COMPUTER ARCHITECTURE

LAB REPORT

Lab 1 - GROUP 1C

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Question 1. Given three processors, P1, P2, and P3 executing the same instruction set with associated

parameters as shown in Table 1:

Processor	**Clock rate**	**Average CPI**	**IPS**	**Cycles in 10s**	**IC**
P1	3 GHz	1.5	2*10^9	3*10^10	2*10^10
P2	2.5 GHz	1.0	2.5*10^9	2.5*10^10	2.5*10^10
P3	4.0 GHz	2.2	1.8181*10^9	4*10^10	1.8181*10^10

Table 1: Information for Question 1

a)Which processor has the highest performance expressed in instruction per second?

IPS = Clock rate / Average CPI

So, P2 has the highest performance express in IPS

b)If the processors each execute a program in 10 seconds, find the number of cycles and the number of instructions. t = 10s

Cycles = IPS * time * CPI

IC = Cycles / CPI = IPS*time

c) We are trying to reduce the time by 30% but this lead to an increase of 20% in the CPI. What clock rate should we have to get this time reduction?

Processor	Clock rate (old)	Average CPI (old)	IC	New CPI	New clock rate
P1	3 GHz	1.5	2*10^10	1.8	5.14 GHz
P2	2.5 GHz	1.0	2.5*10^10	1.2	2.05 GHz
P3	4.0 GHz	2.2	1.8181*10^10	2.64	6.85 GHz

Time=7s

CPU Time = (IC * CPI) /clock rate

CPU Time = (IC * new CPI) /new clock rate

Question 2. For problems below, use the information in the following table (Table 2):

Processor	Clock rate	No. Instruction	Time	IPC	
P1	3 GHz	20 ×10^9	7 s	0.95	
P2	2.5 GHz	30 ×10^9	10 s	1.2	
P3	4.0 GHz	90 ×10^9	9 s	2.5	

a) ***Find the IPC (instructions per cycle) for each processor***

IPC = No. Ins /(Clock rate * Time)

b)***Find the clock rate for P2 that reduces its execution time to that of P1***

Let x is the new clock rate so that p2 has the same cpu time as p1

IPC = No. Ins /(Clock rate * Time)

1.2 = 30*10^9 / (x * 7)

X= 3.57 GHz

c)***Find the number of instructions for P2 that reduces its execution time to that of P3***

IPC = No. Ins /(Clock rate * Time)

1.2 = z / (2.5*10^9 * 9)

Z = 2.7*10^10

<u>Question 3.</u> Consider two different implementations of the same instruction set architecture. There are four

classes of instructions, A, B, C, and D. The clock rate and CPI of each implementation are given in the

following table (Table 3).

a. Given a program with 106 instructions divided into classes as follows: 10% class A, 20% class B, 50% class

C, and 20% class D, which implementation is faster?

Processor	**Clock rate**	**CPI A**	**CPI B**	**CPI C**	**CPI D**		**Global CPI**	**Clock cycles**
P1	2.5 GHz	1	2	3	3			
P2	3 GHz	2	2	2	2			
Instruction		10^5	2*10^5	5*10^5	2*10^5			
CPU time P1		0.00004	0.00016	0.0006	0.00024	0.00104s	2.6	2.60*10^6
CPU Time P2		0.000066	0.000133	0.000333	0.000133	0.00065s	1.95	1.95*10^6

CPU time = (IC * CPI) / Clock rate

b)What is the global CPI for each implementation?

CPU time = (IC * CPI) / Clock rate

c)Find the clock cycles required in both cases.

Clock Cycles = (IC * Global CPI)

Problem 4.A program consists of 1000 instructions in which 20% loadstore instructions, 10% jump instructions, 20% branch instructions, and arithmetic instructions. Assume that CPIs for those instructions are 2.5, 1, 1.5, and 2, respectively. The program is executed on a 2 GHz processor.

