Assignment - 4

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1 (a) 30% RAW dependency and 20% branch dependency

Assumption - Instruction are high and thus CPI without hazards = 1. Also, IC & T_c remains same in all cases and every dependency causes hazard

(i) Case-1 stalls for each RAW hazard = 3 [Assumed]
Further, stalls for each branch dependency = 2 [Assumed]

$$\Rightarrow (CPI)' = (CPI) + \frac{30}{100} \times 3 + \frac{20}{100} \times 2$$

$$\Rightarrow CPI' = 1 + 0.9 + 0.4 = 2.3$$

$$\Rightarrow \text{Speedup} = \frac{CPI}{CPI'} = \frac{1}{2.3} = 0.435$$

Therefore, speedup decreases (<1) if we introduce dependencies

Case-2 stalls for each RAW hazard = 3 [Assumed], branch = 2 [Assumed]
Now, instead of waiting for PC, we can guess with 70% of branch instructions included (wrongly guessed)

$$\Rightarrow CPI' = (CPI + \frac{30}{100} \times 3 + \frac{20}{100} \times 2 \times \frac{70}{100} = 2.18$$

$$\text{Speedup} = \frac{CPI}{CPI'} = \frac{1}{2.18} = 0.458$$

Here, too, we observe the same. But it results in better outcome than case-1

(ii) with branch predictor , (same assumptions)

$$CPI' = CPI + \frac{30}{100} \times 3 + \frac{20}{100} \times 2 \times \left(1 - \frac{8}{100}\right)$$

$$CPI' = 1 + 0.9 + 0.8 = 1.98$$

$$\text{Speedup} = \frac{CPI}{CPI'} = \frac{1}{1.98} = 0.505$$

Here, too, we observe decrease in speedup with dependency. But this performs better than previous case

(b) 10% branch dependency

stalls for each branch dependency = 2 [Assumi]

$$CPI' = CPI + \frac{90}{100} \times 2 = 1.8$$

$$\text{Speedup} = \frac{CPI}{CPI'} = \frac{1}{1.8} = 0.555$$

∴ Speedup ↓ with introduction of dependency

Case-2 Here instead of waiting for PC, we can guess with 70% of branch instruction included (i.e. wrongly guessed)

$$\therefore CPI' = CPI + \frac{40}{100} \times 2 \times \frac{70}{100}$$

$$CPI' = 1 + 0.56 = 1.56$$

$$\text{Speedup} = \frac{CPI}{CPI'} = \frac{1}{1.56} = 0.6410$$

Here, we observe same as previous, but it is better

(ii) ~~50%~~ with branch predictor
if branch prediction incorrect then
stalls for branch dependy = 2 [Assume]

$$\therefore CPI' = CPI + \frac{40}{100} \times 2 \times \left(1 - \frac{50}{100}\right)$$

$$\therefore \text{Speedup} = \frac{CPI}{CPI'} = \frac{1}{1.16} = 0.8621$$

Here, too, speedup decreases but it is significantly better than previous cases

2. Base CPI = 1.5 [Assume]
instructions are high & thus CPI without hazards = 1 [Assume]
Stalls for branch dependency = 2 [Assume]
Given 20% branch instruction
$\Rightarrow$ CPI = $1 + \frac{20}{100} \times 2 = 1.4$ [If all take branch]

As $1.5 > 1.4$, there are also other hazards present in the instructions.
Further, if we use delayed branching we have to account other hazards.

$\therefore$ If after delaying there are no change in hazards present in instruction (assumption),

$$CPI' = CPI_{base} - \frac{20}{100} \times \frac{85}{100} \times (2-1)$$

[as delay slot = 2-1]

$\Rightarrow$ $CPI' = 1.5 - 0.17 = 1.33$