CS2700 Homework 1

Phillip Janowski (pajmc2@mail.umsl.edu)

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Question 1.

2.2 Consider two different machines, with two different instruction sets, both of which have a clock rate of 200 MHz. The following measurements are recorded on the two machines running a given set of benchmark programs:

Instruction Type	Instruction Count (millions)	Cycles Per Instruction
Machine A		
Arithmetic and logic	8	1
Load and store	4	3
Branch	2	4
Others	4	3
Machine B		
Arithmetic and logic	10	1
Load and store	8	2
Branch	2	4
Others	4	3

(a) Determine the effective CPI, MIPS rate, and execution time for each machine.
Solution:

$$CPU_A = \frac{\sum CPI_i * I_i}{I_c} = \frac{(8*1+4*3+2*4+4*3)*10^6}{(8+4+2+4)*10^6} = 2.\overline{22}$$

$$MIPS_A = \frac{f}{CPI_A * 10^6} = \frac{200*10^6}{2.22*10^6} = 90$$

$$CPU_A = \frac{I_c * CPI_A}{f} = \frac{18*10^6*2.2}{200*10^6} = .2 \text{ seconds}$$

$$CPI_B = \frac{\sum CPI_i * I_i}{I_c} = \frac{(10*1+8*2+2*4+4*3)*10^6}{(10+8+2+4)*10^6} = 1.91\overline{6}$$

$$MIPS_B = \frac{f}{CPI_B * 10^6} = \frac{200*10^6}{1.92*10^6} = 104$$

$$CPU_B = \frac{I_c * CPI_B}{f} = \frac{24*10^6*1.92}{200*10^6} = .23 \text{ seconds}$$

(b) Comment on the results.
Solution:
Machine B takes more CPU time to finish its benchmark even though it has a higher MIPS that Machine A

Question 2.

2.5 The following table, based on data reported in the literature [HEAT84], shows the execution times, in seconds, for five different benchmark programs on three machines.

Benchmark	Processor		
	R	M	Z
E	417	244	134
F	83	70	70
H	66	153	135
I	39449	35527	66000
K	771	368	369

(a) Compute the speed metric for each processor for each benchmark, normalized to machine R. That is, the ratio values for R are all 1.0. Other ratios are calculated using Equation (2.5) with R treated as the reference system. Then compute the arithmetic mean value for each system using Equation (2.3). This is the approach taken in [HEAT84].
Solution:

$$\text{Arithmetic Mean} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

Normal to R

	R	M	Z
E	$417/417 = 1$	$417/244 = 1.71$	$417/134 = 3.11$
F	$83/83 = 1$	$83/70 = 1.186$	$80/70 = 1.186$
H	$66/66 = 1$	$66/153 = .431$	$66/135 = .4\overline{88}$
I	$39449/39449 = 1$	$39449/35527 = 1.11$	$39449/66000 = .598$
K	$772/772 = 1$	$772/368 = 2.098$	$772/369 = 2.092$
AM	$\frac{(1 * 5}{5} = 1$	$\frac{1.71 + 1.186 + .431 + 1.11 + 2.098}{5} = 1.307$	$\frac{3.11 + 1.186 + .488 + .598 + 2.092}{5} = 1.4948$

(b) Repeat part (a) using M as the reference machine. This calculation was not tried in [HEAT84].
Solution:

	R	M	Z
E	.585	1	1.821
F	.843	1	1
H	2.318	1	1.133
I	.899	1	.538
K	.477	1	.997
AM	1.0244	1	1.0978

(c) Which machine is the slowest based on each of the preceding two calculations?
Solution: Z is slowest in both

(d) Repeat the calculations of parts (a) and (b) using the geometric mean, defined in Equation (2.6). Which machine is the slowest based on the two calculations?
Solution:

Geometric Mean (GM) $= e^{\frac{1}{n} \sum_{i=1}^{n} ln(x_c)}$
Normal R
$GM_R = e^{1/5*(\ln(1))*5} = 1$
$GM_M = e^{1/5*(\ln(1.71*1.186*.431*1.11*2.098)} = 1.153$
$GM_Z = e^{1/5*(\ln(3.11*1.186*.488*.598*2.092)} = 1.176$

Normal M
$GM_R = e^{1/5*(\ln(.585*.843*2.318*.899*.477)} = .867$
$GM_M = e^{1/5*(\ln(1))*5} = 1$
$GM_Z = e^{1/5*(\ln(.585*.843*2.318*.899*.477)} = 1.020$
Based on these calculations, Machine R is the slowest

Question 3.

