through Gen_Z). Useful for testing recursive spawning and deep process hierarchies.
- void * u_crash (void *arg)

  Test command that writes a large pattern to a file and then crashes. Useful for testing file system durability and crash recovery. Requires the filesystem to be able to hold at least 5480 bytes in a file.

5.44.1 Function Documentation

5.44.1.1 u_crash()

```
void * u_crash (
            void * arg)
```

Test command that writes a large pattern to a file and then crashes. Useful for testing file system durability and crash recovery. Requires the filesystem to be able to hold at least 5480 bytes in a file.

Example Usage: crash

5.44.1.2 u_hang()

```
void * u_hang (
            void * arg)
```

Test command that spawns 10 child processes and waits on them (blocking). Useful for testing the scheduler and wait functionality.

Example Usage: hang

5.44.1.3 u_nohang()

```
void * u_nohang (
            void * arg)
```

Test command that spawns 10 child processes and waits on them (non-blocking). Useful for testing the scheduler with non-blocking waits.

Example Usage: nohang

5.44.1.4 u_recur()

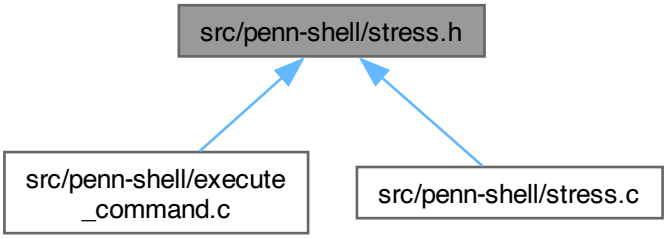
```
void * u_recur (
            void * arg)
```

Test command that recursively spawns 26 processes (Gen_A through Gen_Z). Useful for testing recursive spawning and deep process hierarchies.

Example Usage: recur

5.45 src/penn-shell/stress.h File Reference

This graph shows which files directly or indirectly include this file:



Functions

- void * u_hang (void *)

  Test command that spawns 10 child processes and waits on them (blocking). Useful for testing the scheduler and wait functionality.
- void * u_nohang (void *)

  Test command that spawns 10 child processes and waits on them (non-blocking). Useful for testing the scheduler with non-blocking waits.
- void * u_recur (void *)

  Test command that recursively spawns 26 processes (Gen_A through Gen_Z). Useful for testing recursive spawning and deep process hierarchies.
- void * u_crash (void *)

  Test command that writes a large pattern to a file and then crashes. Useful for testing file system durability and crash recovery. Requires the filesystem to be able to hold at least 5480 bytes in a file.

5.45.1 Function Documentation

5.45.1.1 u_crash()

```
void * u_crash (
            void * arg)
```

Test command that writes a large pattern to a file and then crashes. Useful for testing file system durability and crash recovery. Requires the filesystem to be able to hold at least 5480 bytes in a file.

Example Usage: crash

5.45.1.2 u_hang()

```
void * u_hang (
            void * arg)
```

Test command that spawns 10 child processes and waits on them (blocking). Useful for testing the scheduler and wait functionality.

Example Usage: hang

5.45.1.3 u_nohang()

```
void * u_nohang (
            void * arg)
```

Test command that spawns 10 child processes and waits on them (non-blocking). Useful for testing the scheduler with non-blocking waits.

Example Usage: nohang

5.45.1.4 u_recur()

```
void * u_recur (
            void * arg)
```

Test command that recursively spawns 26 processes (Gen_A through Gen_Z). Useful for testing recursive spawning and deep process hierarchies.

Example Usage: recur

5.46 stress.h

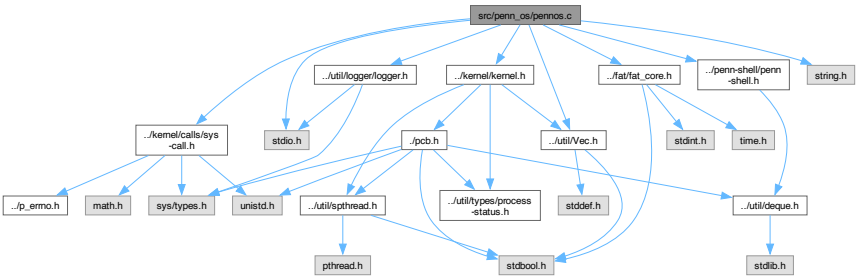
Go to the documentation of this file.

```
00001 #ifndef STRESS_H_
00002 #define STRESS_H_
00003
00004 void* u_hang(void*);
00005 void* u_nohang(void*);
00006 void* u_recur(void*);
00007
00008 // this one requires the fs to hold at least 5480 bytes for a file.
00009 void* u_crash(void*);
00010
00011 #endif
```

5.47 src/penn_os/pennos.c File Reference

```
#include <stdio.h>
#include <string.h>
#include "../fat/fat_core.h"
#include "../kernel/calls/sys-call.h"
#include "../kernel/kernel.h"
#include "../penn-shell/penn-shell.h"
#include "../util/Vec.h"
#include "../util/logger/logger.h"
```

Include dependency graph for pennos.c:



Functions

- void * torta (void *args)
- int main (int argc, char *argv[])

5.47.1 Function Documentation

5.47.1.1 main()

```
int main (
            int argc,
            char * argv[])
```

5.47.1.2 torta()

```
void * torta (
            void * args)
```

5.48 src/penn_os/pennos.h File Reference

5.49 pennos.h

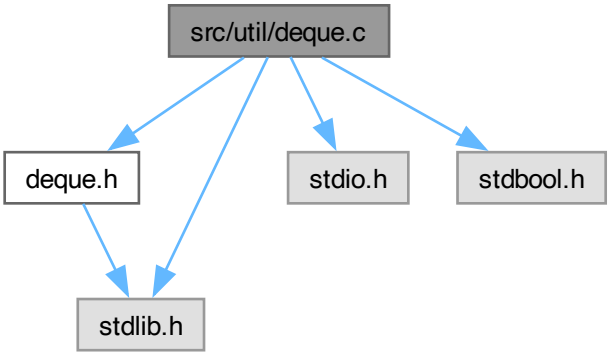
Go to the documentation of this file.

```
00001 #ifndef PENNOS_H
00002 #define PENNOS_H
00003
00004 #endif
```

5.50 src/util/deque.c File Reference

```
#include "deque.h"
#include <stdio.h>
#include <stdlib.h>
#include <stdbool.h>
```

Include dependency graph for deque.c:



Functions

- Deque * deque_new (void(*func)(void *))
  Create a new deque.
- int deque_size (Deque *q)
  Get the number of elements in the deque.
- void deque_push_front (Deque *q, void *value)
  Insert an element at the front of the deque.
- void deque_push_back (Deque *q, void *value)
  Insert an element at the back of the deque.
- void * deque_get_nth_elem (Deque *q, int n)
  Get the data at the nth position in the deque (0-based index).
- void * deque_remove_nth_elem (Deque *q, int n)
  Remove and return the data at the nth position in the deque (0-based index).
- void * deque_get_front (Deque *q)
  Get the data at the front of the deque without removing it.
- void * deque_pop_front (Deque *q)
  Remove and return the data at the front of the deque.
- void * deque_get_back (Deque *q)
  Get the data at the back of the deque without removing it.
- void * deque_pop_back (Deque *q)
  Remove and return the data at the back of the deque.
- void clear_deque (Deque *q)
  Remove all elements from the deque and free their memory using delete_mem.
- void * deque_remove_specific (Deque *q, void *data)
  Remove and return the first occurrence of a specific value from the deque.
- bool deque_contains (Deque *q, void *data)
  Check if the deque contains a specific value.

