Threads, IPC, Synchronization in Linux

Chapter 12

Beginning Linux Programming

Chapter 12

THREADS

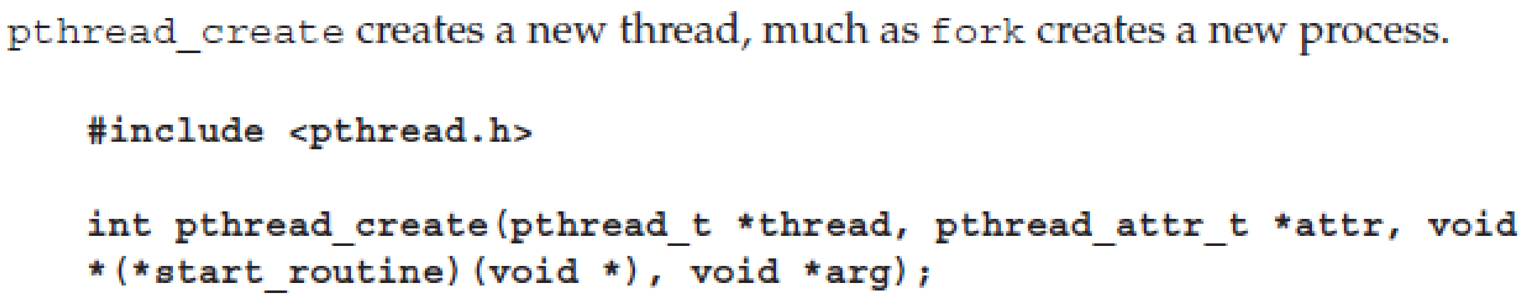
Thread

- All the program that we have written so far have had just one thread of execution
- Time to do many tasks within a single program
- We need many threads of execution in a single program
- **Writing multithreaded programs requires very careful design**
- In Linux we would use POSIX Threads, usually referred to as Pthreads inshaAllah

Thread

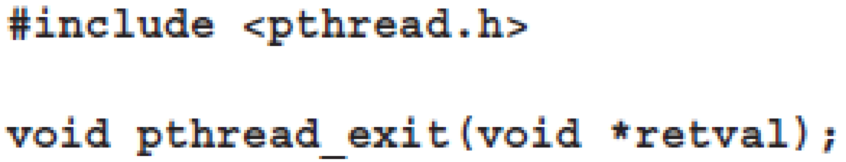
- The subroutines which comprise the Pthreads API can be informally grouped into
- three major classes:
  - **Thread management**
  - **Mutexes**
  - **Semaphores**

Threads

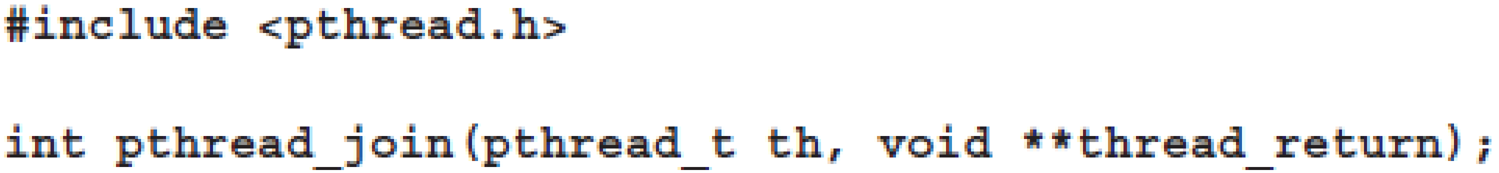


`pthread_create` creates a new thread, much as `fork` creates a new process.

