Two Hours

UNIVERSITY OF MANCHESTER
SCHOOL OF COMPUTER SCIENCE

Introduction to Computer Systems

Wednesday 23rd January 2008     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** Each part is worth 2 marks. 

OVERALL TOTAL (40 marks)

a) What is an *Embedded Computer System*?

b) Represent the 8-bit, binary integer 01110101_2 as a XX_{10} 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 8-bits, calculate the number’s range.

d) Convert the hexadecimal number 0xBEEF to a binary number.

e) Name the main constituent parts that make up the *Little Man Computer*.

f) The instructions in a *Little Man Computer* are encoded as decimal numbers. Explain, in detail, the significance of each digit (or pair of digits). For example given the instruction 137, explain the significance of each digit (or pair of digits).

g) When a program executes an instruction, it utilises a fetch, decode, and execute sequence. Explain the meaning of *fetch*, *decode*, and *execute* in this context.

h) Given a 16KB memory, determine the number of address-lines needed to address it.

i) Differentiate between the terms RAM and ROM.

j) Given that a 1MB ROM has a starting address 0x00000000 in a memory map, calculate the ROM’s highest physical memory mapped address.

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

l) In the context of process states, differentiate between ready and waiting states. Give a reason why a process may be in the wait state.

m) Give a brief description of a local area network (LAN) and a wide area network (WAN) as a means to transmit data in a computer network. Give an example of each.

n) Name three physical media that support the transmission of digital information using physical connections.

o) Name the four layers in a typical 4-layer data transmission protocol that ensure that computers can communicate with one another.

p) In the context of the *Little Man Computer*, briefly explain the two numbers each mailbox is associated with.

q) In the context of a processor, what is meant by the term synchronous?

r) In the context of the *Little Man Computer* write down the code (Address, Opcode, Mnemonic) given the following sequence of operations: Input x, Store 88.

s) Perform the long division of two 8-bit, binary integers: 00010001_2 divided by 00000101_2. In the final answer state the result in a quotient and remainder format.

t) Explain what is meant by *unconditional jump* and *conditional branch* in the context of the *Little Man Computer*. Give an example of a Mnemonics for each one.
2. a) Identify the main components of the basic hardware of a computer 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. Calculate the range for:

      i.ii) 6 bits; and
      i.ii) 12 bits. (2 marks)

   ii) Using positive (unsigned) integers, add the following pair of bytes together: 00000101₂ + 00001100₂. (2 marks)

   iii) Add -31₁₀ to 15₁₀ after first converting them to two's (2's) complement binary representation. (4 marks)

   iv) Using long multiplication, calculate the following using binary integer arithmetic: 00001001₂ × 00000101₂. (6 marks)

c) In the context of binary arithmetic explain what is meant by an overflow. Give an example of when an overflow would occur – depicting the full mathematical operation to show how an overflow occurs. (4 marks)

3. a) The Little Man Computer follows a sequence when it runs a program. Explain, in detail, the steps the Little Man Computer cycles through in order to run a program, i.e. what are the explicit steps the 'little man' actually takes. (12 marks)

b) A Little Man Computer is to be utilised to add two numbers X & Y.

   i) Draw up a high level flow chart to depict the process of reading in two numbers, adding them, and then outputting the resultant. (2 marks)

   ii) Draw up a detailed view flow chart to depict the explicit [low level] process of reading in two numbers, adding them, and then outputting the resultant. (3 marks)

   iii) Tabulate the Address, Opcode, & Mnemonic for the process of reading in two numbers, adding them, and then outputting the resultant. Write down the required addresses, associated with the Opcode and the Mnemonic for each step of the process of adding the two numbers. (11 marks)

   If the above calculation is changed to subtraction of two numbers, tabulate the Address, Opcode, & Mnemonic for the process of reading in two numbers, subtracting them, and then outputting the resultant. Write down the required addresses, associated with the Opcode and the Mnemonic for each step of the process of adding the two numbers. (2 marks)
4. a) Convert the decimal numbers $54_{10}$ and $87_{10}$ to 8-bit, two's complement binary integers. Using binary arithmetic and showing full workings, subtract $54_{10}$ from $87_{10}$ (i.e. $87_{10} - 54_{10}$). Convert the binary result to decimal so proving that the binary arithmetic is correct. (8 marks)

b) A fixed-point representation uses a byte and has the decimal point between bits 3 and 4 (i.e. there are 4 bits to the left of the point and 4 bits to the right of the point). Convert $4.125_{10}$ and $1.53_{10}$ to fixed-point binary numbers using this representation. Comment on the precision of the representation with respect to the conversions made. (10 marks)

c) With reference to storage explain the difference between volatile and non-volatile memory. Also state why a computer system may require both. (4 marks)

d) Computer systems use different types of volatile and non-volatile memory. Explain, in some detail, the different types of volatile and non-volatile memory. Note that the descriptions should not include mechanical types of secondary memory; e.g. hard disks, & CD etc, it should only include silicon primary memories. (8 marks)

5. a) A processor has an address bus width of 48 bits. What is the maximum size of memory that can be addressed by this processor? State the result as a decimal number and the appropriate SI units. (4 marks)

b) How many bits are required in the address bus to address a 1.024KB memory? (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. If 95% of the memory accesses are serviced by M1, what is the average access time of the two-level memory system? (8 marks)

d) A three-level memory system consists of M1 (access time 15ns), M2 (access time 60ns) and M3 (access time 400ns). 75% of memory accesses are serviced by M1; of the remaining accesses 15% are serviced by M2 and 10% by M3. What is the average access time of this three-level memory system? (10 marks)

e) A hard disk spins at 600 rpm, what is the rotational latency of the disk? (4 marks)

END OF EXAMINATION