5.50.1 Function Documentation

5.50.1.1 clear_deque()

```
void clear_deque (
            Deque * q)
```

Remove all elements from the deque and free their memory using delete_mem.

Parameters

q	Pointer to the Deque.

5.50.1.2 deque_contains()

```
bool deque_contains (
            Deque * q,
            void * value)
```

Check if the deque contains a specific value.

Parameters

q	Pointer to the Deque.
value	Pointer to the data to search for.

Returns

true if value is found, false otherwise or if q is NULL.

5.50.1.3 deque_get_back()

```
void * deque_get_back (
            Deque * q)
```

Get the data at the back of the deque without removing it.

Parameters

q	Pointer to the Deque.

Returns

Pointer to the data at the back, or NULL if deque is empty or q is NULL.

5.50.1.4 deque_get_front()

```
void * deque_get_front (
            Deque * q)
```

Get the data at the front of the deque without removing it.

Parameters

q	Pointer to the Deque.

Returns

Pointer to the data at the front, or NULL if deque is empty or q is NULL.

5.50.1.5 deque_get_nth_elem()

```
void * deque_get_nth_elem (
            Deque * q,
            int n)
```

Get the data at the nth position in the deque (0-based index).

Parameters

q	Pointer to the Deque.
n	Index of the element to retrieve.

Returns

Pointer to the data at position n, or NULL if out of bounds or q is NULL.

5.50.1.6 deque_new()

```
Deque * deque_new (
            void(* func )(void *))
```

Create a new deque.

Parameters

func	Function pointer to free memory for stored data (can be NULL).

Returns

Pointer to the created Deque, or NULL on allocation failure.

5.50.1.7 deque_pop_back()

```
void * deque_pop_back (
            Deque * q)
```

Remove and return the data at the back of the deque.

Parameters

q	Pointer to the Deque.

Returns

Pointer to the removed data, or NULL if deque is empty or q is NULL.

5.50.1.8 deque_pop_front()

```
void * deque_pop_front (
            Deque * q)
```

Remove and return the data at the front of the deque.

Parameters

q	Pointer to the Deque.

Returns

Pointer to the removed data, or NULL if deque is empty or q is NULL.

5.50.1.9 deque_push_back()

```
void deque_push_back (
            Deque * q,
            void * value)
```

Insert an element at the back of the deque.

Parameters

q	Pointer to the Deque.
value	Pointer to the data to insert.

5.50.1.10 deque_push_front()

```
void deque_push_front (
            Deque * q,
            void * value)
```

Insert an element at the front of the deque.

Parameters

q	Pointer to the Deque.
value	Pointer to the data to insert.

5.50.1.11 deque_remove_nth_elem()

```
void * deque_remove_nth_elem (
            Deque * q,
            int n)
```

Remove and return the data at the nth position in the deque (0-based index).

Parameters

q	Pointer to the Deque.
n	Index of the element to remove.

Returns

Pointer to the removed data, or NULL if out of bounds or q is NULL.

5.50.1.12 deque_remove_specific()

```
void * deque_remove_specific (
            Deque * q,
            void * value)
```

Remove and return the first occurrence of a specific value from the deque.

Parameters

q	Pointer to the Deque.
value	Pointer to the data to remove.

Returns

Pointer to the removed data, or NULL if not found or q is NULL.

5.50.1.13 deque_size()

```
int deque_size (
            Deque * q)
```

Get the number of elements in the deque.

Parameters

q	Pointer to the Deque.

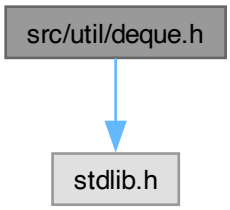
Returns

Number of elements in the deque, or 0 if q is NULL.

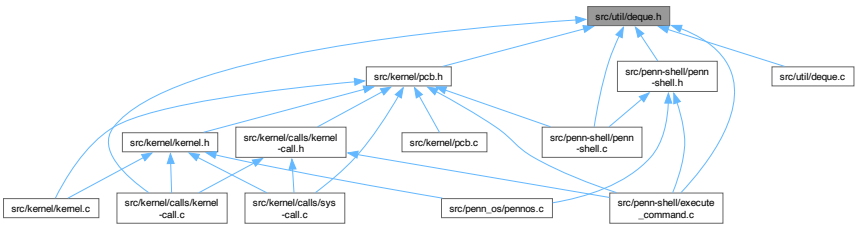
5.51 src/util/deque.h File Reference

```
#include <stdlib.h>
```

Include dependency graph for deque.h:



This graph shows which files directly or indirectly include this file:



Classes

- struct Node

  Node structure for doubly-linked list used in Deque.
- struct Deque

  Double-ended queue (deque) structure.

Macros

- #define DEQUE_H

Typedefs

- typedef struct Node Node

  Node structure for doubly-linked list used in Deque.
- typedef struct Deque Deque

  Double-ended queue (deque) structure.

Functions

- Deque * deque_new (void(*func)(void *))
  Create a new deque.
- int deque_size (Deque *q)
  Get the number of elements in the deque.
- void deque_push_front (Deque *q, void *value)
  Insert an element at the front of the deque.
- void deque_push_back (Deque *q, void *value)
  Insert an element at the back of the deque.
- void * deque_get_front (Deque *q)
  Get the data at the front of the deque without removing it.
- void * deque_pop_front (Deque *q)
  Remove and return the data at the front of the deque.
- void * deque_get_back (Deque *q)
  Get the data at the back of the deque without removing it.
- void * deque_pop_back (Deque *q)
  Remove and return the data at the back of the deque.
- void clear_deque (Deque *q)
  Remove all elements from the deque and free their memory using delete_mem.
- void * deque_get_nth_elem (Deque *q, int n)
  Get the data at the nth position in the deque (0-based index).
- void * deque_remove_nth_elem (Deque *q, int n)
  Remove and return the data at the nth position in the deque (0-based index).
- void * deque_remove_specific (Deque *q, void *value)
  Remove and return the first occurrence of a specific value from the deque.
- bool deque_contains (Deque *q, void *value)
  Check if the deque contains a specific value.

5.51.1 Macro Definition Documentation

5.51.1.1 DEQUE_H

```
#define DEQUE_H
```

5.51.2 Typedef Documentation

5.51.2.1 Deque

```
typedef struct Deque Deque
```

Double-ended queue (deque) structure.

The Deque supports insertion and removal of elements from both ends. It uses a doubly-linked list of Node structures. The delete_mem function pointer is used to free memory for stored data.

5.51.2.2 Node

```
typedef struct Node Node
```

Node structure for doubly-linked list used in Deque.

This structure represents a node in the deque, holding a pointer to data and pointers to the next and previous nodes in the list.

5.51.3 Function Documentation

5.51.3.1 clear_deque()

```
void clear_deque (
            Deque * q)
```

Remove all elements from the deque and free their memory using delete_mem.

