# National University of Computer and Emerging Sciences

## Operating System Lab – 07

*Lab Manual*

## Contents

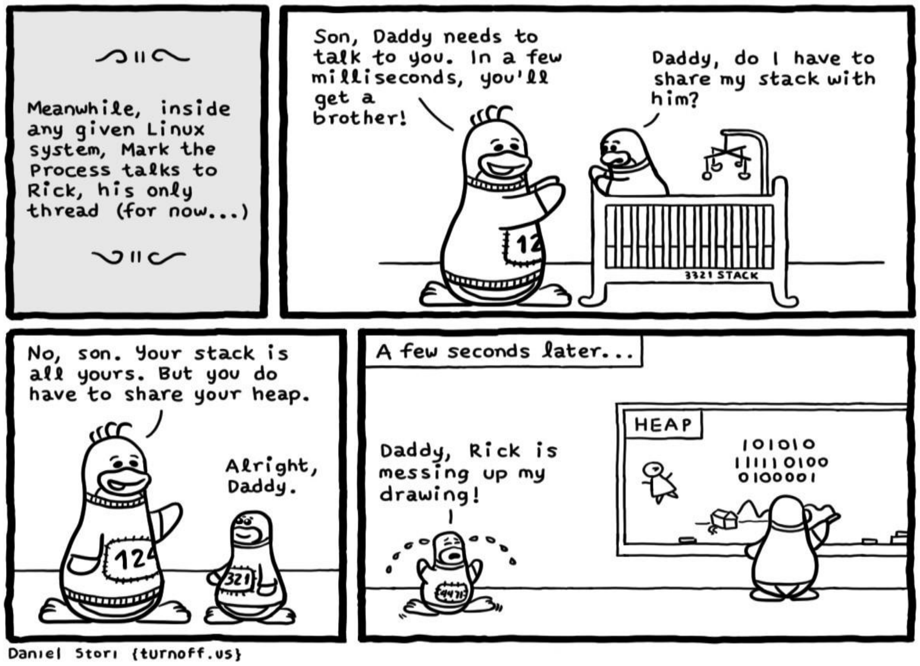
## Objective

In this lab you are introduce to multithreaded programming using **pthread_create** system call . We will learn how create multithreads and how to join them .First we will understand system calls related to multithreaded programming then we will move towards multithreaded programming. Our main objective are

- Thread creation in Linux
- Joining of thread in Linux
- Initializing thread attributes
- Setting Attribute detach state
- Destroying attribute

## What are Threads?

Threads are often described as **light-weight processes**. They can work like two or more processes sharing the same address space i.e. *they will work independently like processes but can share the same global variables*. They are mostly used when two tasks can be done independently without depending much on each other.


Meanwhile, inside any given Linux system, Mark the Process talks to Rick, his only thread (for now...)
Son, Daddy needs to talk to you. In a few milliseconds, you'll get a brother!
Daddy, do I have to share my stack with him?
12
3321 STACK
No, son. Your stack is all yours. But you do have to share your heap.
Alright, Daddy.
12
321
A few seconds later...
Daddy, Rick is messing up my drawing!
HEAP
101010
11111 0100
0100001
Daniel Stori {turnoff.us}

## Basic System Calls Related to Multithread Programming

The following are two basic system calls related to multithreaded programming however, there are many system call available.

| S.NO | System Call | Description |
|---|---|---|
| **1** | Pthread_create() | For creating threads |
| **2** | Pthread_join() | Wait of thread termination |

## ‘pthread_create()’ System Call

This system call is used to create new thread, a syntax is given below

```
#include<pthread.h> int
pthread_create(

pthread_t *thread,                //id of thread
const pthread_attr_t *attr,       //attributes of thread
void *(*start_routine) (void*),  //function that is to assign
void *arg                        //arguments that have to pass to thread function

);
```

**Return Values:**

If successful it return 0 otherwise it generates a nonzero number.

**thread :** is a pthread_t variable, pthread_t is a data type that holds information about threads. Each thread requires one pthread_t variable.

**attr :** is a variable of type pthread_attr_t, if specified it holds details about the thread, like scheduling policy, stack size etc. If we specify NULL the thread runs with default parameters.

