

**NANYANG TECHNOLOGICAL UNIVERSITY**  
**SEMESTER 1 EXAMINATION 2019-2020**  
**CE2005/CZ2005 – OPERATING SYSTEMS**

Nov/Dec 2019

Time Allowed: 2 hours

**INSTRUCTIONS**

1. This paper contains 4 questions and comprises 7 pages.
  2. Answer **ALL** the questions.
  3. This is a closed-book examination.
  4. Questions **DO NOT** carry equal marks.
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1. (a) Consider the following user level solution to the critical section problem, where the code for a process  $P_i$  ( $i = 0$  or  $1$ ) is shown. **flag** is a Boolean variable array, one for each of the two processes and **turn** is an integer.

**Process  $P_i$ :**

```
While(1){  
    flag[i]=true;  
    turn=i;  
    while(flag[i+1 mod 2] and turn == i+1 mod 2);  
    critical-section  
    flag[i]=false;  
    remainder-section  
}
```

- (i) Explain how the mutual exclusion property is violated by the above solution.  
(4 marks)
- (ii) Propose a simple modification to fix the problem.  
(3 marks)

Note: Question No. 1 continues on Page 2

- (b) Consider the following set of processes to be scheduled.

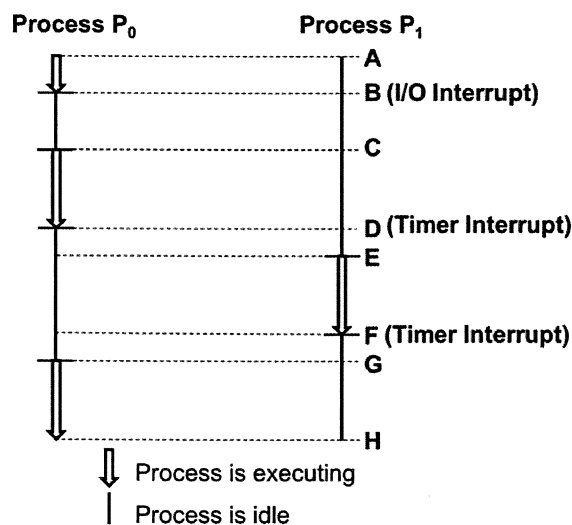
**Table Q1**

Process	Arrival Time	Arrival Order	CPU Burst Length
P1	0	0	4
P2	0	1	4
P3	3	-	2
P4	5	-	2

Suppose we wish to use Round Robin (RR) scheduling with a fixed quantum size  $Q$ . Determine a value for  $Q$  that results in **minimizing the maximum waiting time among all processes** in Table Q1. Justify your answer.

(8 marks)

- (c) Suppose a system comprises only two process  $P_0$  and  $P_1$  whose execution is as shown in Figure Q1. In the figure, there are 7 time instants, denoted **A, B, C, D, E, F** and **G**. At instant **B**, an I/O interrupt is received, whereas at instant **D**, a timer interrupt is received.



**Figure Q1**

- (i) Describe with justifications all the state transitions for each process in Figure Q1.
- (5 marks)
- (ii) Identify the time durations during which the OS Kernel is executing. Explain its main operations in those executions.
- (5 marks)

2. (a) Indicate whether the following statements are true or false. Justify your answers.
- (i) To prevent race conditions, it is sufficient to ensure that each read or write to any shared variable is atomic. (2 marks)
  - (ii) Simple batch systems cannot be used in multiprocessors. (2 marks)
  - (iii) Direct Memory Access (DMA) uses interrupts. (2 marks)
  - (iv) I/O instructions cannot be directly executed by a “root” user in Linux. (2 marks)
  - (v) Base and limit registers are used by the kernel to access the Process Control Block (PCB) of the current running process. (2 marks)
  - (vi) Wait() system call of a semaphore system executes in the user mode. (2 marks)
- (b) Construct the resource-allocation graph for the following sequence of resource requests. Assume there is only one instance of each resource type. Is the system deadlocked? Justify your answer.

Each request is of the form: “**Process** requests **Resource**”

**P<sub>1</sub>** requests **R**  
**P<sub>2</sub>** requests **S**  
**P<sub>3</sub>** requests **T**  
**P<sub>1</sub>** requests **S**  
**P<sub>3</sub>** requests **R**

(3 marks)

Note: Question No. 2 continues on Page 4

- (c) Consider the following implementations of the semaphore system calls **Wait()** and **Signal()**.

