Computer Systems Coursework Part 1, 2019–2020

Please consult the module web page and the links therein about deadlines, late submission and plagiarism before submitting your solutions.

Your answers to these problems should contain explanations of the computations and calculations. If you make additional assumptions, state them explicitly and provide justifications for them.

1. The function F is defined as $F(1) = F(2) = F(3) = 1$ and for $n \geq 3$,

$$F(n+1) = F(n) + (F(n-1) \cdot F(n-2))$$

i.e., the $(n+1)$th value is given by the sum of the nth value and the multiplication of the $(n-1)$th and $(n-2)$th values.

   (a) Write an assembly program for computing the kth value $F(k)$, where k is an integer bigger than 3 read from a memory location M, and storing $F(k)$ at memory location M. Use the instruction set in the Instruction Set Architecture document:

   `http://www.dcs.bbk.ac.uk/~szabolcs/CompSys/isa.pdf`

   [10 marks]

   (b) Consider a pipelined processor, where the pipeline stages are F (fetch), D (decode), R (register read), E (execute) and W (write back). Describe what happens in the pipeline stages for the various types (data movement, data processing, control) of instructions.

   [10 marks]

   (c) Show the execution of your program on the above pipelined processor for $k = 5$ by drawing a diagram. Assume that the fetched and decoded instructions are stored in an instruction window IW with a capacity of 12 instructions, and that there is no resource conflict between fetching instructions and executing data transfer instructions. Explain where and why delay slots appear.

   [15 marks]

   Subtotal: [35 marks]

2. A computer uses virtual memory (implemented as paging). It has a cache, main memory and a hard disk.

Cache access involves 5 ns lookup and 10 ns transfer time of a word into a register. Main memory access involves 15 ns lookup and 80 ns data transfer time into a register (this is done in parallel with transferring the data into the cache). Accessing the hard disk involves 4 ms seek time and 6 ms transfer time into main memory. The cache hit ratio is 0.4. In the case of a cache miss, the probability that the word is in the main memory is 0.7.

(a) Describe the necessary steps and compute the load time when the referenced word is

- in the cache,

[2 marks]

- in main memory (but not in the cache),

[3 marks]

- on the hard disk (but not in main memory).

[5 marks]

(b) Compute the average load time.

[5 marks]

Subtotal: [15 marks]

Total: [50 marks]