Homework #1

Assigned: 14/03/2023
Due: 21/03/2023

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1. (**25 pts**) Consider three different processors P1, P2 and P3 executing the same instruction set. Clock rates and CPIs of the processors are given below.

Processor	Clock Rate	CPI
P1	2.0 GHz	1.0
P2	2.5 GHz	1.25
P3	3.0 GHz	2.5

a. (**5 pts**) Compute MIPS rates of the processors.

MIPS = IC/(CPU_time * 10^6) = f/(CPI * 10^6)

MIPS_P1 = (2 * 10^9) / (1 * 10^6) = **2 * 10^3 MIPS**
MIPS_P2 = (2.5 * 10^9) / (1.25 * 10^6) = **2 * 10^3 MIPS**
MIPS_P3 = (3 * 10^9) / (2.5 * 10^6) = **1,20 * 10^3 MIPS**

b. (**5 pts**) The programs C1, C2 and C3 are executed in P1, P2 and P3, respectively. All executions take 5 seconds. Find the number of instructions for each program.

IC = MIPS * (CPU_time * 10^6)

IC_C1 = (2 * 10^3) * (5 * 10^6) = **10 * 10^9 instructions**
IC_C2 = (2 * 10^3) * (5 * 10^6) = **10 * 10^9 instructions**
IC_C3 = (1,20 * 10^3) * (5 * 10^6) = **6 * 10^9 instructions**

c. (**15 pts**) The modification to reduce the execution time by 20%, leads to an increase of 20% in the CPI. What should be the new clock rates of the processors to achieve the targeted performance.

NewCPU_time = 4s, NewCPI_P1 = 1.2, NewCPI_P2 = 1.5, NewCPI_P3 = 3

CPU_time = CC * CT = (CPI * IC) * CT = (CPI * IC)/f —> f = (CPI * IC)/CPU_time

f_P1 = (1.2 * (10 * 10^9)) / 4 = 3 * 10^9 = **3 GHz**
f_P2 = (1.5 * (10 * 10^9)) / 4 = 3.75 * 10^9 = **3.75 GHz**
f_P3 = (3 * (6 * 10^9)) / 4 = 4.5 * 10^9 = **4.5 GHz**

2. (**30 pts**) Consider two processors (P1 and P2) are the different implementations of the same ISA. The clock rates of the processors are 2.5 GHz and 3 GHz, respectively. The instructions are divided into three classes according to their CPIs, which are given below.

	P1	P2
Class A	1	2
Class B	1.5	2
Class C	3	2

Given a program with a dynamic instruction count of 10^6 instructions divided into classes as follows: 40% class A, 35% class B and 25% class D.

a. (**10 pts**) What is the global CPI for each implementation?

Weighted average for P1 = (0.4 * 1) + (0.35 * 1.5) + (0.25 * 3) / 1 = **1.675 CPI**
Weighted average for P2 = (0.4 * 2) + (0.35 * 2) + (0.25 * 2) / 1 = **2.0 CPI**

b. (**10 pts**) Find the clock cycles required in both cases.

# of class A instructions = 4 * 10^5
# of class B instructions = 3.5 * 10^5
# of class C instructions = 2.5 *10^5

CC = CPI * IC

CC_P1 = (1 * (4 * 10^5)) + (1.5 * (3.5 * 10^5)) + (3 * (2.5 * 10^5)) = **1.675 * 10^6 cycles**

CC_P2= (2 * (4 * 10^5)) + (2 * (3.5 * 10^5)) + (2 * (2.5 * 10^5)) = **2 * 10^6 cycles**

c. (**10 pts**) Find the execution time in both cases.

CPU_time = CC * CT = CC/f

CPU_time_P1 = (1.675 * 10^6) / (2.5 * 10^9) = **0.67 * 10^-3 seconds**

CPU_time_P2 = (2 * 10^6) / (3 * 10^9) = **0.667 * 10^-3 seconds**

3. (**30 pts**) Consider a given benchmark has an instruction count of 2.1 x 10^{12} and a reference time of 8000s. The execution of the benchmark takes 900 s on a processor with the cycle time of 0.25 ns.

a. (**10 pts**) Find the CPI of the processor.

CPU_time = CC * CT = (CPI * IC) * CT

CPI = CPU_time / (IC * CT)

CPI_P = 900 / ((2.1 * 10^12) * (2.5 * 10^-10)) = 900 / (525) = **1.714 CPI**

b. (**5 pts**) Find the SPECratio of the processor.

SPECratio = CPU_time_REF / CPU_time_MY

SPECratio_P = 8000/900 = **8.889**

c. (**15 pts**) Suppose that a new version of the processor with the clock rate of 4.5 GHz is developed. A couple of new instructions have been added to new design and the number of instructions has been reduced by 15%. The SPECratio for the new version is 12. Find the execution time and CPI of the new processor.

CPU_time_MY-new = 8000 / 12 = **666.667 seconds**

IC_P-new = 1.785 * 10^12

CPI = CPU_time * f / IC

CPI = ((666.667) * (4.5 * 10^9)) / (1.785 * 10^12) =1680* 10 ^ -3 = **1.68 CPI**

Execution time for the benchmark on the new processor is **666.667** seconds and new CPI of it is **1.68**