National Textile University

Department of Computer Science

Subject:

Operating System

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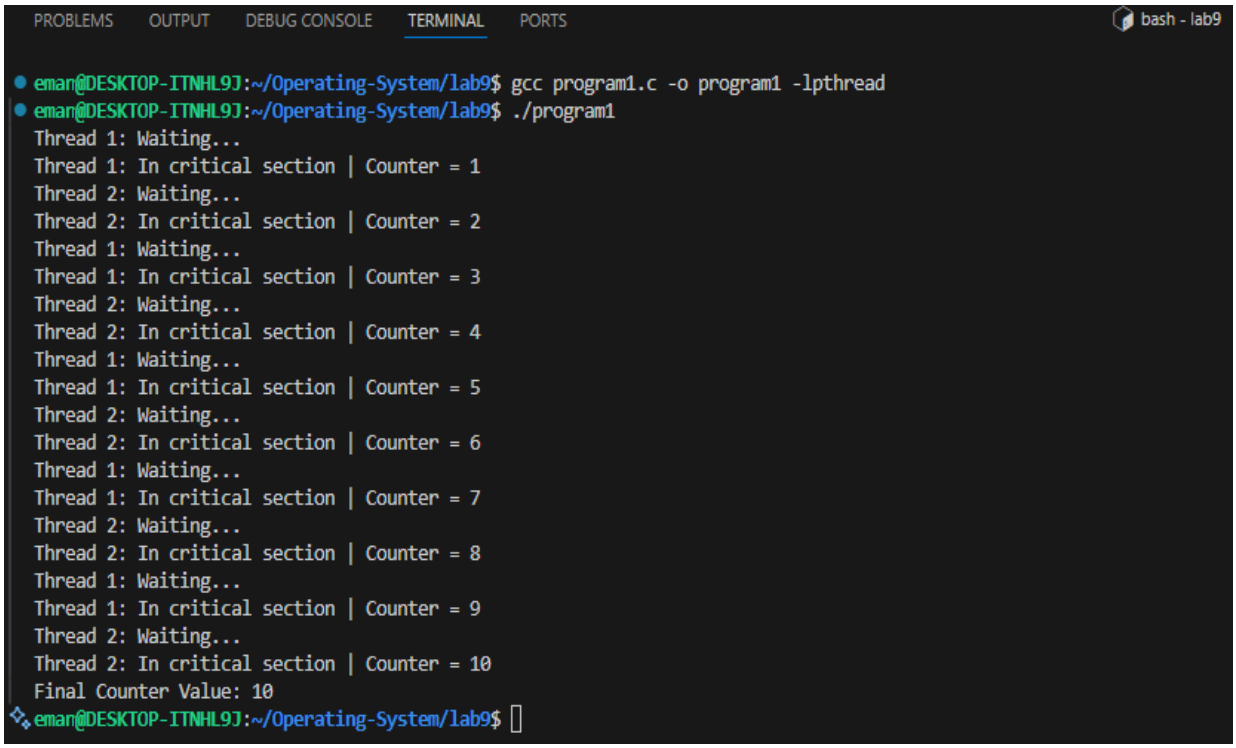
Semester:

05

Semaphore Operations

```c
#include <stdio.h>
#include <pthread.h>
#include <semaphore.h>
#include <unistd.h>
sem_t mutex; // Binary semaphore
int counter = 0;
void* thread_function(void* arg) {
int id = *(int*)arg;
for (int i = 0; i < 5; i++) {
printf("Thread %d: Waiting...\n", id);
sem_wait(&mutex); // Acquire
// Critical section
counter++;
printf("Thread %d: In critical section | Counter = %d\n", id,
counter);
sleep(1);
sem_post(&mutex); // Release
sleep(1);
}
return NULL;
}
int main() {
sem_init(&mutex, 0, 1); // Binary semaphore initialized to 1
pthread_t t1, t2;
int id1 = 1, id2 = 2;
pthread_create(&t1, NULL, thread_function, &id1);
pthread_create(&t2, NULL, thread_function, &id2);
pthread_join(t1, NULL);
pthread_join(t2, NULL);
printf("Final Counter Value: %d\n", counter);
sem_destroy(&mutex);
return 0;
}
```

