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COE 308 – Computer Architecture (T041)

Quiz # 01 - Solution

Suppose that a program is being run on a processor consists of the following instruction mix:

Operation	Frequency	Clock cycle count per instruction
ALU operations	40%	4
Loads	20%	2
Stores	20%	2
Branches	20%	3

With the current processor, **75%** of all Branch operations are conditional branches. Each conditional branch requires an ALU operation to be executed immediately before the branch operation is executed. Other than being used by the conditional branch operation, the result of the ALU operation is not being used further in the program. Furthermore, the ALU operation is using operands that are being used further in the program.
A designer decides to investigate a modified architecture for the processor by introducing a new Branch operation that performs the required ALU operation needed to perform the conditional branch, and branches accordingly. The new Branch operation has a clock cycle count of 4. The modified processor's clock cycle is **20% faster** than the current processor's clock cycle. Which processor version has a better performance?

Solution:

CPI_{old} = (40% * 4) + (20% * 2) + (20% * 2) + (20% * 3) = 3

$CPU\ time_{old}$ = CPI_{old} * $Instruction\ Count_{old}$ * $Clock\ Cycle_{old}$
= 3 * $Instruction\ Count_{old}$ * $Clock\ Cycle_{old}$

With new architecture:
ALU operations: 40% - (20% * 75%) operations with 4 clock cycles per instruction
Load operations: No change
Store operations: No change
Branches: (20% * 75%) operations use the new Branch operation with 4 clock cycles per instruction, and
20% - (20% * 75%) operations use the original Branch operation with 3 clock cycles per instruction

Overall program reduces to 100% - (20% * 75%) = 85%

CPI_{new} = [(40% - (20% * 75%)) * 4 + 20% * 2 + 20% * 2 + (20% * 75%) * 4 + (20% - (20% * 75%) * 3] / 85%
= 2.55 / 0.85 = 3

$Clock\ Cycle_{old}$ = (1 + 20%) * $Clock\ Cycle_{new}$ = 1.2 * $Clock\ Cycle_{new}$ $\Rightarrow$ $Clock\ Cycle_{new}$ = 0.83 * $Clock\ Cycle_{old}$

$CPU\ time_{new}$ = CPI_{new} * $Instruction\ Count_{new}$ * $Clock\ Cycle_{new}$
= 3 * (85% * $Instruction\ Count_{old}$) * (0.83 * $Clock\ Cycle_{old}$)
= 2.12 * $Instruction\ Count_{old}$ * $Clock\ Cycle_{old}$

Since $CPU\ time_{old}$ > $CPU\ time_{new}$, then **modified** CPU is **faster**.