Parameters

q	Pointer to the Deque.

5.51.3.2 deque_contains()

```
bool deque_contains (
            Deque * q,
            void * value)
```

Check if the deque contains a specific value.

Parameters

q	Pointer to the Deque.
value	Pointer to the data to search for.

Returns

true if value is found, false otherwise or if q is NULL.

5.51.3.3 deque_get_back()

```
void * deque_get_back (
            Deque * q)
```

Get the data at the back of the deque without removing it.

Parameters

q	Pointer to the Deque.

Returns

Pointer to the data at the back, or NULL if deque is empty or q is NULL.

5.51.3.4 deque_get_front()

```
void * deque_get_front (
            Deque * q)
```

Get the data at the front of the deque without removing it.

Parameters

q	Pointer to the Deque.

Returns

Pointer to the data at the front, or NULL if deque is empty or q is NULL.

5.51.3.5 deque_get_nth_elem()

```
void * deque_get_nth_elem (
            Deque * q,
            int n)
```

Get the data at the nth position in the deque (0-based index).

Parameters

q	Pointer to the Deque.
n	Index of the element to retrieve.

Returns

Pointer to the data at position n, or NULL if out of bounds or q is NULL.

5.51.3.6 deque_new()

```
Deque * deque_new (
            void(* func )(void *))
```

Create a new deque.

Parameters

func	Function pointer to free memory for stored data (can be NULL).

Returns

Pointer to the created Deque, or NULL on allocation failure.

5.51.3.7 deque_pop_back()

```
void * deque_pop_back (
            Deque * q)
```

Remove and return the data at the back of the deque.

Parameters

q	Pointer to the Deque.

Returns

Pointer to the removed data, or NULL if deque is empty or q is NULL.

5.51.3.8 deque_pop_front()

```
void * deque_pop_front (
            Deque * q)
```

Remove and return the data at the front of the deque.

Parameters

q	Pointer to the Deque.

Returns

Pointer to the removed data, or NULL if deque is empty or q is NULL.

5.51.3.9 deque_push_back()

```
void deque_push_back (
            Deque * q,
            void * value)
```

Insert an element at the back of the deque.

Parameters

q	Pointer to the Deque.
value	Pointer to the data to insert.

5.51.3.10 deque_push_front()

```
void deque_push_front (
            Deque * q,
            void * value)
```

Insert an element at the front of the deque.

Parameters

q	Pointer to the Deque.
value	Pointer to the data to insert.

5.51.3.11 deque_remove_nth_elem()

```
void * deque_remove_nth_elem (
            Deque * q,
            int n)
```

Remove and return the data at the nth position in the deque (0-based index).

Parameters

q	Pointer to the Deque.
n	Index of the element to remove.

Returns

Pointer to the removed data, or NULL if out of bounds or q is NULL.

5.51.3.12 deque_remove_specific()

```
void * deque_remove_specific (
            Deque * q,
            void * value)
```

Remove and return the first occurrence of a specific value from the deque.

Parameters

q	Pointer to the Deque.
value	Pointer to the data to remove.

Returns

Pointer to the removed data, or NULL if not found or q is NULL.

5.51.3.13 deque_size()

```
int deque_size (
            Deque * q)
```

Get the number of elements in the deque.

Parameters

q	Pointer to the Deque.

Returns

Number of elements in the deque, or 0 if q is NULL.

5.52 deque.h

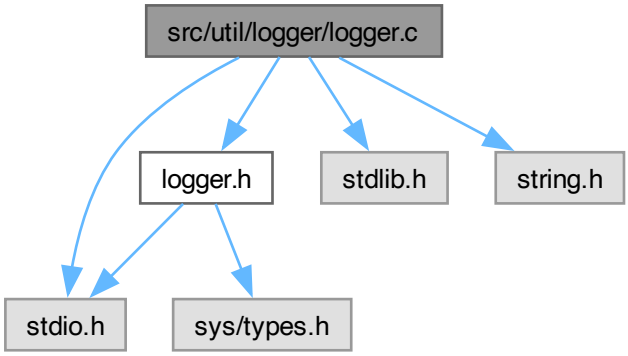
Go to the documentation of this file.

```
00001 #include <stdlib.h>
00002 // Node structure (reused for all types)
00003 #ifndef NODE_H
00004 #define NODE_H
00011 typedef struct Node {
00012   void *data;
00013   struct Node *next;
00014   struct Node *prev;
00015 } Node;
00016 #endif
00017
00018 #ifndef DEQUE_H
00019 #define DEQUE_H
00020 // Deque structure
00028 typedef struct Deque {
00029   Node *front;
00030   Node *tail;
00031   int size;
00032   void (*delete_mem)(void *);
00033 } Deque;
00034 #endif
00041 Deque *deque_new(void (*func)(void *));
00042
00049 int deque_size(Deque *q);
00050
00057 void deque_push_front(Deque *q, void *value);
00058
00065 void deque_push_back(Deque *q, void *value);
00066
00073 void *deque_get_front(Deque *q);
00074
00081 void *deque_pop_front(Deque *q);
00082
00089 void *deque_get_back(Deque *q);
00090
00097 void *deque_pop_back(Deque *q);
00098
00104 void clear_deque(Deque *q);
00105
00113 void *deque_get_nth_elem(Deque *q, int n);
00114
00122 void *deque_remove_nth_elem(Deque *q, int n);
00123
00131 void *deque_remove_specific(Deque *q, void *value);
00132
00140 bool deque_contains(Deque *q, void *value);
```

5.53 src/util/logger/logger.c File Reference

```
#include "logger.h"
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
```

Include dependency graph for logger.c:



Functions

- void init_logger (const char *log_filename)

  Initializes the logger.
- void log_event (unsigned long tick, const char *event, pid_t pid, int priority, const char *name)

  Logs an event.

5.53.1 Function Documentation

5.53.1.1 init_logger()

```
void init_logger (
            const char * log_filename)
```

Initializes the logger.

Parameters

log_filename	The name of the log file.

5.53.1.2 log_event()

```
void log_event (
            unsigned long tick,
            const char * event,
            pid_t pid,
            int priority,
            const char * name)
```

Logs an event.

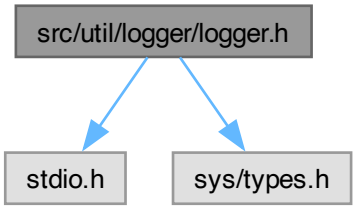
Parameters

tick	The tick count.
event	The event description.
pid	The process ID.
priority	The priority level.
name	The process name.

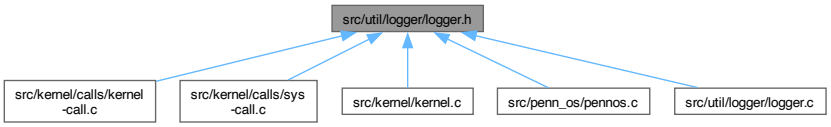
5.54 src/util/logger/logger.h File Reference

```
#include <stdio.h>
#include <sys/types.h>
```

Include dependency graph for logger.h:



This graph shows which files directly or indirectly include this file:



Functions

- void init_logger (const char *log_filename)

  Initializes the logger.
- void log_event (unsigned long tick, const char *event, pid_t pid, int priority, const char *name)

  Logs an event.

