Assignment 1

CMPT 215
Due: July 13^{th}, 2017
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Total: 50 marks

Problem 1.
(8 marks) Define and write the equations for the following metrics in terms of instruction count (I), number of clock cycles (C) and clock cycle time (T).

i Frequency

Solution:
Frequency is the clock rate, actually is the frequency of clock cycle per second

$$Frequency\ (clock\ rate) = \frac{1}{T\ (clock\ cycle\ time)} \tag{1}$$

ii CPI

Solution:
CPI is the average number of clock cycles required per instruction executed

$$CPI = \frac{C(total\ number\ of clock\ cycle)}{I(total\ number\ machine\ language\ instructions\ executed)} \quad (2)$$

iii MIPS

Solution:
MIPS is million instructions per second

$$MIPS = \frac{Instruction\ count}{s \times 10^6} = \frac{Frequency}{CPI \times 10^6} = \frac{\frac{1}{T}}{\frac{C}{I} \times 10^6} = \frac{I}{T \times C \times 10^6} \quad (3)$$

iv CPU execution time

Solution:
CPU execution time is the time that is spent by CPU to execute a task

$$CPU\ execution\ time = I \times T \times CPI = I \times T \times \frac{C}{I} = T \times C \quad (4)$$

Computer System Metrics			
Instruction type	CPI	Frequency	Clock cycle(ns)
A	1	20%	0.5
B	2	40%	0.5
C	3	30%	0.5
D	4	10%	0.5

Problem 2.
(6 marks) Calculate the following performance metrics using the given values in the table above and showing all **steps and units**.

i CPI

Solution:
$CPI = (CPI_A \times Freq_A) + (CPI_B \times Freq_B) + (CPI_C \times Freq_C) + (CPI_D \times Freq_D) = (1 \times 20\%) + (2 \times 40\%) + (3 \times 30\%) + (4 \times 10\%) = 2.3$

ii MIPS

Solution:
$MIPS = \frac{Instruction\ count}{s \times 10^6} = \frac{Frequency}{CPI \times 10^6} = \frac{Clock\ rate\ (GHz)}{CPI} \times 1000 = \frac{\frac{1}{0.5ns}\ (GHz)}{2.3} \times 1000 = \frac{2GHz}{2.3} \times 1000 = 869.6(Million\ instructions\ per\ second)$

iii CPU execution time for 500 instructions

Solution:
$CPU_{exec} = I \times CPI \times Clock\ cycle\ time = 500 \times 2.3 \times 0.5ns = 500 \times 2.3 \times 0.5 \times 10^{-}9s = 5.75 \times 10^{-}7s$

Problem 3.
(4 marks) Suppose it is possible to third (1/3) the number of type C instructions in the table above, what will be the new CPI value?

Solution:
If the type C instructions become $\frac{1}{3}$,the CPI_C will become 3 times of the original according to the CPI function ($\frac{total number of clock cycle}{total number of instruction count}$), so the new CPI will be $CPI_{new} = (CPI_A \times Freq_A) + (CPI_B \times Freq_B) + (new\ CPI_C \times Freq_C) + (CPI_D \times Freq_D) = (1 \times 20\%) + (2 \times 40\%) + (9 \times 30\%) + (4 \times 10\%) = 4.1$

Problem 4.
(4 marks) Describe and write the equation for *Ambdals law.*

Solution:
Ambdals Law: the limitation of the performance improvement with a give system depends on the amount that the improved feature are used. The function is:
$exec_{new} = \frac{portion\ affected}{improvement factor} + portion\ unaffected$

Problem 5.
(10 marks) Convert the following integers into binary and hexadecimal.

i 27

Solution:
binary: $27 = 2^4 + 2^3 + 2^1 + 2^0 = 11011$
hexadecimal: $1b$ *where* (0001 *is* 1)(1011 *is* 11 *is* b)

ii 400

Solution:
binary: $400 = 2^8 + 2^7 + 2^4 = 110010000$
hexadecimal: 190 *where* (0001 *is* 1)(1001 *is* 9)(0000 *is* 0)

iii 88

Solution:
binary: $88 = 2^6 + 2^4 + 2^3 = 1011000$
hexadecimal: 58 *where* (0101 *is* 5)(1000 *is* 8)

iv 10

Solution:
binary: $10 = 2^3 + 2^1 = 1010$
hexadecimal: *a where in hexadecimal a represents* 10

v 99

Solution:
binary: $99 = 2^6 + 2^5 + 2^1 + 2^0 = 1100011$
hexadecimal: 63 *where* (0110 *is* 6)(0011 *is* 3)

Problem 6.
(5 marks) Convert the following binary to their integer values.

i 1001

Solution:
$2^0 + 0 + 0 + 2^3 = 9$

ii 101110

Solution:
$2^5 + 0 + 2^3 + 2^2 + 2^1 + 0 = 46$

iii 111001

Solution:
$2^5 + 2^4 + 2^3 + 0 + 0 + 2^0 = 57$

iv 01100011

Solution:
$2^6 + 2^5 + 0 + 0 + 0 + 2^1 + 2^0 = 99$

v 01110010

Solution:
$2^6 + 2^5 + 2^4 + 0 + 0 + 0 + 2^1 + 0 = 114$

Problem 7.
(3 marks) What is the difference between 1's compliment and 2's compliment? When are they used and what applications are they used in?

Solution:
The difference between 1's compliment and 2's compliment is that after reverse the 1 to 0 and 0 to 1, 1's compliment do nothing more, but 2's compliment needs to add 1 to the reversed digits
1's compliment used in the past, and no longer use now, it is now using to Internet communication, to compute the check sums that is used in packets error detection purposes
2's compliment is used to display signed number in almost computer now

Problem 8.
(10 marks) Convert the following to 8-bit 1's compliment and 2'compliment.

i 20

Solution:
binary of 8-bits of 20 : 00010100
1's compliment: 00010100 because 20 is unsigned or non-negative number
2's compliment: 00010100 because 20 is unsigned or non-negative number

ii 0

Solution:
binary of 8-bits of 0 : 00000000
1's compliment: 00000000 because 0 is unsigned or non-negative number
2's compliment: 00000000 because 0 is unsigned or non-negative number

iii -100

Solution:
binary of 8-bits of 100 : 01100100
1's compliment: 10011011
2's compliment: 10011100

iv 127

Solution:
binary of 8-bits of 127 : 01111111
1's compliment: 01111111 because 127 is unsigned or non-negative number
2's compliment: 01111111 because 127 is unsigned or non-negative number

v -127

Solution:
binary of 8-bits of 127 : 01111111
1's compliment: 10000000
2's compliment: 10000001

Bonus:

Problem 9.
(3 marks) Name the top three fastest machines in the world and mention which benchmark was used to test their performance.

Solution:
Top 1: Sunway TaihuLight
Top 2: Tianhe-2
Top 3: Titan (supercomputer)
to test their performance, they used LINPACK benchmark to rate.

Sunway TaihuLight: 93 petaflops
Tianhe-2: 33 petaflops
Titan: 17petaflops