CS3853: Computer Architecture
Prof. Vijayalakshmi Saravanan
Assignment 2
Solution
FALL 2017
Total Marks: 36

Name: Solution
Banner Id:

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?

$n = \frac{ET_B}{ET_A}$ or $ET_B = n\,ET_A = ET_A + (n-1)ET_A$

Percentage speed up $= (n-1) \times 100\,\%$

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

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

$$\text{or,} \quad \frac{ET_B}{ET_A} = \frac{100+n}{100}$$

$$\therefore \text{Speed up} = \frac{100+n}{100}$$

2. An application spends 25% 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] What speedup will we expect from adding both enhancements at the same time?

2 pt for equation
2 " " result

$f_1 = 25\%, \; S_1 = 2$

$f_2 = 40\%, \; S_2 = 1.5$

$$S = \frac{1}{1 - f_1 - f_2 + \frac{f_1}{S_1} + \frac{f_2}{S_2}}$$

$$= \frac{1}{1 - 0.25 - 0.4 + \frac{0.25}{2} + \frac{0.4}{1.5}} = 1.35$$

(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?

2 pt for equation
2 " " result

$$S = \frac{1}{1 - f_2 + \frac{f_2}{S_2'}}$$

$$\text{or}, \; 1.35 = \frac{1}{1 - 0.4 + 0.4/S_2'}$$

$$\text{or}, \; S_2' = 2.84$$

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

Instruction Type	Frequency	Average CPI
ALU Operations	63%	1
Loads	15%	1.5
Stores	13%	1.5
Branches	9%	4

Table 1: Information about different instruction type

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

$$CPI = 0.63 \times 1 + 0.15 \times 1.5 + 0.13 \times 1.5 + 0.09 \times 4$$

$$= 1.41$$

2 pt for equation, 2pt for result

(a) [4 pt] How much faster will this application run on 50 processors?

$$S = \frac{1}{1 - f + \frac{f}{S_{enh}}}$$

Here, $f = (100 - 25)\% = 75\%$

$S_{enh} = 50$

$$= \frac{1}{1 - 0.75 + \frac{0.75}{50}}$$

$$= 3.77$$

2 pt for equation, 2 pt of final result

(b) [4 pt] How about 500 processors?

$$S = \frac{1}{1 - 0.75 + \frac{0.75}{500}}$$

Here, $S_{enh} = 500$

$$= 3.98$$

2 pt for equation, 2pt for result

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

$$S_{max} = \frac{1}{1 - f}$$

$$= \frac{1}{0.25}$$

$$= 4$$

2 pt for equation, 2 pt for result

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 1.5. The present system spends 25% of its time doing loads, and 40% of its time doing I/O.

(b) [4 pt] A student designs a new instruction that combines a load with an ALU operation. If 40% of the original loads can be replaced with this new instruction, what would be the new frequency of different type of instructions?

Assume 100 total instructions in old system.

New system:

Count of ALU operations = $63 - 0.4 \times 15 = 57$

" " Loads = $\cancel{0}15 - 0.4 \times 15 = 9$

" " Stores = 13

" " Branches = 9

" " new ins = $0.4 \times 15 = 6$

Total = 94

2 pt for this part

∴ Frequency of ALU = $57/94 = 60.6\%$

" " Loads = $9/94 = 9.6\%$

" " Stores = $13/94 = 13.8\%$

" " Branches = $9/94 = 9.6\%$

Freq of new ins = $6/94 = 6.4\%$

2 pt for the rest

(c) [4 pt] If the CPI of the new instruction is 2.5, what is the overall CPI?

$CPI = 0.606 \times 1 + 0.096 \times 1.5 + 0.138 \times 1.5$

$+ 0.096 \times 4 + 0.064 \times 2.5$

$= 1.501$

2 pt for equation

2 pt for the result