CITY UNIVERSITY OF HONG KONG

Course code & title: CS3103 Operating Systems

Session : Semester B 2001/02

Time allowed : Two hours

This paper has SEVEN pages (including this cover page)

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1. This paper consists of 2 sections. There are 7 questions in Section A and 5 questions in Section B.

2. Answer ALL questions in Section A.

3. Answer any FOUR of the five questions in Section B.

4. Start a new page for each question.

Materials, aids & instruments permitted to be used during examination:

Approved calculator

Section A (28 marks)
Answer ALL questions in this section

1. How is I/O protection achieved through the dual-mode operation ? (4 marks)

2. What is the main function of a device status table when asynchronous I/O is adopted ? (4 marks)

3. Concurrent processes must be synchronized to prevent race conditions. What is a race condition? (3 marks)

4. Explain the difference between internal and external fragmentation. Which one occurs in paging systems? Which one occurs in systems using pure segmentation? (4 marks)

5. Describe the main steps in a file open system call in terms of the associated in-memory file system structures. (5 marks)

6. Describe the main approaches for keeping track of free blocks on a disk ? (4 marks)

7. Suppose a disk drive has 5000 cylinders, numbered 0 to 4999. The drive is currently serving a request at cylinder 143, and the previous request was at cylinder 135. The queue of pending requests, in FIFO order, is 76, 1365, 829, 1573, 825, 1329, 120. Starting from the current head position, what is the total distance (in cylinders) that the disk arm moves for the following algorithms:

    a. SSTF
    b. LOOK (4 marks)

Section B (72 marks)
Answer any FOUR of the five questions in this section

Question 1 (18 marks)

(a) What is the difference between a physical address and a virtual address? (4 marks)

(b) Describe how a virtual address is translated into a physical address in paging. (6 marks)

(c) A computer with a 32-bit virtual address uses a two-level page table. Virtual addresses are split into a 9-bit top-level page table field, an 11-bit second-level page table field, and an offset. How large are the pages and how many pages are there in the address space? (3 marks)

(d) Assume we have a demand-paged memory with memory access time of 50 nanoseconds. The page table is held in registers with negligible look up time. It takes 8 milliseconds to service a page fault if an empty page is available or the replaced page is not modified, and 20 milliseconds if the replaced page is modified. Assume that the page to be replaced is modified 70 percent of the time. What is the maximum acceptable page-fault rate for an effective access time of no more than 300 nanoseconds? (5 marks)

Question 2 (18 marks)

(a) Below is a solution to the Readers-Writers problem using semaphores. In this solution, readers have priority. Modify the codes for both writer and reader processes such that writers have priority. That is, the solution has to guarantee that no new readers are allowed to access to the data object once at least one writer is ready. You may add more semaphores and variables, if necessary. (10 marks)

```
semaphore    x=1, wsem=1;
int          readcount=0;

void writer()
{
        while (true)
        {
                wait(wsem);
                        ...
                writing is performed
                        ...
                signal(wsem);
        }
}

void reader()
{
        while (true)
        {
                wait(x);
                readcount++;
                if (readcount == 1)   wait(wsem);
                signal(x);
                        ...
                reading is performed
                        ...
                wait(x);
                readcount--;
                if (readcount == 0)   signal(wsem);
                signal(x):
        }
}
```

(b) There are four conditions that must be present for a deadlock to occur. State and briefly explain these four conditions. (8 marks)

Question 3 (18 marks)

(a) Describe any three benefits of multithreaded programming in contrast with single-threaded process. (6 marks)

(b) What resources are used when a thread is created? How do they differ from those used when a process is created? (4 marks)

(c) Five processes A to E, arrive for execution at the same time. They have CPU-burst time of 10, 6, 2, 4, and 8 seconds. Their priorities are 3, 5, 2, 1, and 4, respectively, with 5 being the highest priority. For each of the following scheduling algorithms, determine the mean process turnaround time. Ignore process switching overhead.

(i) Round robin
(ii) Priority scheduling
(iii)First-come, first-served (run in order A, B, C, D, E)
(iv)Shortest job first

For (i), assume that the system is multiprogrammed, and that each process gets its fair share of the CPU. For (ii) to (iv), assume that only one process at a time runs, until it finishes. (8 marks)

Question 4 (18 marks)

(a) Describe and compare the three main methods (contiguous, linked and indexed) of disk space allocation. (8 marks)

(b) Consider a file currently consisting of 100 blocks, and an extra block is to be added to the file based on each of the three allocation strategies. Assume that the following conditions hold :

- The block to be added is already in memory.
- The FCB (and the index block, in the case of indexed allocation) is already in memory.
- In the contiguous case, there is no room to grow in the beginning but room to grow in the end.

Calculate the number of disk I/O operations required for the three allocation strategies in the following cases and provide a detailed explanation of your answers:

i. The new block is added at the beginning.
ii. The new block is added after the 50^{th} block.
iii. A block is removed from the beginning.
iv. The 51^{st} block is removed. (10 marks)

Question 5 (18 marks)

(a) Define the following terms for a disk read/write operation:

- Transfer rate
- Seek time
- Rotational latency (3 marks)

(b) (i) Suppose a disk drive spins at 7,200RPM (revolutions per minute), has a sector size of 512 bytes, and holds 160 sectors per track. Calculate the average rotational latency and the transfer rate of this drive. (7 marks)

(ii) Suppose all files are allocated contiguously, and that a compact operation is performed on this disk to remove any external fragmentation. Assuming a seek time of 5 ms and an average file size of 8 KB, how long does it take to read a file into main memory then write it back to the disk at a new location ? Using these numbers, how long would it take to compact a 16-GB disk which is half-filled ? (8 marks)

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