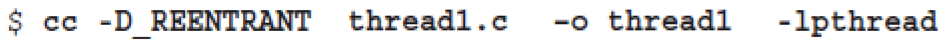
```
#include <pthread.h>

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



```
#include <pthread.h>

void pthread_exit(void *retval);
```

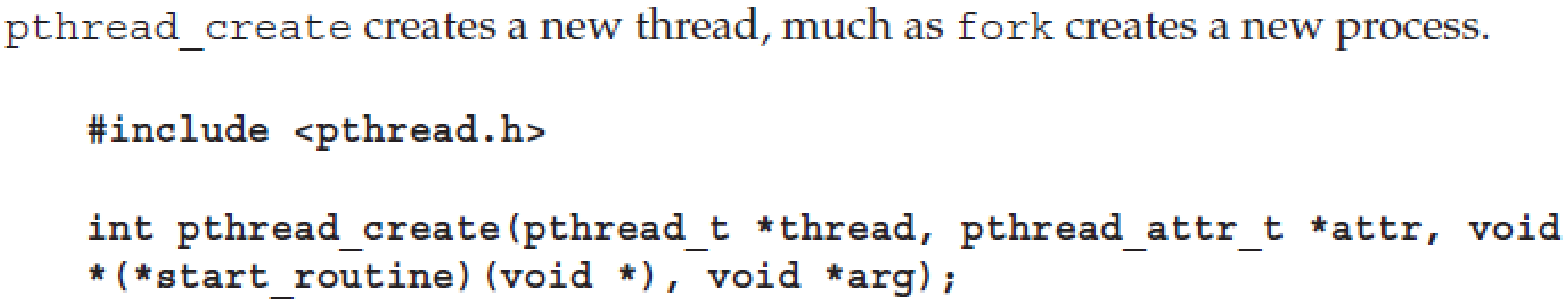


```
#include <pthread.h>

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



```
$ cc -D_REENTRANT  thread1.c  -o thread1  -lpthread
```

Thread Creation



pthread_create creates a new thread, much as fork creates a new process.

```
#include <pthread.h>

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

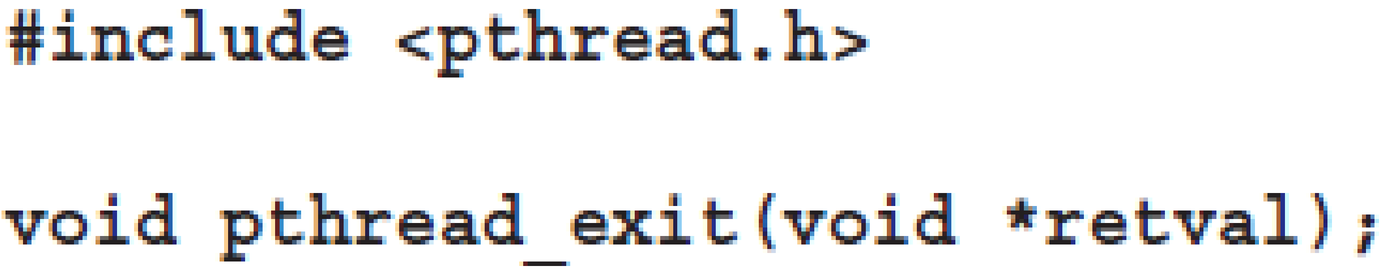
- Arguments
  - pointer to pthread object (used as thread identifier)
  - the thread attributes (NULL for us)
  - the address of a **function** taking a pointer to void as a parameter and the function will return a pointer to void
    - the thread would execute this
    - we can pass any type of single argument and return a pointer to any type (needs typecasting)
  - argument passed to this function
- Returns 0 on success

Simple Example

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

void * threadFunc1(void * arg){
    int i;
    for(i=1;i<=5;i++){
        printf("%s\n",(char*)arg);
        sleep(1);
    }
}
int main(void){
    pthread_t thread1;
    pthread_t thread2;
    char * message1 = “I am thread 1”;
    char * message2 = “I am thread 2”;

    pthread_create(&thread1,NULL,threadFunc1,(void*)message1 );
    pthread_create(&thread2,NULL,threadFunc1,(void*)message2 );
    while(1);
    return 0;
}
```

