Two Hours

UNIVERSITY OF MANCHESTER
SCHOOL OF COMPUTER SCIENCE

Introduction to Computer Systems

Date: Thursday 20th May 2010
Time: 09.45 – 11.45

Please answer Question ONE (worth 40% of the paper)
and
any TWO Questions from Question 2, 3, 4 and 5 (each worth 30% of the paper)

This is a CLOSED book examination

The use of electronic calculators is NOT permitted
1. **COMPULSORY** (overall 40 marks – each question worth 2 marks)

a) An overflow can occur when adding unsigned binary integers together. Demonstrate overflow detection by choosing a pair of 8-bit unsigned binary integers which cause an overflow.

b) What is the difference between assembly language and machine language?

c) The interpretation of the ‘M’ in 1MB and 1MHz differs; realistic examples are 800 MHz and 640MB. Explain the difference between 1MB and 1MHz.

d) Convert the 16-bit binary number 1110001111000001 into its hexadecimal equivalent.

**NOTE:** You must show full working.

e) State the meaning of the term memory hierarchy.

f) Represent the decimal integer 12₁₀ as an 8-bit (unsigned) binary integer.

**NOTE:** You must show full working.

g) What does a bootstrap program do?

h) What two components form the basic architecture of an operating system? In your answer, comment on the most basic function of an operating system.

i) Explain what happens during ‘add’ instructions carried out by the Little Man Computer.

j) Give two reasons for packet usage when transmitting data in a computer network.

k) Why is a token ring network preferable to a bus-based network (such as Ethernet)? (State circumstances when this would be the case.)

l) Simple data I/O (Input and Output) uses Status Registers. List the two steps taken to read a character using a Status Register.

m) Software is a term for the set of programs that run on a computer system. What is a program?

n) What is a program counter with respect to the Little Man Computer?
(Question 1 continues from the previous page)

o) Computer systems (especially the processor) use *Synchronous* logic design [principles]. Explain the term *synchronous* in a processor system; what ensures that operations in hardware are *synchronous*?

p) Distinguish between *'word-address'* and *'byte-address'* in the context of a memory access.

q) What is a *Flash* memory and in what type of applications is it used?

r) For an address bus width of 10 calculate the size of the address space.

**NOTE:** You must show full working.

s) With respect to memory and memory hierarchy what does "average access time" depend upon?

r) A hard disk has a rotational speed of 10,800 RPM, what is the average rotational latency of this disk?

**NOTE:** You must show full working.

(2 marks each – 40 overall)
2. a) **NOTE:** To gain full marks you must show full working.
   
i) Convert the decimal numbers $35_{10}$ and $75_{10}$ to 8-bit, two’s complement binary integers.
   
ii) Using binary arithmetic and showing full working, subtract $35_{10}$ from $75_{10}$ (that is $75_{10} - 35_{10}$).
   
iii) Convert the binary result [of 2.a.ii)] to decimal; proving the binary arithmetic is correct. (8 marks)

b) **NOTE:** To gain full marks you must show full working.

With respect to bases (radices), state the range of numbers represented by a 6-digit number in the following bases (radices)?

i) 6-digit number base 3

ii) 6-digit number base 8. (8 marks)

c) Computer systems use different types of optical storage media. Explain, in some detail, the differences between the following types:

i) CD-ROM

ii) DVD-ROM (8 marks)

d) With reference to storage, explain the difference between static RAM and dynamic RAM. (6 marks)
3. a) An Amplitude Shift Keying (ASK) modulation scheme is used to transmit a byte of data with the hexadecimal value 3A. Sketch the waveform that will be transmitted. State any assumptions that you make. (6 marks)

b) A local area network (LAN) implementing the Ethernet protocol uses a bus topology and a LAN implementing a token ring protocol uses a ring topology. Explain how both Ethernet and token ring LANs transmit data from a source node to a destination node. You should also explain what happens when two nodes wish to transmit data simultaneously in the context of each type of LAN. (12 marks)

