SLIATE

SRI LANKA INSTITUTE OF ADVANCED TECHNOLOGICAL EDUCATION

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Higher National Diploma in Information Technology

Second Year, First Semester Examination – 2022

HNDIT3052 – Operating Systems

Model Paper

Instructions for Candidates:	No. of questions : 5
Answer only four (4) questions	No. of pages : 3
All questions carry equal marks	Time : Two (2) hours

Question 01

i. List five examples of an operating systems. [5 marks]

- **Microsoft Windows**: A popular operating system developed by Microsoft.
- **macOS**: A line of operating systems developed by Apple.
- **Linux:** An open-source operating system.
- **Android**: A mobile operating system developed by Google.
- **iOS**: A mobile operating system developed by Apple.

ii. Briefly describe the purpose of an operating system. [6 marks]

- **Process Management**: The OS manages processes in the system, including process scheduling, process creation, process termination, and process synchronization.
- **Memory Management**: The OS manages the computer's memory, including memory allocation, memory protection, and memory mapping.
- **File System Management**: The OS manages the computer's file system, including file creation, file deletion, file read, and file write.

iii. Write down two system calls with its purpose. [6 marks]

- **fork()**: This system call is used to create a new process. It is often used in multitasking operating systems.
- **exec()**: This system call is used to execute a new program. It replaces the current process image with a new process image.

iv. Briefly describe four types of operating systems. [8 marks]

- **Batch Operating Systems:** These are non-interactive systems that are used to run batch jobs. They are used in mainframes and minicomputers.
- **Time-Sharing Operating Systems**: These are interactive systems that allow multiple users to use the computer at the same time. They are used in personal computers and workstations.
- **Distributed Operating Systems**: These are used in networks of computers that communicate with each other. They are used in distributed systems and network operating systems.
- **Real-Time Operating Systems**: These are used in systems where the response time is very critical. They are used in embedded systems and real-time systems.

(Total 25 Marks)

Question 02

i. State three differences between a process and a thread? [6 marks]

Ownership

- Process- Each process has its own memory space and resources.
- Thread- Threads share memory space and resources with other threads in the same process.

Context Switching

- Process- Switching between processes involves saving and restoring the entire state of the process, which is a heavyweight operation.
- Thread- Switching between threads in the same process involves only saving and restoring the state of the CPU's registers, which is much faster.

Communication

- Process- Processes can communicate with each other through IPC mechanisms.
- Thread-Threads within the same process can communicate using shared memory or other synchronization primitives.

ii. Compare and contrast Process control block and Thread control block. [8 marks]

Purpose

- Process Control Block (PCB)- The PCB is used to store information about a process, including its state, program counter, CPU registers, memory limits, list of open files, etc.
- Thread Control Block (TCB)- The TCB is used to store information about a thread, including its state, program counter, CPU registers, stack pointer, etc.

Memory Allocation

- Process Control Block (PCB)- Each process has its own separate memory space, and the PCB is stored in the main memory.
- Thread Control Block (TCB)- Threads share the same memory space as the process, and the TCB is stored in the main memory.

Communication

- Process Control Block (PCB)- Processes can communicate with each other through IPC mechanisms.
- Thread Control Block (TCB)- Threads within the same process can communicate using shared memory or other synchronization primitives.

Scheduling

- Process Control Block (PCB)- Processes are scheduled for execution on the CPU.
- Thread Control Block (TCB)- Threads are scheduled for execution on the CPU.

Memory Management

- Process Control Block (PCB)- Processes have their own memory space and are responsible for managing their own memory.
- Thread Control Block (TCB)- Threads share the memory space of the process and are responsible for managing their own memory.

iii. Briefly describe two different types of threads. [6 Marks]

- **User-level threads**: These are threads that are managed entirely by user-level threads library. They are not aware of the existence of kernel-level threads.

- **Kernel-level threads**: These are threads that are managed directly by the operating system. They are aware of the existence of other threads and can be scheduled by the operating system.

iv. Process can have different types of states. What are they? [5 Marks]

- **New**: The process is being created.
- **Ready**: The process is waiting to be assigned to a processor.
- **Running**: Instructions are being executed.
- **Waiting**: The process is waiting for some event to occur (such as an I/O completion).
- **Terminated**: The process has finished execution.

