

**Birkbeck
(University of London)**

MSc Examination

Department of Computer Science and Information Systems

COMPUTER SYSTEMS (COIY060H7)

CREDIT VALUE: 15 credits

Date of examination: 25/05/2017

Duration of paper: 14:30–16:30

There are five questions in this paper; each of them is compulsory and worth 20 marks.
The paper is not prior-disclosed.
The use of electronic calculators is not permitted.

1. Consider the following assembly code.

```
1. LOAD R, #1
2. LOAD S, #1
3. LOAD T, #(k-2)
4. ADD AC, R, S
5. T--                // SUB T, T, 1
6. LOAD R, S
7. LOAD S, AC
8. BRP 4, T
9. STOR M, AC
```

where R, S, T, AC are registers, M is a memory location, # denotes numeric value and BRP X, Y stands for “branch to X if Y is positive”.

- (a) Explain what this code computes (assuming that k is a natural number greater than two).
(6 marks)
- (b) Identify the various addressing modes in the code.
(6 marks)
- (c) Explain the main idea of the pipeline.
(2 marks)
- (d) Identify the dependencies in the code.
(6 marks)
2. Consider the code in the previous question.
- (a) Explain the effect of (conditional) branch instructions on the pipeline and describe the delayed branch technique.
(6 marks)
- (b) Show the pipeline activity when the code is executed with input value $k=4$ on a RISC computer using the delayed branch technique. There are five pipeline stages: fetch, decode, register read, execute and write back, and there is an instruction cache on board (initially empty) that can store ten decoded instructions. You can assume that certain instructions skip some of the stages, but make these assumptions explicit.
(14 marks)
3. (a) Explain the main idea of paging and its benefit over traditional (non-virtual) memory managements.
(6 marks)

- (b) Explain what the page table (PT) and the translation lookaside buffer (TLB) are and how they are used in a paging system to compute physical addresses. (6 marks)

- (c) Assume that

- accessing and searching the TLB takes 5 ns,
- transferring the data from the TLB into a register takes 10 ns,
- updating a record in the TLB takes 15 ns,
- accessing and searching the PT takes 50 ns,
- transferring the data from the PT into a register takes 70 ns,
- the TLB hit ratio is 0.6.

How many nanoseconds are needed on average to perform all the TLB and PT operations needed to compute the physical address for a given virtual address (assuming that all referenced pages are in main memory).

(8 marks)

4. (a) Explain the importance of input/output (I/O) management in the context of operating systems.

(4 marks)

- (b) Explain how RAID schemas help improving disk I/O.

(6 marks)

- (c) A hard disk spins at 6000 rpm (revolution per minute), and it takes $100\ \mu\text{s}$ (on average) for the head to traverse one track. Consider the following sequence of disk track requests: 27, 129, 110, 186, 147, 41, 10, 64, 120. Assume that initially the head is at track 30 and is moving in the direction of decreasing track number. Compute the time it takes to serve the requests using FIFO, SSF (shortest seek first) and SCAN (elevator) algorithms.

(10 marks)

5. Consider the following attempt to solve the dining philosophers problem for five

philosophers.

```
semaphore fork[5] = 1
semaphore s = 1
int i

void philosopher(int i)
{
    while(true){
        think();
        wait(s);
        wait(fork[i]);
        wait(fork[i + 1] mod 5);
        signal(s);
        eat();
        wait(s);
        signal(fork[i]);
        signal(fork[i + 1] mod 5);
        signal(s);
    }
}
```

- (a) Explain what semaphores are and the effect of the wait and signal operations. Describe how semaphores can be used for concurrent programming. (6 marks)
- (b) Explain whether this code avoids deadlock. (6 marks)
- (c) Explain whether this code avoids starvation. (4 marks)
- (d) Modify the code so that it provides a satisfactory solution. Justify your answer. (4 marks)