

Two hours

**UNIVERSITY OF MANCHESTER  
SCHOOL OF COMPUTER SCIENCE**

System Architecture

Date: Tuesday 7th June 2011

Time: 09:45 - 11:45

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**Please answer any THREE Questions from the FOUR questions provided**

**Use a SEPARATE answerbook for each SECTION**

**For full marks your answers should be concise as well as accurate.  
Marks will be awarded for reasoning and method as well as being correct.**

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This is a CLOSED book examination

The use of electronic calculators is permitted provided they are  
not programmable and do not store text.

**[PTO]**

**Section A****1. Caches**

- a) Explain why, with modern CPU and memory technology, a processor would be unable to run at full speed without the addition of caches.  
(2 marks)
- b) Describe the terms 'Temporal Locality' and 'Spatial locality' and discuss how these influence the structure and operation of a cache.  
(4 marks)
- c) Describe three different replacement policies which can be used to select a line in a fully associative cache to be replaced when the cache is full and a new entry is to be made.  
(3 marks)
- d) Describe the control information needed for each cache line if a 'write back' policy is used for cache write operations.  
(2 marks)
- e) Discuss the factors which influence the 'Hit Rate' in a cache and discuss why, in order to improve the hit rate, it is not possible simply to increase the level 1 cache size.  
(4 marks)
- f) A processor has 3 levels of caching. The first level cache has an access time of 1 cycle and a hit rate of 98%. The second level cache has an access time of 4 cycles and a hit rate of 90%. The third level cache has an access time of 10 cycles and a hit rate of 70%. The main memory access time is 100 cycles. Calculate the average access time seen by the processor when addressing the level 1 cache.  
(5 marks)

## 2. Pipelines

- a) Describe the term ‘Instruction Level Parallelism’ and show, with the aid of an example, how it can occur in the execution of an arithmetic expression.  
(4 marks)
- b) Describe the structure of a pipelined processor which can be used to exploit instruction level parallelism to increase the execution rate beyond one instruction per clock cycle.  
(4 marks)
- c) Why will such a processor not always achieve the performance which might be expected from the hardware resources if the instructions are fetched in fixed groups in the order they appear in the program.  
(2 marks)
- d) Discuss how, by re-ordering instructions at either software or hardware level, these problems can be reduced.  
(4 marks)
- e) The following sequence of instructions can be re-ordered to maximise their execution in parallel. Given an optimum instruction order and deduce the minimum number of cycles needed to complete the execution. Assume that all instructions take one cycle to execute.

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ADD R3, R2, R1
SUB R2, R2, R1
MUL R3, R2, R3
ADD R6, R4, R5
SUB R4, R4, R5
MUL R4, R4, R6
MUL R3, R3, R4

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Assume the instructions are ARM like, that is an instruction of the form

OP Ra, Rb, Rc

uses Rb and Rc as source operands to OP and produces the result in Ra.

(6 marks)

[PTO]

**Section B**

## 3. Virtualization

- a) Explain how “Abstraction”, “Translation”, and “Multiplexing” can be used to characterise Virtual Machine technology used in the delivery of computer services.  
(6 marks)
- b) Describe how “System Virtualization” software provides abstraction, translation and multiplexing, using an example for each case.  
(9 marks)
- c) It is required to consolidate two servers using system virtualization into a single server. Explain how you would configure the consolidation server, if the virtualization software requires 512 Mbyte of RAM for its own purposes, adds a 10% RAM overhead to each of its guests, and runs the workloads approximately 20% slower than native.  
(3 marks)
- d) Why is consolidation still potentially valuable in spite of these resource overheads?  
(2 marks)

4. Storage

- a) What are the three parameters we use to characterise the performance of disk drives, such as the 3.5 inch drives in your desktop PC? What are typical values for these parameters?  
(6 marks)
- b) At the time of writing, a disk drive with 3TB ( $3 \times 10^{12}$  bytes) capacity can be bought in small quantities for just over £100. If it has performance as in your estimates, how long would it take to fill the drive up
- i) if all data was written consecutively?  
(2 marks)
- ii) if the data was written to locations entirely at random, in units of 1 Kbyte  
(3 marks)
- iii) if the data were written to locations entirely at random, in units of 10Mbytes  
(2 marks)
- c) Other than performance and the size of the filestorage required, what are the other reasons that more than one disk drive may be used in a single system, and how are they used to achieve these reasons?  
(4 marks)
- d) What do the numeric answers you obtained in part (b) above suggest as a constraint for these multi-disk systems?  
(3 marks)

**END OF EXAMINATION**