(Total 25 Marks)

Question 03

i. Briefly describe the following terms in process synchronization. [6 marks]

a) Semaphores

- Semaphores are a synchronization tool used to control access to a shared resource by multiple processes. They are integer variables that are manipulated using two atomic operations: increment (wait) and decrement (signal).

b) Monitors

- Monitors are a high-level abstraction that provides a convenient and effective mechanism for process synchronization. They are used to encapsulate the shared data and the operations on that data, providing a mechanism for mutual exclusion and synchronization.

ii. What is the main purpose of having CPU scheduling? [4 marks]

- The main purpose of having CPU scheduling is to manage the execution of processes in a computer system. It ensures that all processes get a fair share of the CPU, preventing any single process from monopolizing the system.

iii. Discuss the differences between preemptive and non-preemptive approaches.

CPU Usage

- **Preemptive Scheduling**- The CPU can be used by another process or thread even if the current process or thread is not finished.
- **Non-Preemptive Scheduling**- The CPU can only be used by the current process or thread until it is finished.

Context Switching

- **Preemptive Scheduling**- Context switching can occur at any time, even while a process or thread is running.
- **Non-Preemptive Scheduling**- Context switching can only occur when a process or thread is finished.

Response Time

- **Preemptive Scheduling**- Preemptive scheduling can provide a more responsive system as processes can be interrupted and resumed quickly.
- **Non-Preemptive Scheduling**- Non-preemptive scheduling can provide a more predictable response time as processes are not interrupted.

Real-Time Systems

- **Preemptive Scheduling**- Preemptive scheduling is often used in real-time systems where response time is critical.
- **Non-Preemptive Scheduling**- Non-preemptive scheduling is often used in non-real-time systems where predictability is more important.

Example

- **Preemptive Scheduling**- Round Robin Scheduling, Shortest Remaining Time First (SRTF), Priority Scheduling are examples of preemptive scheduling.
- **Non-Preemptive Scheduling**- First-Come, First-Served (FCFS) is an example of non-preemptive scheduling.

[5 Marks]

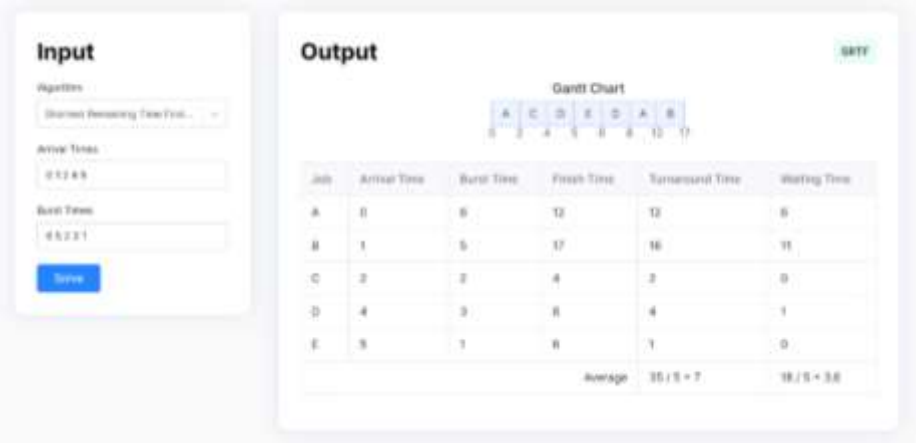
iv. Consider the following four processes to run in a single CPU. All times are given in milli seconds.

Process	Arrival Time	Burst Time
P1	0	6
P2	1	5
P3	2	2
P4	4	3
P5	5	1

a) Draw the Gantt chart to show the execution of the above process for **First Come First Serve (FCFS)** and **Shortest Remaining Time First (SRTF)** algorithms.

Gantt chart for FCFS (First Come First Serve) algorithm:

Gantt chart for SRTF (Shortest Remaining Time First) algorithm:



[6 marks]

b) Calculate the average completion time when scheduling these processes according to **FCFS** and **SRTF** algorithms.