5.54.1 Function Documentation

5.54.1.1 init_logger()

```
void init_logger (
            const char * log_filename)
```

Initializes the logger.

Parameters

log_filename	The name of the log file.

5.54.1.2 log_event()

```
void log_event (
            unsigned long tick,
            const char * event,
            pid_t pid,
            int priority,
            const char * name)
```

Logs an event.

Parameters

tick	The tick count.
event	The event description.
pid	The process ID.
priority	The priority level.
name	The process name.

5.55 logger.h

Go to the documentation of this file.

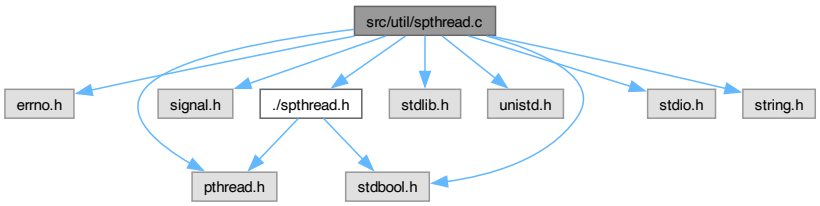
```
00001 #ifndef LOGGER_H
00002 #define LOGGER_H
00003
00004 #include <stdio.h>
00005 #include <sys/types.h>
00006
00012 void init_logger(const char *log_filename);
00013
00023 void log_event(unsigned long tick, const char *event,
00024                pid_t pid, int priority, const char *name);
00025
00026 #endif
```

5.56 src/util/spthread.c File Reference

```
#include <errno.h>
#include <pthread.h>
#include <signal.h>
#include <stdbool.h>
#include <stdlib.h>
#include <unistd.h>
#include "./spthread.h"
#include <stdio.h>
```

```
#include <string.h>
```

Include dependency graph for spthread.c:



Classes

- struct spthread_fwd_args_st
- struct spthread_signal_args_st
- struct spthread_meta_st

Macros

- #define _GNU_SOURCE
- #define MILISEC_IN_NANO 100000
- #define SPTHREAD_RUNNING_STATE 0
- #define SPTHREAD_SUSPENDED_STATE 1
- #define SPTHREAD_TERMINATED_STATE 2
- #define SPTHREAD_SIG_SUSPEND -1
- #define SPTHREAD_SIG_CONTINUE -2

Typedefs

- typedef void *(* pthread_fn) (void *)
- typedef struct spthread_fwd_args_st spthread_fwd_args
- typedef struct spthread_signal_args_st spthread_signal_args
- typedef struct spthread_meta_st spthread_meta_t

Functions

- int spthread_create (spthread_t *thread, const pthread_attr_t *attr, pthread_fn start_routine, void *arg)
- int spthread_suspend (spthread_t thread)
- int spthread_suspend_self ()
- int spthread_continue (spthread_t thread)
- int spthread_cancel (spthread_t thread)
- bool spthread_self (spthread_t *thread)
- int spthread_join (spthread_t thread, void **retval)
- void spthread_exit (void *status)
- bool spthread_equal (spthread_t first, spthread_t second)
- int spthread_disable_interrupts_self ()
- int spthread_enable_interrupts_self ()

5.56.1 Macro Definition Documentation

5.56.1.1 _GNU_SOURCE

```
#define _GNU_SOURCE
```

5.56.1.2 MILISEC_IN_NANO

```
#define MILISEC_IN_NANO 100000
```

5.56.1.3 SPTHREAD_RUNNING_STATE

```
#define SPTHREAD_RUNNING_STATE 0
```

5.56.1.4 SPTHREAD_SIG_CONTINUE

```
#define SPTHREAD_SIG_CONTINUE -2
```

5.56.1.5 SPTHREAD_SIG_SUSPEND

```
#define SPTHREAD_SIG_SUSPEND -1
```

5.56.1.6 SPTHREAD_SUSPENDED_STATE

```
#define SPTHREAD_SUSPENDED_STATE 1
```

5.56.1.7 SPTHREAD_TERMINATED_STATE

```
#define SPTHREAD_TERMINATED_STATE 2
```

5.56.2 Typedef Documentation

5.56.2.1 pthread_fn

```
typedef void *(* pthread_fn) (void *)
```

5.56.2.2 spthread_fwd_args

```
typedef struct spthread_fwd_args_st spthread_fwd_args
```

5.56.2.3 spthread_meta_t

```
typedef struct spthread_meta_st spthread_meta_t
```

5.56.2.4 spthread_signal_args

```
typedef struct spthread_signal_args_st spthread_signal_args
```

5.56.3 Function Documentation

5.56.3.1 spthread_cancel()

```
int spthread_cancel (
            spthread_t thread)
```

5.56.3.2 spthread_continue()

```
int spthread_continue (
            spthread_t thread)
```

5.56.3.3 spthread_create()

```
int spthread_create (
            spthread_t * thread,
            const pthread_attr_t * attr,
            pthread_fn start_routine,
            void * arg)
```

5.56.3.4 spthread_disable_interrupts_self()

```
int spthread_disable_interrupts_self ()
```

5.56.3.5 spthread_enable_interrupts_self()

```
int spthread_enable_interrupts_self ()
```

5.56.3.6 spthread_equal()

```
bool spthread_equal (
            spthread_t first,
            spthread_t second)
```

5.56.3.7 spthread_exit()

```
void spthread_exit (
            void * status)
```

5.56.3.8 spthread_join()

```
int spthread_join (
            spthread_t thread,
            void ** retval)
```

5.56.3.9 spthread_self()

```
bool spthread_self (
            spthread_t * thread)
```

5.56.3.10 spthread_suspend()

```
int spthread_suspend (
            spthread_t thread)
```

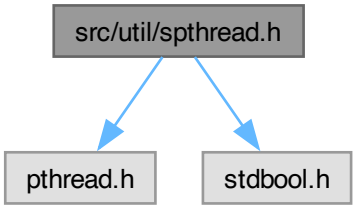
5.56.3.11 spthread_suspend_self()

```
int spthread_suspend_self ()
```

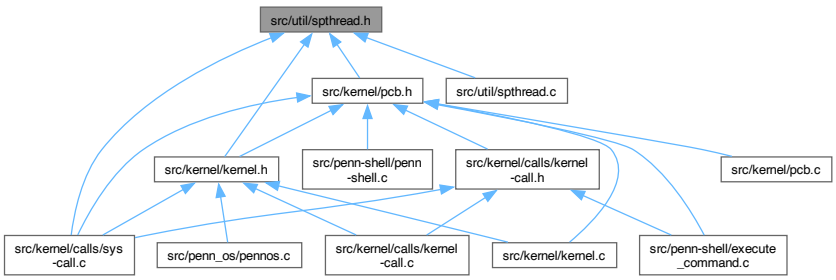
5.57 src/util/spthread.h File Reference

```
#include <pthread.h>
#include <stdbool.h>
```

Include dependency graph for spthread.h:



This graph shows which files directly or indirectly include this file:



Classes

- struct spthread_st

Macros

- #define SIGPTHD SIGUSR1

Typedefs

- typedef struct spthread_st spthread_t

Functions

- int spthread_create (spthread_t ∗thread, const pthread_attr_t ∗attr, void ∗(∗start_routine)(void ∗), void ∗arg)
- int spthread_suspend (spthread_t thread)
- int spthread_suspend_self ()
- int spthread_continue (spthread_t thread)
- int spthread_cancel (spthread_t thread)
- bool spthread_self (spthread_t ∗thread)
- int spthread_join (spthread_t thread, void ∗∗retval)
- void spthread_exit (void ∗status)
- bool spthread_equal (spthread_t first, spthread_t second)
- int spthread_disable_interrupts_self ()
- int spthread_enable_interrupts_self ()

5.57.1 Macro Definition Documentation

5.57.1.1 SIGPTHD

```
#define SIGPTHD SIGUSR1
```

5.57.2 Typedef Documentation

5.57.2.1 spthread_t

```
typedef struct spthread_st spthread_t
```

5.57.3 Function Documentation

5.57.3.1 spthread_cancel()

```
int spthread_cancel (
            spthread_t thread)
```

5.57.3.2 spthread_continue()

```
int spthread_continue (
            spthread_t thread)
```

5.57.3.3 spthread_create()

```
int spthread_create (
            spthread_t * thread,
            const pthread_attr_t * attr,
            void *(* start_routine )(void *),
            void * arg)
```

5.57.3.4 spthread_disable_interrupts_self()

```
int spthread_disable_interrupts_self ()
```

5.57.3.5 spthread_enable_interrupts_self()

```
int spthread_enable_interrupts_self ()
```

5.57.3.6 spthread_equal()

```
bool spthread_equal (
            spthread_t first,
            spthread_t second)
```

5.57.3.7 spthread_exit()

```
void spthread_exit (
            void * status)
```

5.57.3.8 spthread_join()

```
int spthread_join (
            spthread_t thread,
            void ** retval)
```

5.57.3.9 spthread_self()

```
bool spthread_self (
            spthread_t * thread)
```

5.57.3.10 spthread_suspend()

```
int spthread_suspend (
            spthread_t thread)
```

5.57.3.11 spthread_suspend_self()

```
int spthread_suspend_self ()
```

5.58 spthread.h

Go to the documentation of this file.

```
00001 #ifndef SPTHREAD_H_
00002 #define SPTHREAD_H_
00003
00004 #include <pthread.h>
00005 #include <stdbool.h>
00006
00007 // CAUTION: according to `man 7 pthread`:
00008 //
00009 //   On older Linux kernels, SIGUSR1 and SIGUSR2
00010 //   are used.  Applications must avoid the use of whichever set of
00011 //   signals is employed by the implementation.
00012 //
00013 // This may not work on other linux versions
00014
00015 // SIGNAL PTHREAD
00016 // NOTE: if within a created spthread you change
00017 // the behaviour of SIGUSR1, then you will not be able
00018 // to suspend and continue a spthread
00019 #define SIGPTHD SIGUSR1
00020
00021 // declares a struct, but the internals of the
00022 // struct cannot be seen by functions outside of spthread.c
00023 typedef struct spthread_meta_st spthread_meta_t;
00024
00025 // The spthread wrapper struct.
00026 // Sometimes you may have to access the inner pthread member
00027 // but you shouldn't need to do that
00028 typedef struct spthread_st {
00029   pthread_t thread;
00030   spthread_meta_t* meta;
00031 } spthread_t;
00032
00033 // NOTE:
00034 // None of these are signal safe
00035 // Also note that most of these functions are not safe to suspension,
00036 // meaning that if the thread calling these is an spthread and is suspended
00037 // in the middle of spthread_continue or spthread_suspend, then it may not work.
00038 //
00039 // Make sure that the calling thread cannot be suspended before calling these
00040 // functions. Exceptions to this are spthread_exit(), spthread_self() and if a
```