Terminal:


PROBLEMS
OUTPUT
DEBUG CONSOLE
TERMINAL
PORTS
bash - lab9
eman@DESKTOP-ITNHL9J:~/Operating-System/lab9$ gcc program1.c -o program1 -lpthread
eman@DESKTOP-ITNHL9J:~/Operating-System/lab9$ ./program1
Thread 1: Waiting...
Thread 1: In critical section | Counter = 1
Thread 2: Waiting...
Thread 2: In critical section | Counter = 2
Thread 1: Waiting...
Thread 1: In critical section | Counter = 3
Thread 2: Waiting...
Thread 2: In critical section | Counter = 4
Thread 1: Waiting...
Thread 1: In critical section | Counter = 5
Thread 2: Waiting...
Thread 2: In critical section | Counter = 6
Thread 1: Waiting...
Thread 1: In critical section | Counter = 7
Thread 2: Waiting...
Thread 2: In critical section | Counter = 8
Thread 1: Waiting...
Thread 1: In critical section | Counter = 9
Thread 2: Waiting...
Thread 2: In critical section | Counter = 10
Final Counter Value: 10
eman@DESKTOP-ITNHL9J:~/Operating-System/lab9$

Initializing Semaphore with 0:

Explanation: As we have initialized with 0 the threads will be blocked ie both will keep waiting

```c
#include <stdio.h>
#include <pthread.h>
#include <semaphore.h>
#include <unistd.h>
sem_t mutex; // Binary semaphore
int counter = 0;
void* thread_function(void* arg) {
int id = *(int*)arg;
for (int i = 0; i < 5; i++) {
printf("Thread %d: Waiting...\n", id);
sem_wait(&mutex); // Acquire
// Critical section
counter++;
printf("Thread %d: In critical section | Counter = %d\n", id,
counter);
sleep(1);
sem_post(&mutex); // Release
sleep(1);
}
return NULL;
}
int main() {
sem_init(&mutex, 0, 0); // Binary semaphore initialized to 1
pthread_t t1, t2;
int id1 = 1, id2 = 2;
pthread_create(&t1, NULL, thread_function, &id1);
pthread_create(&t2, NULL, thread_function, &id2);
pthread_join(t1, NULL);
pthread_join(t2, NULL);
printf("Final Counter Value: %d\n", counter);
sem_destroy(&mutex);
return 0;
}

```

Terminal:

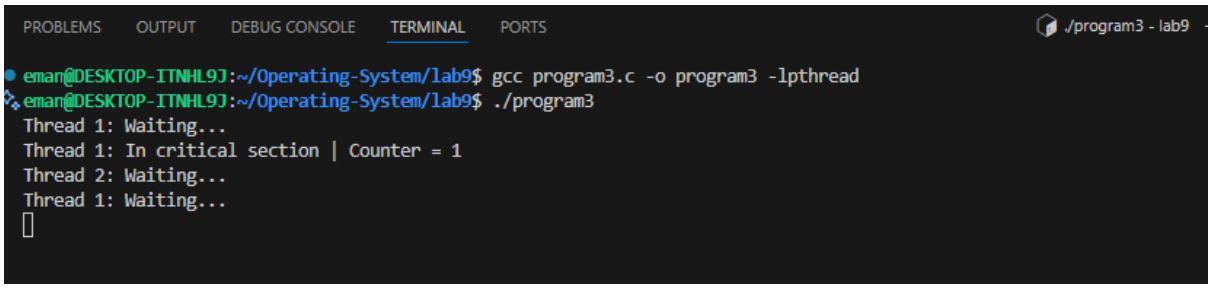
Commenting Post:

