Homework Assignment 1

Collaboration Policy. Homework will be done individually: each student must hand in their own answers. It is acceptable for students to collaborate in understanding the material but not in solving the problems or programming. Use of the Internet is allowed, but should not include searching for existing solutions.

Under absolutely no circumstances code can be exchanged between students. If some code was shown in class, it can be used, but it must be obtained from Canvas, the instructor or the Course Assistants..

Assignments from previous offerings of the course must not be re-used. Violations will be penalized.

Late Policy. No late submissions will be allowed without consent from the instructor. If urgent or unusual circumstances prohibit you from submitting a homework assignment in time, please e mail me; otherwise the Syllabus late penalty applies.

Deliverable. A single professionally typed pdf or MS Word file on Canvas. **Show your work in detail**, not just answer. No handwritten work or pictures of handwritten work are accepted.

Problem 1 (15 points) Consider three different processors P1, P2, and P3 executing the same instruction set. P1 has a 3.2 GHz clock rate and a CPI of 1.5. P2 has a 2.0 GHz clock rate and a CPI of 1.0. P3 has a 4.0 GHz clock rate and has a CPI of 2.3.

a. Calculate the performance of each processor expressed in instructions per second. b. If each of these processors executes a program in 10 seconds, calculate the number of cycles and the number of instructions.

c. We are trying to reduce the execution time of P2 by 30%, but this leads to an increase of20% in the CPI. What should the clock rate be to obtain this reduction in execution time?

Problem 2 (15 points) Consider two different implementations of the same instruction set architecture. The instructions can be divided into four classes according to their CPI (classes A, B, C, and D). P1 with a clock rate of 2.5 GHz and CPIs of 1, 2, 3, and 3 for the corresponding classes, and P2 with a clock rate of 3 GHz 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: 30% class A, 20% class B, 30% class C, and 20% class D, which is faster: P1 or P2?

a. What is the total CPI for each implementation?

b. Calculate the clock cycles required in both cases.

Problem 3 (20 points) Compilers can have a profound impact on the performance of an application. Assume that for a program, compiler A results in a dynamic instruction count of 1.0E9 and has an execution time of 1.2 s, while compiler B results in a dynamic instruction

count of 1.2E9 and an execution time of 1.5 s.

a. Find the average CPI for each program given that the processor has a clock cycle time of 1ns.

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 As code versus the clock of the processor running compiler Bs code?

c. A new compiler is developed that uses only 6.0E8 instructions and has an average CPI of1.1. What is the speedup of using this new compiler versus using compiler A or B on the original processor?

Problem 4 (15 points) Assume a 15 cm diameter wafer costs $12, contains 84 dies, and has 0.022 defects/cm^2. Assume a 20 cm diameter wafer costs $15, contains 100 dies, and has 0.031 defects/cm^2.

a. Calculate the yield for both wafers.

b. Calculate the cost per die for both wafers.

c. If the number of dies per wafer is increased by 10% and the defects per area unit increases by 15%, find the die area and yield.

Problem 5 (15 points) A version of Pentium has a clock rate of 3.2 GHz and voltage of 1.2V.It consumes 12W of static power and 48 W of dynamic power.

a. What is the average capacitive load of this processor?

b. If the total dissipated power is to be reduced by 10% (from both dynamic and static power), how much should the voltage be reduced to maintain the same leakage current?

Problem 6 (20 points) Assume a program requires the execution of 50E06 floating point (FP) instructions, 100E06 integer (INT) instructions, 80E06 load/store (L/S) instructions, and 16E06 branch (B) 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. How much faster can we execute the program if the CPI of INT and FP instructions is reduced by 40% and the CPI of L/S and Branch is reduced by 30%?

b, By how much must we improve the CPI of FP instructions if we want the program to run 20% faster? (That is to take 80% of the original time.)

c. By how much must we improve the CPI of L/S instructions if we want the program to run 30% faster?