



Contents

What are Pthreads?

- Pthread
- The Pthread API

How Pthread Works?

- Creating PThreads
- Attributes of Threads

Synchronization

- Mutex
- Spin Locks
- Barriers
- Semaphores

Reference

Operating System

Multi-Threaded Programming with Pthread

Ho Chi Minh City, February 25, 2018

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Contents

① What are Pthreads?

Pthread

The Pthread API

② How Pthread Works?

Creating PThreads

Attributes of Threads

③ Synchronization

Mutex

Spin Locks

Barriers

Semaphores

④ Reference



Contents

What are Pthreads?

Pthread

The Pthread API

How Pthread Works?

Creating PThreads

Attributes of Threads

Synchronization

Mutex

Spin Locks

Barriers

Semaphores

Reference



Contents

What are Pthreads?

Pthread

The Pthread API

How Pthread Works?

Creating PThreads

Attributes of Threads

Synchronization

Mutex

Spin Locks

Barriers

Semaphores

Reference

What is an Pthread?

POSIX Thread, or Pthread, is a POSIX standard for threads. The standard, POSIX.1c, Threads extensions (IEEE Std 1003.1c-1995), defines an API for creating and manipulating threads.



Contents

What are Pthreads?

Pthread

The Pthread API

How Pthread Works?

Creating PThreads

Attributes of Threads

Synchronization

Mutex

Spin Locks

Barriers

Semaphores

Reference

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Pthread in C/C++

Pthreads are defined as a set of C/C++ language programming types and procedure calls, implemented with a **pthread.h** header file. In GNU/Linux, the pthread functions are not included in the standard C/C++ library. They are in libpthread, therefore, we should add -lpthread to link our program.

The Pthread API



Pthreads API can be grouped into four:

- Thread management
- Mutexes
- Condition variables
- Synchronization

Contents

What are Pthreads?

Pthread

The Pthread API

How Pthread Works?

Creating PThreads

Attributes of Threads

Synchronization

Mutex

Spin Locks

Barriers

Semaphores

Reference

Creating new PThread



Contents

What are Pthreads?

Pthread
The Pthread API

How Pthread Works?

Creating PThreads

Attributes of Threads

Synchronization

Mutex
Spin Locks
Barriers
Semaphores

Reference

- `main()` program is a single, default thread. All other threads must be explicitly created

```
pthread_create (pthread_t *thread, pthread_attr_t  
*attr, void *(*start_routine)(void *), void *arg)
```

- **thread**: An identifier for the new thread returned by the subroutine.
- **attr**: An attribute object that may be used to set thread attributes.
- **start_routine**: The routine that the thread will execute once it is created.
- **arg**: A single argument that may be passed to **start_routine**.

Example

```
#include <pthread.h>
#include <stdio.h>
#include <stdlib.h>

void *worker_thread(void *arg)
{
    printf("This is worker_thread()\n");
    pthread_exit(NULL);
}

int main()
{
    pthread_t my_thread;
    int ret;

    printf("In main: creating thread\n");
    ret = pthread_create(&my_thread, NULL, &worker_thread, NULL);
    if(ret != 0) {
        printf("Error: pthread_create() failed\n");
        exit(EXIT_FAILURE);
    }

    pthread_exit(NULL);
}
```

Figure: Sample of creating a child thread



Contents

What are Pthreads?

- Pthread
- The Pthread API

How Pthread Works?

- Creating PThreads
- Attributes of Threads

Synchronization

- Mutex
- Spin Locks
- Barriers
- Semaphores

Reference

Attributes

- By default, a thread is created with certain attributes. Some of these attributes can be changed by the programmer via the thread attribute object.
- **pthread_attr_init()** and **pthread_attr_destroy()** are used to initialize/destroy the thread attribute object.
- Other routines are then used to query/set specific attributes in the thread attribute object.



Contents

What are Pthreads?

Pthread
The Pthread API

How Pthread Works?

Creating PThreads

Attributes of Threads

Synchronization

Mutex
Spin Locks
Barriers
Semaphores

Reference



Attributes

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- **pthread_attr_init()** and **pthread_attr_destroy()** are used to initialize/destroy the thread attribute object.
- Other routines are then used to query/set specific attributes in the thread attribute object.

How to terminate a PThread?

- The thread returns from its starting routine.
- The thread makes a call to the **pthread_exit** subroutine.
- The thread is canceled by another thread via the **pthread_cancel** routine.
- The entire process is terminated due to a call to either the **exec** or **exit** subroutines.

Contents

What are Pthreads?

Pthread
The Pthread API

How Pthread Works?

Creating PThreads

Attributes of Threads

Synchronization

Mutex
Spin Locks
Barriers
Semaphores

Reference



Contents

What are Pthreads?

Pthread
The Pthread API

How Pthread Works?

Creating PThreads
Attributes of Threads

Synchronization

Mutex
Spin Locks
Barriers
Semaphores

Reference

Join

- A thread can execute a thread join to wait until the other thread terminates.

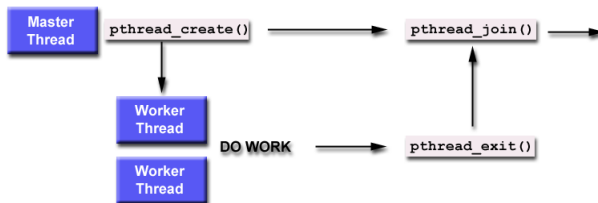


Figure: Work flow of PThread



Contents

What are Pthreads?