Thread Exit

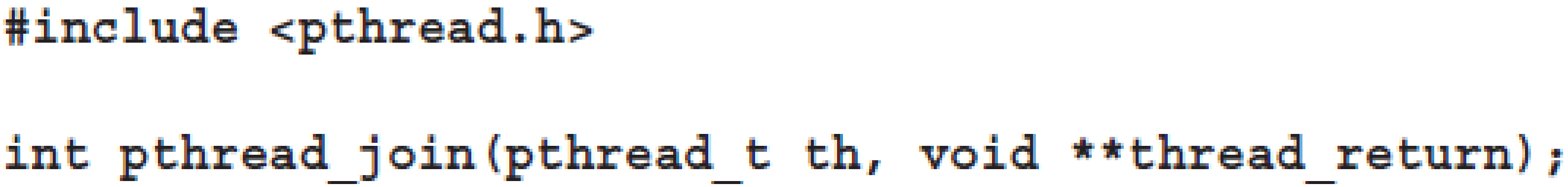
- When a thread terminates, it calls the pthread_exit function
  - terminates the calling thread,
  - returns a pointer to an object



```
#include <pthread.h>

void pthread_exit(void *retval);
```

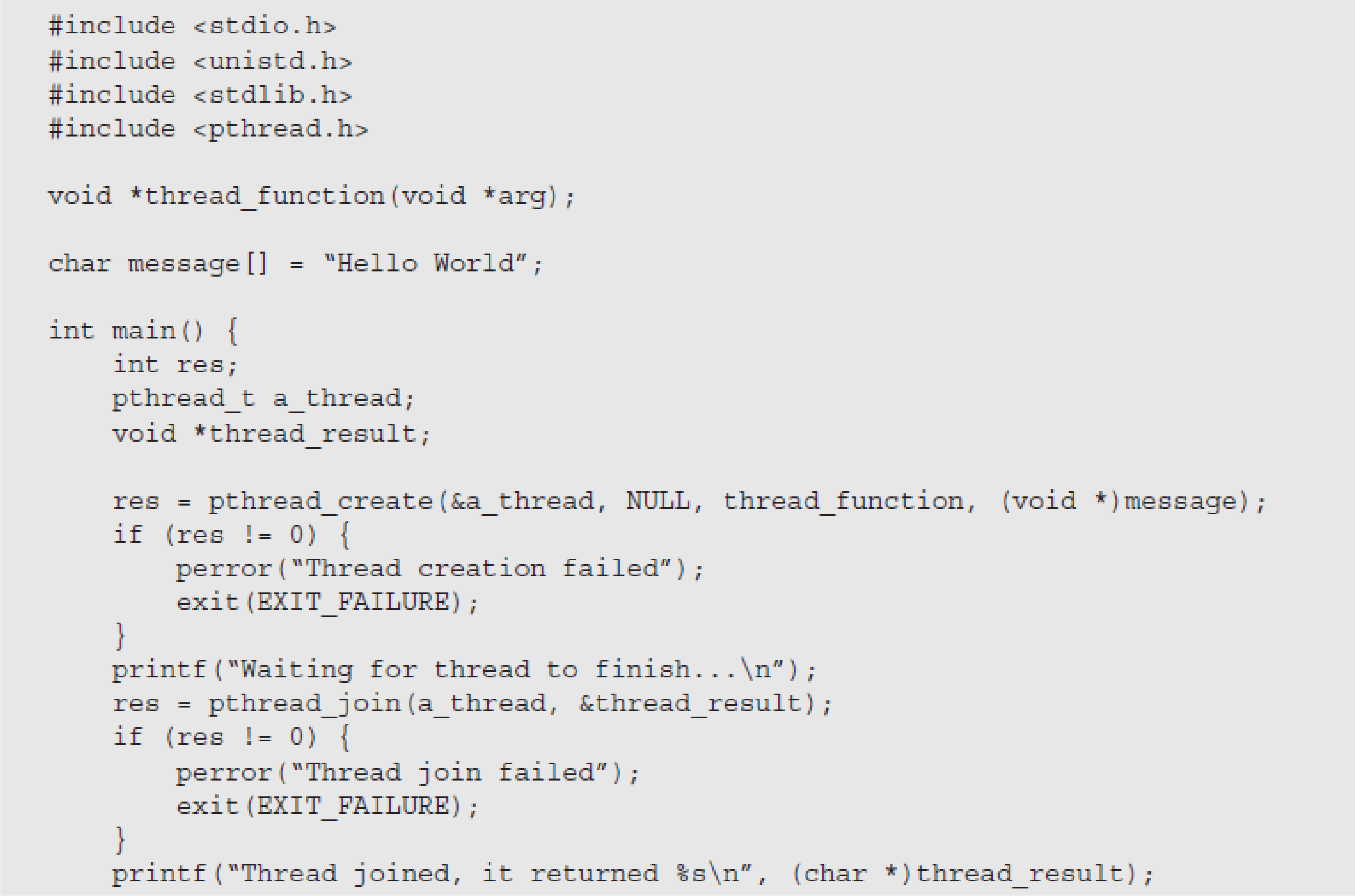
Thread Join

- The first parameter is the thread for which to wait
  - the identifier that pthread_create filled in for us.
- The second argument is a pointer to a pointer that itself points to the return value from the thread.



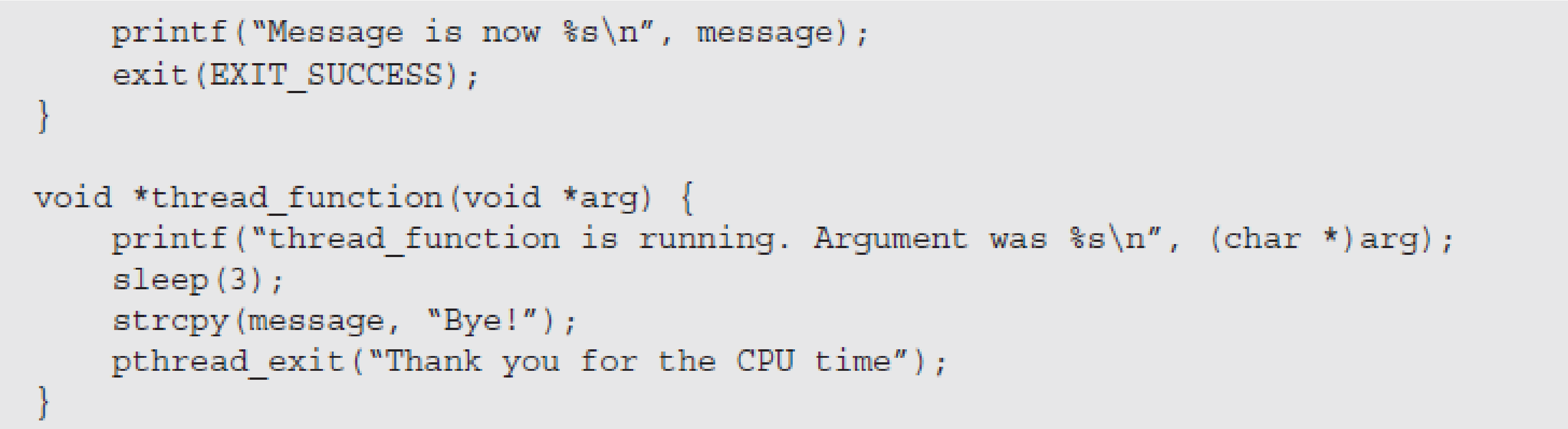
```
#include <pthread.h>

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

Thread Join



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

void *thread_function(void *arg);

char message[] = “Hello World”;

int main() {
    int res;
    pthread_t a_thread;
    void *thread_result;

    res = pthread_create(&a_thread, NULL, thread_function, (void *)message);
    if (res != 0) {
        perror(“Thread creation failed”);
        exit(EXIT_FAILURE);
    }
    printf(“Waiting for thread to finish...\n”);
    res = pthread_join(a_thread, &thread_result);
    if (res != 0) {
        perror(“Thread join failed”);
        exit(EXIT_FAILURE);
    }
    printf(“Thread joined, it returned %s\n”, (char *)thread_result);
```

