CS147 Homework 1

Frank Mock

September 9, 2015

1.5

a.

P2 has the highest performance in terms of instructions per second because...

P1's performance $\frac{3\times10^9 cycles}{second} \times \frac{instructions}{1.5cycles} = \frac{3\times10^9 instructions}{1.5second} = 2 \times 10^9 \frac{instructions}{second}$

P2's performance $\frac{2.5\times10^9 cycles}{second} \times \frac{instructions}{1.0cycles} = \frac{2.5\times10^9 instructions}{1.0second} = 2.5\times10^9 \frac{instructions}{second}$

P3's performance $\frac{4\times10^9 cycles}{second} \times \frac{instructions}{2.2cycles} = \frac{4\times10^9 instructions}{2.2second} = 1.8\times10^9 \frac{instructions}{second}$

As you can see, P2 can do the most instructions per second.

b.

P1 number of instructions $= \frac{10second}{1} \times \frac{2\times10^9 instructions}{second} = 20 \times 10^9 instructions$

P1 number of cycles $= \frac{10second}{1} \times \frac{3\times10^9 cycles}{second} = 30 \times 10^9 cycles$

P2 number of instructions $= \frac{10second}{1} \times \frac{2.5\times10^9 instructions}{second} = 25\times10^9 instructions$

P2 number of cycles $= \frac{10second}{1} \times \frac{2.5\times10^9 cycles}{second} = 25 \times 10^9 cycles$

P3 number of instructions $= \frac{10second}{1} \times \frac{1.8\times10^9 instructions}{second} = 18\times10^9 instructions$

P3 number of cycles $= \frac{10second}{1} \times \frac{4\times10^9 cycles}{second} = 40 \times 10^9 cycles$

c.

Each processor clock rate needs to be increased by a factor of 1.7. I used the equation given in the text for execution time to calculate this.

$Time = \frac{Seconds}{Program} = \frac{Instructions}{Program} \times \frac{Clockcycles}{Instruction} \times \frac{Seconds}{Clockcycle}$

If P1's execution time is $10\frac{seconds}{program} = \frac{1sec}{3\times10^9 cycles} \times \frac{1.5cycles}{instruction} \times \frac{20\times10^9 instruction}{program}$

Then the following equation reflects the 30% reduction in execution time and a 20% increase in CPI as stated in the problem, where the variable n is the Clock Rate increase factor.

$7\frac{seconds}{program} = \frac{1sec}{n3\times10^9 cycles} \times \frac{1.2\cdot1.5cycles}{instruction} \times \frac{20\times10^9 instruction}{program} = \frac{36\times10^9 second}{n3\times10^9 program}$

$\frac{36\times10^9}{21\times10^9} = n \approx 1.7$ increase in the clock rate for P1.

The same is true for P2 $10\frac{seconds}{program} = \frac{1sec}{2.5\times10^9 cycles} \times \frac{1.0cycles}{instruction} \times \frac{25\times10^9 instruction}{program}$

Then the following equation reflects the 30% reduction in execution time and a 20% increase in CPI as stated in the problem, where the variable n is the Clock Rate increase factor.

$7\frac{seconds}{program} = \frac{1sec}{n2.5\times10^9 cycles} \times \frac{1.2\cdot1.0cycles}{instruction} \times \frac{25\times10^9 instruction}{program} = \frac{30\times10^9 second}{n2.5\times10^9 program}$

$\frac{30\times10^9}{17.5\times10^9} = n \approx 1.7$ increase in the clock rate for P2.

P3's cycle rate should also be increased by 1.7

1.6

P2 is faster by approximately 1.6 times. To determine this I used the equation in the book for CPU time:

$CPU\ Time = Instruction\ Count \times CPI \times Cycle\ Time$

To use this equation, first I needed to convert the given clock rate of each processor to a Cycle Time.

P1 Cycle Time $= \frac{1}{2.5\times10^9} = .000000000400 = 400_p s$

P2 Cycle Time $= \frac{1}{3.0\times10^9} = .000000000333 = 333_p s$

P1 $CPU\ Time = I + 2.6 + 400_p s = I \times 1040_p s$

P2 $CPU\ Time = I + 2.0 + 333_P S = I \times 666_p s$ Faster!

P2 is faster by $\frac{1040}{666} = 1.561561562 \approx 1.6$ times faster.

a.

I used the equation $CPI = \frac{Clock\ Cycles}{InstructionCount}$ to determine the CPI of each processor.

P1 $CPI = \frac{2{,}600{,}000}{1{,}000{,}000} = 2.6$

P2 $CPI = \frac{2{,}000{,}00}{1{,}000{,}000} = 2$

b.

I used the equation $Clock\ Cycles = \sum_{i=1}^{n}(CPI_i \times Instruction\ Count)$

P1 $Clock\ Cycles = 1 \times 100,000 + 2 \times 200,000 + 3 \times 500,000 + 3 \times 200,000 = 2,600,000$

P2 $Clock\ Cycles = 2 \times 100,000 + 2 \times 200,000 + 2 \times 500,000 + 2 \times 200,000 = 2,000,000$

1.7

a.

