CS 465 - Homework 1 – Fall 2016

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Team Allowed: maximum of two per team.
State clearly team member names and GMU IDs as comments in source code and each page of submitted report.
Late submissions are not accepted.
How to submit: A zip file answering all questions from Parts 1, 2, and 3. The submission will be made via a blackboard link available to you. For team projects, only one member of the team should submit the zip file and the other should submit a one-page PDF file stating the names of both members of the team.

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

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

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

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

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

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

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:

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

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

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

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.