CS 695: Advanced Computer Architecture (Spring 2023)

Homework 1

Question 1

[15 points] Show that the ratio of the geometric means is equal to the geometric mean of the performance ratios and that the reference computer of SPECRatio does not matter.

Question 2

When parallelizing an application, the ideal speedup is speeding up by the number of processors. This is limited by two things: percentage of the application that can be parallelized and the cost of communiation. Amdahl's Law takes into account the former but not the latter.

2.1 [2 points] What is the speedup with N processors if 80% of the application is paralellizable, ignoring the cost of communication?

2.2 [3 points] What is the speedup with eight processors if, for every processor added, the communication overhead is 0.5% of the original execution time.

2.3 [3 points] What is the speedup with eight processors if, for every time the number of processors is doubled, the communication overhead is increased by 0.5% of the original execution time?

2.4 [3 points] What is the speedup with N processors if, for every time the number of processors is doubled, the communication overhead is increased by 0.5% of the original execution time?

2.5 [9 points] Write the general equation that solves this question: What is the number of processors with the highest speedup in an application in which P% of the original execution time is parallelizable, and, for every time the number of processors is doubled, the communication is increased by 0.5% of the original execution time?

Question 3

3.1 [5 points] Why memory hierarchy?

3.2 [15 points] Supposing a cache system with the following specs:

L1 Caches	64KB
L2 Caches	4MB
L3 Caches	64MB

Alice and Bob are competing with each other for improving the performance of this cache system. Alice chooses to improve the L1 Caches and achieves a speedup of 30 on the L1 Cache. Bob decides to work on the L3 Caches and manages to get a speedup of 2 on the L3 Cache. Who wins? Why?

Question 4

Assuming register 2 reads value 210 and register 4 reads value 3 right before executing the following code snippet:

```
add $2, $4, $2
mul $1, $2, $4
sub $1, $1, $4
add $1, $1, 3
```

[10 points] What are the final values of all the used registers? Please show it step by step.

Question 5

Suppose we made the following measurements:

Frequency of FP operations = 25%
Average CPI of FP operations = 6.0
Average CPI of other oinstructions = 1.44
Frequency of FSQRT = 4%
CPI of FSQRT = 30

Assume that the two design alternatives are to decrease the CPI of FSQRT to 4.0 or to decrease the average CPI of all FP operations to 3.0.

5.1 [5 points] What is the original CPI?

5.2 [5 points] What is the CPI if we choose to decrease the CPI of FSQRT?

5.3 [5 points] What is the CPI if we choose to decrease the average CPI of all FP operations?

5.4 [5 points] Which one should we choose? Why?