**start_routine :** is the function the thread executes. The function needs to have a void* pointer as argument and must return a void* pointer ( void* can be interpreted as a pointer to anything ).

**arg :** is a void pointer which points to any data type.

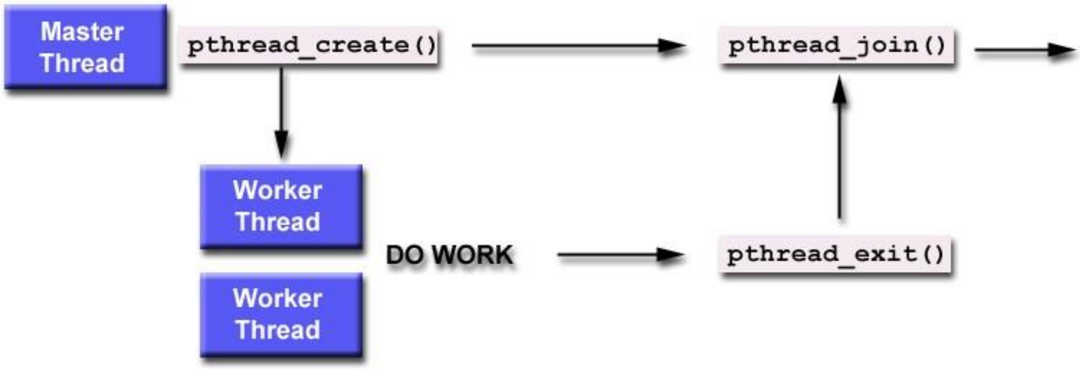
## ‘pthread_join()’ System Call

This system call waits for the thread specified by thread to terminate. A syntax is shown below:

```
 Int pthread_join (

 Pthread_t thread,         //id of thread which have to join

void **retval              //return status of thread

 );
```

**Return Values:**

If successful it return 0 otherwise it generates a nonzero number.



## Example 1: *Two Threads displaying two strings “Hello” and “How are you?” independent of each other*

- Create a new file thread.c with .c extension using any editor  Type the following code.

```
#include <stdio.h>
#include <pthread.h>
#include <stdlib.h> void
* thread1()
{
while(1){
printf("Hello!!\n");
}
}
void * thread2()
{
while(1){
printf("How are you?\n");
}
}
int main()
{
int status; pthread_t tid1,tid2;
pthread_create(&tid1,NULL,thread1,NULL);
pthread_create(&tid2,NULL,thread2,NULL);
pthread_join(tid1,NULL);
pthread_join(tid2,NULL); return 0;}
```

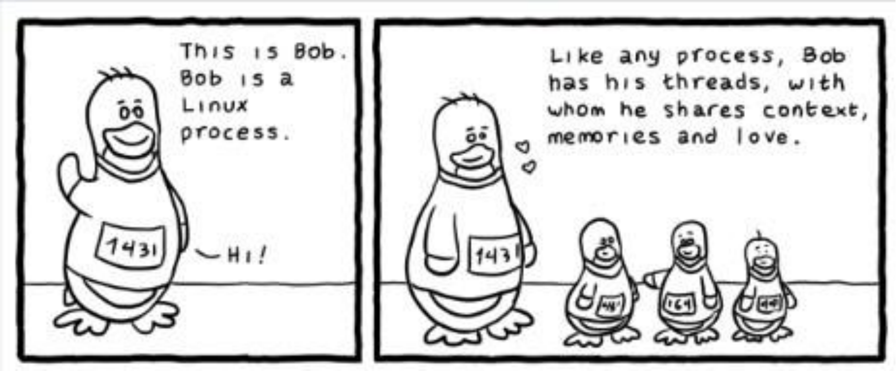
- Save and exit.
- To compile it type the following command on terminal.

```
gcc –o thread thread.c -lpthread
```

- Run it by using following command.

```
./thread
```

The –lpthread at the end to link the pthread library.


