⇒ ES215 Assignment 2

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(2) Program A: CPU Time = 6s CPI = 6 Core 1
Program B: CPU Time = 5s CPI = 5 Core 2
Clock Rate = 1 GHz (Both cores)

↳ Instruction count (IC) = $\frac{\text{CPU Time} \times \text{Clock Rate}}{\text{CPI}}$

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

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

As program runs parallely on cores 1 & 2
Execution time = 6s

↳ Combined Throughput = $\frac{\text{Total Instruction count}}{\text{Execution Time}}$

$= \frac{IC_A + IC_B}{6} = \frac{2 \times 10^9}{6} = 3.33 \times 10^8$

∴ Combined throughput of processor $= 3.33 \times 10^8$

(3) Processor X
Clock Rate = 2 GHz
$IC_A = 10 \times 10^9$
$CPI_A = 3$

$\text{CPU Time} = \frac{IC_A \times CPI}{\text{Clock Rate}}$

$= \frac{10 \times 10^9 \times 3}{2 \times 10^9} = 15s$

∴ Program A takes 15s to complete in Processor X

③ Processor Y
Clock Rate = 4GHz
$IC_A = 7 \times 10^9$
CPI = 5

$$\text{CPU Time} = \frac{7 \times 10^9 \times 5}{4 \times 10^9} = 8.75\text{s}$$

$$\therefore \text{Speed up} = \frac{\text{CPU Time (Processor X)}}{\text{CPU Time (Processor Y)}} = \frac{15}{8.75} = 1.714$$

∴ Program A runs 1.714 times faster on Y than X

④ Clock Rate = CR
$CR_{old} = 1 \times 10^9$ Hz $IC = 9 \times 10^9$ CPI = 1.5
$CR_{new} = 2 \times 10^9$ Hz $IC = 9 \times 10^9$ (Assuming same)

↳ $\text{CPU Time}_{old} = \frac{9 \times 10^9 \times 1.5}{10^9} = 13.5\text{s}$

↳ $\text{CPU Time}_{new} = \frac{13.5}{4} = 3.375\text{s}$

$$\therefore CPI_{new} = \frac{\text{CPU Time}_{new} \times CR_{new}}{IC_{new}} = \frac{3.375 \times 2 \times 10^9}{9 \times 10^9} = 0.75$$

∴ Average CPI of Program A on new design = 0.75

(5) Total power = 80 W
CR = 2×10^9 Hz
Voltage = 5V

⇒ Assuming $\frac{\text{Dynamic Power}}{\text{Static Power}} = \frac{4}{1}$

$4x + x = 80 \rightarrow x = 16$
$DP_{old} = 64$ W $SP_{old} = 16$ W

(a) Dynamic Power $\propto$ frequency $\sim N * C * V^2 * f * A$
$DP_{old} = 64$ W (4:1 ratio)
$f_{R\,new} = 5 \times 10^9$ Hz

$\therefore$ Dynamic Power consumed $= \left(\frac{5 \times 10^9}{2 \times 10^9}\right) \times 64$

$= \underline{160 \text{ W}}$

(b) $\text{Voltage}_{new} = 2V$

Static Power $\propto$ Voltage $\sim N * V * e^{-V_t}$

$\therefore$ Static Power (New) $= \left(\frac{2}{5}\right) \times 16$

$= \underline{6.4 \text{ W}}$

Dynamic Power $\propto (\text{Voltage})^2$

$\therefore$ Dynamic Power (New) $= \frac{4}{25} \times 64$

$= \underline{10.24 \text{ W}}$

$\therefore$ Total Power $= 10.24 + 6.4$

$= \underline{16.64 \text{ W}}$

$\therefore$ Fraction of Static Power $= \frac{6.4}{16.64} = \underline{0.3846} = \underline{38.46\%}$

① MIPS Code : Github Repository

↳ Assumptions (Array initialized by us)
↳ In the code, I have initialized the array for size 10.