

UNIVERSITY OF EDINBURGH
COLLEGE OF SCIENCE AND ENGINEERING
SCHOOL OF INFORMATICS

INFR09015 OPERATING SYSTEMS

Wednesday 6th May 2015

09:30 to 11:30

INSTRUCTIONS TO CANDIDATES

Answer any TWO questions.

All questions carry equal weight.

CALCULATORS MAY NOT BE USED IN THIS EXAMINATION

Year 3 Courses

Convener: S. Viglas

External Examiners: A. Cohn, T. Field

THIS EXAMINATION WILL BE MARKED ANONYMOUSLY

1. (a) What is the difference between a blocked process and a ready process? [2 marks]
 (b) Using the following `test_and_set()` function, implement “blocking locks”.

```
bool test_and_set(bool *flag) {
    bool old = *flag;
    *flag = True;
    return old;
}
```

In other words, write `Acquire()` and `Release()` functions which avoid busy-waiting. You are provided with a wait queue and two functions (`enqueue_process()` and `dequeue_process()`) that can be used to manipulate the wait queue. Specifically, `enqueue_process()` puts a calling process into the wait queue and lets it go to sleep, whereas `dequeue_process()` takes one waiting process out of the wait queue and places it onto the front of the ready queue. (Hint: do spinlocking only for queue manipulation, not for an entire critical section.) [6 marks]

- (c) List four necessary conditions for deadlock. Explain each condition in one or two sentences. [4 marks]
 (d) Five silent philosophers sit at a round table with bowls of spaghetti. Forks are placed between each pair of adjacent philosophers.

Each philosopher must alternately think and eat. However, a philosopher can only eat spaghetti when he has both left and right forks. Each fork can be held by only one philosopher and so a philosopher can use the fork only if it is not being used by another philosopher. After he finishes eating, he needs to put down both forks so they become available to others. A philosopher can take the fork on his right or the one on his left as they become available, but cannot start eating before getting both of them. Eating is not limited by the remaining amounts of spaghetti or stomach space; an infinite supply is assumed.



- i. Depending on how the philosophers pick up forks, they may need to eternally wait for each other to release a fork. Provide one example of when such a situation can occur. [4 marks]
 ii. Discuss a solution (or strategy) to prevent deadlock. [6 marks]
 (e) In a batch system using shortest-job-first (SJF) scheduling, what is the average turnaround time for a set of four jobs whose running times are 13, 3, 10 and 15 minutes? Show your work. [3 marks]

2. (a) What is the difference between a virtual page and a page frame? [2 marks]
- (b) What is the difference between a TLB miss and a page fault? [3 marks]
- (c) Suppose an OS supports virtual memory. A virtual address is 32 bits long and a page comprises 4KB (2^{12} bytes). A single-level page table is used. If a process uses 1024 (2^{10}) pages of its virtual address space, how much space would be occupied by the page table for that process? Assume each page table entry occupies 4 bytes. [4 marks]
- (d) In a computer, four page frames are currently available, and an OS employs the LRU page replacement algorithm. Assume that a process pages against itself. A process has a code snippet that accesses five pages sequentially (i.e., from page 1 to page 5). Initially the five pages are stored only on disk. If the process executes this code snippet twice, how many page faults will occur? In addition, using Belady's algorithm, calculate the number of page faults. To receive full credit, show your work. [6 marks]
- (e) Suppose you have a file system where the block size is 2KB, a disk address is 32 bits, and an i-node contains the disk addresses of: (1) the first 12 blocks of a file, (2) a single indirect block, and (3) a double indirect block. Note that in answering the following questions, you do not need to simplify arithmetic expressions.
- i. What is the largest file that can be represented by an i-node? [5 marks]
- ii. Suppose you want to create a new file of the size that you computed in i. above. How many free blocks on the disk would there need to be in order to create that file? [5 marks]

3. (a) Describe the elevator disk scheduling algorithm. [3 marks]

(b) Suppose that you have a disk drive where there are 65,536 (i.e., 2^{16}) cylinders, each cylinder contains 16 tracks, each track contains 256 sectors, and each sector contains 512 bytes. Suppose also that the platters are spinning at 6000 rpm (i.e., 100 rotations per second) and it takes $(1000 + N)$ microseconds for the head to move N cylinders. Assume further that the disk block size is 4 sectors.

For the following questions, you must show all your work. You do not need to simplify complicated arithmetic expressions, nor do you need to use a calculator.

- i. What is the total storage capacity of the disk drive? You can leave the number in powers of two, if convenient. [3 marks]
- ii. If the average seek requires that the head move halfway across the disk, what is the average seek time? [3 marks]
- iii. If, once the head arrives at the right cylinder, the disk has to rotate 180 degrees on average for the requested block to come under the head, what is the average rotational delay? [3 marks]
- iv. How long does the head spend on a sector when it reads data from the sector to the controller's buffer? How long does it take to read one block if the head is on the first sector of the block? Note that a block consists of contiguous sectors. [3 marks]
- v. Suppose the CPU issues read requests for 64 blocks randomly scattered around the disk. How long will it take for all 64 blocks to be read? For our purposes, assume that the transfer of data from the controller's buffer to main memory takes zero time. Let the average seek time be S , the average rotational time be L and the read time of one block to the controller's buffer be R . Assume that the time unit of L , S and R is microseconds (μs). [5 marks]
- vi. Now assume that the 64 blocks that the CPU wants to read are contiguous on the same track. How long will it take for all 64 blocks to be read? Again, assume that the transfer of data from the controller's buffer to main memory takes zero time. You can use the same notations (i.e., L , S and R). [5 marks]