**Homework 2**

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3.15.5

P1 = (3 x 10^9/)/1.5 = 2 x 10^9 instructions per second

P2 = (2.5 x 10^9/)/1.0 = 2.5 x 10^9 instructions per second

P3 = (4 x 10^9/)/2.2 = 1.82 x 10^9 instructions per second

Therefore, p2 has the highest performance for instructions per second.



Number of cycles

P1, P2, P3 = clock rate x time

P1 = 3x10^9 x 10 = 30 x 10^9 cycles

P2 = 2.5x10^9 x 10 = 25 x 10^9 cycles

P3 = 4x10^9 x 10 = 40 x 10^9 cycles

Number of Instructions

P1 = (clock rate x time)/CPI OR (number of cycles)/CPI

= (3 x 10^9 x 10)/1.5 = 2 x 10^10 instructions

P2 = (2.5x10^9 x 10)/1.0 = 2.5 x 10^10 instructions

P3 = (4x10^9 x 10)/2.2 = 1.82 x 10^10 instructions



Execution time = (Number of instructions \* CPI)/clock rate, if we reduce execution by 30% and CPI is increasing by 20%, the execution time \*0.7 = (number of instructions \* CPI \* 1.2)/New clock rate.

The new clock rate = (clock rate x 1.2)/0.7 = 1.71 x clock rate

The new clock rate for each is:

P1 = 3 GHz x 1.71 = 5.13 GHz

P2 = 2.5 GHz x 1.71 = 4.27 GHz

P3 = 4 GHz x 1.71 = 6.84 GHz

Therefore, the clock rate will now be 1.71 x clock rate

3.15.7

Average CPI = summation(instruction count\*CPI)/total instruction count

P1:

Average CPI = (1\*10^5\*10%\*1 + 1\*10^5\*20%\*2 + 1\*10^5\*50%\*3 + 1\*10^5\*20%\*3)/1\*10^5 = 2.6

P2:

Average CPI = (1\*10^5\*10%\*2 + 1\*10^5\*20%\*2 + 1\*10^5\*50%\*2 + 1\*10^5\*20%\*2)/1\*10^5 = 2.0

CPI for P1 = 2.6

CPI for P2 = 2.0



Clock cycle = instruction count\*average CPI

P1: 1\*10^5\*2.6 = 2.6\*10^5 cycles

P2: 1\*10^5\*2 = 2\*10^5 cycles

3.15.8



CPU time = instruction count \* CPI \* clock cycle

CPI = CPU time/(instruction count \*clock cycle time)

A: 1.1/(1.0E9 x 1.0E-9) = 1.1

B: 1.5/(1.2E9 x 1.0E-9) = 1.25



B/A = (clock cycle time (B) \* CPI(B) / clock cycle time(A) \* CPI(A)

(1.1 \* 1.0E09)/ (1.25 \* 1.0E09)

= 1.14

B is 1.14 times faster than A



For the original processor with a clock cycle time of 1

CPU time of A/CPU time of new = (instruction count \* CPI) of A/(instruction count \* CPI) of new

= (1.0E9 \* 1.1) of A / (6.0E8 \* 1.1) of new

= 1.67

CPU time of B/CPU time of new = (instruction count \* CPI) of B/(instruction count \* CPI) of new

= (1.2E9 \* 1.25) of B / (6.0E8 \* 1.1) of new

= 2.27

3.15.10



Clock cycles = number of instructions \* CPI

Execution time = clock cycles/clock rate

Clock cycles = (2.56 \* 10^9)\*1 + (1.28\*10^9)\*12(126\*10^6)\*5

= 1.92 \* 10^10

Execution time = (1.92\*10^10)/2\*10^9) = 9.6s

Clock cycles of P = 2.56 \* 10^9/0.7p \* 1 + 1.28 \* 10^9 \* 12 + 256 \* 10^6 \* 5

= 2.56 \* 10^10/p + 1.28 \* 10^9

Total execution time = ((2.56 \* 10^10)/P + 1.28 \* 10^9)/2 \* 10^9

= 12.8/p + 0.64

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| P | 1 | 2 | 4 | 8 |
| Execution time (seconds) | 9.6 | 7.02 | 3.86 | 2.25 |
| Speed-up (relative) | 1 | 1.37 | 2.49 | 4.27 |

* 1. When doubled (CPU Execution time: clock cycles/clock rate)

