Introduction to Computer Systems

Date: Thursday 16th May 2013
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
Section A

1. The Little Man Computer is constantly repeating the sequence listed in figure 1.a. The steps are out of order; re-write the list in the correct order. (2 marks)

1. Repeats the cycle until a Halt;
2. Decodes the instruction;
3. Obeys (or executes) the instruction;
4. Reads the Program Counter;
5. Goes to the mailbox specified by the Program Counter;
6. Reads the slip of paper.

Question [Figure] 1 a) Diagram of LMC 6-sequential repeated steps.

b) Give brief a description of the attributes of SRAM (speed, cost, die area) and the ways in which an SRAM might be used within a computer system. (2 marks)

c) With respect to byte-addressable memory, state what you understand the concept of ‘byte-addressable memory’ to mean, and state how a processor can read or write 32 bits at a time; e.g. how does this relate to byte-addressable memory? (2 marks)

d) Give a brief description of a DRAM. (2 marks)

e) What is a ‘Calculator’ with respect to the Little Man Computer? Also state what the ‘Calculator’ in the LMC simulates in a processor. (2 marks)

f) The Little Man Computer’s (LMC’s) instruction Add is one of a set; explain explicitly what the LMC does when performing this instruction. (2 marks)

g) What is the purpose of ‘Data Transmission Protocols’? Also name three areas the protocols cover. (2 marks)

h) Convert the 16-bit binary number 1111010111100111 into its hexadecimal equivalent. NOTE: To gain full marks you must show full working. (2 marks)

[PTO]
Because the communication medium must be shared, the messages sent from computer to computer are broken into packets. State why packets are used. (2 marks)

In the context of an operating system and single-user systems', what is meant by the term ‘Time-sharing in a single-user computer’? (2 marks)

A processor requires an operating system (OS) to function. A basic operating system is composed of: File, Network, Window, and memory managers; and Scheduler plus device drivers. State which of these is in the ‘shell’ and which in the ‘kernel’ of the basic OS. (2 marks)

For an address bus width of 24 bits, calculate the size of the address space. NOTE: To gain full marks you must show full working. (2 marks)

Which part of the Little Man Computer (described in the lectures) corresponds to the ‘Input/Output Mechanism’ part of a real computer system? In your answer briefly describe the part. (2 marks)

With respect to memory and a memory hierarchy, calculate the ‘Average memory cost’ given: the primary memory is 8GB and costs £80.00 and the secondary memory is 1000GB and costs £60.00. (2 marks)

Explain what is meant by ‘bridge,’ in the context of networks. (2 marks)

A hard disk has a specific format or disk organisation; which implies the read from (write to) disk takes time. Briefly differentiate between ‘seek time’ and ‘rotational latency.’ (2 marks)
q) The diagrams in figure 1.q. show two different typical memory timing diagrams. Name the two different types; do not name the signals. (2 marks)

![Diagram A](image1)

![Diagram B](image2)

Question [Figure] 1. q) Diagram of a typical memory timing diagrams.

r) A ‘program’ in a computer system is composed of two components. Briefly name and describe the two different components. (2 marks)

s) Represent the decimal integer $24_{10}$ (twenty-four) as an 8-bit (unsigned) binary integer. NOTE: To gain full marks you must show full working (e.g. Repeated division). (2 marks)

t) A hard disk has a rotational speed of 5,400 RPM, what is the average rotational latency of this disk? NOTE: To gain full marks you must show full working. (2 marks)
Section B

2. The little man in the Little Man Computer (LMC) does what he is told. In fact he repeatedly steps through six sequential steps. Answer the following question on the six sequential steps:

a) Mailboxes hold two different types of information. Explain the differences between the two different types of information. (6 marks)

b) Explain what happens during ‘sub’ instructions carried out by the Little Man Computer. (3 marks)

c) 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>298</td>
<td>STA 98</td>
</tr>
<tr>
<td>002</td>
<td>500</td>
<td>IN (B)</td>
</tr>
<tr>
<td>003</td>
<td>299</td>
<td>STA 99</td>
</tr>
<tr>
<td>004</td>
<td>500</td>
<td>IN (C)</td>
</tr>
<tr>
<td>005</td>
<td>398</td>
<td>ADD 98</td>
</tr>
<tr>
<td>006</td>
<td>399</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. Complete this table to depict the process of reading in and then adding a sequence of three numbers A, B & C; filling in the three extra columns with the appropriate numbers. (9 marks)
d) The program below is a variation of the examples presented in Lecture series and of the question in 2.c, above. It will not operate correctly (as the one in the 2.c. does).

