National University of Computer and Emerging Sciences

Karachi Campus

Operating Systems (CS 2006)

Final Exam

Date: May 20, 2024

Total Time (Hrs.): 3

Total Marks: 50

Total Questions: 5

Course Instructor(s)

Dr. Nadeem Kafi, Dr. Nausheen Shoaib, Dr. Shahbaz Siddiqui, Ms. Anaum Hamid, Ms. Safia Baloch, Ms. Mubashra Fayyaz, Ms. Atiya Jokhio, Mr. Minhal Raza, Ms. Saeeda, Ms. Hania Shah

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Roll No Section Student Signature

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Attempt all the questions in order. Carefully read and follow all instructions. Each violation shall be penalized.

CLO # 4 - Understand synchronization and deadlocks. Implement synchronization using Mutex/Semaphores.

Q1. [15 marks] *Instruction: Write answers as bullets points.*

a) Consider a ticket booking system where the available number of tickets for each program must be maintained. A person who wishes to book a ticket calls the bookTicket() function, which checks if tickets are available and then decreases the available tickets count by one. This is illustrated in the code shown. Now **explain** how a race condition is possible in this situation. Also, **show a Pthread library-based C program** that avoids race condition using a mutex. [1 + 3]

```
void bookTicket() {
    if (availableTickets > 0)
        availableTickets--;
}
```

b) Explain **synchronization issue(s)** in producer and consumer in a producer-consumer problem. Write and explain C code snippets that use two types of semaphores as a solution for this problem. [2+2]

c) Write answers to the following questions:

i. Why **hardware atomic instructions** are necessary in the implementation of locking primitives? [1]

ii. How do two threads become deadlocked while accessing resources? **Write C code snippet using semaphores** and a step-by-step explanation for any scenario. [3]

d) How busy waiting is implemented during synchronization? **Write two C code snippets** showing two different methods. **Also, explain the working of any one snippet using a dry** run with variable values. Assume two processes where one is executing in its critical section and other is waiting [2 + 1].

CLO # 5 - Understand virtual memory and its management.

Q2. [15 marks] *Instruction: Write answers as bullets points. Make suitable assumptions, if needed.*

a) Explain **external** fragmentation in main memory **using a labeled diagram**. What causes **internal** fragmentation in a page? Explain with an example. [2 + 1]

b) Page faults are critical in a virtual memory system.

i. **Explain** Page fault processing **using a labelled diagram.** [2]

ii. In a computer system, memory access time is 40 nanoseconds and hard disk access time is 1.25 milliseconds. Calculate effective memory access time if page fault probability is 0.000025. [2]

c) LRU is one of the many page replacement algorithms. Explain its two implementations as follows:

i. Use a labelled diagram and stepwise hints to **describe clock (second chance) algorithm**. Show it does approximate LRU functionality. [2]

ii. Now, **enhance** the above algorithm to ensure that dirty victim pages are flushed to memory before reuse. [2]

d) Suppose a program is accessing main memory in a virtual memory system having a page size of 2K.
   i. State the difference between paged and demand paged memory system? [1]
   ii. Show a labelled diagram which show how a virtual memory address generated by a program is translated into a physical address. Now, in your diagram, assume suitable values for page number and page offset and show how the processor calculates the physical address. [3]

CLO # 1 - Describe, discuss, and analyze, services provided by the modern Operating Systems.

Q3. [6 marks] *Instruction: Avoid unnecessary details in your answers.*

a) Create a diagram **illustrating the interrupt handling process** in a typical operating system. What is the purpose of timer in operating systems and how it is related to interrupts. [1+2]

b) Describe **execution steps of a (generic) system call using two modes** in a modern operating system with the help of a labelled diagram. What **problems do you expect if OS executes this system call in user mode only**? Explain. [2+1]

CLO # 2 - Understand, design, and implement solutions employing concepts of Processes and Threads

Q4. [6 marks]

a) Consider Google's Chrome browser as a multi-process architecture. What benefit would this implementation provides to the user? [2]

b) Show how many processors are needed to gain a 3.5 times speedup if the serial portion is 20%. [2]

c) Explain different types of mapping between user-level and kernel-level threads. [2]

CLO # 3 – Understand mechanisms for scheduling of tasks in modern operating systems.

Q5. [8 marks] *Instruction: Write answers as bullets points.*

a) Consider **Linux Completely Fair Scheduler**. Explain: i) the computations done to takes scheduling decisions, and ii) give a diagram to show how CFS efficiently computes the next runnable task. [2+2]

b) Assume an Operating System **uses FCFS scheduler**. Suppose there are only two processes: first is running with fifty threads to compute the value of Pi using 5000K iterations, and the second process is an Internet browser where a single tab is shown to the user. **Explain how you change the code of first process such that the FCFS scheduler run** both processes alternatively in this case. *Write precise answer in 2-3 lines only* [2].

c) Compare and contrast **pre-emptive** and **non-preemptive** scheduling [2].