CAO HW1

Remy Jaspers - 4499336

February 14, 2017

1

To calculate the number of instructions per second, we need to find the cycle time and multiply this with the average number of cycles per instruction or CPI, according to paragraph 1.6. Cycle time is the reciprocal of the frequency, or $\frac{1}{F}$. No information is given about the number of instructions, so we assume the instruction count I is equal for both ISA's.

$$\text{CPU Time} = \text{Instruction count * Cycles per instruction * Cycle time} \tag{1}$$

For P1:

$$\text{CPU Time} = I \cdot \frac{1}{4 \cdot 10^9} \cdot 2.2 = I \cdot 5.5 \cdot 10^{-10} \text{ seconds} \tag{2}$$

P2:

$$\text{CPU Time} = I \cdot \frac{1}{3 \cdot 10^9} \cdot 1.5 = I \cdot 5 \cdot 10^{-10} \text{ seconds} \tag{3}$$

From which we can conclude that P2 is $\frac{5.5}{5} = 1.1$ times as fast as P1. Or in terms of instructions per second, for P1:

$$\text{IPS} = \frac{4 \cdot 10^9}{2.2} = 1.82 \cdot 10^9 \tag{4}$$

and P2:

$$\text{IPS} = \frac{3 \cdot 10^9}{1.5} = 2 \cdot 10^9 \tag{5}$$

From which is clearly visible that P2 is faster.

2

The classic CPU performance equation, as stated in 1.6 is:

$$T = \frac{I \cdot \text{CPI}}{F} \tag{6}$$

We can find the number of instructions I for P1 as follows:

$$I = \frac{T \cdot F}{\text{CPI}} \tag{7}$$

Substitution for known variables for P1:

$$I = \frac{5 \cdot 4 \cdot 10^9}{2.2} = 9.09 \cdot 10^9 \text{ instructions} \tag{8}$$

P2:

$$I = \frac{5 \cdot 3 \cdot 10^9}{1.5} = 1 \cdot 10^{10} \text{ instructions} \tag{9}$$

The number of cycles is given in the numerator, P1 has $20 \cdot 10^9$ cycles and P2 $15 \cdot 10^9$ cycles, respectively. Obviously, the number of cycles is equal to the time multiplied by the number of cycles per second.

3

A 20 percent reduction in execution time and an increase of 10 percent in the CPI yields the following formula:

$$0.8 \cdot T = \frac{I \cdot (1.1 \cdot \text{CPI})}{F} \tag{10}$$

Which can be rewritten in F:

$$F = \frac{I \cdot (1.1 \cdot \text{CPI})}{T} \tag{11}$$

The target frequency for P1 is:

$$F = \frac{9.09 \cdot 10^9 \cdot (1.1 \cdot 2.2)}{0.8 * 5} = 5.5 \cdot 10^9 \text{ Hz} \tag{12}$$

And for P2:

$$F = \frac{1 \cdot 10^{10} \cdot (1.1 \cdot 1.5)}{0.8 * 5} = 4.125 \cdot 10^9 \text{ Hz} \tag{13}$$

4

The average weighted CPI for each implementation is defined as the sum of all CPI classes multiplied by their weights. We begin by calculating the number of clock cycles for P1:

$$(0.6 * 1) + (0.3 * 1.5) + (0.1 * 4.1) = 1.46 \text{ cycles} \tag{14}$$

and for P2:

$$(0.6 * 2.5) + (0.3 * 1) + (0.1 * 1) = 1.9 \text{ cycles} \tag{15}$$

5

Average weighted CPI is recommended for computing performance, because one can immediately see which class of instructions one has to reduce on the source level to gain performance. Without the weights, it is impossible to know which class of instructions affects performance.