For FCFS:
Average Completion Time = (6 + 11 + 13 + 16 + 17) / 5 = 63 / 5 = 12.6 milliseconds

For SRTF:
Average Completion Time = (12 + 17 + 4 + 8 + 6) / 5 = 47 / 5 = 9.4 milliseconds

[4 marks]
(Total 25 Marks)

Question 04

i. List four conditions that lead to a deadlock in a system. [4 Marks]

- **Mutual Exclusion**: At least one resource must be held in a non-sharable mode.
- **Hold and Wait**: A process is holding at least one resource and waiting to acquire additional resources that are currently held by other processes.
- **No Preemption**: A resource can be released only voluntarily by the process holding it.
- **Circular Wait**: A set of waiting processes is waiting for a resource held by another process in the set, which is also waiting for a resource held by another process in the set, and so on until each process is waiting for a resource that is being held by another process in the set.

ii. Apply Banker's Algorithm to answer the following.

	Claimed			Allocated			Available		
	R1	R2	R3	R1	R2	R3	R1	R2	R3
P1	3	2	2	2	0	1	0	1	1
P2	6	1	3	5	1	1			
P3	3	1	4	2	1	1			
P4	4	2	2	0	0	2			

a) Find the safe sequence of the above processes, if any.

- The safe sequence of the above processes is: P1, P2, P3, P4.

[6 Marks]

iii. Briefly describe the following. [4 Marks]

a) Deadlock prevention

- Deadlock prevention is a strategy used to prevent a system from entering a deadlock state. It involves preventing one of the four Coffman conditions for deadlock from occurring.

b) Deadlock Avoidance

- Deadlock avoidance is a strategy used to ensure that a system will never enter a deadlock state. It involves using algorithms to test for the avoidance of a deadlock before the system is allocated resources.

iv. Briefly describe the different types of directory structures [6 Marks]

- **Single-Level Directory**: In this type, all files are contained in the same directory.
- **Two-Level Directory**: In this type, files are divided into different categories or groups, and each category has its own subdirectory.
- **Hierarchical Directory**: In this type, directories can be arranged in a tree-like structure, with each directory having a parent and child directories.
- **Acyclic-Graph Directory**: In this type, directories form a directed acyclic graph (DAG).

v. Briefly describe the file operations below. [5 Marks]

a) Truncate

- This operation changes the size of a file. If the file size is increased, the new area is filled with null bytes. If the file size is decreased, data beyond the new end of file is lost.

b) Append

- This operation adds data to the end of a file. If the file does not exist, it is created.

(Total 25 Marks)

Question 05

i. What is the purpose of the memory management unit? [4 marks]

The purpose of the memory management unit (MMU) is to translate logical addresses generated by the CPU into physical addresses that can be used to access the main memory. It also manages the allocation and deallocation of memory space.

ii. Compare and contrast virtual memory and primary memory. [6 marks]

Definition

Virtual Memory- Virtual memory is a memory management technique that allows programs to run larger than the physical memory. It uses a portion of the hard disk as a "virtual" memory.

Primary Memory- Primary memory, also known as main memory, is the physical memory in a computer where data is stored for immediate access.

Size

Virtual Memory- Virtual memory can be larger than physical memory.

Primary Memory- Physical memory is limited by the amount of physical memory installed in the computer.

Access

Virtual Memory- Virtual memory is slower to access than physical memory because it is stored on a hard disk.

Primary Memory- Physical memory is faster to access because it is stored directly on the computer's motherboard.

Usage

Virtual Memory- Virtual memory is used in systems with limited physical memory.
Primary Memory- Primary memory is used in all systems, as it's the main storage for data and instructions.

iii. List two advantages and two disadvantages in virtual memory. [4 marks]

Advantages of Virtual Memory:

- It allows the execution of programs that are larger than the physical memory.
- It allows multiple programs to be run simultaneously.

Disadvantages of Virtual Memory:

- It requires a significant amount of overhead to manage the virtual memory system.
- It can lead to slower access times to data, as data must be fetched from the hard disk.

iv. Describe the swapping process using a suitable diagram. [6 Marks]

The operating system identifies a process that is not currently being used and moves it to the hard disk, freeing up space in the RAM.

The operating system then loads a different process into the RAM.

When the original process is needed again, it is swapped back into the RAM from the hard disk.

v. Describe the following terms.

[5 Marks]

a) paging

This is a memory management scheme that divides the main memory into fixed-size blocks called pages. The main memory is also divided into blocks of the same size, and the operating system loads and runs each process in these blocks.

b) Segmentation

This is a memory management technique that divides a process's address space into variable-sized segments. Each segment is allocated in a memory area of the process's address space. The segments are of different sizes and are allocated and deallocated dynamically during program execution.

(Total 25 Marks)