Using the equation $CPU\ Time = Instruction\ Count \times CPI \times Clock\ Cycle\ Time$

With Compiler A

$1.1 = 1,000,000,000 \times CPI \times 0.000000001$
$1.1 = 1 \times CPI$
$CPI = 1.1$

With Compiler B

$1.5 = 1,200,000,000 \times CPI \times 0.000000001$
$1.5 = 1.2 \times CPI$
$CPI = 1.25$

b.

If the execution time is the same then...

$\frac{Instruction\ Count_A \times CPI}{Clock\ Rate_A} = \frac{Instruction\ Count_B \times CPI}{Clock\ Rate_B}$

$\frac{1{,}000{,}000{,}000 \times CPI}{Clock\ Rate_A} = \frac{1{,}200{,}000{,}000 \times CPI}{Clock\ Rate_B}$

The clock running compiler A's code is 1.2 times faster.

c.

With the new compiler: $CPU\ Time = 6.0 \times 10^8 \times 1.1 \times 0.000000001$

$CPU\ Time = .66\ seconds$

This is $\frac{1.1\ seconds}{0.66\ seconds} \approx 1.66$ times faster than compiler A

This is $\frac{1.5\ seconds}{0.66\ seconds} \approx 2.27$ times faster than compiler B

1.8

1.8.1

Using the equation $Capacitive\ Load = \frac{Power}{Voltage^2 \times Frequency}$

For the Pentium 4: $Capacitive\ Load = \frac{100}{1.25^2 \times 3.6 \times 10^(9)} = 1.8 \times 10^{-8}$

For the Core i5 : $Capacitive\ Load = \frac{70}{0.9^2 \times 3.4 \times 10^(9)} = 2.5 \times 10^{-8}$

1.8.2

For the Pentium 4, since the total power consumed is 100 (10 watts static and 90 watts dynamic) then 10% of the total is Static.

The ratio of static power to dynamic power is $\frac{10}{90} = \frac{1}{9} \approx 0.111111$

For the Core i5, since the total power consumed is 70 watts (30 W of static and 40 W of dynamic) then the total static is:
$\frac{70}{100} = \frac{n}{30}$ $\quad\quad \frac{2100}{100} = n = 21\%$

The ratio of static power to dynamic power is $\frac{0.21}{0.28} = 0.75$

1.8.3

Using $Power_d + Power_s = voltage^2 \times frequency \times capacitiveload$

since we want to maintain the same leakage current only $Power_d$ is reduced by 10% and n will be the factor that the voltage is reduced by.

Pentium 4: $90(.9) + 10 = n1.25^2 \times 3.6 \times 10^9 \times 1.8 \times 10^{-8}$
$90 = n101.25 \quad\quad n \approx 0.8893$
The voltage should be reduced by about 11%

Core i5: $40(.9) + 30 = n0.9^2 \times 3.4 \times 10^9 \times 2.5 \times 10^{-8}$

$66 = n68.85 \qquad n \approx 0.9586$

The voltage should be reduced by about 4%

1.11

1.11.1

$CPI = \frac{CPU\ Time}{IC \times Cycle\ Time}$

$= \frac{750}{2.389 \times 10^{12} \times 3.33 \times 10^{-10}}$

$= 0.942759419 \qquad \text{or} \qquad \approx 0.94$

1.11.2

SPECratio $= \frac{ReferenceTime}{ExecutionTime} = \frac{9650}{750} = \frac{193}{15} \approx 12.87$

1.11.3

n represents the factor by which the CPU time is increased if the instruction count is increased by 10%

$0.942759419 = \frac{750n}{(1.1)2.389 \times 10^{12} \times 3.33 \times 10^{-10}}$

$824.999 = 750n$

$n = 1.1$ CPU execution time is increased 10%

the new CPU Execution time is 825 seconds

1.11.4

n represents the factor by which the CPU time is increased if the instructions are increased by 10% and the CPI is increased by 5%

$(1.05)0.942759419 = \frac{750n}{((1.1)2.389\times10^{12})(3.33\times10^{-10})}$

$0.98989739 = \frac{750n}{875.0907}$

$866.24999 = 750n$

$n = 1.15$ The CPU execution time is increased by 15%

the new CPU Execution time is 862.5 seconds

1.11.5

The new SPECratio is $\frac{9650}{862.5}$ ≈ 11.19

1.11.6

$CPI = \frac{700}{((0.85)2.389\times10^{12})(2.5\times10^{-10})}$

$= \frac{700}{507.6625}$

$= 1.378868 \quad \approx 1.38$

1.11.7

Since the clock rate was increased there will be more clock cycles per instruction and yield a larger CPI

1.11.8

I used the proportion $\frac{750}{100} = \frac{700}{n}$ where n is the percentage of the previous CPU time

$750n = 70000$ $n = 93.333$ CPU time reduced by about 7%