Introduction to Computer Systems (ITMB)

Date: Thursday 19th May 2011
Time: 14:00 - 16:00

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)

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.

This is a CLOSED book examination

The use of electronic calculators is NOT permitted
Section A

1. Draw a diagram of a memory hierarchy composed of: a cache, a processor, secondary memory and primary memory; giving typical sizes of storage in each and approximate speeds of each. (2 marks)

b) What is an End-User Computer? (2 marks)

c) In the context of an operating system, what is meant by the term bootstrapping? (2 marks)

d) A processor can facilitate multiple users (a multi-user system). Explain what scheme the multi-user system uses to support them. (2 marks)

e) Which parts of the Little Man Computer (described in the lectures) corresponds to the input/output parts of a real computer system? (2 marks)

f) With reference to storage explain the difference between volatile and non-volatile memory. (2 marks)

g) The processor is connected to the memory by a number of buses. Name the buses that connect the two, plus give a brief description of each. (2 marks)

h) What is a Wide Area Network (WAN)? (2 marks)

i) Differentiate between: a bridge and a router (or gateway); in the context of connecting networks together. (2 marks)

j) A hard disk has a rotational speed of 4,500 RPM, what is the average rotational latency of this disk? NOTE: To gain full marks you must show full working. (2 marks)

k) In the context of reading a character [from a keyboard] using a Status Register and a Data Register, answer the following:

i) What function does the status registers perform? (1 mark)

ii) Explain the function of the status register when reading a character from a keyboard. (1 mark)
l) With respect to memory and a memory hierarchy, state what ‘Average memory cost’ depends on? (2 marks)

m) What is the difference between assembly language and machine language? (2 marks)

n) 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)

o) For an address bus width of 8, calculate the size of the address space. NOTE: To gain full marks you must show full working. (2 marks)

p) Modern processors have data buses that are wider than one byte (8 bits) these are typically 4 bytes (32 bits). Given that the processor can read or write, say, 32 bits at a time, how does this relate to byte-addressable memory? (2 marks)

q) What is an EEPROM and in what type of applications is it used? (2 marks)

r) Explain how the ‘sum’ and ‘borrow’ bits are calculated by drawing up a table of four columns. In the first two columns state all four possible bit [subtraction] combinations. In the third and fourth calculate the ‘sum’ in the third column and the ‘borrow’ in the fourth column. (2 marks)

s) What is a Calculator with respect to the Little Man Computer? (2 marks)

t) Convert the 16-bit binary number 0111 0110 1010 0010 into its hexadecimal equivalent. NOTE: To gain full marks you must show full working. (2 marks)
Section B

2. In the context of networking data transmission protocols and packets:

a) Explain in full what is meant by ‘Data Transmission Protocols.’ (4 mark)

b) Explain in detail why ‘Packets’ are utilized and all the functionality they provide the network. (8 marks)

c) The diagram below depicts two types of wide area network (WAN) switching modes; Switching Mode 1 and Switching Mode 2. Name both, and give a description of each. (8 marks)

<table>
<thead>
<tr>
<th>i) Switching Mode 1?</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Switching Mode 1" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ii) Switching Mode 2?</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image2" alt="Switching Mode 2" /></td>
</tr>
</tbody>
</table>

Question 2 b) Labelled sketches of basic hardware of two types of WAN switching modes.

d) A Frequency Shift Keying (FSK) modulation scheme is used to transmit a byte of data with the hexadecimal value A3. Sketch the waveform that will be transmitted. State any assumptions that you make. (6 marks)

e) One of the means of transmitting data in a computer system is transmitting an Ethernet data packet of data. Sketch an Ethernet data packet; labelling all constituent parts. Add any Meta data that will help explain the sub-blocks in the packet. (4 marks)
3. a) A two-level memory system consists of fast memory (M1) with an access time of 2ns and a slower memory (M2) with an access time of 10ns. 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. (8 marks)

b) Calculate the number of bits required to address a 64KB memory? NOTE: To gain full marks you must show full working. (4 marks)

c) In respect to reading and writing multiple bytes in a computer system with a 16-bit address bus and 32-bit data bus. Given the diagram below; explain exactly what is meant by ‘reading and writing multiple bytes.’

