CECS 341: Computer Architecture Organization
Homework 1 – Performance Evaluation and Amdahl's Law
Due: Sunday Sep 20, 2020, by 11PM

Student ID:
Name:

Note: Submit your HW into BeachBoard Dropbox. Each HW has its own Dropbox folder.
Note: Your submissions should be **clearly and neatly**.

Problem 1 (40 points):

Consider the following two processors. P1 has a clock rate of 4 GHz, average CPI of 0.9, and requires the execution of 5.0E9 instructions. P2 has a clock rate of 3 GHz, an average CPI of 0.75, and requires the execution of 1.0E9 instructions.

a. One usual fallacy is to consider the computer with the largest clock rate as having the highest performance. Check if this is true for P1 and P2.
b. Another fallacy is to consider that the processor executing the largest number of instructions will need a larger CPU time. Considering that processor P1 is executing a sequence of 1.0E9 instructions and that the CPI of processors P1 and P2 do not change, determine the number of instructions that P2 can execute in the same time that P1 needs to execute 1.0E9 instructions.
c. A common fallacy is to use MIPS (millions of instructions per second) to compare the performance of two different processors and consider that the processor with the largest MIPS has the largest performance. Check if this is true for P1 and P2.
d. Another common performance figure is MFLOPS (millions of floating-point operations per second), defined as:

$$MFLOPS = No. FP\ operations/(execution\ time\ \times 1E6)$$

Assume that 40% of the instructions executed on both P1 and P2 are floating-point instructions. Find the MFLOPS figures for the processors.

Problem 2 (20 points):

A program P running on a single-processor system takes time T to complete. Let us assume that 40% of the program's code is associated with "data management housekeeping" (according to Amdahl) and, therefore, can only execute sequentially on a single processor. Let us further assume that the rest of the program (60%) is "embarrassingly parallel" in that it can easily be divided into smaller tasks executing concurrently across multiple processors (without any interdependencies or communications among the tasks).

a. Calculate T2, T4, T8, which are the times to execute program P on a two-, four-, eight-processor system, respectively.
b. Calculate $T\infty$ on a system with an infinite number of processors. Calculate the speedup of the program on this system, where speedup is defined as $\frac{T}{T\infty}$. What does this correspond to?

Student ID:
Name:

Problem 3 (15 points):

Assume that we are considering enhancing a machine by adding a vector mode to it. When a computation is performed in vector mode, it is 20 times faster than the normal mode of execution. We call percentage of time that could be spent using vector mode the percentage of vectorization.

a. What percentage of vectorization is needed to achieve a speedup of 2?
b. What percentage of vectorization is needed to achieve one-half of the maximum speedup attainable from using vector mode?
c. Suppose you have measured the percentage of vectorization for programs to be 70%. The hardware design group says they can double the speed of vector rate with a significant additional engineering investment. You wonder whether the compiler crew could increase the use of vector mode as another approach to increasing performance. How much of an increase in the percentage of vectorization (relative to the current usage) would the compiler team need to obtain the same performance gain? Which investment would you recommend?

Problem 4 (15 points):

Assume a program requires the execution of 50×10^6 FP (Floating Point) instructions, 110×10^6 INT (integer) instructions, 80×10^6 L/S (Load/Store) instructions, and 16×10^6 branch instructions. The CPI for each type of instruction is 1, 1, 4, and 2, respectively. Assume that the processor has a 2GHz clock rate.

a. By how much must we improve the CPI of FP (Floating Point) instructions if we want the program to run two times faster?
b. By how much must we improve the CPI of L/S (Load/Store) instructions if we want the program to run two times faster?
c. By how much is the execution time of the program improved if the CPI of INT (Integer) and FP (Floating Point) instructions are reduced by 40% and the CPI of L/S (Load/Store) and Branch is reduced by 30%?

Problem 5 (10 points):

Processor A has a clock rate of 3.6 GHz and voltage 1.25V. Assume that, on average, it consumes 90W of dynamic power.

Processor B has a clock rate of 3.4 GHz and voltage of 0.9V. Assume that, on average, it consumes 40W of dynamic power.

For each processor find the average capacitive loads.

Good Luck