c) Explain why fully-connected point-to-point networks are infeasible to implement when the number of nodes is large. In answering the question, you should state the number of connections required for fully-connected, point-to-point networks of 5 nodes and 100 nodes. (6 marks)

d) Finally, compare and contrast the ring and the Bus Network Topologies. In your answers briefly discuss issues such as: i. usage; ii. Connectivity (with respect to wiring); iii. Failures; iv. Speed (bps); v. Which is best for long distance and which for heavy traffic. (6 marks)
4. A number of components make up the Little Man Computer (LMC). One of the components is a set of mailboxes. Answer the following questions about mailboxes:

a) State what element the mailboxes hold. (2 marks)

b) Mailboxes hold two different types of information. Explain, in some detail, the differences between the two different types of information. (10 marks)

c) Does the mailbox as a component in the LMC distinguish between two different elements that it stores? Answer this question with a brief sentence. Hint: Does the mailbox component treat, or encode, or store the two different elements in a similar fashion or not. (3 marks)

d) LMC use PCs (Program counters). State what process the PC undertakes with respect to the mailboxes. (6 marks)

e) The assembly language segment below gives the mailbox address (Memory Location); the Opcode; and the Mnemonic for the Opcode.

<table>
<thead>
<tr>
<th>Memory Location</th>
<th>Opcode</th>
<th>Mnemonic</th>
</tr>
</thead>
<tbody>
<tr>
<td>000</td>
<td>500</td>
<td>IN (A)</td>
</tr>
<tr>
<td>001</td>
<td>210</td>
<td>STA 98</td>
</tr>
<tr>
<td>002</td>
<td>500</td>
<td>IN (B)</td>
</tr>
<tr>
<td>003</td>
<td>205</td>
<td>STA 99</td>
</tr>
<tr>
<td>004</td>
<td>500</td>
<td>IN (C)</td>
</tr>
<tr>
<td>005</td>
<td>310</td>
<td>ADD 98</td>
</tr>
<tr>
<td>006</td>
<td>305</td>
<td>ADD 99</td>
</tr>
<tr>
<td>007</td>
<td>600</td>
<td>OUT</td>
</tr>
<tr>
<td>008</td>
<td>700</td>
<td>COB</td>
</tr>
</tbody>
</table>

Draw up a table, similar to the one below, which has the three extra columns: for mailbox 98 and 99; and the calculator.

The variables take on the values: A = 1, B = 2 & C = 3.

Draw up this table to depict the process of reading in and then adding a sequence of three numbers A, B & C using the data structure below; filling in the three extra columns with the appropriate numbers.

<table>
<thead>
<tr>
<th>Instruction</th>
<th>Mailbox</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td>Mnemonic</td>
</tr>
<tr>
<td>000</td>
<td></td>
</tr>
</tbody>
</table>

(9 marks)
5. a) Given the decimal number \(-3_{10}\) (minus three) convert this to:
   
   i) A sign and magnitude 8-bit binary number; and then
   
   ii) State the problem that occurs with a sign and magnitude representation that calls for special consideration when undertaking arithmetic. (4 marks)
   
   b) Calculate the number of bits required to address a 16KB memory?
   
   NOTE: To gain full marks you must show full working. (4 marks)
   
   c) A two-level memory system consists of fast memory (M1) with an access time of 5ns and a slower memory (M2) with an access time of 80ns. M1 services 90% of the memory accesses, what is the average access time of the two-level memory system?
   
   NOTE: To gain full marks you must show full working. (8 marks)
   
   d) A hard disk is organized [or formatted] so the data stored on them is positioned at particular locations. This is archived using two organisational methods. Name the two methods, and give a description of each. (10 marks)
   
   e) A hard disk spins at 5400 rpm, what is the rotational latency of the disk?
   
   NOTE: To gain full marks you must show full working. (4 marks)
   
   END OF EXAMINATION