9.5 Convert the following binary numbers to their decimal equivalents

(a) $001100 = 2^6 * 0 + 2^5 * 0 + 2^4 * 1 + 2^3 * 1 + 0 + 0 = 16 + 8 = 24$

(b) $000011 = 0 + 0 + 0 + 0 + 2^2 * 1 + 2^1 * 1 = 6$

(c) $011100 = 0 + 2^5 * 1 + 2^4 * 1 + 2^3 * 1 + 0 + 0 = 56$

(d) $111100 = 2^6 + 2^5 + 2^4 + 2^3 + 0 + 0 = 120$

(e) $101010 = 2^6 + 0 + 2^4 + 0 + 2^2 + 0 = 84$

Question 4.

9.7 Convert the following decimal numbers to their binary equivalents

(a) $64 \rightarrow 64/2 = 32R0 \mid 32/2 = 16R0 \mid 16/2 = 8R0 \mid 8/2 = 4R0 \mid 4/2 = 2R0 \mid 2/2 = 1R0 \mid 1/2 = 0R1$
=1000000

(b) $100 \rightarrow 50R0 \mid 25R0|12R1|6R0|3R0|1R1|0R1$
=1100100

(c) $111 \rightarrow 55R1|27R1|13R1\ |6R1|\ 3R0|1R1|0R1$
=1101111

(d) $145 \rightarrow 72R1|36R0|18R0|9R0|4R1|2R0|1R0|0R1$
= 10010001

(e) $255 \rightarrow 127R1|63R1|31R1|15R1|7R1|3R1|1R1|0R1$
$=1111111$

Question 5.

9.11 Convert the following hexadecimalnumbers to their decimal equivalents

(a) C $\rightarrow 12 * 16^0 = 12$

(b) D3.E $\rightarrow 13 * 16^1 + 3 * 16^0 + 14 * 16^-1 = 211.875$

(c) D52 $\rightarrow 13 * 16^2 + 5 * 16^1 + 2 * 16^0 = 3410$

(d) 67E $\rightarrow 6 * 16^2 + 7 * 16^1 + 14 * 16^0 = 1662$

(e) ABCD $\rightarrow 10 * 16^3 + 11 * 16^2 + 12 * 16^1 + 13 * 16^0 = 43981$

Question 6.

9.13 Convert dec to hex

(a) $16 \rightarrow 16/16 = 1R0 \rightarrow 1 * 16^1 + 0 * 16^0 = 10_{16}$

(b) $80 \rightarrow 80/16 = 5R0 \rightarrow 5 * 16^1 + 0^16^0 = 50_{16}$

(c) $2560 \rightarrow 2560/16 = 160R0 \rightarrow 160/16 = AR0$
$= A00_{16}$

(d) $3000 \rightarrow 3000/16 = 187R8 \rightarrow 187/16 = 11R11$
$= BB8_{16}$

(e) $625000 \rightarrow 62500/16 = 3906R4 \rightarrow 3906/16 = 244R2 \rightarrow 244/16 = 15R4$
$= F424_{16}$

Question 7.

10.11 Find the following differences using two's compliment arithmetic

(a) $111000 - 110011 \rightarrow 111000 + 001101 = 000101$

(b) $11001100 - 00101110 \rightarrow 11001100 + 11101110 = 00111010$

(c) $111100001111 - 110011110011 \rightarrow 111100001111 + 001100001101 = 001000011100$

