National University of Computer and Emerging Sciences

Operating System Lab – 07

MULTITHREADING

Contents

Objective

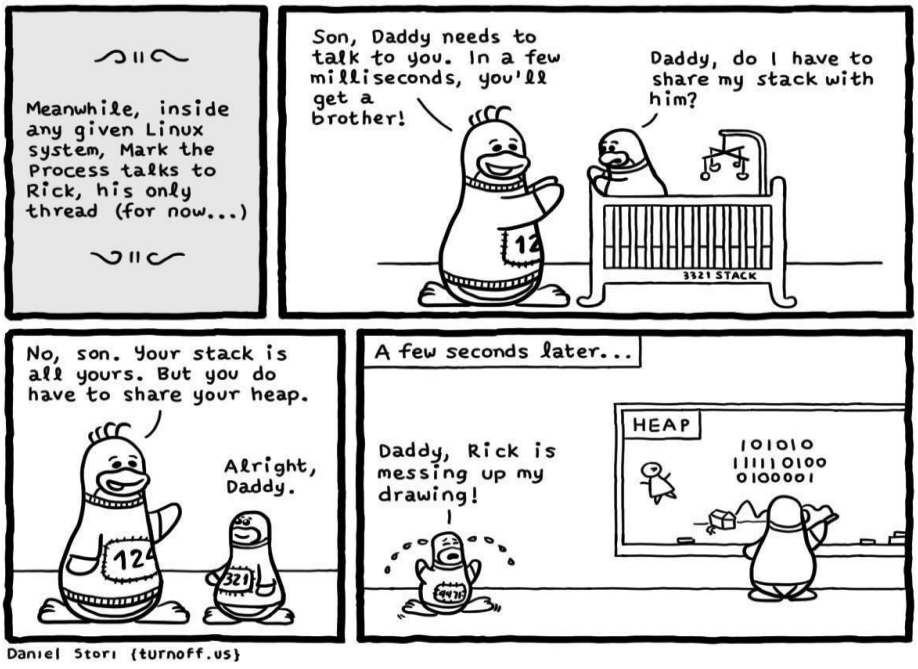
Introduction to multithreaded programming using **POSIX thread (pthread) libraries**.

Our main objectives are:

1. Thread creation in Linux
2. Joining of thread in Linux
3. Initializing thread attributes
4. Setting Attribute detach state.
5. Destroying attribute

Threads

Threads are often described as **lightweight 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.

- 

Basic System Calls Related to Multithread Programming

The following are two basic system calls related to multithreaded programming however, there are many system calls 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 *threaded,              //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

);
```

```
Example: pthread_create(&id[0], NULL, printNumber, &arg);
```

Arguments	Syntax	Description
ID	`pthread_t *`	Reference (or pointer) tothe ID of the thread.
attr	`pthread_attr_t *`	Used to set the attributes of a thread (e.g., the stack size, scheduling policy, etc.) Passing NULL suffices for most applications.
Starting routine	`void *`	The name of the function that the thread starts to execute. If the function's return type is void *, then its name is simply written; otherwise, it must be type-cast to void *.
arg	`void *`	This is the argument that the *starting routine* takes. If it takes multiple arguments, a struct is used.

Return Values:

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

pthread_join() -System Call

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

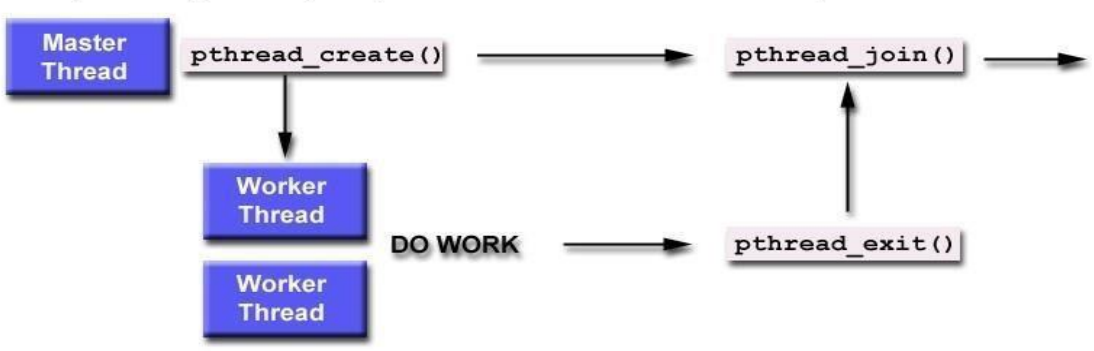
```
Int pthread_join (

Pthread_t threaded,     //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*

1. Create a new file thread.c with .c extension using any editor
2. 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;}
```

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

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

- **gcc** is the compiler command.
- **thread.c** is the name of c program source file.
- **-o** is option to make object file.
- **thread** is the name of object file.
- **-lpthread** is option to execute pthread.h library file.

5. Run it by using following command.

