ECE331 Homework 1

Answers

1. Moore's Law is a prediction that the number of transistors in an integrated circuit will double every two years. Answer the following:
   a. Describe three aspects of performance that have improved as a result of this increasingly dense integration.
   - Power efficiency
   - more on chip memory
   - more transistors per chips
     b. Transistor feature sizes have steadily decreased while the overall integrated circuit (die) size has not changed significantly. Why?
   - the overall die size has not changed because there is a balance between the cost of the die and the amount of processors they put on each die, the manufacturer has decided that the size that the dies were back then are still the best size cost wise.
2. In a few clear and concise sentences each, and in your own words, describe the function of each of the following combinational hardware elements. (i.e. what goes into each of these elements and what comes out?)
   1. Multiplexer (MUX)
      - in short a multiplexer is a data selector that can chose one of many inputs to output. it can take in many data lines and outputs just one of those lines at once
   2. magnitude comparator
      - compares 2 input numbers and outputs whether one is greater than, less than, or equal to the other.
   3. line decoder
      - a line decoder takes in one or more input lines (n) of data and outputs 2^n lines. for example if in a 2 to 4 line decoder takes in 00, then the output will be the first line only
   4. full adder
      - a component that adds 2 binary digits together, 2 inputs of 2 numbers to be added and 3 outputs, 1, 0, and a carry. the carry is for when the output is greater than 1

5. arithmeticlogic unit
    - this is a key element that is optimized to carry out mathematical operations (ADD SUB MUL & sometimes DIV). usually has 3 inputs, the 2 numbers to be operated on, and the operation to perform. output depends on chip, has output of operation, and often zero flag (if output is 0), carry (if output is greater than bit range), negative flag (if output is negative), overflow flag (if output is higher than maximum value possible)

3. The following question refers to the ALU and data path depicted on Lecture 2, slides 13 and 14. Using this hardware:
    1. Compute C+B-D-A using a series of assembly pseudo instructions of the form depicted on Lecture 2, Slides 14 and 15.
        - In X (load C) In Y(loan B), C + B = X, In Y (load D), X - D = X, In Y (load A), X - A = X → OUT
    2. Show the contents of a control ROM, depicted on Lecture 2, Slide 15, that defines control signals and instructs the data path to perform the computation steps listed in (a)
        -

Present State	Next State	Function	Load X	Load Y	In Pass	Alu Pass	Out Pass
000	001	000	1	0	1	0	0
001	010	000	0	1	1	0	0
010	011	011	1	0	0	1	0
011	100	000	0	1	1	0	0
100	101	010	1	0	0	1	0
101	110	000	0	1	1	0	0
110	000	010	0	0	0	1	1

4. Write ARM assembly code that implements the following line of C: B = A[0] - A[1] + A[2] + A[3] - 10; (Assume that the base address of A is stored in x19 and the address of B is stored in x20)

```c
    LDR     x0, [x19, #0]      // Load A[0] into x0
    LDR     x1, [x19, #8]      // Load A[1] into x1
(assuming 64-bit integers, so 8 bytes offset)
    LDR     x2, [x19, #16]     // Load A[2] into x2
    LDR     x3, [x19, #24]     // Load A[3] into x3

    SUB     x0, x0, x1         // x0 = A[0] - A[1]
    ADD     x0, x0, x2         // x0 = (A[0] - A[1]) + A[2]
    ADD     x0, x0, x3         // x0 = (A[0] - A[1] + A[2])
+ A[3]
    SUB     x0, x0, #10        // x0 = (A[0] - A[1] + A[2]
+ A[3]) - 10

    STR     x0, [x20]          // Store the result into B
```

5. There are five basic elements of every computer system. How does control relate to the other four elements and what is its function?
    1. control
        - is the brain of the computer
    2. data path
        - the control unit tells the data path which operation to perform, such as perform arithmetic or inputting data. the control unit controls what the data path does with data
    3. Memory
        - the control unit tells memory where to read and write data
    4. input
        - the control unit tells input when and where to input data
    5. output
        - the control unit tells output when, where and how to output data, like in a specific format
6. Answer the following, showing your work:
    1. What is the 2's complement of 0b10111101?
        - invert all the bits = 0b01000010
        - add 1 = 0b01000011

    - viola
2. Represent 0xE37A in binary format
    - 0b 1110 0011 0111 1010
    - E = 1110, 3 = 0011, 7 = 0111, A = 1010
3. Represent 0b1110101011100101 in hexadecimal format
    - 0xEAE5
    - E = 1110, A = 1010, E = 1110, 5 = 0101
4. Show 0d4923 (decimal) in hexadecimal, in both big- and little- endian formats, assuming a 16-bit unsigned integer datatype
    - 4926 / 16 = 307R11(B)
    - 307 / 16 = 19R3(3)
    - 19/16 = 1R3(3)
    - 1/16 = 0R1(1)
    - In hex big endian = 133B, little endian = B331