Clock rate = 2GHz	Load	Jump	Branch	Arithmetic	Total
IC	200	100	200	500	1000
CPI	2.5	1	1.5	2	**1.9 (average)**
Execution time	//	//	//	//	**9.5*10^(-7)**
New Execution time	//	//	//	//	8.25*10^(-7)

Execution time = (total) (CPI * IC)/clock rate

b)What is the average CPI of the above the program?

CPI avarage = exe time * clock rate / IC

c)Assume that we are trying to improve the loadstore instructions such that the execution time for this instructions type is reduced by a factor of 2. What is the speed-up of the program?

New Load = 1/2 old Load = 100

New Execution time = (total) (CPI * IC)/clock rate

<u>**Problem 5.**</u>**Suppose we have made the following measurements: - Frequency of FP operations = 25% - Average CPI of FP operations = 4.0 - Average CPI of other instructions = 1.33 - Frequency of FPSQR= 2% - CPI of FPSQR = 20 Assume that the two design alternatives are to decrease the CPI of FPSQR to 2 or to decrease the average CPI of all FP operations to 2.5. Compare these two design alternatives using the processor performance equation.**

- Total original CPI = Average CPI of FP operations * Frequency of FP operations + Average CPI of other instructions * Frequency of other instructions

  = 4 * 25% + 1.33 * 75% = 1.9975

  - Method 2:
- CPI of old FPSQR = 20 * 2% = 0.4
- CPI of new FPSQR = 2 * 2% = 0.04
- reduce of CPI in FPSQR = 0.4 - 0.04 = 0.36
- new total CPI when reduce the average CPI of all FP operations to 2.5

  = 1.9975 - 0.35 = 1.6375

  - Method 1

- new total CPI when the average CPI of all FP operations to 2.5

  = Average new CPI of FP operations * Frequency of FP operations + Average CPI of other instructions * Frequency of other instructions

  = 2.5 * 25% + 1.33 * 75% = 1.6225

Speed up time:

Method 1: speed up = Old CPI/ New CPI = 1.9975/1.6225 = 1.231

Method 2: speed up = Old CPI/ New CPI = 1.9975/1.6375 = 1.219

6) Assume a program requires the execution of: - 50 × 106 FP instructions, - 110 × 106 INT instructions, - 80 × 106 L/S instructions, - and 16 × 106 branch instructions. The CPI for each type of instruction is 1, 1, 4, and 2, respectively. Assume that the processor has a 2 GHz clock rate.

Clock rate = 2GHz	FP	INT	L/S	branch	
IC	50*10^6	110*10^6	80*10^6	16*10^6	//
CPI	1	1	4	2	//
Exe time	//	//	//	//	0.256s

Execution time = (total) (CPI * IC)/clock rate

a. By how much must we improve the CPI of FP instructions if we want the program to run two times faster?

New exe = exe / 2 = 0.128s

New exe = (50*1-^6 + x * 110*10^6 + 4*80*10^6 + 2 * 16*10^6) / 2*10^9

x = -4.12

So, the new CPI of FP is -4.12 . The program is not executable

b. By how much must we improve the CPI of L/S instructions if we want the program to run two times faster?

New exe = exe / 2 = 0.128s

New exe = (50*10^6 + 110*10^6 + x * 80*10^6 + 2 * 16*10^6) / 2*10^9

x = 0.8

So, the new CPI of L/S is 0.8

-> 0.8/4 = 0.2, so reduction is 80%

c. By how much is the execution time of the program improved if the CPI of INT and FP instructions is reduced by 40% and the CPI of L/S and Branch is reduced by 30%?

New exe = (50*10^6 * 0.6 + 110*10^6 * 0.6 + 4 * 80*10^6 * 0.7+ 2 * 16*10^6 * 0.7) / 2*10^9

= 0.1712

new exe / old exe = 0.1712 / 0.256 = .66875

-> Speed up 33.125%