This is Bob. Bob is a Linux process.
1431
Hi!
Like any process, Bob has his threads, with whom he shares context, memories and love.
1431

## Example 2: *Create a function message() that takes threadid as argument and prints the message with thread id. There should be at least four independent threads*

- Create a new file msgthreads.c with .c extension using any editor □ Type the following code.

```
#include <stdio.h>
#include <pthread.h>
#include <stdlib.h>
#define NUM_THREADS 4
#define MSG “Hello from message”

void *message(void *threadid) {
        printf(“msgthreads [INFO] Message: %s \t Thread ID: %ld \n”, MSG, (long) *threadid);
}

int main() {
        pthread_t threads[NUM_THREADS];
        int rc;
        long t;

for(t=0;t<NUM_THREADS;t++) { printf ("IN:main
        creadting thread %ld\n", t);
        rc = pthread_create(&threads[t],0, message,(void *)t);
}
pthread_join(threads[0],0);
pthread_join(threads[1],0);
pthread_join(threads[2],0);
pthread_join(threads[3],0);  return
0;
}
```

- Save and exit.
- To compile it type the following command on terminal.

```
gcc –o msgtheads  msgthreads.c –lpthread
```

- Run it by using following command.

```
./msgthreads
```

**Note:** remove pthread_join system call and then observe the changes

## Attributes in Threads

Previously we passed a NULL in place of thread attribute however, we may place thread attributes that uses default attributes of threads. However, we may create and customize a thread attribute object to specify other values for the attribute.

Thread attributes are thread characteristics that affect the behavior of the thread. Different attributes are available depending on the programming language and application programming interface (API) set you are using. Methods for using an attribute and its effect on the thread depend on how the programming language and API set externalize the thread attribute to your application. You can set the thread attributes at the time you start a thread or change them after the thread is actively running.

## System Calls related to Attributes of Threads

The following are the system calls related to threads' attribute.

| S.NO | System Call | Description |
|---|---|---|
| 1 | pthread_attr_init() | Initializes a thread attributes object |
| 2 | pthread_attr_setdetachstate() | Controls detach state of a thread |
| 3 | pthread_attr_destroy() | Destroys attribute objects |

### 'pthread_attr_init()' System Call

This initializes a thread attributes object attr with the default value. The syntax is shown below:

```
int pthread_attr_init(pthread attr t *attr)
```

**Return Values:**

If successful completion, it will return a 0 otherwise, an error number is returned to indicate the error.

### 'pthread_attr_setdetachstate()' System Call

The detachstate attribute controls whether the thread is created in a detached state.

```
int pthread_attr_setdetachstate(pthread_attr_t *attr, int detachstate)
```

**PTHEAD_CREATE_DETACHED** Thread state is detached means it cannot be joined with other threads.

**PTHREAD_CREATE_JOINABLE** Thread state is joinable means it can be joined with other threads

### 'pthread_attr_destroy()' System Call

When a thread attributes objects is no longer required, it should be destroyed using this system call.

```
int pthread_attr_destroy(pthread_attr_t *attr)
```

**Return Values:**

If successful completion, it will return a 0 otherwise, an error number is returned to indicate the error.

## Thread Attribute List

The following are some thread attributes which you may find useful

### Priority:

Affects the amount of processing time that the system gives the thread before letting another thread or process interrupt it

### Stack size:

Affects the number of functions that a thread can call before the thread fails due to insufficient stack space

### Name:

Affects the ability to debug or track the actions of a thread through your application

### Thread group:

Affects the ability to easily manage more than one thread at a time

### Detach state:

Affects how you reclaim or leave active resources associated with a thread when a thread ends

### Scheduling policy:

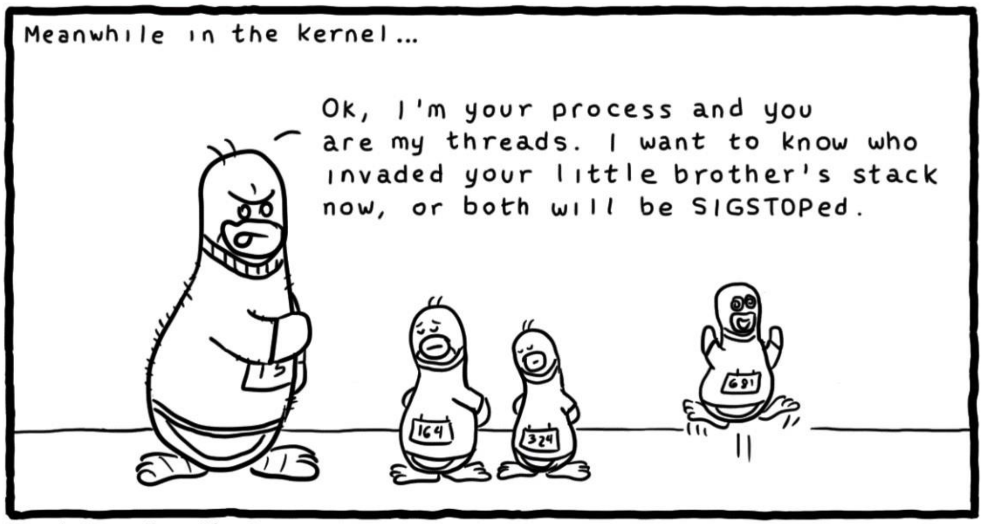
Affects how the threads are scheduled within the system or within the application. This relates to thread priority.

