National Textile University

Department of Computer Science

Subject: Operating System

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After Mid's first Homework

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Operating Systems – COC 3071

SE 5th A – Fall 2025

After-mid Homework -1

Part 1: Semaphore theory

1. A counting semaphore is initialized to 7. If 10 wait() and 4 signal() operations are performed, find the final value of the semaphore.

   Initial value = 7

   - 10 wait() → 7 − 10 = **−3**
   - 4 signal() → −3 + 4 = **1**
   - Semaphore value is 1

2. A semaphore starts with value 3. If 5 wait() and 6 signal() operations occur, calculate the resulting semaphore value.

   Initial value = 3

   - 5 wait() → 3 − 5 = **−2**
   - 6 signal() → −2 + 6 = **4**
   - Final semaphore value **= 4**

3. A semaphore is initialized to 0. If 8 signal() followed by 3 wait() operations are executed, find the final value.

   Initial value = 0

   - 8 signal() → 0 + 8 = **8**
   - 3 wait() → 8 − 3 = **5**
   - Final semaphore value **= 5**

4. A semaphore is initialized to 2. If 5 wait() operations are executed:

   Initial value = 2

- 5 wait() operations

a) How many processes enter the critical section?

- Only **2** processes can enter (value becomes 0)

b) How many processes are blocked?

Remaining waits = 5 − 2 = **3 blocked**

Answer:

- Enter CS = **2**
- Blocked = **3**

5. A semaphore starts at 1. If 3 wait() and 1 signal() operations are performed:

Initial value = 1

- 3 wait() → 1 − 3 = **−2**
- 1 signal() → −2 + 1 = **−1**

a) Processes blocked

- Semaphore −1 → **1 process blocked**

b) Final value

- **Final semaphore value = −1**

6.

semaphore S = 3;

wait(S) =2
wait(S)=1

signal(S)=2
wait(S)=1

wait(S)=0

a) How many processes enter the critical section?

- Semaphore never goes negative → **5 processes enter**

b) What is the final value of S?

- S=0

7.

semaphore S = 1;

S = 1
wait(S) → 0
wait(S) → -1 (blocked)
signal(S) → 0 (one wakes)
signal(S) → 1

a) How many processes are blocked?
Only one
b) What is the final value of S?
One (s=1)

8.
A binary semaphore is initialized to 1. Five wait() operations are executed without any signal(). How many processes enter the critical section and how many are blocked?

Binary semaphore = 1

- 5 wait() without signal
- 1 process enters CS
- Remaining 4 are blocked

Answer:

- Enter CS = **1**
- Blocked = **4**

9.A counting semaphore is initialized to 4. If 6 processes execute wait() simultaneously, how many proceed and how many are blocked?

Initial value = 4

- 6 wait() simultaneously
- 4 proceed
- 6 − 4 = **2 blocked**

Answer:

- Proceed = **4**
- Blocked = **2**

10.A semaphore S is initialized to 2.

a) Track the semaphore value after each operation.
   - wait(S)=1
   - wait(S)=0
   - wait(S)=-1 (blocked)
   - signal(S)=0
   - signal(S)=1
   - wait(S)=0

b) How many processes were blocked at any time?
   - One process was blocked

11. A semaphore is initialized to 0. Three processes execute wait() before any signal(). Later, 5 signal() operations are executed.

Initial value = 0

- 3 processes wait() → **3 blocked**
- 5 signal() operations

a) How many processes wake up?
   3 processes wake up
b) What is the final semaphore value?
   Semaphore value=2

Part 2: Semaphore Coding

Consider the Producer–Consumer problem using semaphores as implemented in Lab-10 (Lab-plan attached). Rewrite the program in your own coding style, compile and execute it successfully, and explain the working of the code in your own words.

Submission Requirements:

- Your rewritten source code
- A brief description of how the code works
- Screenshots of the program output showing successful execution

Code:

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

#define BUF_SIZE 5
#define PRODUCE_COUNT 3
#define THREADS 2

// Shared buffer and indices
int sharedBuffer[BUF_SIZE];
int writeIndex = 0;
int readIndex = 0;

// Synchronization primitives
sem_t semEmptySlots;
sem_t semFilledSlots;
pthread_mutex_t bufferLock;

// Producer thread function
void* producerTask(void* arg) {
    int producerId = *(int*)arg;

    for (int i = 0; i < PRODUCE_COUNT; i++) {
        int data = producerId * 100 + i;

        // Wait until an empty slot is available
        sem_wait(&semEmptySlots);

        // Lock buffer before accessing it
```

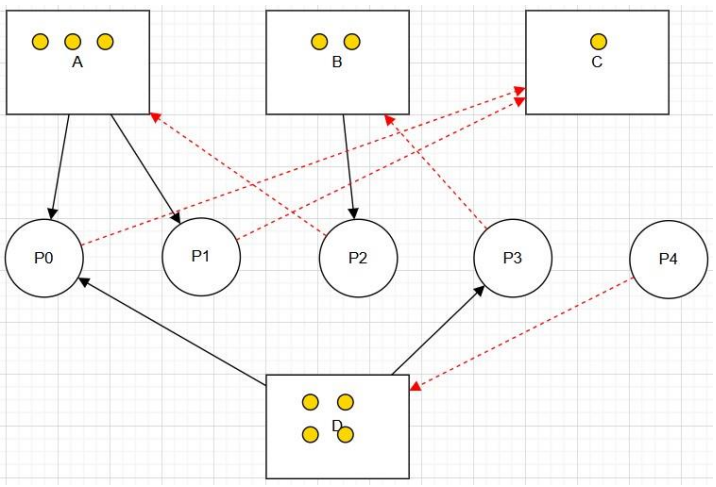
```
        pthread_mutex_lock(&bufferLock);

        sharedBuffer[writeIndex] = data;
        printf("Producer %d produced %d at index %d\n",
               producerId, data, writeIndex);

        writeIndex = (writeIndex + 1) % BUF_SIZE;