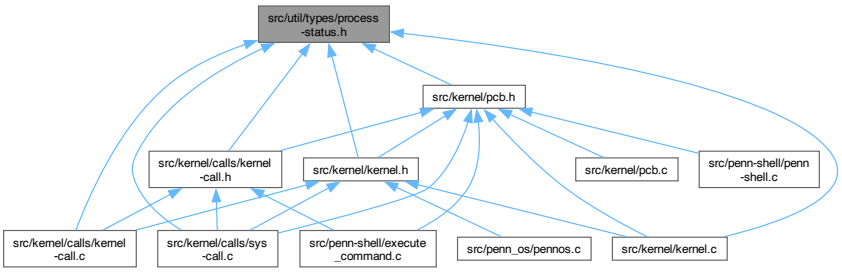
```
00041 // thread is continuing or suspending itself.
00042 //
00043 // spthread_create:
00044 // this function works similar to pthread_create, except for two differences.
00045 // 1) the created pthread is able to be asychronously suspended, and continued
00046 //    using the functions:
00047 //      - spthread_suspend
00048 //      - spthread_continue
00049 // 2) The created pthread will be suspended before it executes the specified
00050 //    routine. It must first be continued with `spthread_continue` before
00051 //    it will start executing.
00052 //
00053 // It is worth noting that this function is not signal safe.
00054 // In other words, it should not be called from a signal handler.
00055 //
00056 // to avoid repetition, see pthread_create(3) for details
00057 // on arguments and return values as they are the same here.
00058 int spthread_create(spthread_t* thread,
00059                     const pthread_attr_t* attr,
00060                     void* (*start_routine)(void*),
00061                     void* arg);
00062
00063 // The spthread_suspend function will signal to the
00064 // specified thread to suspend execution.
00065 //
00066 // Calling spthread_suspend on an already suspended
00067 // thread does not do anything.
00068 //
00069 // It is worth noting that this function is not signal safe.
00070 // In other words, it should not be called from a signal handler.
00071 //
00072 // args:
00073 // - pthread_t thread: the thread we want to suspend
00074 //   This thread must be created using the spthread_create() function,
00075 //   if created by some other function, the behaviour is undefined.
00076 //
00077 // returns:
00078 // - 0 on success
00079 // - EAGAIN if the thread could not be signaled
00080 // - ENOSYS if not supported on this system
00081 // - ESRCH if the thread specified is not a valid pthread
00082 int spthread_suspend(spthread_t thread);
00083
00084 // The spthread_suspend_self function will cause the calling
00085 // thread (which should be created by spthread_create) to suspend
00086 // itself.
00087 //
00088 // returns:
00089 // - 0 on success
00090 // - EAGAIN if the thread could not be signaled
00091 // - ENOSYS if not supported on this system
00092 // - ESRCH if the calling thread is not an spthread
00093 int spthread_suspend_self();
00094
00095 // The spthread_continue function will signal to the
00096 // specified thread to resume execution if suspended.
00097 //
00098 // Calling spthread_continue on an already non-suspended
00099 // thread does not do anything.
00100 //
00101 // It is worth noting that this function is not signal safe.
00102 // In other words, it should not be called from a signal handler.
00103 //
00104 // args:
00105 // - spthread_t thread: the thread we want to continue
00106 //   This thread must be created using the spthread_create() function,
00107 //   if created by some other function, the behaviour is undefined.
00108 //
00109 // returns:
00110 // - 0 on success
00111 // - EAGAIN if the thread could not be signaled
00112 // - ENOSYS if not supported on this system
00113 // - ESRCH if the thread specified is not a valid pthread
00114 int spthread_continue(spthread_t thread);
00115
00116 // The spthread_cancel function will send a
00117 // cancellation request to the specified thread.
00118 //
00119 // as of now, this function is identical to pthread_cancel(3)
00120 // so to avoid repitition, you should look there.
00121 //
00122 // Here are a few things that are worth highlighting:
00123 // - it is worth noting that it is a cancellation __request__
00124 //   the thread may not terminate immediately, instead the
00125 //   thread is checked whenever it calls a function that is
00126 //   marked as a cancellation point. At those points, it will
00127 //   start the cancellation procedure
```

```
00128 // - to make sure all things are de-allocated properly on
00129 //   normal exiting of the thread and when it is cancelled,
00130 //   you should mark a defered de-allocation with
00131 //   pthread_cleanup_push(3).
00132 //   consider the following example:
00133 //
00134 //     void* thread_routine(void* arg) {
00135 //        int* num = malloc(sizeof(int));
00136 //        pthread_cleanup_push(&free, num);
00137 //        return NULL;
00138 //     }
00139 //
00140 //    this program will allocate an integer on the heap
00141 //    and mark that data to be de-allocated on cleanup.
00142 //    This means that when the thread returns from the
00143 //    routine specified in spthread_create, free will
00144 //    be called on num. This will also happen if the thread
00145 //    is cancelled and not able to be exited normally.
00146 //
00147 //    Another function that should be used in conjunction
00148 //    is pthread_cleanup_pop(3). I will leave that
00149 //    to you to read more on.
00150 //
00151 // It is worth noting that this function is not signal safe.
00152 // In other words, it should not be called from a signal handler.
00153 //
00154 // args:
00155 // - spthread_t thread: the thread we want to cancel.
00156 //   This thread must be created using the spthread_create() function,
00157 //   if created by some other function, the behaviour is undefined.
00158 //
00159 // returns:
00160 // - 0 on success
00161 // - ESRCH if the thread specified is not a valid pthread
00162 int spthread_cancel(spthread_t thread);
00163
00164 // Can be called by a thread to get two peices of information:
00165 // 1. Whether or not the calling thread is an spthread (true or false)
00166 // 2. The spthread_t of the calling thread, if it is an spthread_t
00167 //
00168 // almost always the function will be called like this:
00169 // spthread_t self;
00170 // bool i_am_spthread = spthread_self(&self);
00171 //
00172 // args:
00173 // - spthread_t* thread: the output parameter to get the spthread_t
00174 //   representing the calling thread, if it is an spthread
00175 //
00176 // returns:
00177 // - true if the calling thread is an spthread_t
00178 // - false otherwise.
00179 bool spthread_self(spthread_t* thread);
00180
00181 // The equivalent of pthread_join but for spthread
00182 // To make sure all resources are cleaned up appropriately
00183 // spthreads that are created must at some ppoint have spthread_join
00184 // called on them. Do not use pthread_join on an spthread.
00185 //
00186 // to avoid repetition, see pthread_join(3) for details
00187 // on arguments and return values as they are the same as this function.
00188 int spthread_join(spthread_t thread, void** retval);
00189
00190 // The equivalent of pthread_exit but for spthread
00191 // spthread_exit must be used by spthreads instead of pthread_exit.
00192 // Otherwise, calls to spthread_join or other functions (like spthread_suspend)
00193 // may not work as intended.
00194 //
00195 // to avoid repetition, see pthread_exit(3) for details
00196 // on arguments and return values as they are the same as this function.
00197 void spthread_exit(void* status);
00198
00199 // The equivalent of pthread_equal but for spthread.
00200 // It two spthread_t's describe the same thread, returns a
00201 // non-zero value; otherwise it returns 0.
00202 bool spthread_equal(spthread_t first, spthread_t second);
00203
00204 // Calling this function from an spthread prevents it from
00205 // being suspended until re-enabled by the sibling function
00206 // "spthread_enable_interrupts_self".
00207 //
00208 // This is done by blocking the SIG_PTHD signal
00209 //
00210 // returns 0 on success, or -1 on error
00211 int spthread_disable_interrupts_self();
00212
00213 // Calling this function from an spthread re-enables it to
00214 // being suspendable. Should be called after it's sibling function
```

```
00215 // "spthread_disable_interrupts_self".
00216 //
00217 // This is done by unblocking the SIG_PTHD signal
00218 //
00219 // returns 0 on success, or -1 on error
00220 int spthread_enable_interrupts_self();
00221
00222 #endif  // SPTHREAD_H_
```

5.59 src/util/types/process-status.h File Reference

This graph shows which files directly or indirectly include this file:



Macros

- #define pid_t int

Enumerations

- enum ProcessStatus {
  PROCESS_STATUS_RUNNING , PROCESS_STATUS_WAITING , PROCESS_STATUS_ZOMBIE ,
  PROCESS_STATUS_STOPPED ,
  PROCESS_STATUS_BLOCKED , PROCESS_STATUS_DEAD }

5.59.1 Macro Definition Documentation

5.59.1.1 pid_t

```
#define pid_t int
```

5.59.2 Enumeration Type Documentation

5.59.2.1 ProcessStatus

```
enum ProcessStatus
```

Enumerator

PROCESS_STATUS_RUNNING	
PROCESS_STATUS_WAITING	
PROCESS_STATUS_ZOMBIE	
PROCESS_STATUS_STOPPED	
PROCESS_STATUS_BLOCKED	
PROCESS_STATUS_DEAD	

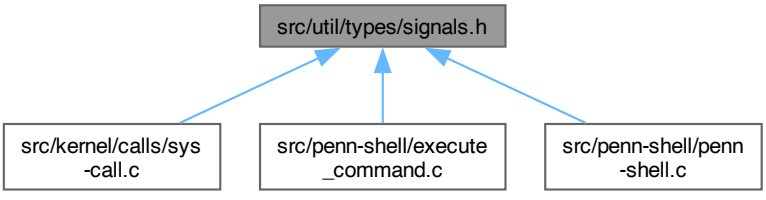
5.60 process-status.h

Go to the documentation of this file.

```
00001 // Process status enum
00002 // This enum is used to represent the status of a process in the system.
00003 // It is used in the PCB (Process Control Block) structure to indicate the
00004 // current state of the process.
00005 // The enum values are used to determine the scheduling and execution
00006 // behavior of the process
00007 #ifndef PROCESS_STATUS_H
00008 #define PROCESS_STATUS_H
00009 typedef enum {
00010   PROCESS_STATUS_RUNNING,
00011   PROCESS_STATUS_WAITING,
00012   PROCESS_STATUS_ZOMBIE,
00013   PROCESS_STATUS_STOPPED,
00014   PROCESS_STATUS_BLOCKED,
00015   PROCESS_STATUS_DEAD
00016 } ProcessStatus;
00017 #endif
00018
00019 #ifndef pid_t
00020 #define pid_t int
00021 #endif
```

5.61 src/util/types/signals.h File Reference

This graph shows which files directly or indirectly include this file:



