ES215 _ COA _ Assignment - 4

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1). Let's assume the no. of instructions to be "N".

- Baseline is a pipeline with larger value of N.

Therefore, $\boxed{CPI_{baseline} = 1}$ $\left(\Rightarrow \frac{N+4}{N} \Rightarrow 1 + \underbrace{\frac{4}{N}}_{\approx 0 \text{ (if } N >> 4)} \right)$

- Speedup = $\frac{CPI_{baseline}}{CPI_{pipeline}}$ (Because ~~no~~ IC and Clock rate are going to be the same in both the cases).

a) i) 30% RAW dependency and 20% branch dependency :

We know that $CPI_{pipeline} = \sum CPI_{instruction} * fraction_{instruction}$

$\therefore$

$$CPI_{pipeline} = \overbrace{(1-0.3-0.2) * 1}^{\text{No dependency}} + (0.3)(1 + stall_{\text{RAW dependency}}) + (0.2)(1 + stall_{\text{branch dependency}})$$

We know that

$$\boxed{\begin{aligned} stall_{\text{RAW dependency}} &= 3 \\ stall_{\text{branch dependency}} &= 2 \end{aligned}}$$

$\therefore$ $CPI_{pipeline} = (0.5 * 1) + (0.3 * 4) + (0.2 * 3)$

$$\boxed{CPI_{pipeline} = 2.3}$$

$\therefore$ Speedup $= \frac{1}{2.3} = \underline{\underline{0.4348}}$

ii) <u>If we used a branch predictor with 80% accuracy:</u>

- This means that ~~the~~ 20% (inaccurate) of 20% branch dependent instructions are stalled by 2.
- And as we did before, 30% RAW dependent instructions are stalled by 3.

$\therefore$ $CPI_{pipeline} = (0.5 * 1) + (0.3)(1+3) + (0.2)(1+(0.2)*2)$

$$\boxed{CPI_{pipeline} = 1.98}$$

$\therefore$ Speedup $= \frac{1}{1.98} = \underline{\underline{0.5051}}$

b) i) 40 % branch dependency:

$\Rightarrow CPI_{pipeline} \Rightarrow (1-0.4)*1 + (0.4)(1+ stall_{branch\ dependency})$

$\Rightarrow 0.6*1 + (0.4)(1+2)$

$$\boxed{CPI_{pipeline} = 1.8}$$

$\therefore$ Speedup $= \frac{1}{1.8} = \underline{\underline{0.5556}}$

ii) If we used a branch predictor with 80% accuracy:

- This means that 20% (inaccuracy) of 40% branch dependent instructions are stalled by 2.

$\therefore CPI_{pipeline} \Rightarrow (1-0.4)*1 + (0.4)(1+(0.2)(2))$

$\Rightarrow (0.6)*1 + (0.4)(1.4)$

$\Rightarrow 1.16.$

$\therefore$ Speedup $\Rightarrow \frac{1}{1.16} \Rightarrow \underline{\underline{0.8621}}$

2) <u>Given</u>: 20% ⇒ branch instructions.

85% ⇒ Filled delay slots.

$CPI_{base} = 1.5$ — no delay slot used.

$$\Rightarrow CPI_{base} = (0.8)(CPI_{non-branch}) + (0.2)(CPI_{branch})$$

$$\Rightarrow \boxed{1.5 = (0.8)(CPI_{non-branch}) + (0.2)(CPI_{branch})} \rightarrow (1)$$

For each delay slot filled, CPI reduces by 1.

- fraction of branch instructions where delay slot is filled

$$\Downarrow$$

$$(0.2)(0.85) \Rightarrow 0.17$$

- fraction of branch instructions where delay slots are not filled ⇒ $(0.2)(0.15) \Rightarrow 0.03$

$$\therefore \boxed{CPI = (0.8)(CPI_{non-branch}) + 0.17(CPI_{branch} - 1) + 0.03(CPI_{branch})} \rightarrow (2)$$

(1) - (2)

$$\Rightarrow 1.5 - CPI = 0.17$$

$$\Rightarrow \boxed{CPI = 1.33}$$