If you comment out `sem_post()`, the thread **never releases the semaphore**, so the second thread can **never enter the critical section**.
This causes the program to **freeze (deadlock)** forever.

```
#include <stdio.h>
#include <pthread.h>
#include <semaphore.h>
#include <unistd.h>
sem_t mutex; // Binary semaphore
int counter = 0;
void* thread_function(void* arg) {
int id = *(int*)arg;
for (int i = 0; i < 5; i++) {
printf("Thread %d: Waiting...\n", id);
sem_wait(&mutex); // Acquire
// Critical section
counter++;
printf("Thread %d: In critical section | Counter = %d\n", id,
counter);
sleep(1);
//sem_post(&mutex); // Release
sleep(1);
}
return NULL;
}
int main() {
sem_init(&mutex, 0, 1); // Binary semaphore initialized to 1
pthread_t t1, t2;
int id1 = 1, id2 = 2;
pthread_create(&t1, NULL, thread_function, &id1);
pthread_create(&t2, NULL, thread_function, &id2);
```

```
pthread_join(t1, NULL);
pthread_join(t2, NULL);
printf("Final Counter Value: %d\n", counter);
sem_destroy(&mutex);
return 0;
}
```

Terminal:

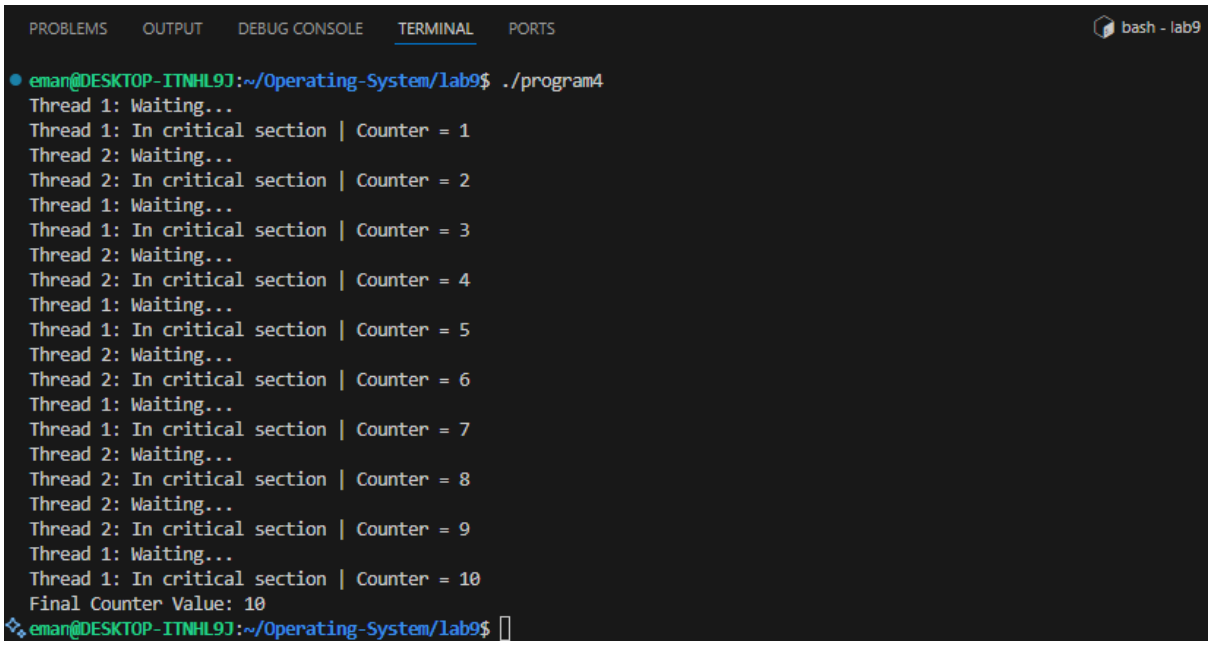


Commenting Wait:

```
#include <stdio.h>
#include <pthread.h>
#include <semaphore.h>
#include <unistd.h>
sem_t mutex; // Binary semaphore
int counter = 0;
void* thread_function(void* arg) {
int id = *(int*)arg;
for (int i = 0; i < 5; i++) {
printf("Thread %d: Waiting...\n", id);
//sem_wait(&mutex); // Acquire
// Critical section
counter++;
printf("Thread %d: In critical section | Counter = %d\n", id,
counter);
sleep(1);
sem_post(&mutex); // Release
sleep(1);
}
return NULL;
}
int main() {
sem_init(&mutex, 0, 1); // Binary semaphore initialized to 1
pthread_t t1, t2;
int id1 = 1, id2 = 2;
pthread_create(&t1, NULL, thread_function, &id1);
pthread_create(&t2, NULL, thread_function, &id2);
```

```
pthread_join(t1, NULL);
pthread_join(t2, NULL);
printf("Final Counter Value: %d\n", counter);
sem_destroy(&mutex);
return 0;
}
```