Thread Join



```
    printf(“Message is now %s\n”, message);
    exit(EXIT_SUCCESS);
}

void *thread_function(void *arg) {
    printf(“thread_function is running. Argument was %s\n”, (char *)arg);
    sleep(3);
    strcpy(message, “Bye!”);
    pthread_exit(“Thank you for the CPU time”);
}
```

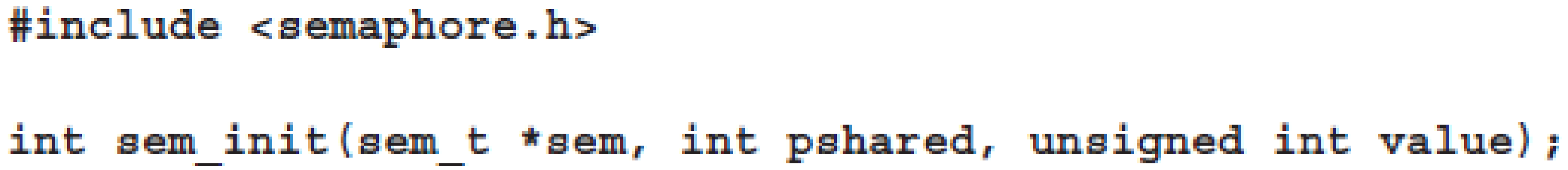
Requirements

- we must define the macro _REENTRANT
- include the file pthread.h, and
- link with the threads library using –lpthread or -pthread
- To compile & link a source file named thread
  - **gcc -D_REENTRANT thread.c -o thread –lpthread**
- Run
  - **./thread**

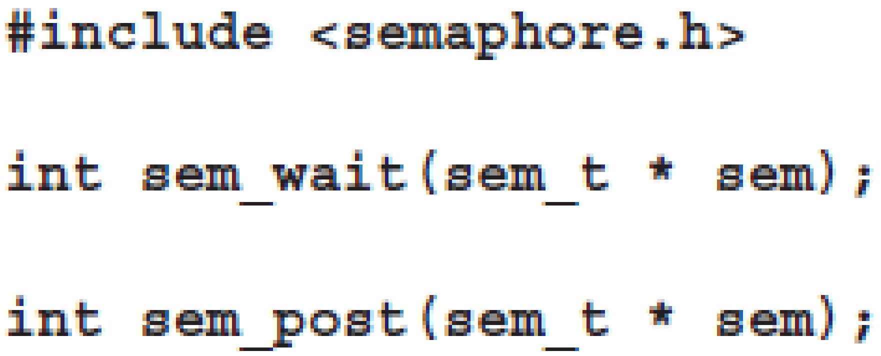
Chapter 14

SEMAPHORES

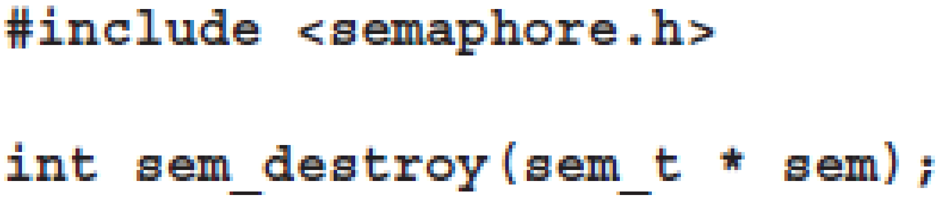
Semaphores in Thread



```
#include <semaphore.h>

int sem_init(sem_t *sem, int pshared, unsigned int value);
```

