National Textile University

Department of Computer Science

Subject:

Operating Systems

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Example 1:

Code:

```c
#include <stdio.h>
#include <pthread.h>
#include <semaphore.h>
#include <unistd.h>
sem_t parking_spaces;
void* car(void* arg) {
int id = *(int*)arg;
printf("Car %d is trying to park...\n", id);
sem_wait(&parking_spaces); // Try to get a space
printf("Car %d parked successfully!\n", id);
sleep(2); // Stay parked for 2 seconds
printf("Car %d is leaving.\n", id);
sem_post(&parking_spaces); // Free the space
return NULL;
}
int main() {
pthread_t cars[10];
int ids[10];
// Initialize: 3 parking spaces available
sem_init(&parking_spaces, 0, 3);
// Create 10 cars (more than spaces!)
for(int i = 0; i < 10; i++) {
ids[i] = i + 1;
pthread_create(&cars[i], NULL, car, &ids[i]);
}
// Wait for all cars
for(int i = 0; i < 10; i++) {
pthread_join(cars[i], NULL);
}
sem_destroy(&parking_spaces);
return 0;
}
```

Output:

Demonstration:

In this parking lot simulation program, we have 3 parking spaces initialized as `sem_init(&parking_spaces, 0, 3)` . 10 cars are trying to park. These threads are created as `pthread_t cars[10]`. To avoid the racing condition for this program, we have a car function, in which we have used `sem_wait(&parking_spaces)` and `sem_post(&parking_spaces)`.

`sem_wait(&parking_spaces)` ensures that:

- If a parking space is available, the cards park and decrement the parking spaces.
- If no space is available and parking spaces ==0 then cars wait until the space is free.

`sem_post(&parking_spaces)` ensures that:

The car leaves and frees up the space and increments parking spaces.

As a result, 3 cars park while other 7wait until the parking spaces are free.

Example 2:

Code:

