Name: **SOLUTION**

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COE 308 – Computer Architecture (T032)

Quiz # 01 (SOLUTION)

***** Show all your work. No credit will be given if work is not shown! *****

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, **25%** of all ALU operations read both operands directly from memory and write results directly to memory, the remaining ALU operations read both operands from registers and write results to registers.
A designer decides to investigate a modified architecture for the processor by allowing **only** ALU operations that read both operands directly from registers and write results to registers, and, hence, require additional Load and Store commands. Assume that each operand is used only once in the program, and that each result must be stored to a unique memory location. The modified processor's clock cycle is **50% 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 = 3.0

$CPU\ time_{old}$ = CPI_{old} * $Instruction\ Count_{old}$ * $Clock\ Cycle_{old}$
= 3.0 * $Instruction\ Count_{old}$ * $Clock\ Cycle_{old}$

With modified architecture:
ALU operations: (40% * 25%) operations will be replaced with 4 clock cycles per instruction, and 40% - (40% * 25%) operations will remain the same with 4 clock cycles per instruction
Load operations: (20% + 2 * (40% * 25%)) operations with 2 clock cycles
Store operations: (20% + (40% * 25%)) operations with 2 clock cycles
Branches: No change

Overall program becomes 100% + 3* (40% * 25%) = 130%

CPI_{new} = [(40% * 25%) * 4 + (40% - (40% * 25%)) * 4 + (20% + 2 * (40% * 25%)) * 2 + (20% + (40% * 25%)) * 2 + 20% * 3] / 130%
= 3.6 / 1.3 = 2.77

$Clock\ Cycle_{old}$ = 1.50 * $Clock\ Cycle_{new}$ $\Rightarrow$ $Clock\ Cycle_{new}$ = 0.67 * $Clock\ Cycle_{old}$

$CPU\ time_{new}$ = CPI_{new} * $Instruction\ Count_{new}$ * $Clock\ Cycle_{new}$
= 2.77 * (130% * $Instruction\ Count_{old}$) * (0.67 * $Clock\ Cycle_{old}$)
= 2.4 * $Instruction\ Count_{old}$ * $Clock\ Cycle_{old}$

Since ($CPU\ time_{new}$) < ($CPU\ time_{old}$), then performance of **modified (or new) processor is better**.

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