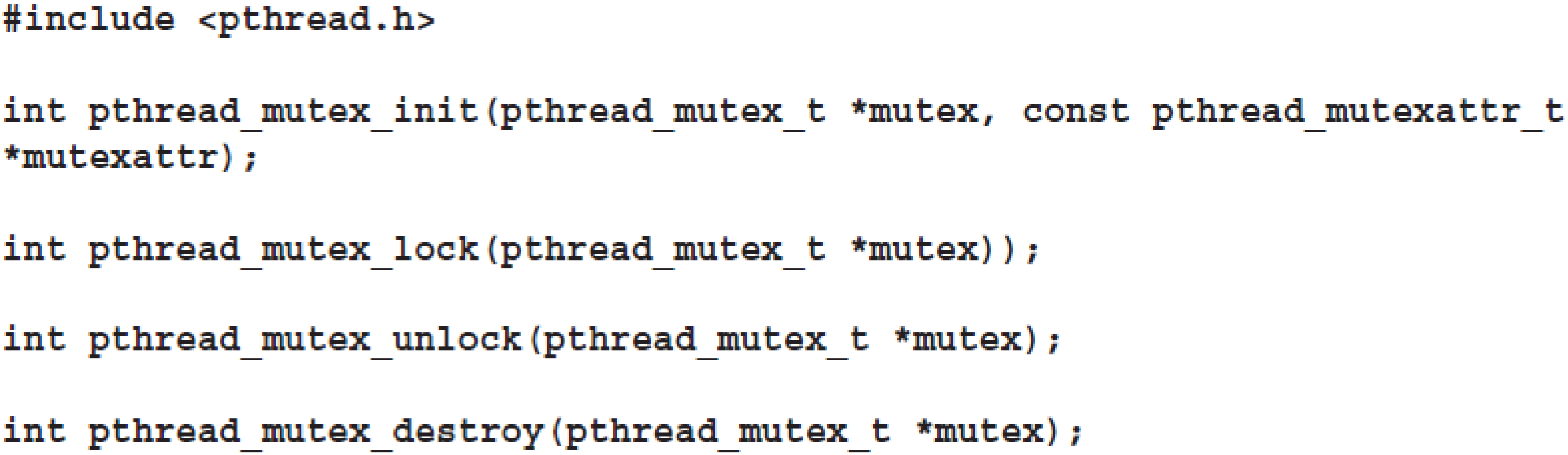


```
#include <semaphore.h>

int sem_wait(sem_t * sem);

int sem_post(sem_t * sem);
```



