ES 215 – Assignment - 2

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2) Given: Execution time$_A$ = 6 secs , $CPI_A = 6$

Execution time$_B$ = 5 secs , $CPI_B = 5$

$CR_A = CR_B = 10^9$ Hz.

Here **Execution time = CPU time**.

$$\Rightarrow (\text{CPU time})_A = \frac{(IC)_A \times CPI_A}{CR_A}.$$

$$\Rightarrow 6 = \frac{IC_A \times 6}{10^9} \Rightarrow \boxed{IC_A = 10^9}$$

↓

Instruction count of Prog. A

$$\Rightarrow (\text{CPU time})_B = \frac{IC_B \times CPI_B}{CR_B}$$

$$\Rightarrow 5 = \frac{IC_B \times 5}{10^9} \Rightarrow \boxed{IC_B = 10^9}$$

↓

Instruction count of program B

$$MIPS_A = \frac{IC_A}{\text{Execution time}_A \times 10^6} = \frac{10^9}{6 \times 10^6} = \frac{10^3}{6} \text{ MIPS}$$

$$MIPS_B = \frac{IC_B}{\text{Execution time}_B \times 10^6} = \frac{10^9}{5 \times 10^6} = \frac{10^3}{5} \text{ MIPS}$$

⇒ Combined Throughput of the processor ⇒ $MIPS_A + MIPS_B$

(Since its a dual core processor and Program A runs on Core 1 and Program B on Core 2)

$$\Rightarrow \frac{10^3}{6} + \frac{10^3}{5}$$

$$= \frac{11}{30} \times 10^3 \Rightarrow 366.67 \text{ MIPS}$$

3) Given: $CR_x = 2\ GHz$, $(IC_A)_x = 10 \times 10^9$, $(CPI_A)_x = 3$, $CR_y = 4\ GHz$, $(IC_A)_y = 7 \times 10^9$, $(CPI_A)_y = 5$

$\Rightarrow ((\text{CPU time})_A)_x \Rightarrow \dfrac{(IC_A)_x \cdot (CPI_A)_x}{CR_x}$

↓ Program A in processor x

$\Rightarrow \dfrac{10 \times 10^9 \times 3}{2 \times 10^9} \Rightarrow 15$ secs

$\Rightarrow \left((\text{CPU time})_A\right)_y \Rightarrow \dfrac{(IC_A)_y \cdot (CPI_A)_y}{CR_y}$

↓ Program A in processor Y.

$\Rightarrow \dfrac{7 \times 10^9 \times 5}{4 \times 10^9}$

$\Rightarrow 35/4 = 8.75$ secs

$\Rightarrow$ Speedup (Y/x) $\Rightarrow \dfrac{(\text{CPU time}_A)_x}{(\text{CPU time}_A)_y}$

$\Rightarrow 15/8.75 = 1.3714$

4) Let the old processor be 'x'.

Let the newly designed processor be 'y'.

Given: $CR_x = 1\,GHz$, $(IC_A)_x = 9\times10^9$, $(CPI_A)_x = 1.5$

$CR_y = 2\,GHz$, $(CPU\ time_A)_y = \frac{1}{4}(CPU\ time_A)_x$

$$\Rightarrow (CPU\ time_A)_x \Rightarrow \frac{(IC_A)_x \times (CPI_A)_x}{CR_x}$$

$$\Rightarrow \frac{9\times10^9 \times 1.5}{10^9} \Rightarrow 13.5 \text{ secs}$$

Since, we are executing

Let's assume that $(IC_A)_x = (IC_A)_y = 9\times10^9$.

$$\Rightarrow (CPU\ time_A)_y \Rightarrow \frac{(IC_A)_y \times (CPI_A)_y}{CR_y}$$

$$\Rightarrow \frac{9\times10^9 \times (CPI_A)_y}{2\times10^9}$$

$$\Rightarrow \frac{1}{4/2} \times 13.5 = \frac{9}{2} \times (CPI_A)_y$$

$$\Rightarrow (CPI_A)_y = \text{Average CPI on processor } y \Rightarrow 0.75$$

5) Given: $P_{total} = 80\,W$, operating Voltage = 5V

$f = 2\,GHz$.

a) We know that $\boxed{P_{total} = P_{static} + P_{dynamic}}$

And a processor consumes approximately 40% of total power as "static power" → (P_{static})

$\therefore P_{static} = \frac{40}{100} \times 80 = 32\,W$

$P_{dynamic} = 80 - 32 = 48\,W$

$\Rightarrow P_{static} = V \cdot I = 5I$

$P_{dynamic} = \frac{1}{2} C V^2 f = \frac{1}{2} C (25) (2 \times 10^9)$

$= 25C \times 10^9$.

$\therefore 5I = 32 \Rightarrow \boxed{I = 6.4\,A}$

$25C \times 10^9 = 48 \Rightarrow \boxed{C = 1.92\,nF}$

Now at $f' = 5\,GHz$,

$$P_{dynamic} \Rightarrow \frac{1}{2} C V^2 f' = \frac{1}{2}(1.92 \times 10^{-9})(25)(5 \times 10^{9})$$

$$\Rightarrow 120\,W$$

b) $V' = 2V$, $f = 2\,GHz$

$$P_{total} \Rightarrow V'I + \frac{1}{2} C (V')^2 f$$

$$\Rightarrow 2(6.4) + \frac{1}{2}(1.92 \times 10^{-9})(4)(2 \times 10^{9})$$

$$\Rightarrow \underbrace{12.8}_{P_{static}} + \underbrace{7.68}_{P_{dynamic}} \Rightarrow 20.48\,W$$

$\Rightarrow$ % of Static Power $\Rightarrow \dfrac{P_{static}}{P_{total}} \times 100$

$$\rightarrow \frac{12.8}{20.48} \times 100$$

$$\Rightarrow 62.5\,\%$$