Macros

- #define P_SIGTERM 1
- #define P_SIGSTOP 2
- #define P_SIGCONT 3

5.61.1 Macro Definition Documentation

5.61.1.1 P_SIGCONT

```
#define P_SIGCONT 3
```

5.61.1.2 P_SIGSTOP

```
#define P_SIGSTOP 2
```

5.61.1.3 P_SIGTERM

```
#define P_SIGTERM 1
```

5.62 signals.h

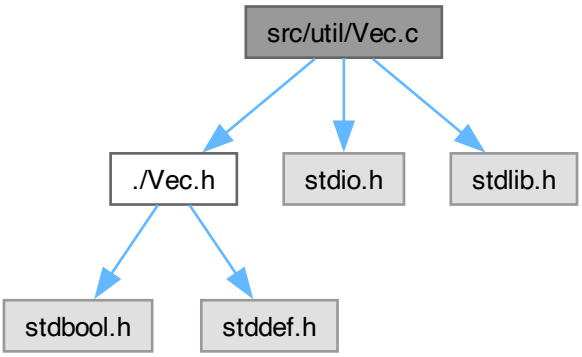
Go to the documentation of this file.

```
00001 #ifndef PENNOS_SIGNALS_H
00002 #define PENNOS_SIGNALS_H
00003
00004 #define P_SIGTERM 1
00005 #define P_SIGSTOP 2
00006 #define P_SIGCONT 3
00007
00008 #endif
```

5.63 src/util/Vec.c File Reference

```
#include "./Vec.h"
#include <stdio.h>
#include <stdlib.h>
```

Include dependency graph for Vec.c:



Functions

- Vec vec_new (size_t initial_capacity, ptr_dtor_fn ele_dtor_fn)
- ptr_t vec_get (Vec *self, size_t index)
- void vec_set (Vec *self, size_t index, ptr_t new_ele)
- void vec_push_back (Vec *self, ptr_t new_ele)
- bool vec_pop_back (Vec *self)
- void vec_insert (Vec *self, size_t index, ptr_t new_ele)
- void vec_erase (Vec *self, size_t index)
- void vec_resize (Vec *self, size_t new_capacity)
- void vec_clear (Vec *self)
- void vec_destroy (Vec *self)

5.63.1 Function Documentation

5.63.1.1 vec_clear()

```
void vec_clear (
            Vec * self)
```

5.63.1.2 vec_destroy()

```
void vec_destroy (
            Vec * self)
```

5.63.1.3 vec_erase()

```
void vec_erase (
            Vec * self,
            size_t index)
```

5.63.1.4 vec_get()

```
ptr_t vec_get (
            Vec * self,
            size_t index)
```

5.63.1.5 vec_insert()

```
void vec_insert (
            Vec * self,
            size_t index,
            ptr_t new_ele)
```

5.63.1.6 vec_new()

```
Vec vec_new (
            size_t initial_capacity,
            ptr_dtor_fn ele_dtor_fn)
```

Creates a new empty Vec(tor) with the specified initial_capacity and specified function to clean up elements in the vector.

Parameters

initial_capacity	the initial capacity of the newly created vector, non negative
ele_dtor_fn	a function pointer to a function that takes in a ptr_t (a vector element) and cleans it up. This is commonly just `free` but custom functions can be passed in. NULL can also be passed in to specify that there is no cleanup function that needs to be called on each element.

Returns

a newly created vector with specified capacity, 0 length and the specified element destructor (cleanup) function.

Postcondition

if memory allocation fails, the function will panic.

5.63.1.7 vec_pop_back()

```
bool vec_pop_back (
            Vec * self)
```

5.63.1.8 vec_push_back()

```
void vec_push_back (
            Vec * self,
            ptr_t new_ele)
```

5.63.1.9 vec_resize()

```
void vec_resize (
            Vec * self,
            size_t new_capacity)
```

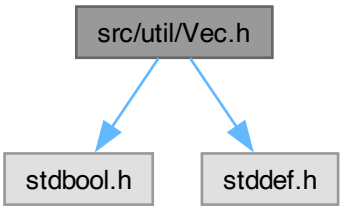
5.63.1.10 vec_set()

```
void vec_set (
            Vec * self,
            size_t index,
            ptr_t new_ele)
```

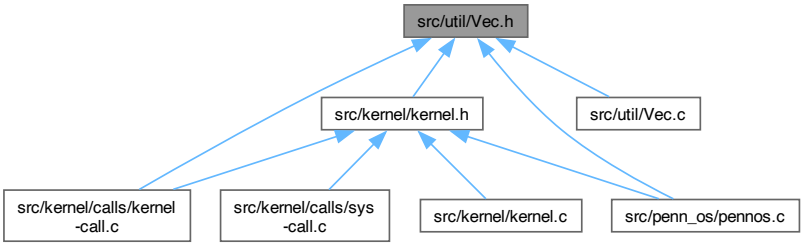
5.64 src/util/Vec.h File Reference

```
#include <stdbool.h>
#include <stddef.h>
```

Include dependency graph for Vec.h:



This graph shows which files directly or indirectly include this file:



Classes

- struct vec_st

Macros

- #define vec_capacity(vec)
- #define vec_len(vec)
- #define vec_is_empty(vec)

Typedefs

- typedef void * ptr_t
- typedef void(* ptr_dtor_fn) (ptr_t)
- typedef struct vec_st Vec

Functions

- Vec vec_new (size_t initial_capacity, ptr_dtor_fn ele_dtor_fn)
- ptr_t vec_get (Vec *self, size_t index)
- void vec_set (Vec *self, size_t index, ptr_t new_ele)
- void vec_push_back (Vec *self, ptr_t new_ele)
- bool vec_pop_back (Vec *self)
- void vec_insert (Vec *self, size_t index, ptr_t new_ele)
- void vec_erase (Vec *self, size_t index)
- void vec_resize (Vec *self, size_t new_capacity)
- void vec_clear (Vec *self)
- void vec_destroy (Vec *self)

5.64.1 Macro Definition Documentation

5.64.1.1 vec_capacity

```
#define vec_capacity(
              vec)
```

Value:

```
((vec)->capacity)
```

5.64.1.2 vec_is_empty

```
#define vec_is_empty(
              vec)
```

Value:

```
((vec)->length == 0)
```

5.64.1.3 vec_len

```
#define vec_len(
              vec)
```

Value:

```
((vec)->length)
```

5.64.2 Typedef Documentation

5.64.2.1 ptr_dtor_fn

```
typedef void(* ptr_dtor_fn) (ptr_t)
```

5.64.2.2 ptr_t

```
typedef void* ptr_t
```

5.64.2.3 Vec

```
typedef struct vec_st Vec
```

5.64.3 Function Documentation

5.64.3.1 vec_clear()

```
void vec_clear (
            Vec * self)
```

5.64.3.2 vec_destroy()

```
void vec_destroy (
            Vec * self)
```

5.64.3.3 vec_erase()

```
void vec_erase (
            Vec * self,
            size_t index)
```

5.64.3.4 vec_get()

```
ptr_t vec_get (
            Vec * self,
            size_t index)
```

5.64.3.5 vec_insert()

```
void vec_insert (
            Vec * self,
            size_t index,
            ptr_t new_ele)
```

5.64.3.6 vec_new()

```
Vec vec_new (
            size_t initial_capacity,
            ptr_dtor_fn ele_dtor_fn)
```

Creates a new empty Vec(tor) with the specified initial_capacity and specified function to clean up elements in the vector.

