# NANYANG TECHNOLOGICAL UNIVERSITY

## SEMESTER 1 EXAMINATION 2018-2019

## CE2005/CZ2005 – OPERATING SYSTEMS

Nov/Dec 2018 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) Indicate whether the following statements are true or false. Justify your answers.

(i) In many-one mapping of logical to physical threads, when a running logical thread blocks, the CPU scheduler can simply switch to one of the other mapped logical threads.

(2 marks)

(ii) The resource-allocation graph of Figure Q1 shows a deadlocked system.

(2 marks)

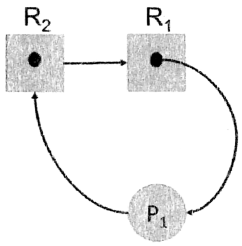


**Figure Q1**

(iii) Kernel mode of operation is equivalent to having "Administrator" privileges in Windows or "root" privileges in Linux.

(2 marks)

Note: Question No. 1 continues on Page 2

(iv) When the value of a semaphore is positive, it denotes the number of processes that have currently locked this semaphore.

(2 marks)

(v) The base and limit register values used for memory protection are stored in the Process Control Block (PCB).

(2 marks)

(b) Consider a set of processes to be scheduled as shown in Table Q1. Suppose the I/O bursts for both processes P1 and P2 occur immediately after 1 unit of their CPU burst is completed. For example, P1 first completes 1 unit of CPU burst, followed by 2 units of I/O burst, and finally the remaining 4 units of CPU burst.

**Table Q1**

| Process | Arrival Time | CPU Burst Length | I/O Burst Length |
|---|---|---|---|
| P1 | 0 | 5 | 2 |
| P2 | 1 | 4 | 2 |
| P3 | 2 | 3 | 0 |
| P4 | 3 | 2 | 0 |

(i) Construct the Gantt chart for the Shortest Remaining Time First (SRTF) scheduling algorithm of the above processes.

(4 marks)

(ii) Compute the turnaround and waiting times for each process in the above schedule.

(4 marks)

(c) Suppose the atomic hardware instruction **TestAndSet** is implemented as:

```
boolean TestAndSet (boolean *target) {
      boolean rv = *target;
      *target = false;
      return rv;
}
```

Give the code for **Entry** and **Exit** sections using this TestAndSet, which ensures mutual exclusion for critical sections in processes.

(4 marks)

Note: Question No. 1 continues on Page 3

(d) Consider the following blocking implementations of the semaphore system calls **Wait()** and **Signal()**. If these system calls are guaranteed to be atomic, do they ensure mutual exclusion? Justify your answer.

| | |
|---|---|
| `Wait (Semaphore S) {`<br>`  S.value--;`<br>`  If (S.value<0) {`<br>`  block();`<br>`  }`<br>`}` | `Signal (Semaphore S) {`<br>`  If (S.value<0) {`<br>`  wakeup();`<br>`  }`<br>`  S.value++;`<br>`}` |

(3 marks)

2. (a) Indicate whether the following statements are true or false. Justify your answers.

(i) A thread is a lightweight process with its own stack space and registers, but shares heap, data and code segments with the other threads in the process.

(2 marks)

(ii) A trap is an interrupt generated by the CPU in response to a faulty software instruction or system call.

(2 marks)

(iii) Multiprogramming and multithreading are two different names for the same OS concept.

(2 marks)

(iv) It is possible to simultaneously have more than one process in the "Running" state.

(2 marks)

(v) Upon a context switch, the context of the running process is stored in its stack space.

(2 marks)

(b) Consider the snapshot of a system's state, with five processes (P1, P2, P3, P4 and P5) and two resource types (A and B) as shown in Table Q2 in the following page.

Note: Question No. 2 continues on Page 4

**Table Q2**

| | | Available |
|---|---|---|
| | | A B |
| | | 4 3 |
| **Process** | **Allocation** | **Max** |
| | A B | A B |
| P1 | 0 1 | 3 3 |
| P2 | 1 0 | 4 5 |
| P3 | 0 1 | 5 4 |
| P4 | 1 0 | 3 3 |
| P5 | 0 0 | 5 5 |

(i) What are the total number of instances of each resource type (A and B) in this system?

(2 marks)

(ii) Is the above system state safe? Justify your answer.

(4 marks)

(iii) What are the minimum values required in the Available matrix of Table Q2 to ensure that the system is safe. Justify your answer.

(5 marks)

(iv) Suppose P2 requests for 3 instances each of A and B when the system state is as shown in Table Q2. Is it safe to grant this request? Justify your answer.

(4 marks)

3. (a) Indicate whether the following statements about memory management are true or false. Justify your answers.

(i) Using translation look-aside buffer (TLB) always improves the effective memory access time.

(2 marks)

(ii) If a page fault occurs and there is no free frame available, two page transfers, one in and one out, must be performed.

(2 marks)

(iii) Variable frame allocation implies a global policy must be used for page replacement.

(2 marks)

Note: Question No. 3 continues on Page 5

(b) Memory allocation can be carried out using either dynamic partitioning or segmentation method. Discuss similarities and differences between dynamic partitioning and segmentation.

(4 marks)

(c) Consider a three-level paging scheme where 32-bit logical addresses are partitioned as follows:

| 8 bits | 7 bits | 7 bits | 10 bits |
|---|---|---|---|

There are $2^{20}$ frames in the physical memory. Assume that the memory is accessed in bytes.

(i) What is the page size?

(2 marks)

(ii) What is the size of physical memory?

(2 marks)

(iii) Can the outermost level page table fit in a single frame? Explain your answer.

(2 marks)

(iv) If single-level paging scheme is used, how many entries are there in the page table?

(2 marks)

(v) What is the address format if two-level paging scheme is used?

(2 marks)

(d) Some page replacement algorithms suffer from Belady's anomaly.

(i) Describe what Belady's anomaly is.

(2 marks)

(ii) Does Least-Recently-Used (LRU) page replacement algorithm suffer from Belady's anomaly? Explain your answer.

(4 marks)

Note: Question No. 3 continues on Page 6

(e) Locality of a process can be captured using its working set defined using a working set window $\Delta$. Discuss its effect on page fault frequency and the number of processes in memory when $\Delta$ is either too small or too large. Assume that memory allocation is based on working set (that is, only the pages in the working set are loaded into memory).

(4 marks)

4. (a) Indicate whether the following statements about file system and I/O are true or false. Justify your answers.

(i) Using either a symbolic or a hard link, a file can have different names.

(2 marks)

(ii) Block size affects both data rate and disk utilization. Large block size results in high data rate and high disk utilization.

(2 marks)

(iii) A process will be in waiting state after performing an I/O system call if non-blocking I/O is used.

(2 marks)

(iv) Buffer holds a copy of the data that resides elsewhere.

(2 marks)

(b) Consider a file system on a disk that has both logical and physical block sizes of 512 bytes. Assume that the directory entry of the file to be accessed is already in the memory. For each of the three file allocation methods (i.e., contiguous, linked and indexed), how many disk I/O operations are required if 600 bytes of data are read from byte 5200 of the file?

(6 marks)

(c) Assume that a disk drive has 200 cylinders, numbered 0 to 199. The disk head is currently at cylinder 100. The disk queue contains the pending I/O request for the following cylinders: 150, 110, 80, 160, 5 and 190.

(i) Determine the servicing order of these requests, assuming that the Shortest-Seek-Time-First (SSTF) disk scheduling algorithm is used.

(3 marks)

Note: Question No. 4 continues on Page 7

(ii) Explain why SSTF disk scheduling algorithm may cause starvation problem and propose a solution to solve the problem.

(3 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.