Computer Operating Systems, Practice Session 4

Threads

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Today

Computer Operating Systems, PS 4

- Thread Creation and Termination
- Joining Threads
- Using Global Variables in Threads

Thread Creation

```
#include <pthread.h>

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

`pthread_t *thread`	: Pointer to the thread to be created
`const pthread_attr_t *attr`	: Pointer to attributes of the thread to be created
`void *(*start_routine)(void*)`	: Pointer to the routine that will start the thread
`void *arg`	: Pointer to the arguments for the start routine

returns 0 on success and an error number on failure

Example Program 1

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

void* print_message_function(void *ptr){
  char *message;
  // interpreting as char *
  message = (char *) ptr;
  printf("\n %s \n", message);
  // terminating the thread
  pthread_exit(NULL);
}

int main(){
  pthread_t thread1, thread2, thread3;
  char *message1 = "Hello";
  char *message2 = "World";
  char *message3 = "!...";
```

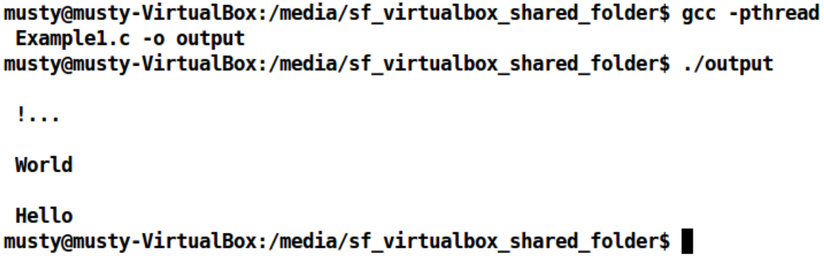
Example Program 1

```
  // creating 3 threads with start routine as print_message_function
  // and start routine arguments as message1, message2 and message3
  if(pthread_create(&thread1,NULL,print_message_function,(void *)
     message1)){
        fprintf(stderr,"pthread_create failure\n");
        exit(-1);
  }
  if(pthread_create(&thread2,NULL,print_message_function,(void *)
     message2)){
        fprintf(stderr,"pthread_create failure\n");
        exit(-1);
  }
  if(pthread_create(&thread3,NULL,print_message_function,(void *)
     message3)){
        fprintf(stderr,"pthread_create failure\n");
        exit(-1);
  }
  // to block main to support its threads until they terminate
  pthread_exit(NULL);
}
```

Compiling a Program Including Thread/s

- Source File: `source.c`
- Executable File: `output`
- These applications should be linked with thread library. Sample, proper compilation:
  `gcc -pthread source.c -o output`

Output of the Example Program 1



```
musty@musty-VirtualBox:/media/sf_virtualbox_shared_folder$ gcc -pthread
 Example1.c -o output
musty@musty-VirtualBox:/media/sf_virtualbox_shared_folder$ ./output

 !...

 World

 Hello
musty@musty-VirtualBox:/media/sf_virtualbox_shared_folder$ 
```

Example Program 2

```c
#include <pthread.h>
#include <stdio.h>
#include <stdlib.h>
#include <math.h>
#define NUM_THREADS 4

 void *BusyWork(void *t){
     int i;
     long tid;
     double result=0.0;
     tid = (long)t;
     printf("Thread %ld starting...\n", tid);
     for (i=0; i<1000000; i++){
         result = result + sin(i) * tan(i);
     }
     printf("Thread %ld done. Result = %e\n", tid, result);
     pthread_exit((void*) t);
 }
```

Barney B. (2013). POSIX Threads Programming. Retrieved March 03, 2014, from https://computing.llnl.gov/tutorials/pthreads/