Pthread
The Pthread API

How Pthread Works?

Creating PThreads
Attributes of Threads

Synchronization

Mutex

Spin Locks
Barriers
Semaphores

Reference

- A mutex lock is a mechanism that can be acquired by only one thread at a time. For other threads to get the same mutex, they must wait until it is released by the current owner of the mutex.
- The **mutex lock** is one of ways of synchronizing data sharing methods.



Mutex Attributes

- To create a mutex that can be shared between processes, we need to set up the attributes for **pthread_mutex_init()**.

```
#include <pthread.h>

int main()
{
    pthread_mutex_t myMutex;
    pthread_mutexattr_t myMutexAttr;
    pthread_mutexattr_init(&myMutexAttr );
    pthread_mutexattr_setpshared(&myMutexAttr , PTHREAD_PROCESS_SHARED);

    pthread_mutex_init(&myMutex , &myMutexAttr );
    //...

    pthread_mutexattr_destroy(&myMutexAttr );
    pthread_mutex_destroy(&myMutex );
    return 0;
}
```

Figure: Mutex example

Contents

What are Pthreads?

Pthread
The Pthread API

How Pthread Works?

Creating PThreads
Attributes of Threads

Synchronization

Mutex
Spin Locks
Barriers
Semaphores

Reference



Mutex Attributes

- **pthread_mutexattr_setpshared()** with a pointer to the attribute structure and the value **PTHREAD_PROCESS_SHARED** sets the attributes to cause a shared mutex to be created.
- Mutexes are not shared between processes by default. Calling **pthread_mutexattr_setpshared()** with the value **PTHREAD_PROCESS_PRIVATE** restores the attribute to the default.
- Calling **pthread_mutexattr_init()** to set the attributes of the initialized mutex. They can be disposed of by a call to **pthread_mutexattr_destroy()**.

Contents

What are Pthreads?

Pthread
The Pthread API

How Pthread Works?

Creating PThreads
Attributes of Threads

Synchronization

Mutex

Spin Locks
Barriers
Semaphores

Reference



Contents

What are Pthreads?

- Pthread
- The Pthread API

How Pthread Works?

- Creating PThreads
- Attributes of Threads

Synchronization

Mutex

- Spin Locks
- Barriers
- Semaphores

Reference

Example



Contents

What are Pthreads?

Pthread
The Pthread API

How Pthread Works?

Creating PThreads
Attributes of Threads

Synchronization

Mutex
Spin Locks
Barriers
Semaphores

Reference

- A spin lock polls its lock condition repeatedly until that condition becomes true. Spin locks are most often used on multiprocessor systems where the expected wait time for a lock is small.



Contents

What are Pthreads?

- Pthread
- The Pthread API

How Pthread Works?

- Creating PThreads
- Attributes of Threads

Synchronization

- Mutex
- Spin Locks**
- Barriers
- Semaphores

Reference

Example



Contents

What are Pthreads?

Pthread
The Pthread API

How Pthread Works?

Creating PThreads
Attributes of Threads

Synchronization

Mutex
Spin Locks

Barriers

Semaphores

Reference

- As one of the synchronization methods, a barrier tells a group of threads or processes must stop at the barrier and cannot proceed until all other threads/processes reach this barrier.



Contents

What are Pthreads?

- Pthread
- The Pthread API

How Pthread Works?

- Creating PThreads
- Attributes of Threads

Synchronization

- Mutex
- Spin Locks

Barriers

- Semaphores

Reference

Example



Contents

What are Pthreads?

Pthread
The Pthread API

How Pthread Works?

Creating PThreads
Attributes of Threads

Synchronization

Mutex
Spin Locks
Barriers

Semaphores

Reference

- A semaphore is a counting and signaling mechanism. We use it to allow threads access to a specified number of items. If there is a single item, then a semaphore is virtually the same as a mutex.
 - **sem_init()**, **sem_open()**,
 - **sem_destroy()**
 - **sem_post(sem_t *sem)**
 - **sem_wait(sem_t *sem)**



Contents

What are Pthreads?

Pthread
The Pthread API

How Pthread Works?

Creating PThreads
Attributes of Threads

Synchronization

Mutex
Spin Locks
Barriers

Semaphores

Reference

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 - `sem_init()`, `sem_open()`,
 - `sem_destroy()`
 - `sem_post(sem_t *sem)`
 - `sem_wait(sem_t *sem)`

Risk?

- RACE CONDITION!
- DEAD LOCK!



Contents

What are Pthreads?

- Pthread
- The Pthread API

How Pthread Works?

- Creating PThreads
- Attributes of Threads

Synchronization

- Mutex
- Spin Locks
- Barriers

Semaphores

Reference

Example

- **Pthreads Programming.** B. Nichols et al. O'Reilly and Associates
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Contents

What are Pthreads?

Pthread
The Pthread API

How Pthread Works?

Creating PThreads
Attributes of Threads

Synchronization

Mutex
Spin Locks
Barriers
Semaphores

Reference



Contents

What are Pthreads?

- Pthread
- The Pthread API

How Pthread Works?

- Creating PThreads
- Attributes of Threads

Synchronization

- Mutex
- Spin Locks
- Barriers
- Semaphores

Reference

Thanks!