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18. Construct a C program to simulate producer-consumer problem using semaphores.

AIM:

To construct a C program to simulate the Producer-Consumer problem using semaphores, ensuring synchronization between the producer and consumer processes while preventing race conditions and buffer overflows or underflows.

ALGORITHM:

1. Initialization:

- Define a shared buffer with a fixed size.
- Initialize three semaphores:
 - empty: Counts the number of available slots in the buffer (initially equal to the buffer size).
 - full: Counts the number of filled slots in the buffer (initially zero).
 - mutex: Ensures mutual exclusion for buffer access (initialized to 1).

2. Producer Process:

- Repeatedly execute the following steps:
 1. Wait (sem_wait) on the empty semaphore to ensure a free slot is available.
 2. Wait (sem_wait) on the mutex semaphore to gain exclusive access to the buffer.
 3. Produce an item and place it in the buffer.
 4. Signal (sem_post) the mutex semaphore to release the buffer.
 5. Signal (sem_post) the full semaphore to indicate a filled slot.

3. Consumer Process:

- Repeatedly execute the following steps:
 1. Wait (sem_wait) on the full semaphore to ensure a filled slot is available.
 2. Wait (sem_wait) on the mutex semaphore to gain exclusive access to the buffer.
 3. Remove an item from the buffer for consumption.
 4. Signal (sem_post) the mutex semaphore to release the buffer.
 5. Signal (sem_post) the empty semaphore to indicate a free slot.

4. Concurrent Execution:

- Create separate threads for the producer and consumer processes.
- Ensure both threads run concurrently and modify the shared buffer as per their respective logic.

5. Termination:

- Stop the producer and consumer threads after a predefined number of operations or based on user input.
- Destroy all semaphores to release system resources.

PROCEDURE:

1. Start:

Initialize necessary variables, shared buffer, and semaphores.

2. Define Semaphores:

- Create a semaphore empty initialized to the buffer size to track available slots.
- Create a semaphore full initialized to 0 to track filled slots.

- Create a semaphore mutex initialized to 1 to enforce mutual exclusion.
- 3. **Define Shared Buffer:**
 - Set up a circular buffer with a fixed size.
 - Use in and out pointers to manage the producer and consumer operations.
- 4. **Create Producer Thread:**
 - In the producer thread:
 - Wait on empty and mutex semaphores.
 - Produce an item and insert it into the buffer at the in index.
 - Update the in index to the next position in a circular manner.
 - Signal the mutex and full semaphores to indicate a successful operation.
- 5. **Create Consumer Thread:**
 - In the consumer thread:
 - Wait on full and mutex semaphores.
 - Consume an item from the buffer at the out index.
 - Update the out index to the next position in a circular manner.
 - Signal the mutex and empty semaphores to indicate a successful operation.
- 6. **Run Threads Concurrently:**
 - Execute both producer and consumer threads concurrently using pthread_create.
- 7. **Synchronization:**
 - Ensure that both threads operate in sync by using semaphores to handle mutual exclusion and resource tracking.
- 8. **Stop and Cleanup:**
 - Terminate the threads after a fixed number of operations.
 - Destroy the semaphores to release resources.
- 9. **End:**
 - Stop the program after all operations are completed.

CODE:

```
#include <stdio.h>
#include <stdlib.h>
#include <pthread.h>
#include <semaphore.h>
#ifdef _WIN32
#include <windows.h> // For Sleep on Windows
#else
#include <unistd.h> // For sleep on Unix-like systems
#endif

#define BUFFER_SIZE 5

int buffer[BUFFER_SIZE];
int in = 0, out = 0;

sem_t empty, full, mutex;
```

```

void *producer(void *param) {
    int item;
    while (1) {
        item = rand() % 100;
        sem_wait(&empty);
        sem_wait(&mutex);

        buffer[in] = item;
        in = (in + 1) % BUFFER_SIZE;

        printf("Produced: %d\n", item);

        sem_post(&mutex);
        sem_post(&full);

#ifdef _WIN32
        Sleep(1000); // Sleep for 1 second on Windows
#else
        sleep(1); // Sleep for 1 second on Unix-like systems
#endif
    }
}

```

```

void *consumer(void *param) {
    int item;
    while (1) {
        sem_wait(&full);
        sem_wait(&mutex);

        item = buffer[out];
        out = (out + 1) % BUFFER_SIZE;

        printf("Consumed: %d\n", item);

        sem_post(&mutex);
        sem_post(&empty);

#ifdef _WIN32
        Sleep(1000); // Sleep for 1 second on Windows
#else
        sleep(1); // Sleep for 1 second on Unix-like systems
#endif
    }
}

```

```

int main() {

```

```
pthread_t prod, cons;

sem_init(&empty, 0, BUFFER_SIZE);
sem_init(&full, 0, 0);
sem_init(&mutex, 0, 1);


pthread_create(&prod, NULL, producer, NULL);
pthread_create(&cons, NULL, consumer, NULL);


pthread_join(prod, NULL);
pthread_join(cons, NULL);

sem_destroy(&empty);
sem_destroy(&full);
sem_destroy(&mutex);

return 0;
}
```

OUTPUT:

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Produced: 83
Consumed: 83
Produced: 86
Consumed: 86
Produced: 77
Consumed: 77
Produced: 15
Consumed: 15
Produced: 93
Consumed: 93
Produced: 35
Consumed: 35
Produced: 86
Consumed: 86
Produced: 92
Consumed: 92
Produced: 49
Consumed: 49
Produced: 21
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Consumed: 27
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Consumed: 90
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Consumed: 59
Produced: 63
Consumed: 63
Produced: 26
Consumed: 26
Produced: 40
Consumed: 40
Produced: 26
Consumed: 26
Produced: 72
Consumed: 72
Produced: 36
Consumed: 36
Produced: 11

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