All of the times would be doubled



Clock cycle = (2.56 \* 10^9 \* 1)/0.7\*4 + (2.56 \* 10^9 \* 1)/0.7\*4 + 2.56 \* 10^9 \* 5 = 7.72\*10^9 cycles

Processor execution time = clock cycle/clock rate

= 7.72\*10^9 cycles/2\*10^9 cycles/sec = 3.86 sec

(2.56 \* 10^9 \* 1) + (1.28 \* 10^9 \* x) + (2.56 \* 10^8 \* 5) = 3.84 \* 10^9 + 1.28 \* 10^9 \* x

CPU execution time = 3.84 \* 10^9 + 1.28 \* 10^9 \* x / (2 \* 10^9)

x = 3.03

Reduced CPI = x/Original CPI for load instructions

= 3.03/12

= 0.25

1-0.25 = 0.75

Therefore, it is 75% reduced

3.15.12

1. 1. CPI = Execution Time / (Instruction count \* clock cycle time)

CPI = 750 /(2.389E12 \* 0.333\*10^-9) = 0.94

* 1. SPEC ratio = Reference Time/Execution Time

SPEC ratio = 9650/750 = 12.87

* 1. CPU Time = Instruction count \* CPI \* clock cycle time

New CPU Time = 1.1 \* Instruction Count \* CPI \* clock cycle time

New CPU Time (100 + 10 = 110%) = 1.1 \* 750 = 825s

* 1. CPU Time = Instruction Count \* CPI \* clock cycle time

New CPU Time (1.1 \* 1.05) \* instruction count \* CPI \* clock cycle time

New CPU Time (1.1 \* 1.05) \* 750 = 866.25s

* 1. Clock rate = 4 GHz = 4 \* 10^9

Reduced by 15%, meaning 100-15 = 85%, and therefore 0.85

Instruction count = 0.85 \* 2.389E12

Execution time = 700s

New spec ratio = 13.7

* 1. CPI = execution time \* clock rate / new instruction count

New CPI = (700\*4\*10^9)/(0.85\*2.389E12) = 1.38

* 1. CPI change = (new CPI – CPI)/CPI

CPI change = (1.38-0.94)/0.94 = 0.468

* 1. Change in CPU Time = |(new CPU time – CPU time )|/CPU time

Change in CPU Time = |700-750|/750 = 0.07, meaning it’s 7% reduced

* 1. CPI = (execution time \* clock rate)/instruction count

Instruction count = (execution time \* clock rate)/CPI

New execution time = 0.9 \* 960 (reduced 10%)

New clock rate = 4 \* 10^10^9

Instruction count = (0.9\*960\*4\*10^9)/1.61 = 2147 \* 10^9 of instructions

* 1. Clock rate = (instruction count \* CPI) /execution time

Clock rate = (2147\*10^9 \* 1.61)/(0.9 \* 960) = 4 \* 10^9 = 4 GHz

* 1. Clock rate = (instruction count \* new CPI)/new execution time)

Clock rate = (2147 \* 10^9 \* 1.37)/768 = 3.289 \* 10^9 = 3.83 GHz

3.15.15

1. Time = (Instructions \* CPI) / Clock Rate

FP instructions = 50 x 106, CPI = 1  
INT instructions = 110 x 106, CPI = 1  
L/S instructions = 80 x 106 , CPI = 4  
Branch instructions = 16 x 106 CPI = 2  
Clock Rate = 2 x 109Hz

Time = (50 x 1 + 110 x 1 + 80 x 4 + 16 x 2 ) x 10^6/ 2 x 10^9

Time = 256 \* 10 ^3 sec.

* 1. T1 = 256 x 10-3/ 2

T1 = ((50 x CPIFP + 110 x 1 + 80 x 4 + 16 x 2 ) x 106 / 2 x 109)

CPIFP = -4 (negative, so no improvement possible)

* 1. T1 = ((50 x 1 + 110 x 1 + 80 x CPILS + 16 x 2 ) x 106 / 2 x 109)

CPILS = 0.8

* 1. CPI New INT = 0.6  
     CPI New FP = 0.6  
     CPI New LS = 2.8  
     CPI New Branch = 1.4

New Time = (50 x 0.6 + 110 x 0.6 + 80 x 2.8 + 16 x 1.4 ) x 106 / 2 x 109

New Time =  171.2 x 10-3sec

Time Enhanced = Time Original / New Time

Time Enhanced = (256 x 10-3/ 171.2 x 10-3 ) = 1.495