```
./thread
```

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

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

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

```
#include <pthread.h>
#include <stdio.h>
#include <stdlib.h>
#define NUM_THREADS     5

void *PrintHello(void *threadid)
{
  long tid;
  tid = (long)threadid;
  printf("Hello World! It's me, thread #%ld!\n", tid);
  pthread_exit(NULL);
}

int main (int argc, char *argv[])
{
  pthread_t threads[NUM_THREADS];
  int rc;
  long t;
  for(t=0; t<NUM_THREADS; t++){
    printf("In main: creating thread %ld\n", t);
    rc = pthread_create(&threads[t], NULL, PrintHello, (void *)t);
    if (rc){
      printf("ERROR; return code from pthread_create() is %d\n", rc);
      exit(-1);
    }
  }
  pthread_exit(NULL);
}
```

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

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

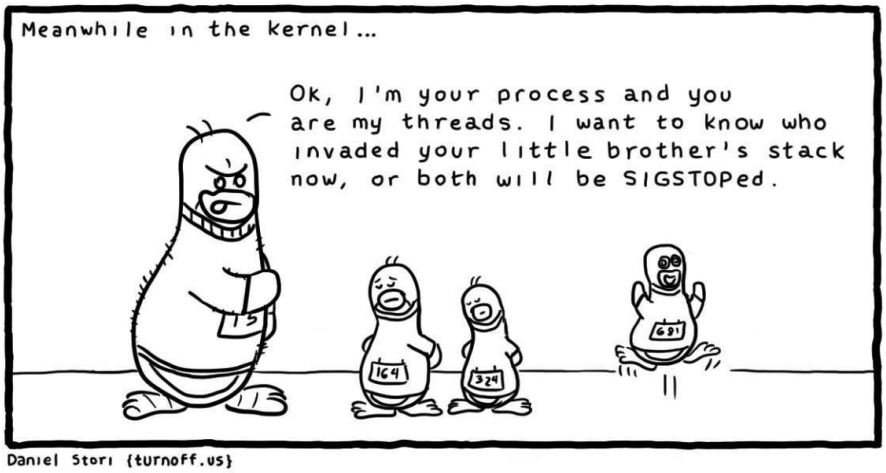
5. Run it by using following command.

```
./msgthreads
```

Note: remove pthread_join system call and then observe the changes

Attributes in Threads

Thread attributes are thread characteristics that affect the behavior of the thread. **NULL** is passed in above examples in place of thread attributes, now we start to place thread attributes that uses default attributes of threads. We may create and customize a thread attribute object to specify othervalues for the attribute.



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

1. 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.

2. 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

3. 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.

`pthread_self()`

Syntax

```
pthread_t tid;
tid = pthread_self();
```

DESCRIPTION

The pthread_self() function shall return the thread ID of the calling thread.

RETURN VALUE

Refer to the DESCRIPTION.

ERRORS

No errors are defined. The pthread_self() function shall not return an error code.

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

1. Create a new file detachthread.c with .c extension using any editor
2. 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;
}
```

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

```
gcc detachthread.c  –o detachthread –lpthread
```

5. Run it by using following command.

```
./detachthread
```

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

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

Lab Activity

1. Write a program that create 3 threads
   a) On successful creation, print “Thread #” in its starting routine and terminate themselves by showing their return value.
   b) On unsuccessful creation, Print “Error”.

```
Thread 1
Thread 2
Thread 3
Thread 1 returns: 0
Thread 2 returns: 0
Thread 3 returns: 0
```

2. Write a program, which make 4 threads. Each thread will print one table out of [5678] up to 1000.

3. Write a program that creates N number of threads specified in the command line, each prints “hello message and its own thread ID”. Sleep the main thread for 1 second and create every 4 or 5 threads. The output of your code should alike:

```
I am thread 1. Created new thread (4) in iteration 0...
Hello from thread 4 - I was created in iteration 0
I am thread 1. Created new thread (6) in iteration 1...
I am thread 1. Created new thread (7) in iteration 2...
I am thread 1. Created new thread (8) in iteration 3...
I am thread 1. Created new thread (9) in iteration 4...
I am thread 1. Created new thread (10) in iteration 5...
Hello from thread 6 - I was created in iteration 1
Hello from thread 7 - I was created in iteration 2
Hello from thread 8 - I was created in iteration 3
Hello from thread 9 - I was created in iteration 4
Hello from thread 10 - I was created in iteration 5
I am thread 1. Created new thread (11) in iteration 6...
I am thread 1. Created new thread (12) in iteration 7...
Hello from thread 11 - I was created in iteration 6
Hello from thread 12 - I was created in iteration 7
```

4. Write a program to sum 10 elements of an array by multithreading.
5. Procom has 4 volunteers on their front desk.
   - Volunteer 1 manages On day registration
   - Volunteer 2 handles announcements
   - Volunteer 3 handles sponsors
   - Volunteer 4 resolve queries of participants

   Implement this system using pthread for 100 participants.