CS220 Quiz#5

General instructions: Please write brief explanation for your answers. If you submit multiple times, your last submission will be used for grading. Please provide an email address below where your responses can be sent.

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Q1. Consider a program that has 15% load/store instructions, 15% conditional branch instructions, 10% other types of control transfer instructions, and 60% arithmetic and logic instructions. The program is executed on a processor with average load/store CPI of 7, conditional branch CPI of 4, other types of control transfer instructions CPI of 3, and arithmetic and logic instructions CPI of 2. Suppose the implementation of only one of the aforementioned four categories of instructions could be optimized to bring the CPI of that category down to 1 while keeping everything else unchanged. What is the maximum speedup achievable by this optimization? [2 points]

Let's assume that there are 100 instructions in the program.
Number of cycles spent in executing load/store = 105
Number of cycles spent in executing conditional branch = 60
Number of cycles spent in executing other control transfer instructions = 30
Number of cycles spent in executing arithmetic and logic instructions = 120
Maximum saving in cycles is obtained by optimizing the CPI of the load/store instructions.
Maximum speedup = (105+60+30+120)/(15+60+30+120) = 315/225 = 1.4

Q2. A certain portion P of a program has been optimized such that the execution time of that portion has become one-fourth of the original time this portion used to take. The execution time of P after the optimization is one-third of the total post-optimization execution time of the program. What is the overall speedup enjoyed by the program due to this optimization? [1 point]

Let us suppose that P originally used to take x fraction of the total original execution time t. That has become tx/4 after optimization. Since tx/4 is one-third of the total post-optimization time, total post-optimization time is 3tx/4. Since the execution time of everything other than P has remained unchanged, we have 2tx/4 = (1-x)t or x=2/3. So, the speedup = t/(3tx/4) = 2.

Q3. Suppose Booth's algorithm is used in a multiplication where the multiplicand and the multiplier are represented in two's complement and their respective values are 0xcddaabbc and 0xddaabbcc. Count the number of addition and subtraction operations. [2 points]

Multiplier = 1101_1101_1010_1010_1011_1011_1100_1100
Number of 0 to 1 transitions = 10 = number of subtractions
Number of 1 to 0 transitions = 9 = number of additions

Q4. By inspecting the quotient of an unsigned division it is possible to infer the sequence of subtractions and additions that would have taken place if the division was done using the non-restoring division algorithm. Calculate the number of addition and subtraction operations if the quotient is 1110. [1 point]

Since the division is unsigned, the first operation is guaranteed to be a subtraction. Next we have another subtraction. At this point, the quotient is 11. After this we have another subtraction making the quotient 111. Then we have another subtraction making the quotient 1111. Finally, an addition makes the quotient 1110. So, there are one addition and four subtractions.