<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</td>
</tr>
<tr>
<td>001</td>
<td>210</td>
<td>STA 10</td>
</tr>
<tr>
<td>002</td>
<td>500</td>
<td>IN</td>
</tr>
<tr>
<td>003</td>
<td>205</td>
<td>STA 05</td>
</tr>
<tr>
<td>004</td>
<td>500</td>
<td>IN</td>
</tr>
<tr>
<td>005</td>
<td>310</td>
<td>ADD 10</td>
</tr>
<tr>
<td>006</td>
<td>305</td>
<td>ADD 05</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>

Explain in full what happened on each line; and why it will not operate correctly and what happens when the program runs. (12 marks)
3. 

a) How many distinct integer values can be transmitted over buses with the following widths (numbers of wires)?

i) 8; and (2 marks)
ii) 16. (2 marks)

NOTE: To gain full marks you must show full working.

b) Explain how binary values are encoded on a CD-ROM, and how the data is read. (4 marks)

c) The frequency (f) of the clock (i.e. the number of times it repeats each second) is expressed in Hz (Hertz); the frequency is directly related to the clock period.

i) For the following clock periods, calculate the frequency at which the clock is running:
   10 μs (microseconds)
   and
   25 ms (milliseconds); (4 marks)

ii) For the following clock frequencies, calculate the clock period:
   500 MHz
   and
   75 kHz (4 marks)
d) With reference to processor interaction with memory and the diagram figure 3.d.

i) State what an area marked by ‘straight-lines’ [prior to T1 and after T3] implies? (2 marks)

ii) What do the T1, T2, & T3 symbolic labelling imply? (2 marks)

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A two-level memory system consists of fast memory (M1) with an access time of 23ns and a slower memory (M2) with an access time of 12ms. M1 services 80% 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. (3 marks)

f) A computer systems has a three-level memory hierarchy (see figure 2.f.) M1 has a cost of 200p/MB, a size of 512MB and an access time of 2ns. M2 has a cost of 20p/MB, a size of 8GB and an access time of 20ns. M3 has a cost of 0.1p/MB, a size of 500GB and an access time of 200ns. Compute the average cost of the memory system expressing your answer in £/GB (pounds per Gigabyte). NOTE: To gain full marks you must show full working. (7 marks)
4.

a) With reference to connecting the processor to memory.
   1. Name the diagram used to look at the logic levels on wires.
   2. Draw a simple diagram depicting two wires (or lines):
      2.1. One, diagram A, changes from 0 to 1 and then to 0 again;
      2.2. The other, diagram B, changes from 1 to 0 and then to 1
   3. Depict, with an arrow and name, the transitions at different times
      on each. (4 marks)

b) Convert the 16-bit integer represented in hexadecimal as 0xA39C to a binary
   number. NOTE: To gain full marks you must show full working. (4 marks)

c) Knowing the size of memory you can determine the number of address lines
   needed to address that memory. With respect to address space size; calculate
   the number of address lines required for the following sizes of memory sizes.
   i) 32 Bytes; (2 marks)
   ii) 256 Bytes. (2 marks)
   NOTE: To gain full marks you must show full working.

d) Perform the following conversions:
   i) Convert the decimal numbers 32_{10} and 15_{10} to 8-bit, two’s complement
      binary integers. NOTE: To gain full marks you must show full
      working (e.g. Repeated division); (4 marks)
   ii) Using binary arithmetic and showing full workings, subtract 15_{10} from
      32_{10} (i.e. 32_{10} - 15_{10}). NOTE: To gain full marks you must show full
      working; (4 marks)
   iii) Convert the binary result [in 2.c.ii.] to decimal; proving the binary
      arithmetic is correct. NOTE: To gain full marks you must show full
      working. (2 marks)

e) With reference to PROM, differentiate between PROM’s and EPROM’s. (8 marks)

[PTO]
5.

a) A Phase Shift Keying (PSK) modulation scheme is used to transmit a 6-bit data block with the binary value 010010₂. Sketch the waveform that will be transmitted. State any assumptions that you make. (6 marks)

b) In the context of networking; differentiate between: 1. Circuit Switching; and 2. Message switching. (4 marks)

c) Given the two network topologies in figure 5.c. (1. & 2.) name and briefly explain the Local Area Network (LAN) protocols that utilise these network topologies. (4 marks)

![Network Topologies Diagram]

Question 5.c. Two network topologies aligned to two LAN protocols.

d) One of the means of transmitting data in a computer system is Ethernet transmission; one of the LAN protocols. While transmitting by this LAN protocol a collision may occur. State what happens when “two computers want to transmit at the same time.” (6 marks)

e) The Token ring is a LAN protocol. Give a description of the Data transmission sequence on the Token Ring [steps (1) to (5)]. Name the original item on the bus and the item placed on the bus when an item is sent in your description. (10 marks)

END OF EXAMINATION