Parameters

initial_capacity	the initial capacity of the newly created vector, non negative
ele_dtor_fn	a function pointer to a function that takes in a ptr_t (a vector element) and cleans it up. This is commonly just `free` but custom functions can be passed in. NULL can also be passed in to specify that there is no cleanup function that needs to be called on each element.

Returns

a newly created vector with specified capacity, 0 length and the specified element destructor (cleanup) function.

Postcondition

if memory allocation fails, the function will panic.

5.64.3.7 vec_pop_back()

```
bool vec_pop_back (
            Vec * self)
```

5.64.3.8 vec_push_back()

```
void vec_push_back (
            Vec * self,
            ptr_t new_ele)
```

5.64.3.9 vec_resize()

```
void vec_resize (
            Vec * self,
            size_t new_capacity)
```

5.64.3.10 vec_set()

```
void vec_set (
            Vec * self,
            size_t index,
            ptr_t new_ele)
```

5.65 Vec.h

Go to the documentation of this file.

```
00001 #ifndef VEC_H_
00002 #define VEC_H_
00003
00004 #include <stdbool.h>
00005 #include <stddef.h>  // for size_t
00006
00007 typedef void* ptr_t;
00008 typedef void (*ptr_dtor_fn)(ptr_t);
00009
00010 typedef struct vec_st {
00011   ptr_t* data;
00012   size_t length;
00013   size_t capacity;
00014   ptr_dtor_fn ele_dtor_fn;
00015 } Vec;
00016
00033 Vec vec_new(size_t initial_capacity, ptr_dtor_fn ele_dtor_fn);
00034
00035 /* Returns the current capacity of the Vec
00036  * Written as a function-like macro
00037  *
00038  * @param vec, a pointer to the vector we want to grab the capacity of.
00039  */
00040 // TODO: finish this macro
00041 #define vec_capacity(vec) ((vec)->capacity)
00042
00043 /* Returns the current length of the Vec
00044  * written as a function-like macro
00045  *
00046  * @param vec, a pointer to the vector we want to grab the len of.
00047  */
00048 // TODO: finish this macro
00049 #define vec_len(vec) ((vec)->length)
00050 /* Checks if the Vec is empty
00051  * written as a function-like macro
00052  *
00053  * @param vec, a pointer to the vector we want to check emptiness of.
00054  */
00055 // TODO: finish this macro
00056 #define vec_is_empty(vec) ((vec)->length == 0)
00057
00058 /* Gets the specified element of the Vec
00059  *
00060  * @param self a pointer to the vector who's element we want to get.
00061  * @param index the index of the element to get.
00062  * @returns the element at the specified index.
00063  * @pre Assumes self points to a valid vector. If the index is >= self->length
00064  * then this function will panic()
00065  */
00066 ptr_t vec_get(Vec* self, size_t index);
00067
00068 /* Sets the specified element of the Vec to the specified value
00069  *
00070  * @param self    a pointer to the vector who's element we want to set.
00071  * @param index   the index of the element to set.
00072  * @param new_ele the value we want to set the element at that index to
00073  * @returns the element at the specified index.
00074  * @pre Assumes self points to a valid vector. If the index is >= self->length
00075  * then this function will panic()
00076  */
00077 void vec_set(Vec* self, size_t index, ptr_t new_ele);
00078
00079 /* Appends the given element to the end of the Vec
00080  *
00081  * @param self      a pointer to the vector we are pushing onto
00082  * @param new_ele   the value we want to add to the end of the container
00083  * @pre Assumes self points to a valid vector.
00084  * @post If a resize is needed and it fails, then this function will panic()
00085  * @post If after the operation the new length is greater than the old capacity
00086  * then a reallocation takes place and all elements are copied over.
00087  * Capacity is doubled. If initial capacity is zero, it is resized to
00088  * capacity 1. Any pointers to elements prior to this reallocation are
00089  * invalidated.
00090  */
00091 void vec_push_back(Vec* self, ptr_t new_ele);
00092
00093 /* Removes and destroys the last element of the Vec
00094  *
00095  * @param self a pointer to the vector we are popping.
00096  * @returns true iff an element was removed.
00097  * @pre Assumes self points to a valid vector.
00098  * @post The capacity of self stays the same. The removed element is
```

```
00099  * destructed (cleaned up) as specified by the dtor_fn provided in vec_new.
00100  */
00101 bool vec_pop_back(Vec* self);
00102
00103 /* Inserts an element at the specified location in the container
00104  *
00105  * @param self    a pointer to the vector we want to insert into.
00106  * @param index   the index of the element we want to insert at.
00107  *                Elements at this index and after it are "shifted" up
00108  *                one position. If index is equal to the length, then we insert
00109  *                at the end of the vector.
00110  * @param new_ele the value we want to insert
00111  * @pre Assumes self points to a valid vector. If the index is > self->length
00112  * then this function will panic().
00113  * @post If after the operation the new length is greater than the old capacity
00114  * then a reallocation takes place and all elements are copied over. Capacity is
00115  * doubled. Any pointers to elements prior to this reallocation are invalidated.
00116  */
00117 void vec_insert(Vec* self, size_t index, ptr_t new_ele);
00118
00119 /* Erases an element at the specified valid location in the container
00120  *
00121  * @param self    a pointer to the vector we want to erase from.
00122  * @param index   the index of the element we want to erase at. Elements
00123  *                after this index are "shifted" down one position.
00124  * @pre Assumes self points to a valid vector. If the index is >= self->length
00125  * then this function will panic().
00126  */
00127 void vec_erase(Vec* self, size_t index);
00128
00129 /* Resizes the container to a new specified capacity.
00130  * Does nothing if new_capacity <= self->length
00131  *
00132  * @param self         a pointer to the vector we want to resize.
00133  * @param new_capacity the new capacity of the vector.
00134  * @pre Assumes self points to a valid vector.
00135  * @post If a resize takes place, then a reallocation takes place and all
00136  * elements are copied over. Any pointers to elements prior to this
00137  * reallocation are invalidated.
00138  * @post The removed elements are destructed (cleaned up).
00139  */
00140 void vec_resize(Vec* self, size_t new_capacity);
00141
00142 /* Erases all elements from the container.
00143  * After this, the length of the vector is zero.
00144  * Capacity of the vector is unchanged.
00145  *
00146  * @param self a pointer to the vector we want to clear.
00147  * @pre Assumes self points to a valid vector.
00148  * @post The removed elements are destructed (cleaned up).
00149  */
00150 void vec_clear(Vec* self);
00151
00152 /* Destruct the vector.
00153  * All elements are destructed and storage is deallocated.
00154  * Must set capacity and length to zero. Data is set to NULL.
00155  *
00156  * @param self a pointer to the vector we want to destruct.
00157  * @pre Assumes self points to a valid vector.
00158  * @post The removed elements are destructed (cleaned up)
00159  * and data storage deallocated.
00160  */
00161 void vec_destroy(Vec* self);
00162
00163 #endif  // VEC_H_
```

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