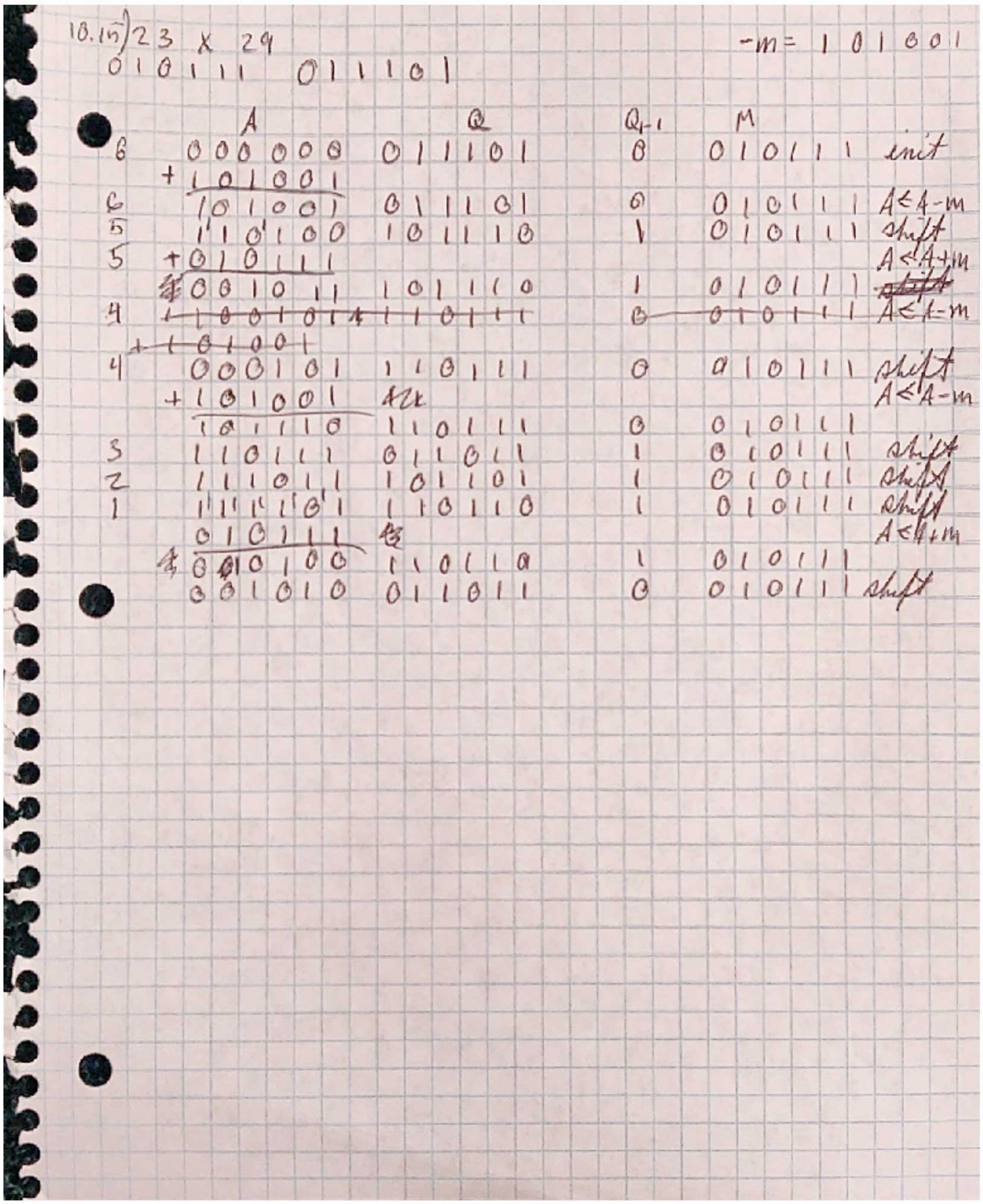
(d) $11000011 - 111010000 \rightarrow 11000011 + 00011000 = 11011011$

Question 8.

10.15 23*29 in binary
$23 * 29 = 667$
23 = 010111, 29=011101
A $\leftarrow$ 000000
Q $\leftarrow$ 011101
$Q_{-1} \leftarrow 0$
M $\leftarrow$ 010111
-M = 101001

Count	A	Q	Q_{-1}	M	Step
6	000000	011101	0	010111	init
6	101001	011101	0	010111	$A \leftarrow A - M$
5	110100	101110	1	010111	shift
5	001011	101110	1	010111	$A \leftarrow A + M$
4	000101	110111	0	010111	shift
4	101110	110111	0	010111	$A \leftarrow A - M$
3	110111	011011	1	010111	shift
2	111011	101101	1	010111	shift
1	010100	110110	1	010111	$A \leftarrow A + M$
0	001010	011011	0	010111	shift

010111*011101 = 001010011011 = 667



10.15) 23 x 29 -m = 101001

010111 011101

	A	Q	Q_{-1}	M	
6	000000	011101	0	010111	init
	+101001				
6	101001	011101	0	010111	A←A-m
5	110100	101110	1	010111	shift
5	+010111				A←A+m
	001011	101110	1	010111	~~shift~~
4	~~+100101~~	~~110111~~	~~0~~	~~010111~~	A←A-m
	~~+101001~~				
4	000101	110111	0	010111	shift
	+101001				A←A-m
	101110	110111	0	010111	
3	110111	011011	1	010111	shift
2	111011	101101	1	010111	shift
1	111101	110110	1	010111	shift
	010111				A←A+m
	010100	110110	1	010111	
	001010	011011	0	010111	shift