EECS 645 – Homework #02 Solutions

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Assigned: February 6, 2018

Due (in class): February 13, 2018

The following questions are on the second EECS 645 homework assignment. The assignment will be posted on the class website.

1. Consider the graph in Figure 1.1 in the textbook. Write an expression that describes the performance improvement from 1978 to 2010. That is:

F(Year) = _________________________

F(Year) = 10^((Year-1978)a)

For F(2019) = 24,129 = 10^32a

To solve for "a" take $\log_{10}$ of both sides => 4.3825 = 32a => a = 0.137

F(Year) = 10^((Year – 1978)*0.137)

2. Consider a CMOS inverter with two transistors (see schematic at the end of this homework assignment). Parameters for this CMOS inverter are:

Parameter	*Value*
Vdd	*3.3 V*
Cg	*0.5 fF*
Frequency	*100 MHz*

Where "fF" is femto Farads and Cg is the capacitive load.

How much energy is used when the input to the inverter switches from 0 -> 1 -> 0? How much power is dissipated if the input signal changes on 25% of the clock cycles?

E = Cg * Vdd^2 = 5.44*10^-15 J

If the 0 -> 1 -> 0 transition happens on 25% of the clock cycles we dissipate

E_d = 5.44*10^-15 * 25*10^6 J = 1.36*10^-6 J in one second.

P = 1.36*10^-6 W

3. Suppose you are manufacturing integrated circuits on a 300 mm diameter silicon wafer. Each integrated circuit (die) is 15 mm by 8 mm. How many complete dies are on the wafer?

The following equation from the text estimated the number of dies per wafer:

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

D = Pi * (150)^2 / 120 / 120 = 589

IncompleteDies = Pi * 300 / Sqrt(2 * 15 * 8) => 61

CompleteDies = 589 – 61 = 528

4. A single disk has a MTTF of 1,000,000 hours. Suppose a storage system has 10 disks. Using the simplifying assumptions that the lifetimes are exponentially distributed and that failures are independent, compute the MTTF of the system as a whole. What is the failure rate of the system as a whole?

Following the example in the text the failure rate for one disk is:

F = 1/1,000,000

For 10 disks the failure rate is:

10 * F or 1/100,000

The MTTF for the system is 100,000 hours

5. List three fallacies in computer architecture and describe each in your own words.

Multiprocessors are a silver bullet.

Falling prey to Amdahl's heartbreaking law.

A single point of failure.

Hardware enhancements that increase performance improve energy efficiency or are at worst energy neutral.

Benchmarks remain valid indefinitely.

The rated mean time to failure of disks is 1,200,000 hours or almost 140 years, so disks practically never fail.

Peak performance tracks observed performance.

Fault detection can lower availability.

6. Consider the component parameters in the following table:

Component type	Product	Performance	Power
Processor	Sun Niagara 8-core	1.2 GHz	72–79 W peak
	Intel Pentium 4	2 GHz	48.9–66 W
DRAM	Kingston X64C3AD2 1 GB	184-pin	3.7 W
	Kingston D2N3 1 GB	240-pin	2.3 W
Hard drive	DiamondMax 16	5400 rpm	7.0 W read/seek, 2.9 W idle

DiamondMax 9	7200 rpm	7.9 W read/seek, 4.0 W idle

Figure 1.23 Power consumption of several computer components.

A cooling door for a rack costs $4000 and dissipates 14 KW into the room; additional cost is required to get it out of the room). How many servers with an Intel Pentium 4 processor, 1 GB 240-pin DRAM, and a single 7200 rpm hard drive can you cool with one cooling door?

Intel Pentium 4 processor: 66 W

Kingston D2N3 1 GB, 240 pin DRAM: 2.3 W

DiamondMax 9: 7.9 W

Total (maximum) power per server: 76.2 W

With 14,000 W per door (cabinet), there can be a maximum of 183 servers per cabinet.

7. Describe RAID 1 in your own words.

RAID 1 makes a copy (mirror) of the primary disk.

8. Availability is the most important consideration for designing servers, followed closely by scalability and throughput.

a. We have a single processor with a failures in time (FIT) of 100. What is the mean time to failure (MTTF) for this system?

A FIT of 100 is a failure rate of 100 per 10^9 hours. We have 100 = 10^9/MTTF => MTTF = 10^7 hours or 10*10^6 hours.

b. If it takes 1 day to get the system running again, what is the availability of the system?

Availability = MTTF / (MTTF + MTTR) => 10^7 / (10^7 + 24) => 0.99999976 = ~1.0