CS3853: Computer Architecture
Homework 1
Spring 2017
Total Marks: 36
Due Date: 01/24/2017

Name:
Banner Id:
Alias:

Solution

1. (a) [2 pt] If system A has a speed up of n over system B, what is the performance improvement of A in terms of percentage?

$$n = \frac{ET_B}{ET_A}$$ (1 pt for this)

$$\Rightarrow ET_B = n\,ET_A$$
$$= ET_A + (n-1)\,ET_A$$
$$= ET_A + (n-1)\times 100\%\ ET_A$$

So, $(n-1)\times 100\%$ improvement (1 pt for this)

(b) [2 pt] If system A performs n% better than system B, what is the speed up of system A over system B?

$$ET_B = ET_A + \frac{n}{100} ET_A$$ (1 pt)
$$= ET_A\left(1 + \frac{n}{100}\right)$$
$$= \frac{100+n}{100} ET_A$$
$$\frac{ET_B}{ET_A} = \frac{100+n}{100}$$

$$\text{Speed up} = \frac{100+n}{100}$$ (1 pt)

2. An application spends 20% of its time in computation that is inherently serial, and the rest can be run in parallel. Assume an ideal speed up for the parallel section

(a) [4 pt] How much faster will this application run on 10 processors?

$$S = \frac{1}{1 - f_{enh} + \frac{f_{enh}}{S_{enh}}}$$
$$= \frac{1}{1 - 0.2 + \frac{0.2}{10}}$$ (2 pt for using right values)
$$= \frac{1}{0.82}$$
$$= 1.219$$

2 pt for any of these answers

(b) [4 pt] How about 100 processors?

$$S = \frac{1}{1-0.2+\frac{0.2}{100}}$$ (2 pt for right values)

$$= \frac{1}{0.802}$$

$$= 1.247$$ } 2 pt for any of these answers

(c) [4 pt] What is the maximum speed up possible by means of multiple processors?

$$S = \frac{1}{1-0.2+\frac{0.2}{\infty}}$$ (2 pt for identifying max ~~S~~ enh to be ∞)

$$= \frac{1}{0.8}$$

$$= 1.25$$ } 2 pt for any of these answers

3. We are examining improving an existing architecture by adding an external cache and a faster disk. For the target application, it is predicted the cache will cause loads to complete twice as fast, while the new disk causes the average I/O request to experience a speedup of 1.2. The present system spends 20% of its time doing loads, and 30% of its time doing I/O.

(a) [4 pt] What speedup will we expect from adding both enhancements at the same time?

$$S = \frac{1}{1-f_1-f_2+\frac{f_1}{S_1}+\frac{f_2}{S_2}}$$ (2 pt for right values)

$$= \frac{1}{1-0.2-0.3+\frac{0.2}{2}+\frac{0.3}{1.2}}$$

$$= 1.176$$ (2 pt for answer)

(b) [4 pt] If we want to make the application get the same speedup while improving only the disk, how much speedup will the disk need to provide?

$$1.176 = \frac{1}{1 - f_2 + \frac{f_2}{S_2'}}$$ (2 pt for setting up this equation)

$$\Rightarrow 1.176 = \frac{1}{1 - 0.3 + \frac{0.3}{S_2'}}$$

$$\Rightarrow \frac{0.3}{S_2'} = \frac{1}{1.176} - 0.7$$

$$S_2' = \frac{0.3}{\frac{1}{1.176} - 0.7} = 1.995$$ (2 pt for final answer)

4. Table 1 gives the frequency and CPI of different type of instructions for a particular machine.

Instruction Type	Frequency	Average CPI
ALU Operations	57%	1
Loads	17%	2
Stores	11%	2
Branches	15%	5

Table 1: Information about different instruction type

(a) [4 pt] What is the overall CPI of this machine?

$$CPI = \sum_i CPI_i \times f_i$$

$$= 1 \times 0.57 + 2 \times 0.17 + 2 \times 0.11 + 5 \times 0.15$$ (3 pt for this equation)

$$= 1.88$$ (1 pt for answer)

(b) [4 pt] A student designs a new instruction that combines a load with an ALU operation. If 25% of the original loads can be replaced with this new instruction, what would be the new frequency of different type of instructions?

Assume total instructions = 100

ALU 57
Load 17
Store 11
Branch 15

After using new instructions

ALU # $57 - 0.25 \times 17 = 52.75$
Load $17 - 0.25 \times 17 = 12.75$
Store 11
Branch 15
New ins $0.25 \times 17 = 4.25$
Total = 95.75 (2pt for up to this)

∴ Frequency

ALU $\frac{52.75}{95.75} = 55.1\%$
Load $\frac{12.75}{95.75} = 13.3\%$
Store $11/95.75 = 11.5\%$
Branch $15/95.75 = 15.7\%$
New ins $= \frac{4.25}{95.75} = 4.4\%$
(2pt for this)

(c) [4 pt] If the CPI of the new instruction is 3, what is the overall CPI?

$CPI = 1 \times 0.551 + 2 \times 0.133 + 2 \times 0.115 + 5 \times 0.157 + 3 \times 0.044$

(3pt for this)

$= 1.964$ (1pt for final answer)