25-1 Computer Architecture Homework #1

Due: 3/31 17:00 p.m.

1. Consider three different processors P1, P2, and P3 executing the same instruction set. P1 has a 3 GHz clock rate and a CPI of 1.5. P2 has a 2.5 GHz clock rate and a CPI of 1.0. P3 has a 4.0 GHz clock rate and has a CPI of 2.2

   A. Which processor has the highest performance expressed in instructions per second?

   B. If the processors each execute a program in 10 seconds, find the number of cycles and the number of instructions

   C. We are trying to reduce the execution time by 30% but this leads to an increase of 20% in the CPI. What clock rate should we have to get this time reduction?

2. The Pentium 4 Prescott processor, released in 2004, had a clock rate of 3.6 GHz and voltage of 1.25 V. Assume that, on average, it consumed 10 W of static power and 90 W of dynamic power.

The Core i5 Ivy Bridge, released in 2021, had a clock rate of 3.4 GHz and voltage of 0.9V. Assume that, on average, it consumed 30 W of static power and 40 W of dynamic power

A. For each processor find the average capacitive loads.

B. Find the percentage of the total dissipated power comprised by static power and the ratio of static power to dynamic power for each technology.

C. If the total dissipated power is to be reduced by 10%, how much should the voltage be reduced to maintain the same leakage current? Note: power is defined as the product of voltage and current.

3. The result of the SPEC CPU2006 bzip2 benchmark running on an AMD Barcelona has an instruction count of 2.389E12, an execution time of 750 s, and a reference time of 9650 s.

   A. Find the CPI if the clock cycle time is 0.333ns.

   B. Find the SPECratio

   C. Find the increase in CPU time if the number of instructions of the benchmark is increased by 10% without affecting the CPI.

   D. Find the increase in CPU time if the number of instructions of the benchmark is increased by 10% and the CPI is increased by 5%.

   E. Find the change in the SPECratio for this change

   F. Suppose that we are developing a new version of the AMD Barcelona processor with a 4 GHz clock rate. We have added some additional instructions to the instruction set in such a way that the number of instructions has been reduced by 15%. The execution time is reduced to 700 s and the new SPECratio is 13.7. Find the new CPI.

   G. This CPI value is larger than obtained in 3-A as the clock rate was increased from 3 GHz to 4 GHz. Determine whether the increase in the CPI is similar to that of the clock rate. If they are dissimilar, why?

   H. By how much has the CPU time been reduced?

   I. For a second benchmark, libquantum, assume an execution time of 960 s, CPI of 1.61, and clock rate of 3 GHz. If the execution time is reduced by an additional 10% without affecting to the CPI and with a clock rate of 4 GHz, determine the number of instructions.

   J. Determine the clock rate required to give a further 10% reduction in CPU time while maintaining the number of instructions and with the CPI unchanged.

   K. Determine the clock rate if the CPI is reduced by 15% and the CPU time by 20% while the number of instructions is unchanged.

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

   A. By how much must we improve the CPI of FP instructions if we want the program to run two times faster?

   B. By how much must we improve the CPI of L/S 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 and FP instructions is reduced by 40% and the CPI of L/S and Branch is reduced by 30%?