Com S 321 **Homework 3** **Due: Thursday, Sept. 14, Midnight**
Fall 2017

1. Suppose you have a load-store computer with the following instruction mix:

Operation	Frequency	Number of clock cycles
ALU ops	40 %	2
Loads	20 %	4
Stores	18 %	4
Branches	22 %	6

The ALU ops (arithmetic logic unit ops) typically use operands in CPU registers and hence they take fewer clock cycles to execute. However, if you want to add a memory operand to a CPU register, then you would have to explicitly load it into a CPU register. For such ALU operations, you would say that they are paired with a load instruction since the value moved from memory would be used only for the particular ALU operation and not used anywhere else. We observe that 30% of the ALU ops are paired with a load (i.e., they occur together), and we propose to replace these ALU ops and their loads with a new instruction. Assume that this new instruction takes 4 clock cycles. However, with the new instruction added, branches will take 8 clock cycles rather than 6. Assuming that the clock rate is unchanged, would this change improve performance? Justify your answer quantitatively. Show all your work.

2. Suppose you have a load/store computer as described above with the following instruction mix:

Operation	Frequency	No. of Clock cycles
ALU ops	35%	1
Loads	25%	2
Stores	15%	2
Branches	25%	3

(a) Compute the CPI. Show all your work.

(b) We observe that 25% of the ALU ops are paired with a load, and we propose to replace these ALU ops and their loads with a new instruction. The new instruction takes 1 clock cycle. With the new instruction added, branches take 5 clock cycles. Compute the CPI for the new version. Show all your work.

(c) If the clock rate for the new version is 30% faster than the old version, which version is faster and by what percent? Justify your answer quantitatively. Show all your work.

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1 • $CPI_{old} = (0.4*2)+(0.2*4)+(0.18*4)+(0.22*6)$
$\boxed{= 3.64}$

• $CPI_{new} = \left[[(0.4-0.12)*2] + [(0.2-0.12)*4] + (0.18*4) + (0.22*8) + (0.12*4) \right] / (1-0.12)$
$\boxed{= 4.36364}$

• $CPU.E.T_{old} = IC_{old} * 3.64 * CCT_{old}$

• $CPU.E.T_{New} = (1-0.12) * IC_{old} * 4.36364 * CCT_{old}$
$= 3.84 * IC_{old} * CCT_{old}$

– No, this will not improve the performance since the old CPU.E.T runs faster than the new. The old version is faster by:
$\frac{3.84}{3.64} = 1 + \frac{N}{100}$, $\boxed{5.495\% = N}$

2 (a) $CPI_{old} = 0.35*1 + 0.25*2 + 0.15*3 + 0.25*3$
$\boxed{= 1.9}$

(b) $CPI_{New} = \left[(0.35-0.0875)*1 + (0.25-0.0875)*2 + 0.15*2 + 0.25*5 + 0.0875*1 \right] / (1-0.0875)$
$\boxed{= 2.43836}$

(c) $\frac{CCT_{old}}{CCT_{New}} = 1.3$, $CCT_{old} = 1.3 * CCT_{New}$

$CPU.ET_{old} = IC_{old} * 1.9 * 1.3 * CCT_{New}$
$= 2.47 * IC_{old} * CCT_{New}$

$CPU.ET_{New} = (1-0.0875) * IC_{old} * 2.43836 * CCT_{New}$
$= 2.225 * IC_{old} * CCT_{New}$

– The New system is faster by: $\frac{2.47}{2.225} = 1 + \frac{N}{100}$

$\boxed{N = 11.011\%}$