Homework 1 Solutions

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1.2

a)

$$\text{Dies per wafer} = \frac{\pi \times (\frac{\text{Wafer diameter}}{2})^2}{\text{Die area}} \times \frac{\pi \times \text{Wafer diameter}}{\sqrt{2 \times \text{Die area}}}$$

$$\text{Die yield} = \text{Wafer yield}\left(1 + \frac{\text{Defect per area} \times \text{Die area}}{\alpha}\right)^{-\alpha}$$

Wafer yield = 100%, $\alpha = 4.0$, old IBM Power5 die size = 389^2, defect rate = $0.30/cm^2$, wafer size = 300mm, cost = \$500

$$147\text{Dies per wafer} \approx \frac{\pi \times (\frac{300}{2})^2}{389} \times \frac{\pi \times 300}{\sqrt{2 \times 389}}$$

$$36\%\text{Die yield} \approx 1.0 \times \left(1 + \frac{.3 \times 3.89}{4.0}\right)^{-4.0}$$

$$\text{Price per Chip} = \frac{\text{Cost to Manufacture}}{Yield \times \text{Dies per wafer}}$$

$$\$9.45 = \frac{\$500}{.36 \times 147}$$

b)

New IMB Power5 Chip = $186mm^2$, defect rate = $0.7/cm^2$

$$330\text{Dies per wafer} \approx \frac{\pi \times \left(\frac{300}{2}\right)^2}{186} - \frac{\pi \times 300}{\sqrt{2 \times 186}}$$

$$32\%\text{Die yield} \approx 1.0 \times \left(1 + \frac{0.7 \times 1.86}{4.0}\right)^{-4.0}$$

$$\$4.73 = \frac{\$500}{0.32 \times 330}$$

c)

New price is 40% more then than their cost.

$$\$3.78 == 0.40 \times \$9.45$$

d)

New chip price is twice the price of original.

$$\$21.73 = 2 \times (\$3.78 + \$9.45) - \$4.73$$

e)

Time to recoup the costs of the new facility, selling old Power5 chips.

$$529 months \approx \frac{\$1,000,000,000}{500,000 \times \$3.78}$$

1.4

a)

Processor uses 79W
Memory uses 3.7W × 2
HD uses 7.9W
Power supply efficiency of 70%

$$79 + 3.7 \times 2 + 7.9 \times 2 = 0.7 \times x$$
$$\frac{102.2}{0.70} = x$$
$$x = 146W \text{ Power supply is needed}$$

b)

HD uses 7.9W read/seek, 4W idle. HD idle rougly 40% of the time uses 4.0W and 7.9W 60% of the time.

$$6.34W = 0.6 \times 7.9 + 0.4 \times 4.0$$

c)

7200 rpm drive is 1.33 times faster than 5400 rpm drive. This means that 5400 rpm drive will need 1.33 times longer to do the same amount of work.

$$1 - (0.6 \times 1.33) \approx 20\% idle$$

1.7

a)

If application is 100% parallelizable. Then for 2 core processor 50% of each application can run on each single core. Therefore you can reduce the frequency of each core by 50% to acheive the same performance.

b)

Using equation in section 1.5.

$$\frac{\text{Power of new}}{\text{Power of old}} = \frac{(V \times 0.50)^2 \times (f \times 0.50)}{V^2 \times f}$$

$$\text{per core} = 0.5^3 = 0.125$$

$$25\% \text{ of the single core processor}$$

c)

There should be $\frac{1}{0.7}$ speedup.

$$\frac{1}{0.7} = \frac{1}{(1-x) + \frac{x}{2}}$$

$$\text{x} = 0.6 \text{ or } 60\%$$

d)

$$\frac{\text{Power of new}}{\text{Power of old}} = \frac{(V \times 0.70)^2 \times (f \times 0.50)}{V^2 \times f}$$

$$\text{per core} = 0.7^2 \times 0.5 = 0.245 \text{per core}$$