In your answer address the following issues:

i) How is the system organized; (3 mark)

ii) What does the processor specify [in terms of address] when it reading and writing multiple bytes; and finally (3 mark)

iii) If a processor reads from address FFF8\textsubscript{16}, what are the addresses of the explicit bytes addressed? (4 mark)

d) To read from or write to a disk, the head must be positioned at the start of the sector; there are two steps to this process. Name and briefly describe the two steps to this process. (4 marks)
e) How many distinct integer values can be transmitted over buses with the following widths (numbers of wires) – or what is the maximum number of different values that can be transmitted – or what is the largest integer value that can be transmitted over busses of sizes:

i) 10? (2 mark)
ii) 15? (2 mark)

NOTE: To gain full marks you must show full working.
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) What element does a mailbox hold? (2 marks)

b) Mailboxes hold two different types of information. Explain the differences between the two different types of information. (6 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? (2 marks)

d) LMC use PCs (Program counters). State what process the PC undertakes with respect to the mailboxes. **Hint:** Process implies a particular course of action that the PC is involved in. (2 marks)

e) The LMC assembly language segment below gives the mailbox address (Memory Location); and the Mnemonic of the assembly language program.

<table>
<thead>
<tr>
<th>Memory Location</th>
<th>Mnemonic</th>
</tr>
</thead>
<tbody>
<tr>
<td>000</td>
<td>IN (A)</td>
</tr>
<tr>
<td>001</td>
<td>STA 98</td>
</tr>
<tr>
<td>002</td>
<td>IN (B)</td>
</tr>
<tr>
<td>003</td>
<td>STA 99</td>
</tr>
<tr>
<td>004</td>
<td>IN (C)</td>
</tr>
<tr>
<td>005</td>
<td>ADD 98</td>
</tr>
<tr>
<td>006</td>
<td>ADD 99</td>
</tr>
<tr>
<td>007</td>
<td>OUT</td>
</tr>
<tr>
<td>008</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. (8 marks)

<table>
<thead>
<tr>
<th>Instruction</th>
<th>Mailbox</th>
<th>Calculator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td>Mnemonic</td>
<td>98</td>
</tr>
<tr>
<td>000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
f) Write a program for the Little Man Computer that will read three numbers from the In Basket. These will be referred to these in the order in which they are read [in sequentially] as No1, No2, and No3. The program should then place the result of: No1 – No2 + No3 in the Out Basket. So, if No1 = 19, No2 = 5 and No3 = 7, the result (in the Out Basket) should be 21.

You should write your answer in LMC assembly language using LMC mnemonics; explicitly a **Mnemonics** column and a **Comments** column.

NOTE: To obtain full marks detailed comments must be provided in your answer. (10 marks)
5. a) Knowing the size of memory you can determine the number of address lines needed to address that memory. With respect to address space size; state the number of address lines required for the following sizes of memory sizes?

   i) 2KBytes;  (2 mark)
   ii) 8Bytes.  (2 mark)

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

b) Perform the following conversions:

   i) Convert the decimal numbers 83\textsubscript{10} and 33\textsubscript{10} to 8-bit, two’s complement binary integers. NOTE: To gain full marks you must show full working (e.g. Repeated division);  (4 mark)
   ii) Using binary arithmetic and showing full workings, subtract 33\textsubscript{10} from 83\textsubscript{10} (i.e. 83\textsubscript{10} - 33\textsubscript{10}). NOTE: To gain full marks you must show full working.;  (4 mark)
   iii) Convert the binary result [in 5.b.ii.] to decimal; proving the binary arithmetic is correct. NOTE: To gain full marks you must show full working.  (2 mark)

c) Convert the 16-bit integer represented in hexadecimal as 0xA7C3 to a binary number. NOTE: To gain full marks you must show full working.  (4 marks)

d) With reference to storage, explain the concept of a Random Access Memory (RAMs).  (6 marks)

e) With reference to Read Only Memories ROMs, differentiate between PROMs and EPROMs.  (6 marks)

END OF EXAMINATION