Birkbeck
(University of London)

MSc Examination

Department of Computer Science and Information Systems

COMPUTER SYSTEMS (COIY060H7)

CREDIT VALUE: 15 credits

Date of examination: 28/05/2015
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-3)
4. ADD  AC, R, S
5. LOAD R, S
6. LOAD S, AC
7. T--
8. BRP  4, T
9. STOR AC, M
```

where `R, S, T, AC` are registers, `M` is a memory location, `#` indicates immediate addressing and `BRP` stands for "branch if positive".

(a) Explain what this code computes (assuming that `k` is a natural number greater than two).

(6 marks)

(b) Explain the effect of the branch instruction on performance when the code is executed on a pipelined processor.

(6 marks)

(c) Explain how a RISC machine would minimize the number of delay slots.

(8 marks)

2. (a) List the most important registers in a generic CPU and briefly explain their functions.

(5 marks)

(b) Briefly describe the compiler-based register optimization technique (typically used for RISC machines).

(7 marks)

(c) Explain what register windows are and how they are used to improve performance.

(8 marks)

3. 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);
  eat();
  signal(fork[i]);
  signal(fork[i + 1]  mod 5);
  signal(s);
 }
}
```

(a) Explain whether this code avoids deadlock.

(7 marks)

(b) Explain whether this code avoids starvation.

(5 marks)

(c) Modify the code so that it provides a satisfactory solution. Justify your answer.

(8 marks)

4. (a) Explain the three fundamental ways in which I/O can be performed and compare their benefits and drawbacks.

(8 marks)

(b) For each of the three ways determine how much CPU time is needed to print a 1KB document. The initial set-up takes 20 milliseconds in each case. It takes 50 microseconds to put a one-byte character in the data register of the controller of the printer, and printing one character takes 50 milliseconds. Assume that each interrupt service procedure needed runs for 70 microseconds and that the data register of the controller of the printer can contain only one character.

(12 marks)

5. (a) Describe what virtual memory is and explain its impact on multiprogramming.

(5 marks)

(b) Describe what hierarchical (a.k.a. multilevel) and inverted page tables are and explain their advantages over a single-level page table.

(5 marks)

(c) Assume that a computer uses 32-bit virtual addresses, byte-level addressing and 4KB pages.

i. Determine the maximum size of the virtual address space per process.

(2 marks)

ii. Compute the number of entries in the single-level page table.

(3 marks)

iii. Describe an architecture for a two-level page table for this computer.

(5 marks)

