POSIX Threads in a nutshell

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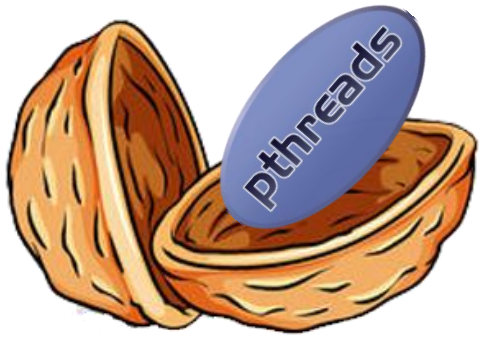


HiPeRT Lab

What will we see

- A mix of theory…
- ..and practice / exercise
  - Don't miss it
- Please, interrupt me

The POSIX IEEE standard

eng.wikipedia.org

POSIX Threads, usually referred to as Pthreads, is an execution model that exists independently from a language, as well as a parallel execution model. It allows a program to control multiple different flows of work that overlap in time.

- Threading API
- Single process
- Shared memory space

The POSIX IEEE standard

- Specifies an operating system interface similar to most UNIX systems
  - It extends the C language with primitives that allows the specification of the concurrency
- POSIX distinguishes between the terms process and thread
  - "A process is an address space with one or more threads executing"
  - "A thread is a single flow of control within a process (a unit of execution)"
- Every process has at least one thread
  - the "`main()`" (aka "master") thread; its termination ends the process
  - All the threads share the same address space, and have a private stack

Thread body

- A (P)thread is identified by a C function, called body:

```
void *my_pthread_fn(void *arg)
{
   // Thread body
}
```

- A thread starts with the first instruction of its body
- The threads ends when the body function ends
  - It's not the only way a thread can die

Thread creation

- Thread can be created using the primitive

pthread.h

```
typedef unsigned int pthread_t;

int pthread_create ( pthread_t *ID,
                     pthread_attr_t *attr,
                     void *(*body)(void *),
                     void * arg
                       );
```

- `pthread_t` is the type that contains the thread ID
- `pthread_attr_t` is the type that contains the parameters of the thread
- `arg` is the argument passed to the thread `body` when it starts

Thread attributes

- Thread attributes specifies the characteristics of a thread
  - We won't see this; leave empty
- Attributes must be initialized and destroyed - always

pthread.h

```
int pthread_attr_init(pthread_attr_t *attr);

int pthread_attr_destroy(pthread_attr_t *attr);
```

Thread termination

- A thread can terminate itself calling

pthread.h

```
void pthread_exit(void *retval);
```

- When the thread body ends after the last "}", `pthread_exit()` is called implicitly

- Exception: when `main()` terminates, `exit()` is called implicitly

Thread IDs

- Each thread has a unique ID

pthread.h

```
pthread_t pthread_self(void);
```

- The thread ID of the current thread can be obtained using

pthread.h

```
int pthread_equal( pthread_t thread1,
                   pthread_t thread2 );
```

- Two thread IDs can be compared using

Joining a thread

- A thread can wait the termination of another thread using

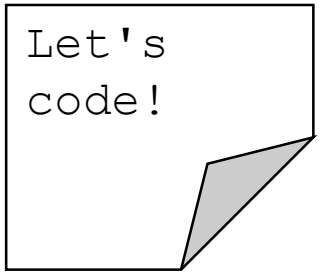
pthread.h

```
int pthread_join ( pthread_t th,
                   void **thread_return);
```

- It gets the return value of the thread or `PTHREAD_CANCELED` if the thread has been killed

- By default, every thread must be joined
  - The join frees all the internal resources
  - Stack, registers, and so on

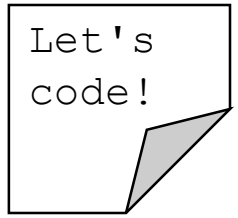
Example



- Filename: `hello_pthreads_world.c`
- The demo explains how to create a thread
  - the `main()` thread creates another thread (called `body()`)
  - the `body()` thread checks the thread Ids using `pthread_equal()` and then ends
  - the `main()` thread joins the `body()` thread
- When compiling under gcc & GNU/Linux, remember
  - the `-lpthread` option!
  - to add `#include "pthread.h"`

- Credits to PJ

How to run the examples



- Download the `Code/` folder from the course website

- Compile

```
$ gcc code.c -o code -lpthread
```

- Run (Unix/Linux)

```
$ ./code
```

- Run (Win/Cygwin)

```
$ ./code.exe
```

References

- "Calcolo parallelo" website
  - http://hipert.unimore.it/people/paolob/pub/PhD/index.html
- My contacts
  - paolo.burgio@unimore.it
  - http://hipert.mat.unimore.it/people/paolob/
- PThreads
  - https://computing.llnl.gov/tutorials/pthreads/
  - http://man7.org/linux/man-pages/man7/pthreads.7.html
- A "small blog"
  - http://www.google.com