CSCI 4593 Spring 2014 **Vince Coghlan**

Homework #1

1.5: (a) For P1:

$$\text{Instructions per second} = \frac{\text{Cycles per second}}{\text{CPI}} \Rightarrow \text{IPS} = \frac{3\text{ GHz}}{1.5} = 2 \cdot 10^9 \text{ IPS}$$

Similarily P2 works at $2.5 \cdot 10^9$ IPS and P2 works at $1.82 \cdot 10^9$ IPS. This means that P2 is the highest preformance.

(b) In 10 seconds, P1 will have executed $2 \cdot 10^{10}$ instructions in $3 \cdot 10^{10}$ clock cycles. Similarily P2 will have executed $2.5 \cdot 10^{10}$ IPS in $2.5 \cdot 10^{10}$ cycles. P3 will have executed $1.82 \cdot 10^{10}$ instructions in $4 \cdot 10^{10}$ cycles.

(c) Reducing the time by 30% means executing the 10 second program down to 7 seconds, and the various processors will need to execute the same amount of instructions in that shorter time period. We can find:

$$f = \#\text{ of Instructions}\frac{1.2 \cdot \text{CPI}}{\text{time}}$$

This leads to the following:

$$f(\text{P1}) = 2 \cdot 10^{10}\frac{1.2 \cdot 1.5}{7} = 5.14\text{ GHz}$$

$$f(\text{P2}) = 2.5 \cdot 10^{10}\frac{1.2 \cdot 1}{7} = 4.29\text{ GHz}$$

$$f(\text{P3}) = 1.82 \cdot 10^{10}\frac{1.2 \cdot 2.2}{7} = 6.86\text{ GHz}$$

1.6: (a) These instructions will be devided into the classes as follows:

Class A: $1 \cdot 10^5$

Class B: $2 \cdot 10^5$

Class C: $5 \cdot 10^5$

Class D: $2 \cdot 10^5$

From this we can figure the time to execute the program for P1 and P2:

Implementation	Time in A	Time in B	Time in C	Time in D	Total Time
P1	40μs	160μs	600μs	240μs	1.04ms
P2	66.7μs	133.3μs	333.3μs	133.3μs	666.6μs

This makes finding the CPI much easier:

$$\text{CPI}_{P1} = 1.04\text{ms}\frac{2.5\text{GHz}}{1 \cdot 10^6} = 2.6$$

$$\text{CPI}_{P2} = 666.6\mu\text{s}\frac{3\text{GHz}}{1 \cdot 10^6} = 2$$

This shows that P1 is faster.

(b) To find the clock cycles:

$$\text{cycles}_{P1} = 1.04\text{ms} \cdot 2.5\text{GHz} = 2.6 \cdot 10^6$$

$$\text{cycles}_{P2} = 666.666\mu\text{s} \cdot 3\text{GHz} = 2 \cdot 10^6$$

1.8.1: The average capacitave load for Pentium is:

$$\frac{90+10}{1.25^2 \cdot 3.6 \cdot 10^9} = 1.778 \cdot 10^{-8}F$$

And the i5:

$$\frac{30+40}{0.9^2 \cdot 3.4 \cdot 10^9} = 2.543 \cdot 10^{-8}F$$

1.9.1: The total execution time for a single processor is:

$$2.56 \cdot 10^9 \frac{1}{2 \cdot 10^9} + 1.28 \cdot 10^9 \frac{12}{2 \cdot 10^9} + 0.256 \cdot 10^9 \frac{5}{2 \cdot 10^9} = 9.6 \text{ seconds}$$

With multiple processors, the first two numbers change, but the last doesnt, this is all in the following table:

# of cores	Total Execution Time	Relative Speedup
1	9.6 seconds	1
2	7.04 seconds	1.36
4	3.84 seconds	2.5
8	2.24 seconds	4.29

1.10.1: To find the yields we must first find the die area. For wafer 1:

$$\text{Die Area} = \frac{\pi(15)^2}{84} = 8.415\text{cm}^2$$

for wafer 2:

$$\text{Die Area} = \frac{\pi(20)^2}{100} = 12.566\text{cm}^2$$

yield for wafer 1 is:

$$\frac{1}{(1 + (0.020 \cdot 8.415/2))^2} = 0.851$$

and wafer 2:

$$\frac{1}{(1 + (0.031 \cdot 12.566/2))^2} = 0.708$$

1.10.3: If the number of dies per wafer is increased by 10% and the defects per area unit increases by 15%, the die area will become:

$$\text{Die Area} = \frac{\text{Wafer Area}}{1.1 \cdot \text{Dies Per Wafer}}$$

and the yield will become

$$\text{yield} = \frac{1}{(1 + (1.15 \cdot \text{Defects per area} + \text{Die Area}/(2 \cdot 1.1)))^2}$$

For the first wafer the new die area is (rounding number of dies up), 7.6cm^2, and the new yield is 0.846. For the second wafer the new die area is 11.4cm^2 and the new yield is 0.691.

1.11.1: The CPI is:

$$750 \frac{3 \cdot 10^9}{1.389 \cdot 10^{12}} = 1.62$$

1.11.2: The spec ratio is:

$$\frac{9650}{750} = 12.87$$

1.11.4: Since

$$\text{CPU Time} = \frac{\text{Instruction Count} \cdot \text{CPI}}{\text{Clock}}$$

The increase is going to be $1.1 \cdot 1.05 \Rightarrow 15.5\%$.

1.11.6: Using the following equation we find:

$$\text{CPI} = \frac{\text{CPU cycles}}{0.85 \cdot \text{Instruction Count}} = \frac{2.8 \cdot 10^{12}}{0.85 \cdot 2.389 \cdot 10^{12}} = 1.38$$

1.12.1: To check the preformance of the processors, I will use the CPU Time metric:

$$\text{CPU Time}_{P1} = \frac{5 \cdot 10^9 \cdot 0.9}{4 \cdot 10^9} = 1.125$$

$$\text{CPU Time}_{P2} = \frac{1 \cdot 10^9 \cdot 0.75}{3 \cdot 10^9} = 0.25$$

P2 is drastically faster than P1.

1.12.3: The MIPS can be calculated like so:

$$\text{MIPS}_{P1} = \frac{4 \cdot 10^9}{0.9 \cdot 10^6} = 4444.44$$

$$\text{MIPS}_{P2} = \frac{3 \cdot 10^9}{0.75 \cdot 10^6} = 4000$$

This shows P1 as being the faster processor.

1.13: (a) 20% reduction of 70 is 56. This means that the total time will be 236s. This is a 5.6% speedup.

(b) To speed the system up by 25% we would need 62.5 less instructions, this means that the reduction of the INT instructions would have to be less than 0, which is impossible. You can not speed up this machine by 1.25 only by speeding up the INT instructions.

1.14: (a) This program takes $256 \cdot 10^6$ instructions and runs it in 256ms. It is impossible to double the speed by only changing the floating point instructions, its just not enough.

(b) The CPI of L/S instructions would have to be 0.8.