# Homework #1

**Assigned**: 14/03/2023

**Due**: 21/03/2023

Rebah Özkoç 29207

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 |

* 1. (**5 pts**) Compute MIPS rates of the processors.

**Solution:**

MIPS of P1 = 2\*10^9/(1\*10^6) = 2000 MIPS

MIPS of P2 = 2.5\*10^9/(1.25\*10^6) = 2000 MIPS

MIPS of P3 = 3\*10^9/(2.5\*10^6) = 1200 MIPS

* 1. (**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.

**Solution:**

Number of instructions = MIPS \* 10^6 \* passed time in seconds

Number of Instructions of P1 = 2000\*10^6\*5 = 1010 Instructions

Number of Instructions of P2 = 2000\*10^6\*5 = 1010 Instructions

Number of Instructions of P3 = 1200\*10^6\*5 = 6 \* 109 Instructions

* 1. (**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.

**Solution:**

t = (IC \* CPI) / f1

(0.8 \* t) = (IC \* 1.2 \* CPI) / f2

F2/F1 = 3/2

P1: f1=2 => f2 = 2\*3/2 = 3 GHz

P2: f1=2.5 => f2 = 2.5\*3/2 = 3.75 GHz

P3: f1=3 => f2 = 3\*3/2 = 4.5 GHz

1. (**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 106 instructions divided into classes as follows: 40% class A, 35% class B and 25% class D.

* 1. (**10 pts**) What is the global CPI for each implementation?

**Solution:**

IC of A : 400000

IC of B : 350000

IC of C: 250000

P1:

CC = (4\*10^5 + 3.5\*10^5\*1.5 + 2.5\*10^5\*3) = 1675000 Cycles

Global CPI = 1675000/10^6=1.675

P2:

CC = (4\*10^5\*2+3.5\*10^5\*2+2.5\*10^5\*2) = 2000000 Cycles

Global CPI = (2\* 10^6) /10^6=2

* 1. (**10 pts**) Find the clock cycles required in both cases.

**Solution:**

CC = IC x CPI

Processor P1:

Clock cycles = 10^6 \* 1.675 = 1675000 Cycles

Processor P2:

Clock cycles = 10^6 x 2.0 = 2000000 Cycles.

* 1. (**10 pts**) Find the execution time in both cases.

**Solution:**

CPU execution time = (IC x CPI)/f = CC / f

Processor P1:

Execution time = 1675000 Cycles / (2.5 \* 10^9) Hz = 0.00067 seconds

Processor P2:

Execution time = 2000000 Cycles / (3 \* 10^9) Hz = 0.000666 seconds

1. (**30 pts**) Consider a given benchmark has an instruction count of 2.1 x 1012 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.
   1. (**10 pts**) Find the CPI of the processor.

**Solution:**

CPI = Clock Count / Instruction Count

Instruction Count = 2.1 \* 1012

Frequency = 1/period = 1/(2.5 \* 10^(-10)) = 4 \* 109 Hz

Clock Count = 900 s \* 4 \* 109 Hz = 3.6 \* 1012

CPI = (3.6 \* 1012) / (2.1 \* 1012) = 1.714

* 1. (**5 pts**) Find the SPECratio of the processor.

**Solution:**

SPECratio = (reference machine time) / (target machine time)

SPECratio = 8000 s / 900 s = 8.889

* 1. (**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.

**Solution:**

New Execution Time = Reference Time / SPECratio = 8000 / 12 = 666.67 seconds

CPI = CC / IC (Clock Count / Instruction Count)

New Instruction Count = 2.1\*1012 \* 0.85 = 1.785\*10^12

New Clock Count = 666.67 s \* 4.5 \* 10^9 Hz = 3.000015 \*10^12

New CPI = (3.000015 \*10^12) / (1.785 x 10^12) = 1.680