Terminal:



Creating Two thread Functions:

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

sem_t mutex; // Binary semaphore
int counter = 0;

// Thread that increments counter
void* increment_thread(void* arg) {
    int id = *(int*)arg;

    for (int i = 0; i < 5; i++) {
        printf("Thread %d: Waiting to increment...\n", id);

        sem_wait(&mutex); // acquire
```

```
        counter++;
        printf("Thread %d: Incremented | Counter = %d\n", id, counter);

        sleep(1);
        sem_post(&mutex); // release
        sleep(1);
    }
    return NULL;
}

// Thread that decrements counter
void* decrement_thread(void* arg) {
    int id = *(int*)arg;

    for (int i = 0; i < 5; i++) {
        printf("Thread %d: Waiting to decrement...\n", id);

        sem_wait(&mutex); // acquire

        counter--;
        printf("Thread %d: Decremented | Counter = %d\n", id, counter);

        sleep(1);
        sem_post(&mutex); // release
        sleep(1);
    }
    return NULL;
}

int main() {
    sem_init(&mutex, 0, 1);   // semaphore = 1

    pthread_t t1, t2;
    int id1 = 1, id2 = 2;

    pthread_create(&t1, NULL, increment_thread, &id1);
    pthread_create(&t2, NULL, decrement_thread, &id2);

    pthread_join(t1, NULL);
    pthread_join(t2, NULL);

    printf("Final Counter Value: %d\n", counter);

    sem_destroy(&mutex);
return 0;
}
```

Terminal:

```
PROBLEMS   OUTPUT   DEBUG CONSOLE   TERMINAL   PORTS                                   bash - lab9

● eman@DESKTOP-ITNHL9J:~/Operating-System/lab9$ gcc program5.c -o program5 -lpthread
● eman@DESKTOP-ITNHL9J:~/Operating-System/lab9$ ./program5
  Thread 1: Waiting to increment...
  Thread 1: Incremented | Counter = 1
  Thread 2: Waiting to decrement...
  Thread 2: Decremented | Counter = 0
  Thread 1: Waiting to increment...
  Thread 1: Incremented | Counter = 1
  Thread 2: Waiting to decrement...
  Thread 2: Decremented | Counter = 0
  Thread 1: Waiting to increment...
  Thread 1: Incremented | Counter = 1
  Thread 2: Waiting to decrement...
  Thread 2: Decremented | Counter = 0
  Thread 1: Waiting to increment...
  Thread 1: Incremented | Counter = 1
  Thread 2: Waiting to decrement...
  Thread 2: Decremented | Counter = 0
  Thread 1: Waiting to increment...
  Thread 1: Incremented | Counter = 1
  Thread 2: Waiting to decrement...
  Thread 2: Decremented | Counter = 0
  Final Counter Value: 0
  eman@DESKTOP-ITNHL9J:~/Operating-System/lab9$
```

Difference between Semaphore and Mutex:

Feature	Mutex	Semaphore
Meaning	A lock	A signaling mechanism (counter)
Ownership	**Owned by a thread** – only the thread that locked it can unlock it	**Not owned** – any thread can signal (V) or wait (P)
Value	Only **0 or 1** (binary)	Can be **0, 1, 2, … N** (counting)
Purpose	Protect **a shared resource**	Control **access to multiple resources** or coordination
When used?	When **only ONE thread** should access a critical section	When **multiple threads** can access up to a limit
Deadlock risk	Higher (if same thread doesn't unlock)	Lower
Example use	Protect a shared variable	Limit access to database connections (e.g., only 10 allowed)