CSE 240A Homework 1
Performance Metrics and ISA

Due October 26, 2021

Instructions

- Submit typed answers to the following questions as a PDF via Gradescope.
- Due: October 26, 2021 at 11:59 PM.
- Homework is to be done individually.
- There are two questions for a total of 30 points (7.5% of your total grade).
- It would be great if you can finish the HW by typing rather than handwriting.

1 CPI (20 points)

Assume a processor with instruction frequencies in percentage and costs
Integer ALU: 50%, 1 cycle
Load: 20%, 2 cycles
Store: 10%, 2 cycles
Branch: 20%, 3 cycles
The clock frequency is 500MHz.

1. Please compute the CPI. (2 points)
2. Please identify which case achieves more performance improvement, and explain why:
   (a) Increase Integer ALU frequency by 20%, and increase Load cycle to 4 cycles.
   (b) Reduce Integer ALU frequency by 20%, and increase Branch frequency by 50%.
   (c) Reduce Branch cycle to 2 cycles, and reduce ALU frequency by 40%. (6 points)
3. Please compute the MIPS (Million instructions per second) for the three cases in Problem 1.2. (3 points)
4. We observe that 30% of Integer ALU operations are paired with Load. If we were to replace these Integer ALU ops and their Loads with a single instruction that executes in 1 clock cycle, the number of clocks cycles taken for the branch operation to perform increases to 5 cycles. Compute the CPI for this new version. (3 points)
5. If a program includes 500 million integer ALU operations, 80 million load operations, 200 million store operations, and 100 million branch operations. How long does it take if we execute it on this processor (in the original statement)? Please provide the answer in seconds. (3 points)
6. If you hope to optimize this processor (in the original statement), which instruction will you plan to optimize, and how? Explain why. (3 points)

2 Amdahl's Law (10 points)

We use the same processor in Problem 1.

1. Using the processor in problem 1's original statement, if I want to achieve at least a 1.15X speedup by accelerating one operation, how can I get there? (Hint: there is no space to speedup ALU, as it only occupies 1 cycle. Every operation at least consumes 1 cycle, and the cycle should be integer.) (3 points)
2. Assume this processor supports parallelization, and if I want to run a program on it: this program contains the same operations with Problem 1.4 . The processor can run at most 1000 threads parallely. Each thread is only used for executing ALU operations (including ALU operations and combined ALU-Load). How much performance improvement can I achieve? (2 points)
3. Unfortunately, my processor is I/O bound, as it consumes 80% of the total time to wait for data. What is the highest speedup of such a processor? (2 points)
4. What are benchmarks? Why do we need them? (3 points)