Introduction to Computer Systems

Date: Tuesday 26th May 2009
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)

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

   a) What is an *End-User Computer*?

   b) Represent the 8-bit, binary integer 10001010₂ as a XXX₁₀ decimal integer.

   c) Using a sign and magnitude representation of an integer, calculation of a number’s range uses the equation: \(2^{n-1} - 1\). Given that a number is to be represented in 4-bits, calculate the number’s range.

   d) Convert the binary sign and magnitude number 11110101₂ to a XXX₁₀ decimal number.

   e) The *reset button* is a component of the *Little Man Computer*. What happens to the *Little Man Computer* when the *reset button* is pressed?

   f) The instructions in a *Little Man Computer* are encoded as decimal numbers. The decimal number is composed of two parts; the first bit is the instruction code (or *Opcode*). Given that the instruction (or Opcode) = 2xx, name the actual instruction the *Little Man Computer* performs and the exact steps the *Little Man Computer* goes through when it is presented with an Opcode = 2xx. Hint, list of instructions and Opcodes: {Load, Store, Add, Subtract, Input, Output, Halt} and {1xx, 2xx, 3xx, 4xx, 5xx, 6xx, 7xx}.

   g) With respect to the relationship of a *Little Man Computer* (e.g. a toy computer) to basic computer hardware (e.g. a physical real computer), explain, in some detail, what the mailboxes are equivalent to in basic computer hardware?

   h) Given an 8KB memory, determine the number of address-lines needed to address it.

   i) Differentiate between the terms PROM and EPROM.

   j) What is the difference between a memory that is *byte-addressable* and one that is *word-addressable*?

   k) What does *average memory cost* depend on, with reference to two-level memory hierarchy?

   l) In the context of hard disks, latency is important. State what latency is related to with respect to a hard disk.

   m) Give a brief description of what networking is and what networking enables; support your answer with examples.

   n) Name two basic methods for communicating over a single wire; give a brief description of each.
o) The characteristics of the signal can be modified to encode the 1s and 0s needed for digital signals – this is called modulation. Name the three modulation techniques that use a sine wave to carry a digital signal.

p) In the context of the Little Man Computer, give a brief description of the calculator.

q) In the context of a processor, draw a simple bus activity diagram for a two-bit bus. In the diagram show both changing state.

r) In the context of the Little Man Computer, write down the code (Address, Opcode, Mnemonic) given the following sequence of operations: Load 88, Output. Hint, list of instructions and Opcodes: {Load, Store, Add, Subtract, Input, Output, Halt} and {1xx, 2xx, 3xx, 4xx, 5xx, 6xx, 7xx}.

s) Perform a conversion from a $117_{10}$ decimal number to a binary integer (8-bit binary integer) $\text{XXXXXXX}_2$. In your answer show the full working out of the long division of the $117_{10}$ decimal number.

t) Explain what is meant by the Opcode 4xx in the context of the Little Man Computer. Explain briefly the steps the Little Man goes through to perform this operation. Hint, list of instructions and Opcodes: {Load, Store, Add, Subtract, Input, Output, Halt} and {1xx, 2xx, 3xx, 4xx, 5xx, 6xx, 7xx}.
2. a) Identify the three main components of the basic hardware that a computer is composed of and briefly describe the function of each of the components you identify.  
(12 marks)

b) A computer utilises binary numbers to store information.

i) Each binary number has a range limitation, i.e. a specified number of digits can only represent a specific range of numbers. Assuming they are unsigned numbers, calculate the range for:

i.i) 7 bits; and
i.ii) 13 bits.  
(2 marks)

ii) Using positive (unsigned) integers, add the following pair of bytes together:  
00000011₂ + 10000011₂.  
(2 marks)

iii) Add 17₁₀ to -20₁₀ after first converting them to two’s (2’s) complement binary representation.  
(4 marks)

iv) Subtract -9₁₀ from -11₁₀ after first converting them to two’s (2’s) complement binary representation.  
(6 marks)

c) In the context of binary number representation, explain the conversion of a decimal number to a 2’s compliment in three easy steps. In your answer list the three steps and explain how the decimal number -117₁₀ is converted to a 2’s compliment number.  
(4 marks)
3. a) The Little Man Computer is composed of a number of components. Name the components and explain, in detail, what each component is and the function it performs. (12 marks)

b) A Little Man Computer is to be utilised to read in and then add a sequence of three numbers: X, Y & Z. Given that the basic instructions Mnemonic for the Little Man Computer are: LDA xx, STA xx, ADD xx, SUB xx, IN, OUT, and HLT or COB, answer the following questions:

i) Draw up a list of instructions Mnemonic to read the three numbers X, Y & Z into the Little Man Computer and sequentially store two of them (the first two) in locations 10, then 11. Note: also include the address of each instruction Mnemonic in the list. (2 marks)

ii) Draw up another list of instructions Mnemonic to perform the addition of X, Y & Z in the Little Man Computer, then output the result, and halt the Little Man Computer. Note: also include the address of each instruction Mnemonic in the list. (3 marks)

iii) Given that the variables are assigned the following values: X = 2, Y = 3 & Z = 4, draw up a table to depict the process of reading in and then adding a sequence of three numbers X, Y & Z using the data structure below. The type of tabulated list you should produce (i.e. the data structure) is:

<table>
<thead>
<tr>
<th>Instruction</th>
<th>Mailbox</th>
<th>Calculator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td>Mnemonic</td>
<td>10</td>
</tr>
</tbody>
</table>

Hint, list of instructions and Opcodes: {Load, Store, Add, Subtract, Input, Output, Halt} and {1xx, 2xx, 3xx, 4xx, 5xx, 6xx, 7xx}. (8 marks)

c) When each of the instructions in the above program is executed the Little Man Computer follows a cycle of three steps. Name and briefly describe each of the three steps. (5 marks)
4. a) Convert the decimal numbers $48_{10}$ and $93_{10}$ to 8-bit, two’s complement binary integers. Using binary arithmetic and showing full workings, subtract $48_{10}$ from $93_{10}$ (i.e. $93_{10} - 48_{10}$). Convert the binary result to decimal so proving that the binary arithmetic is correct. (8 marks)

b) With respect to bases (radices), what range of numbers can be represented by a 4-digit number in the following bases (radices)? i) 4-digit number base 3; ii) 4-digit number base 8. (10 marks)

c) With reference to storage, explain the difference between static RAM and dynamic RAM. (6 marks)

d) Computer systems use different types of optical storage media. Explain, in some detail, the differences between the following types: i) CD-ROM and ii) DVD-ROM. (6 marks)

5. a) A processor can facilitate multiple users (a multi-user system). Explain what scheme the multi-user system uses to support them. (4 marks)

b) Draw a diagram of a system that context switches between three users (User 1; User 2; & User 3) over time. Also explain the basic concept behind context switching. (4 marks)

c) 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 75ns. If 93% of the memory accesses are serviced by M1, what is the average access time of the two-level memory system? (8 marks)

i) 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. (6 marks)

ii) Draw a second diagram of a two-level memory, naming each component. (2 marks)

iii) Then given, a total memory cost of £95.25 for an M1 of 1GB and an M2 of 160GB, calculate the average memory cost. (6 marks)

END OF EXAMINATION