

1. Consider two different implementations of the same instruction set architecture. The instructions can be divided into four classes according to their CPI (class A, B, C, D). P1 with a clock rate of 2.5GHz and CPIs of 1, 2, 3 and 3, and P2 with a clock rate of 3GHz and CPIs of 2, 2, 2, and 2.

Given a program with a dynamic instruction count of $1.0E6$ instructions divided into classes as follows : 10% class A, 20% class B, 50% class C, and 20% class D, which is faster: P1 or P2?

- a. What is the global CPI for each implementation?
- b. Find the clock cycles required in both cases.

2. Compilers can have a profound impact on the performance of an application. Assume that for a program, compiler A results in a dynamic count of $1.0E9$ and has an execution time of 1.1s, while compiler B results in a dynamic instruction count of $1.2E9$ and an execution time of 1.5s.

- a. Find the average CPI for each program given that the processor has a clock cycle time of 1 ns.
- b. Assume the compiled programs run on two different processors. If the execution times on the two processors are the same, how much faster is the clock of the processor running compiler A's code versus the clock of the processor running compiler B's code?
- c. A new compiler is developed that uses only $6.0E8$ instructions and has an average CPI of 1.1. What is the speedup of using this new compiler versus using compiler A or B on the original processor?

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

- 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 4GHz 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 700s and the new SPECratio is 13.7. Find the new CPI.

4. Another pitfall is expecting to improve the overall performance of a computer by improving only one aspect of the computer. Consider a computer running a program the requires 250s, with 70s spent executing FP instructions, 85s executed L/S instructions, and 40s spent executing branch instructions.

- a. By how much is the total time reduced if the time for FP operations is reduced by 20%?
- b. By how much is the time for INT operations reduced if the total time is reduced by 20%?
- c. Can the total time can be reduced by 20% by reducing only the time for branch instruction?