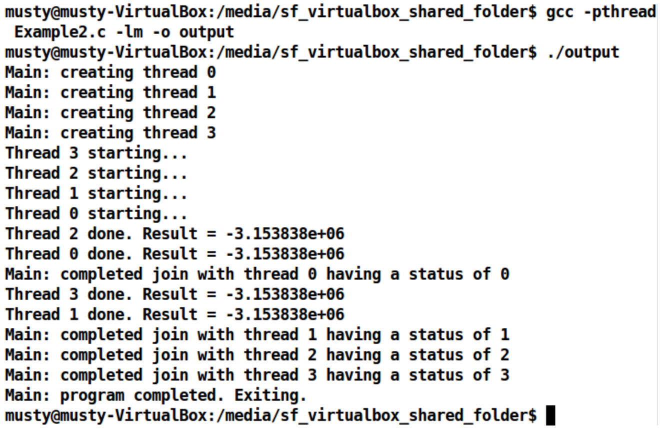
Example Program 2

```c
int main (int argc, char *argv[]){
  pthread_t thread[NUM_THREADS];
  pthread_attr_t attr;
  int rc;
  long t;
  void *status;
  // Initialize and set thread detach state attribute
  // Only threads that are created as joinable can be joined
  // Threads created as PTHREAD_CREATE_DETACHED, cannot be joined
  pthread_attr_init(&attr);
  pthread_attr_setdetachstate(&attr, PTHREAD_CREATE_JOINABLE);
  for(t=0; t<NUM_THREADS; t++) {
    printf("Main: creating thread %ld\n", t);
    // creating thread t
    rc = pthread_create(&thread[t], &attr, BusyWork, (void *)t);
    if (rc) {
      printf("ERROR; return code from pthread_create() is %d\n", rc);
      exit(-1);
    }
  }
```

Example Program 2

```
  // Free library resources used by the attribute
  pthread_attr_destroy(&attr);
  // Join operation is used for synchronization between threads by
  // blocking the calling thread until the specified thread (with
  // given threadid) terminates
  for(t=0; t<NUM_THREADS; t++) {
    rc = pthread_join(thread[t], &status);
    if (rc) {
      printf("ERROR; return code from pthread_join() is %d\n", rc);
      exit(-1);
    }
    printf("Main: completed join with thread %ld having a status of
    %ld\n",t,(long)status);
  }
  printf("Main: program completed. Exiting.\n");
  // to block main to support its threads until they terminate
  pthread_exit(NULL);
}
```

Output of the Example Program 2



```
musty@musty-VirtualBox:/media/sf_virtualbox_shared_folder$ gcc -pthread
 Example2.c -lm -o output
musty@musty-VirtualBox:/media/sf_virtualbox_shared_folder$ ./output
Main: creating thread 0
Main: creating thread 1
Main: creating thread 2
Main: creating thread 3
Thread 3 starting...
Thread 2 starting...
Thread 1 starting...
Thread 0 starting...
Thread 2 done. Result = -3.153838e+06
Thread 0 done. Result = -3.153838e+06
Main: completed join with thread 0 having a status of 0
Thread 3 done. Result = -3.153838e+06
Thread 1 done. Result = -3.153838e+06
Main: completed join with thread 1 having a status of 1
Main: completed join with thread 2 having a status of 2
Main: completed join with thread 3 having a status of 3
Main: program completed. Exiting.
musty@musty-VirtualBox:/media/sf_virtualbox_shared_folder$ 
```

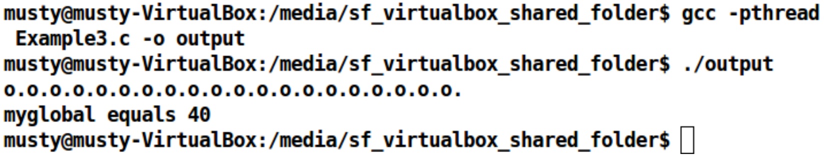
Example Program 3

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

int myglobal;

void* thread_function(void *arg){
  int i,j;
  // changing the value of myglobal in thread_function
  for(i=0;i<20;i++){
      //myglobal++;
      j=myglobal;
      j=j+1;
      myglobal=j;
      printf(".");
      // to force writing all user-space buffered data to stdout
      fflush(stdout);
      sleep(1);
  }
  pthread_exit(NULL);
}
```

Example Program 3

```
int main(void){
  pthread_t mythread;
  int i;
  myglobal=0;
  // creating a thread using thread_function as the start routine
  if(pthread_create(&mythread,NULL,thread_function,NULL)){
    printf("error creating thread");
    abort();
  }
  // changing the value of myglobal in main()
  for(i=0;i<20;i++){
    myglobal = myglobal+1;
    printf("o");
    // to force writing all user-space buffered data to stdout
    fflush(stdout);
    sleep(1);
  }
  printf("\nmyglobal equals %d\n",myglobal);
  // to block main to support its threads until they terminate
  pthread_exit(NULL);
}
```

Output of the Example Program 3



```
musty@musty-VirtualBox:/media/sf_virtualbox_shared_folder$ gcc -pthread
 Example3.c -o output
musty@musty-VirtualBox:/media/sf_virtualbox_shared_folder$ ./output
o.o.o.o.o.o.o.o.o.o.o.o.o.o.o.o.o.o.o.o.
myglobal equals 40
musty@musty-VirtualBox:/media/sf_virtualbox_shared_folder$ 
```