        // Unlock buffer
        pthread_mutex_unlock(&bufferLock);

        // Signal that a new item is available
        sem_post(&semFilledSlots);

        sleep(1);
    }
    return NULL;
}

// Consumer thread function
void* consumerTask(void* arg) {
    int consumerId = *(int*)arg;

    for (int i = 0; i < PRODUCE_COUNT; i++) {

        // Wait until a filled slot is available
        sem_wait(&semFilledSlots);

        // Lock buffer before accessing it
        pthread_mutex_lock(&bufferLock);

        int data = sharedBuffer[readIndex];
        printf("Consumer %d consumed %d from index %d\n",
               consumerId, data, readIndex);

        readIndex = (readIndex + 1) % BUF_SIZE;

        // Unlock buffer
        pthread_mutex_unlock(&bufferLock);

        // Signal that a slot is now empty
        sem_post(&semEmptySlots);

        sleep(2); // Consumer is slower
    }
```

```
    return NULL;
}

int main() {
    pthread_t producers[THREADS], consumers[THREADS];
    int threadIds[THREADS] = {1, 2};

    // Initialize semaphores and mutex
    sem_init(&semEmptySlots, 0, BUF_SIZE);
    sem_init(&semFilledSlots, 0, 0);
    pthread_mutex_init(&bufferLock, NULL);

    // Create producer and consumer threads
    for (int i = 0; i < THREADS; i++) {
        pthread_create(&producers[i], NULL, producerTask, &threadIds[i]);
        pthread_create(&consumers[i], NULL, consumerTask, &threadIds[i]);
    }

    // Wait for threads to finish
    for (int i = 0; i < THREADS; i++) {
        pthread_join(producers[i], NULL);
        pthread_join(consumers[i], NULL);
    }

    // Cleanup resources
    sem_destroy(&semEmptySlots);
    sem_destroy(&semFilledSlots);
    pthread_mutex_destroy(&bufferLock);

    return 0;
}
```

Terminal:

Part 3: RAG (Recourse Allocation Graph)

- Convert the following graph into matrix table ,



a) Allocation matrix

Process	A	B	C	D
P0	1	0	0	1
P1	1	0	0	0
P2	0	1	0	0
P3	0	0	1	1
P4	0	0	0	0

b) Request matrix

Process	A	B	C	D
P0	0	0	0	0
P1	1	0	1	0
P2	1	0	1	0
P3	0	1	0	0
P4	0	0	0	1

Part 4: Banker's Algorithm

System Description:

- The system comprises five processes (P0–P3) and four resources (A,B,C,D).
- Total Existing Resources:

Total			
A	B	C	D
6	4	4	2

- Snapshot at the initial time stage:

	Allocation				Max				Need			
	A	B	C	D	A	B	C	D	A	B	C	D
P0	2	0	1	1	3	2	1	1				
P1	1	1	0	0	1	2	0	2				
P2	1	0	1	0	3	2	1	0				
P3	0	1	0	1	2	1	0	1				

Questions:

1. **Compute the Available Vector**:
    - Calculate the available resources for each type of resource.

Total resources:

A=0,B=4,C=4,D=2

a) Available matrix

Total allocated:

- A: 2 + 1 + 1 + 0 = 4
- B: 0 + 1 + 0 + 1 = 2
- C: 1 + 0 + 1 + 0 = 2
- D: 1 + 0 + 0 + 1 = 2

Total - total allocated

- A: 6 - 4 = 2
- B: 4 - 2 = 2
- C: 4 - 2 = 2
- D: 2 - 2 = 0

Available Vector: [2,2,2,0]

2. **Compute the Need Matrix**:

   • Determine the need matrix by subtracting the allocation matrix from the maximum matrix.

The **Need Matrix** is calculated using the formula: Need = Max - Allocation.

Process	**Max (A B C D)**	**Allocation (A B C D)**	**Need (A B C D)**
P0	3 2 1 1	2 0 1 1	**1 2 0 0**
P1	1 2 0 2	1 1 0 0	**0 1 0 2**
P2	3 2 1 0	1 0 1 0	**2 2 0 0**
P3	2 1 0 1	0 1 0 1	**2 0 0 0**

3. **Safety Check**:

- Determine if the current allocation state is safe. If so, provide a safe sequence of the processes.
- Show how the Available (working array) changes as each process terminates.

To determine if the state is safe, we find a sequence where each process's **Need** <= **Available**. Once a process finishes, it releases its **Allocation** back to the **Available** pool.

Step	**Process**	**Need**	**Available (Work)**	**Can it run?**	**New Available (Work + Allocation)**

1	**P0**	[1, 2, 0, 0]	[2, 2, 2, 0]	**Yes**	[2,2,2,0] + [2,0,1,1]={[4, 2, 3, 1]}
2	**P2**	[2, 2, 0, 0]	[4, 2, 3, 1]	**Yes**	[4,2,3,1] + [1,0,1,0]={[5, 2, 4, 1]}
3	**P3**	[2, 0, 0, 0]	[5, 2, 4, 1]	**Yes**	[5,2,4,1] + [0,1,0,1]={[5, 3, 4, 2]}
4	**P1**	[0, 1, 0, 2]	[5, 3, 4, 2]	**Yes**	[5,3,4,2] + [1,1,0,0] ={[6, 4, 4, 2]}

Yes. **Safe Sequence:** {P0, P2, P3, P1}