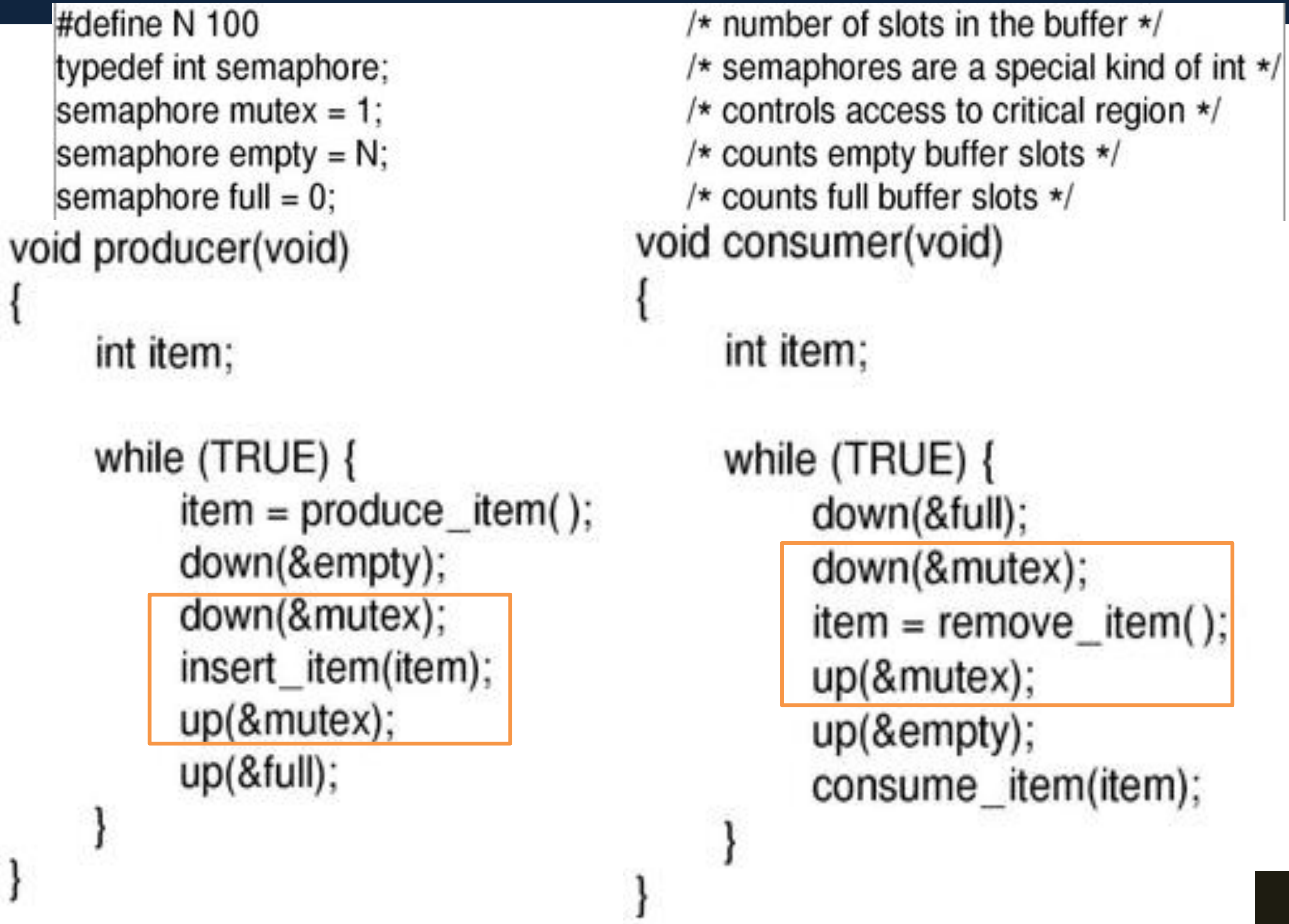
```
#include <semaphore.h>

int sem_destroy(sem_t * sem);
```

Mutex



```
#include <pthread.h>

int pthread_mutex_init(pthread_mutex_t *mutex, const pthread_mutexattr_t
*mutexattr);

int pthread_mutex_lock(pthread_mutex_t *mutex));

int pthread_mutex_unlock(pthread_mutex_t *mutex);

int pthread_mutex_destroy(pthread_mutex_t *mutex);
```

Producer & consumer



```
#define N 100                          /* number of slots in the buffer */
typedef int semaphore;                 /* semaphores are a special kind of int */
semaphore mutex = 1;                   /* controls access to critical region */
semaphore empty = N;                   /* counts empty buffer slots */
semaphore full = 0;                    /* counts full buffer slots */
```

```
void producer(void)
{
     int item;

     while (TRUE) {
          item = produce_item( );
          down(&empty);
          down(&mutex);
          insert_item(item);
          up(&mutex);
          up(&full);
     }
}
```

```
void consumer(void)
{
     int item;

     while (TRUE) {
          down(&full);
          down(&mutex);
          item = remove_item( );
          up(&mutex);
          up(&empty);
          consume_item(item);
     }
}
```