CSCI 654 – Advanced Computer Architecture
Homework 1

Due: September 16, 2016

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1. (a) From Amdahl's law we have that $\frac{1}{(1-p)+p/s}$. By plugging in the values from the problem we see $\frac{1}{0.3+0.7/2} = \frac{1}{0.65}$. Since $1 - 0.65 = 0.35$ you can decrease the frequency by 35% and still get the same performance.

   (b) From the power equation, we know that

$$\frac{\text{new power}}{\text{old power}} = 2 \times \frac{(\text{Voltage} \times 0.65)^2 \times \text{Frequency} \times 0.65}{\text{Voltage}^2 \times \text{Frequency}}$$

   By cancelling out the common terms in the fraction, we get 0.54925.

   (c) To find the parallelization, we set up the following equation with the result of part b.

$$0.54925 = 2 \times \frac{(\text{Voltage} \times 0.3)^2 \times Frequency \times X}{\text{Voltage}^2 \times \text{Frequency}}$$

$$X = \frac{0.54925}{2 \times 0.3^2}$$

   Then we have that $3.05138 = \frac{1}{(1-p)+p/2}$. Solving this gives us $p \approx 0.34456$ so about 34% parallelization gives us a voltage at the voltage floor.

   (d) Again, from the equation in part b, we see that

$$\frac{\text{new power}}{\text{old power}} = 2 \times \frac{(\text{Voltage} \times 0.3)^2 \times \text{Frequency} \times 0.65}{\text{Voltage}^2 \times \text{Frequency}}$$

   After cancelling, this gives us 0.117.

2. (a) Since the FIT for a single computer is given as $\frac{300 \text{ failures}}{1 \text{ billion hours}}$, then the MTTF can be calculated as $\frac{10000000\cancel{00}}{3\cancel{00}} = 3,333,333.3333$ hours. 2/5 of the 20000 machines is 8000, so the MTTF for the system can be calculated as $\frac{10000000}{3} \times 8000 = 26,666,666,666$ hours.

   (b) Since the FIT is given as $\frac{300 \text{ failures}}{1 \text{ billion hours}}$, and 1 billion hours is equal to $41,666,666$ days, then we find that 7.2×10^{-6} failures occur each day. Let's denote the cost to repair a computer as C, then the amount of money lost, per day, to computers failing is $\$7.2 \times 10^{-6}$.

3. (a) $\frac{1}{0.2+0.8/N}$

   (b) $\frac{1}{0.2+0.8/8+8\times 0.005} \approx 2.94118$

(c) To go from 1 to 8 processors, the number of processors doubles three times (once from 1 to 2, once from 2 to 4, and finally from 4 to 8). We can modify the previous answer to get:

$$\frac{1}{0.2 + 0.8/8 + 3 \times 0.005} \approx 2.94118$$

(d) To generalize the above question to find the number of times N doubles we can use $\log_2$. Thus, like above, we have:

$$\frac{1}{0.2 + 0.8/N + \lfloor \log_2(N) \rfloor \times 0.005}$$

Note: the floor function, $\lfloor x \rfloor$ is used here to denote that we're rounding down the result of the logarithm.