King Fahd University of Petroleum and Minerals
College of Computer Sciences and Engineering
Department of Computer Engineering

COE 308 – Computer Architecture (T041)

Homework # 01 (*due date: Sunday 03/10/2004*)

***** 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	25%	3
Loads	45%	2
Stores	10%	2
Branches	20%	3

With the current processor, only **30%** of all ALU operations **read** operands directly from memory, the remaining ALU operations **read** operands from registers. A designer decides to investigate a modified architecture for the processor by forcing all ALU operations **not** to read operands from registers (i.e. all ALU operations are forced to read operands directly from memory). Thus, total **loads** in the program will be reduced. The modified architecture causes the "Loads" operations' clock cycle to increase by 50%. The clock cycle of the modified processor is 10% **slower** than the current processor's clock cycle. Which CPU is faster?

Solution:

CPI_{old} = (25% * 3) + (45% * 2) + (10% * 2) + (20% * 3) = 2.45

$CPU\ time_{old}$ = CPI_{old} * $Instruction\ Count_{old}$ * $Clock\ Cycle_{old}$
= 2.45 * $Instruction\ Count_{old}$ * $Clock\ Cycle_{old}$

With new architecture:
Note that 30% of ALU operations already read operands directly from memory. That is, 100% - 30% = 70% of ALU operations do **NOT** read operands directly from memory, and, thus, will be replaced.

ALU operations: (25% * 70%) operations use the new ALU operations with 3 clock cycles per instruction, and
25% - (25% * 70%) operations use the original ALU operations with 3 clock cycles per instruction
Load operations: 45% - (25% * 70% * 2) operations with 3 clock cycles per instruction
Store operations: No change
Branches: No change

Overall program reduces to 100% - (25% * 70% * 2) = 65%

CPI_{new} = [(25% * 70%) * 3 + (25% - (25% * 70%)) * 3 + (45% - (25% * 70% * 2) * 3 + 10% * 2 + 20% * 3] / 65%
= 1.85 / 0.65 = 2.85

$Clock\ Cycle_{new}$ = (1 + 10%) * $Clock\ Cycle_{old}$ = 1.1 * $Clock\ Cycle_{old}$

$CPU\ time_{new}$ = CPI_{new} * $Instruction\ Count_{new}$ * $Clock\ Cycle_{new}$
= 2.85 * (65% * $Instruction\ Count_{old}$) * (1.1 * $Clock\ Cycle_{old}$)
= 2.035 * $Instruction\ Count_{old}$ * $Clock\ Cycle_{old}$

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