<pre>Wait (Semaphore S) {     If (S.value&lt;=0) {         S.value--;         block();     }     else {         S.value--;     } }</pre>	<pre>Signal (Semaphore S) {     S.value++;     If (S.value&lt;0) {         wakeup();     } }</pre>
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Suppose these system calls are guaranteed to be atomic and a Semaphore S in this system is used to protect critical sections as shown below. Assume S is a binary semaphore and its blocked queue follows First-In-First-Out (FIFO) policy. Explain if this solution ensures mutual exclusion, progress and bounded waiting?

```
Process Pi:
While(1){
    Wait(S);
    Critical-section for Pi
    Signal(S);
    Remainder-section for Pi
}
```

(10 marks)

3. (a) Indicate whether the following statements about memory management are true or false. Justify your answers.
- (i) The size of stack section of a process memory is statically fixed since it is used for storing global parameters/variables. (2 marks)
  - (ii) If address binding is performed during load time, the compiler must generate re-locatable code. (2 marks)
  - (iii) Worst-fit is the dynamic storage allocation algorithm which results in the smallest leftover hole in memory. (2 marks)

Note: Question No. 3 continues on Page 5

- (iv) Inverted page table increases amount of time needed for address translation.  
(2 marks)
  - (v) Using demand-paging increases the degree of multiprogramming and hence always improves CPU utilization.  
(2 marks)
  - (vi) Variable frame allocation implies that a global page replacement policy must be used.  
(2 marks)
- (b) Assume a system uses Translation Look-aside Buffer (TLB) for address translation. It requires 20 nanoseconds to access the TLB, and 80 nanoseconds to access memory.
- (i) Assuming TLB hit ratio is 80%, what is the effective memory access time for this system?  
(2 marks)
  - (ii) What is the minimal TLB hit ratio so that the effective memory access time using TLB is less than that without using TLB?  
(3 marks)
- (c) Compare paging and segmentation memory allocation schemes in terms of fragmentation and support for code sharing.  
(3 marks)

- (d) Table Q3 shows a page table for a system with 16-bit logical and physical addresses and 4K bytes pages. The Time Last Referenced field indicates when a page was last referenced. A dash in the Frame Number field indicates that the page is not in memory. Least-Recently-Used (LRU) page replacement algorithm is used and local replacement policy is assumed.

**Table Q3**

Page Number	Frame Number	Time Last Referenced
0	-	
1	1	268
2	-	
3	-	
4	-	
5	-	
6	-	
7	8	230
8	-	
9	-	
10	4	245
11	-	
12	15	275
13	-	
14	-	
15	-	

- (i) How many bits must be used to represent the page offset in the logical address?  
(2 marks)
- (ii) For the following sequence of logical addresses (in hexadecimal), how many page faults are generated?  
0x76F4, 0xB89F, 0x1A86, 0x6987, 0x7E56, 0xD908  
(3 marks)
- (iii) Show the content of the Frame Number column after the references of the sequence of logical addresses given in Q3(d)(ii).  
(2 marks)
- (iv) Assuming that address translation is resolved after a page fault is handled, what is the physical address (in hexadecimal) that each logical address in the sequence given in Q3(d)(ii) is translated to?  
(3 marks)

4. (a) Open-file table is used to maintain information about files that are currently open. Explain why both per-process open file table and system-wide open file table are required and describe how they are modified in `open()` operation. (4 marks)
- (b) Assume that a file system uses Unix-like inode for file storage space allocation. Each inode structure has 10 direct data block pointers, one single indirect pointer, and one double indirect pointer. The block size of the file system is 1,000 bytes and the block pointer size is 10 bytes. A file, that has been opened, is 110,000 bytes long.
- (i) To read 1,000 bytes from byte 9,500 of the file, how many blocks must the file system retrieve from the disk to satisfy this request? (3 marks)
- (ii) To append a new data block to the end of the file, how many blocks on the disk must the file system access to implement this operation? (3 marks)
- (iii) What is the maximum file size that this inode structure can support? (2 marks)
- (c) Consider a disk queue holding requests to the following cylinders in the arriving order:
- 45, 134, 88, 110, 74, 150
- Assume there are 200 cylinders (numbered from 0 to 199) and current disk head is at 100.
- (i) What is the order that the requests are serviced if Shortest-Seek-Time-First (SSTF) algorithm is used? (3 marks)
- (ii) What is the improvement on total head movement compared to First-Come-First-Served (FCFS) algorithm? (3 marks)
- (iii) Explain why FCFS is a fairer algorithm compared to SSTF. (2 marks)

**END OF PAPER**

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Please read the following instructions carefully:

- 1. Please do not turn over the question paper until you are told to do so. Disciplinary action may be taken against you if you do so.**
2. You are not allowed to leave the examination hall unless accompanied by an invigilator. You may raise your hand if you need to communicate with the invigilator.
3. Please write your Matriculation Number on the front of the answer book.
4. Please indicate clearly in the answer book (at the appropriate place) if you are continuing the answer to a question elsewhere in the book.