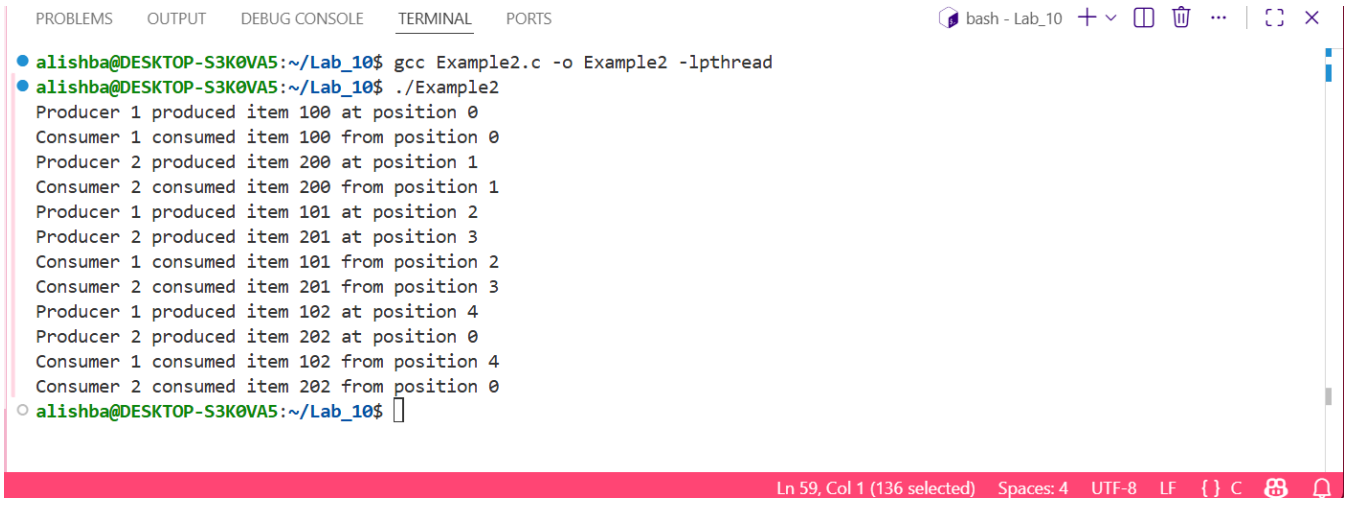
```
#include <stdio.h>
```

```c
#include <pthread.h>
#include <semaphore.h>
#include <unistd.h>
#define BUFFER_SIZE 5
int buffer[BUFFER_SIZE];
int in = 0; // Producer index
int out = 0; // Consumer index
sem_t empty; // Counts empty slots
sem_t full; // Counts full slots
pthread_mutex_t mutex;
void* producer(void* arg) {
int id = *(int*)arg;
for(int i = 0; i < 3; i++) { // Each producer makes 3 items
int item = id * 100 + i;
// TODO: Wait for empty slot
sem_wait(&empty);
// TODO: Lock the buffer
pthread_mutex_lock(&mutex);
// Add item to buffer
buffer[in] = item;
printf("Producer %d produced item %d at position %d\n",
id, item, in);
in = (in + 1) % BUFFER_SIZE;
// TODO: Unlock the buffer
pthread_mutex_unlock(&mutex);
// TODO: Signal that buffer has a full slot
sem_post(&full);
sleep(1);
}
return NULL;
}
void* consumer(void* arg) {
int id = *(int*)arg;
for(int i = 0; i < 3; i++) {
// TODO: Students complete this similar to producer
sem_wait(&full);
pthread_mutex_lock(&mutex);
int item = buffer[out];
printf("Consumer %d consumed item %d from position %d\n",
id, item, out);
out = (out + 1) % BUFFER_SIZE;
pthread_mutex_unlock(&mutex);
sem_post(&empty);
sleep(2); // Consumers are slower
}
```

```
 return NULL;
 }

 int main() {
pthread_t prod[2], cons[2];
 int ids[2] = {1, 2};
 // Initialize semaphores
 sem_init(&empty, 0, BUFFER_SIZE); // All slots empty initially
 sem_init(&full, 0, 0);
 pthread_mutex_init(&mutex, NULL);
 // No slots full initially
 // Create producers and consumers
 for(int i = 0; i < 2; i++) {
 pthread_create(&prod[i], NULL, producer, &ids[i]);
 pthread_create(&cons[i], NULL, consumer, &ids[i]);
 }
 // Wait for completion
 for(int i = 0; i < 2; i++) {
 pthread_join(prod[i], NULL);
 pthread_join(cons[i], NULL);
 }
 // Cleanup
 sem_destroy(&empty);
 sem_destroy(&full);
 pthread_mutex_destroy(&mutex);
 return 0;
}
```

Output:



Demonstration:

- In this producer consumer problem, we have a buffer whose size is specified to 5.
- We have 2 semaphores initialized as empty and full.
- Empty semaphore counts empty slots in the buffer. Initially all slots are empty and size of empty is same as buffer size.
- We have 2 producer threads and 2 consumer threads. One producer thread produces three items as 100, 101 and 102 and other as 200, 201 and 202. 2 consumer threads run three times to consume total of 6 items.
- In producer function, `sem_wait(&empty) decrements the empty slots, lock the mutex and go into critical section to produce the item. After that mutex is unlocked and sem_post(&full) increments the full slots which indicates that some items are produced by producer threads.`
- In consumer function, `sem_wait(&full) decrements the full slots, lock the mutex, go into critical section and consumes the items. After that mutex is unlocked and sem_post(&empty) increments the empty slots which indicates that some items are consumed by consumer threads.`
- In this loop `for(int i = 0; i < 3; i++)` in consumer function, if i<4, each consumer will try to consume 4 items, total of 8 items, but only 6 items are being produced. The last 2 consumers waits and block forever which is a deadlock condition.