Computer Architecture Lab – Week 1's report

Full name	Student ID	Works
Trần Quốc Việt	1953097	1 + 6 + combine
Lý Kim Phong	1952916	2 + 4
Nguyễn Đình Khương Duy	1952207	3 + 5

Question 1

a) General Equation : $IPS = \frac{Clock\ Rate}{CPI}$

$IPS_1 = \frac{3*10^9}{1.5} = 2 * 10^9$

$IPS_2 = \frac{2.5*10^9}{1} = 2.5 * 10^9$

$IPS_3 = \frac{4*10^9}{2.2} \approx 1.82 * 10^9$

Therefore, Processor 2 has the highest IPS.

b.1)

$Cycle\ Count_1 = CPU\ Time_1 * CR_1 = 10 * 3 * 10^9 = 3 * 10^{10}$ (cycles)

$Cycle\ Count_2 = CPU\ Time_2 * CR_2 = 10 * 2.5 * 10^9 = 2.5 * 10^{10}$ (cycles)

$Cycle\ Count_3 = CPU\ Time_3 * CR_3 = 10 * 4 * 10^9 = 4 * 10^9$ (cycles)

b.2) General Equation : IC = CPU Time * IPS.

$IC_1 = IPS_1 * 10 = 2 * 10^{10}$ (instructions)

$IC_2 = IPS_2 * 10 = 2.5 * 10^{10}$ (instructions)

$IC_3 = IPS_3 * 10 = 1.82 * 10^{10}$ (instructions)

c) $CR_{old} = \frac{IC*CPI}{CPU\ Time}$ → $CR_{new} = \frac{IC*\ 1.2CPI}{0.7\ CPU\ Time} = \frac{12}{7} CR_{old}$.

→ $CR_{1new} = \frac{12}{7} * 3 = \frac{36}{7}$ (GHz)

→ $CR_{2new} = \frac{12}{7} * 2.5 = \frac{30}{7}$ (GHz)

→ $CR_{3new} = \frac{12}{7} * 4 = \frac{48}{7}$ (GHz)

Question 2.

a) $CPU\ Time = \frac{\text{Instruction count} * \text{Cycles per Instruction}}{\text{Clock Rate}}$

→ Instructions per Cycle (ICP) = $\frac{1}{\text{Cycles per Instruction}} = \frac{\text{Instruction count}}{\text{CPU Time} * \text{Clock Rate}}$

For P1: ICP = $\frac{20*10^9}{7*3*10^9} = \frac{20}{21}$

For P2: ICP = $\frac{30*10^9}{10*2.5*10^9} = 1.2$

For P3: ICP = $\frac{90*10^9}{9*4*10^9} = 2.5$

b) $CPU\ Time = \frac{\text{Instruction count} * \text{Cycles per Instruction}}{\text{Clock Rate}}$

→ $Clock\ Rate = \frac{\text{Instruction count}}{\text{Instructions per Cycle} * \text{CPU Time}}$

= $\frac{30*10^9}{1.2*7}$ = 3.57 * 10^9 (Hz)

c) $CPU\ Time = \frac{(\text{Instruction count} * \text{Cycles per Instruction})}{\text{Clock Rate}}$

→ Instruction count = CPU Time * Clock Rate * Instructions per Cycle

= 9 * 2.5 * 10^9 * 1.2 = 27 * 10^9 (Instructions)

Question 3:

a) CPU time = $\frac{\sum \text{ICi} * \text{CPIi}}{CR}$

+ P1: CPU time = $\frac{10\% * 10^6 * 1 + 20\% * 10^6 * 2 + 50\% * 10^6 * 3 + 20\% * 10^6 * 3}{2.5 * 10^9}$

= 1.04 ms

+ P2: CPU time = $\frac{10\% * 10^6 * 2 + 20\% * 10^6 * 2 + 50\% * 10^6 * 2 + 20\% * 10^6 * 2}{3 * 10^9}$

= 0.6 ms

→ P2 is faster.

b) Global CPI = $\frac{\sum \text{ICi} * \text{CPIi}}{IC}$

+ P1: Global CPI = 10% * 1 + 20% * 2 + 50% * 3 + 20% * 3

= 2.6

+ P2: Global CPI =10% * 2 + 20% * 2 + 50% * 2 + 20% * 2

= 2

c) Clock Cycles = Global CPI * IC

+P1: Clock Cycles = $2.6 * 10^6$

+P2: Clock Cycles = $2 * 10^6$

Question 4.

a) CPU Time = $\sum_{i=1}^{n} (\frac{\text{Instruction count}_\text{i} * \text{Cycles per Instruction}_\text{i}}{\text{Clock Rate}})$

= $\frac{200 * 2.5 + 100 * 1 + 200 * 1.5 + 500 * 2}{2 * 10^9} = 9.5 * 10^{-7}$(s)

b) $\text{CPI} = \sum_{i=1}^{n}(\frac{\text{Instruction count}_i * \text{CPI}_i}{\text{Instruction count}})$

$= \frac{200 * 2.5 + 100 * 1 + 200 * 1.5 + 500 * 2}{1000} = 1.9$

c) $CPU\ Time = \frac{(\text{Instruction count} * \text{Cycles per Instruction})}{\text{Clock Rate}}$

When reducing the execution time of the loadstore instructions by a factor of 2, its clock cycles are also reduced by a factor of 2.

Clock Cycles = Instruction count * Cycles per Instruction

$\text{CPU Time}_{\text{new}} = \sum_{i=1}^{n}(\frac{\text{Instruction count}_i * \text{Cycles per Instruction}_i}{\text{Clock Rate}})$

$= \frac{200 * 2.5 * 0.5 + 100 * 1 + 200 * 1.5 + 500 * 2}{2 * 10^9} = 8.25 * 10^{-7}\text{s}$

→ Then the execution time of the program will speed up $\frac{9.5 * 10^{-7}}{8.25 * 10^{-7}} = = 1.15$ times

Question 5:

$$\frac{Execution_1}{Execution_2} = \frac{0.25 * 4 + 0.02 * 2 + 0.73 * 1.33}{0.25 * 2.5 + 0.02 * 20 + 0.73 * 1.33}$$

$= 1.0075$

→ The second design is 1.0075 time faster than the first one.

Question 6.

$$CPU\ Time = \frac{IC * CPI}{Clock\ Rate}$$

a) If we want the program to run 2 times faster

→ $\text{CPU Time}_{\text{new}} = 0.5 * \text{CPU Time}_{\text{old}}$

$$\frac{50 * 1 + 110 * 1 + 80 * 4 + 16 * 2}{50 * x + 110 * 1 + 80 * 4 + 16 * 2} = 2$$

→ Solving the equation, we get x = -4.12 → It's impossible to improve the CPI of FP instructions.

b) If we want the program to run 2 times faster

→ $\text{CPU Time}_{new} = 0.5 * \text{CPU Time}_{old}$

$$\frac{50 * 1 + 110 * 1 + 80 * 4 + 16 * 2}{50 * 1 + 110 * 1 + 80 * x + 16 * 2} = 2$$

→ Solving the equation, we get x = 0.8→ We have to reduce the CPI of L/S instructions by 3.2 for the program to run 2 times faster.

c)

$$\frac{50 * 1 + 110 * 1 + 80 * 4 + 16 * 2}{50(1 - 0.4 * 1) + 110(1 - 0.4 * 1) + 80(4 - 0.7 * 4) + 16(2 - 0.7 * 4)}$$

$= \frac{20}{7}$