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Homework Quiz (HW #6)
SOLUTIONS

April 17, 2001
CS152 Computer Architecture and Engineering

This quiz combines two of the problems from homework #6.
Good Luck!

Your Name:	
SID Number:	
Discussion Section:	

Total:	

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Cache organization

Your company has an application that must be run as fast as possible. The hardware division of your company has come up with three separate first-level cache configurations:

- *Machine I:* Direct-mapped with one-word blocks
- *Machine II:* Direct-mapped with four-word blocks
- *Machine III:* Two-way set associative with four-word blocks

For each of these machines, the cache fill penalty is 6 cycles + 1 cycle for each word.

You did some experiments and measured the following instruction mix for the application:
Branch: 18%, Load: 13%, Store: 17%, Float Insts: 20%, Integer: 32%

Further, through a hardware cache monitor, you measured the following miss rates:

- *Machine I:* Instruction miss rate: 4%; Data miss rate: 20%
- *Machine II:* Instruction miss rate: 2%; Data miss rate: 16%
- *Machine III:* Instruction miss rate: 1.5%; Data miss rate: 14%

Finally, the total CPI measured with Machine I is 3.0.

1. Which machine spends the most time waiting for memory? Justify your answer (no guesses!):

Total Loads and Stores = 30%
Miss Penalty for I = 6 + 1 = 7. Miss Penalty for II and III = 6 + 4 = 10

$Total\ Penalty_I = 0.04 \times 7 + 0.30 \times 0.20 \times 7 = 0.28 + 0.42 = 0.70$
$Total\ Penalty_{II} = 0.02 \times 10 + 0.30 \times 0.16 \times 10 = 0.20 + 0.48 = 0.68$
$Total\ Penalty_{III} = 0.015 \times 10 + 0.30 \times 0.14 \times 10 = 0.15 + 00.42 = 0.57$

So, Machine I spends the most time waiting for memory.

2. What is the CPI for Machine III?

Assuming that the base (non-memory) CPI is the same for all machines, we compute this component from Machine I and add in the penalty for Machine III:

$$CPI_{base} = 3.0 - 0.70 = 2.30$$

So, $CPI_{Machine\ I} = 2.30 + 0.57 = 2.87$

3. Suppose that these machines run at 100Mhz (10ns cycle time). What is the average memory access time (AMAT) for each of these machines (in nanoseconds) assuming that machines I and II have a 1 cycle hit time and machine III has a 2 cycle hit time?

Note that 1/1.3 of our memory operations are from instructions, another 0.3/1.3 from data:
$AMAT_I = 10\ ns \times ((1/1.3) \times (1+(0.04)7) + (.3/1.3) \times (1+(.2)7)) = 15.4\ ns?$
$AMAT_{II} = 10ns \times ((1/1.3) \times (1+(0.02)10) + (.3/1.3) \times (1+(.16)10)) = 15.2\ ns$
$AMAT_{III} = 10ns \times ((1/1.3) \times (2+(0.015)10) + (.3/1.3) \times (2+(.14)10)) = 24.4\ ns$