### Inherit scheduling:

Affects how the priority of the thread is determined by the system

You can get much information about these attributes and more information about system calls related to thread attributes: follow the links below

- https://docs.oracle.com/cd/E19455-01/806-5257/6je9h032j/index.html
- http://www.cs.cmu.edu/afs/cs/academic/class/15492-f07/www/pthreads.html
- https://vcansimplify.wordpress.com/2013/03/08/pthread-tutorial-simplified/


Meanwhile in the kernel...
Ok, I'm your process and you are my threads. I want to know who invaded your little brother's stack now, or both will be SIGSTOPed.
15
164
324
681

Daniel Stori {turnoff.us}

## Example 3: *Create a detached thread for a function infoThread()*

- Create a new file detachthread.c with .c extension using any editor  Type the following code.

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

void  *theThread(void  *parm)  {  printf("Entered  the
          thread\n"); return NULL;
}

int main(int argc, char **argv) {
          pthread_attr_t attr;
          pthread_t thread;

          printf("Create a default thread attributes object\n");  pthread_attr_init(&attr);
          printf("Set the detach state thread attribute\n");
          pthread_attr_setdetachstate(&attr,PTHREAD_CREATE_DETACHED);

          printf("Create a thread using the new attributes\n");
          pthread_create(&thread, &attr, theThread, NULL); printf("Destroy
          thread attributes object\n");  pthread_attr_destroy(&attr);
int rc;
rc = pthread_join(thread, NULL);

          printf("Join now fails because the detach state attribute was changed\n pthread_join returns non zero
value %d",rc);

printf("Main completed\n");
return 0;
}
```

- Save and exit.
- To compile it type the following command on terminal.

```
gcc –o detachthead –pthread detachthread.c
```

- Run it by using following command.

```
./detachthread
```

## Kernel Threads

To make concurrency cheaper, the execution aspect of process is separated out into threads. As such, the OS now manages threads and processes. All thread operations are implemented in the kernel and the OS schedules all threads in the system. OS managed threads are called kernel-level threads or light weight processes.

- NT: Threads
- Solaris: Lightweight processes (LWP).

In this method, the kernel knows about and manages the threads. No runtime system is needed in this case. Instead of thread table in each process, the kernel has a thread table that keeps track of all threads in the system. In addition, the kernel also maintains the traditional process table to keep track of processes. Operating Systems kernel provides system call to create and manage threads.

**Advantages:**

- Because kernel has full knowledge of all threads, Scheduler may decide to give more time to a process having large number of threads than process having small number of threads.
- Kernel-level threads are especially good for applications that frequently block.

**Disadvantages:**

- The kernel-level threads are slow and inefficient. For instance, threads operations are hundreds of times slower than that of user-level threads.
- Since kernel must manage and schedule threads as well as processes. It requires a full thread control block (TCB) for each thread to maintain information about threads. As a result, there is significant overhead and increased in kernel complexity.

## To Be Continued

In next lab we will see

- Real-time computation using pthreads
- Introduction of OpenMP with comparison of pthread vs OpenMP.

## Lab Activity

1. Write a program which make 4 threads. Each thread will print one table out of [5678] up to 1000.
2. Write a program which make 4 threads. Program shall compute table of 5 up to 2000 terms. Threads will divide tasks with each other. Each thread will compute 500 terms and sum up the result afterwards.