CS 465 - Homework 1 – Fall 2016

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Part 2 (30% of grade for homework 1): Exercises related to chapter 1.

1. [20% of homework 1] Assume that the CPI for arithmetic, load/store, and branch instructions of a processor is 1, 10, and 6, respectively. Also assume that on a single processor a program requires the execution of $2.56 * 10^9$ arithmetic instructions, $1.28 * 10^9$ load/store instructions, and $1.28 * 10^8$ branch instructions. Assume that each processor has a 2 GHz clock frequency.

a. Find the total execution time (in sec) for this program on a single processor.

	arithmetic instructions	load/store instructions	branch instructions
CPI	1	10	6
Instruction count	2.56*10^9	1.28*10^9	1.28*10^8

$$CPU\ Time = Instruction\ Count\ x\ CPI\ x\ Clock\ Cycle$$
$$= \frac{Instruction\ Count\ x\ CPI}{Clock\ Rate}$$

$$= \frac{1\ x\ 2.56 * 10^9 + 10\ x\ 1.28 * 10^9 + 6\ x\ 1.28 * 10\text{^}8}{2Ghz}$$
$$= \frac{1\ x\ 2.56 * 10^9 + 10\ x\ 1.28 * 10^9 + 6\ x\ 1.28 * 10\text{^}8}{2 * 10^9 \frac{cycles}{seconds}}$$

$$= 8.064\ seconds$$

b. Assume that, as the program is parallelized to run over multiple cores, the number of arithmetic and load/store instructions per processor is divided by 0.8 * p (where p is the number of processors) but the number of branch instructions per processor remains the same. Find the total execution time for this program on 2 and 8 processors and show the relative speedup.

Execution time for 2 processors: 0.8*p=0.8*2=1.6

$$= \frac{\frac{1\ x\ 2.56 * 10^9}{1.6} + \frac{10\ x\ 1.28 * 10^9}{1.6} + 6\ x\ 1.28 * 10\text{^}8}{2 * 10^9 \frac{cycles}{seconds}} = 5.184\ seconds$$

$$\text{Relative speed up } = \frac{Old}{new\ 8\ processor} = \frac{8.064\ seconds}{5.184\ seconds} = 1.555$$

Execution time for 8 processors: 0.8*p=0.8*8=6.4

$$= \frac{\frac{1\ x\ 2.56 * 10^9}{6.4} + \frac{10\ x\ 1.28 * 10^9}{6.4} + 6\ x\ 1.28 * 10\text{^}8}{2 * 10^9 \frac{cycles}{seconds}} = 1.584\ seconds$$

$$\text{Relative speed up } = \frac{Old}{new\ 8\ processor} = \frac{8.064\ seconds}{1.584\ seconds} = 5.091$$

c. If the CPI of the arithmetic instructions was tripled, what would be the impact on the execution time of the program on 1, 2, or 8 processors? Point out the general trend you observe.

Execution time for 1 processors:

$$= \frac{3\ x\ 2.56 * 10^9 + 10\ x\ 1.28 * 10^9 + 6\ x\ 1.28 * 10\text{^}8}{2 * 10^9 \frac{cycles}{seconds}} = 10.624\ seconds$$

Execution time for 2 processors: 0.8*p=0.8*2=1.6

$$= \frac{\frac{3\ x\ 2.56 * 10^9}{1.6} + \frac{10\ x\ 1.28 * 10^9}{1.6} + 6\ x\ 1.28 * 10\text{^}8}{2 * 10^9 \frac{cycles}{seconds}} = 6.784\ seconds$$

Execution time for 8 processors: 0.8*p=0.8*8=6.4

$$= \frac{\frac{3\ x\ 2.56 * 10^9}{6.4} + \frac{10\ x\ 1.28 * 10^9}{6.4} + 6\ x\ 1.28 * 10\text{^}8}{2 * 10^9 \frac{cycles}{seconds}} = 1.984\ seconds$$

The trend is that the times are increasing which means that the exaction is becoming slower for each different processors.

d. To what should the CPI of load/store instructions be reduced in order for a single processor to match the performance of 8 processors using the original CPI values?

We need to find the load store to match the time 1.584 $seconds$ so we need to solve the Equation for the load/store.

$$\frac{1\ x\ 2.56 * 10^9\ + \text{load/store}\ x\ 1.28 * 10^9 + 6\ x\ 1.28 * 10\text{^}8}{2 * 10^9 \frac{cycles}{seconds}} = 1.584\ seconds$$

$$\text{load/store}\ x\ 1.28 * 10^9 = (1.584 *\ 2 * 10^9) - (2.56 * 10^9 +\ +6\ x\ 1.28 * 10^8)$$

$$\text{load/store}\ = \frac{(1.584 *\ 2 * 10^9) - (2.56 * 10^9 + 6\ x\ 1.28 * 10^8)}{1.28 * 10^9}$$

load/store <= -4.125

2. [10% of homework 1] Consider a computer running a program that requires 320 sec, with 90 sec spent executing floating point (FP) instructions, 100 sec executing Load/Store (L/S) instructions, 60 sec spent executing branch (BR) instructions, and 70 sec spent executing integer (INT) instructions.

	Total running Time	floating point (FP) instructions	Load/Store (L/S) instructions	branch (BR) instructions	integer (INT) instructions
	320	90	100	60	70
a	297.5	67.5	100	60	70
b	313	90	100	60	63
c	245	90	100	60-80=-20	70

a. By how much is the total time reduced if the time for FP instructions is reduced by 25% (assuming all other instructions are not changed)?

FP= 0.25*90=22.5 Total time= 320-22.5=297.5

b. By how much is the time for INT instructions reduced if the total time is reduced by 10% (assuming all other instructions are not changed)?

INT=0.10 *70=7 Total time= 320-7=313

c. Can the total time be reduced by 25% by reducing only the time for branch instructions?
Total time needs to be reduced by = 0.25 *320= 80 but the branch instructions takes only 60 seconds so it will be impossible to be reduced less than it takes. Reducing the branch instructions will not help in this case.