1.5 [4] <§1.6> 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?

Number of instructions per second = Clock Rate / CPI

P1: (3 * 10^9)/1.5 = 2 * 10^9 IPS

P2: (2.5 * 10^9)/1 = 2.5 * 10^9 IPS

P3: (4 * 10^9)/2.2 = 1.8 * 10^9 IPS

=> P2 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.

Number of cycles = Clock Rate * Execution Time in seconds

P1: 3 * 10^9 * 10 = 3 * 10^10 cycles

P2: 2.5 * 10^9 * 10 = 2.5 * 10^10 cycles

P3: 4 * 10^9 * 10 = 4 * 10^10 cycles

Number of instructions = IPS * Execution Time in seconds

P1: 2 * 10^9 * 10 = 2 * 10^10 instructions

P2: 2.5 * 10^9 * 10 = 2.5 * 10^10 instructions

P3: 1.8 * 10^9 * 10 = 1.8 * 10^10 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?

Clock Rate = Number of instructions * CPI / Execution Time

New execution time: 10 - (30% * 10 /100%)= 10 - 3 = 7 seconds

New CPI:

- P1: 1.5 + (20% * 1.5 /100%) = 1.8

- P2: 1 + (20% * 1 /100%) = 1.2

- P1: 2.2 + (20% * 2.2 /100%) = 2.64

Clock Rate:

(All answers are divided by 10^9 to get GHz)

P1: [(2 * 10^10) * (1.8)] / 7 = 5.143 GHz

P2: [(2.5 * 10^10) * (1.2)] / 7 = 4.286 GHz

P3: (1.8 * 10^10) * (2.64)] / 7 = 6.789 GHz

1.6 [20]<§1.6>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, and D). P1 with a clock rate of 2.5 GHz and CPIs of 1, 2, 3, and 3, 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 are divided into classes as follows: 10% class A, 20% class B, 50% class C, and 20% class D, which implementation is faster?

Execution Time = Number of instructions * CPI / Clock Rate

P1: 10^6 * [(1 * 0.1) + (2 * 0.2) + (3 * 0.5) + (3 * 0.2)] / 2.5 * 10^9 = 1.04 * 10^-3 sec = 1.04 mili sec

P2: 10^6 * [(2 * 0.1) + (2 * 0.2) + (2 * 0.5) + (2 * 0.2)] / 3 * 10^9 = 0.67 * 10^-3 sec = 0.67 mili sec

=> P2 is faster

a. What is the global CPI for each implementation?

Global CPI = Execution Time * clock rate / Number of instructions

P1: 1.04 * 10^-3 * 2.5 * 10^9 / 10^6 = 2.6

P2: 0.67 * 10^-3 * 3 * 10^9 / 10^6 = 2.01

b. Find the clock cycles required in both cases.

clock cycles = Global CPI * Number of instructions

P1: 2.6 * 10^6

P2: 2.01 * 10^6