L

Solutions to Case Study Exercises

L.1 Chapter 1 Solutions

Case Study 1: Chip Fabrication Cost

1.1 a. $\text{Yield} = \left(1 + \frac{0.7 \times 1.99}{4.0}\right)^{-4} = 0.28$

b. $\text{Yield} = \left(1 + \frac{0.75 \times 3.80}{4.0}\right)^{-4} = 0.12$

c. The Sun Niagara is substantially larger, since it places 8 cores on a chip rather than 1.

1.2 a.

$$\text{Yield} = \left(1 + \frac{0.30 \times 3.89}{4.0}\right)^{-4} = 0.36$$

$$\text{Dies per wafer} = \frac{\pi \times (30/2)^2}{3.89} - \frac{\pi \times 30}{\text{sqrt}(2 \times 3.89)} = 182 - 33.8 = 148$$

$$\text{Cost per die} = \frac{\$500}{148 \times 0.36} = \$9.38$$

b.

$$\text{Yield} = \left(1 + \frac{.7 \times 1.86}{4.0}\right)^{-4} = 0.32$$

$$\text{Dies per wafer} = \frac{\pi \times (30/2)^2}{1.86} - \frac{\pi \times 30}{\text{sqrt}(2 \times 1.86)} = 380 - 48.9 = 331$$

$$\text{Cost per die} = \frac{\$500}{331 \times .32} = \$4.72$$

c. \$9.38 × .4 = \$3.75

d. Selling price = (\$9.38 + \$3.75) × 2 = \$26.26
Profit = \$26.26 – \$4.72 = \$21.54

e. Rate of sale = 3 × 500,000 = 1,500,000/month
Profit = 1,500,000 × \$21.54 = \$32,310,000
\$1,000,000,000/\$32,310,000 = 31 months

1.3 a. $\text{Yield} = \left(1 + \frac{.75 \times 3.80/8}{4.0}\right)^{-4} = 0.71$

$\text{Prob of error} = 1 - 0.71 = 0.29$

b. Prob of one defect = $0.29 \times 0.71^7 \times 8 = 0.21$
Prob of two defects = $0.29^2 \times 0.71^6 \times 28 = 0.30$
Prob of one or two = $0.21 \times 0.30 = 0.51$

c. $0.71^8 = .06$ (now we see why this method is inaccurate!)

d. $0.51/0.06 = 8.5$

e. $x \times \$150 + 8.5x \times \$100 - (9.5x \times \$80) - 9.5x \times \$1.50 = \$200{,}000{,}000$
$x = 885{,}938$ 8-core chips, 8,416,390 chips total

Case Study 2: Power Consumption in Computer Systems

1.4 a. $.70x = 79 + 2 \times 3.7 + 2 \times 7.9x = 146$

b. $4.0\text{ W} \times .4 + 7.9\text{ W} \times .6 = 6.34\text{ W}$

c. The 7200 rpm drive takes 60 s to read/seek and 40 s idle for a particular job. The 5400 rpm disk requires 4/3 × 60 s, or 80 s to do the same thing. Therefore, it is idle 20% of the time.

1.5 a. $$\frac{14\text{ KW}}{(79\text{ W} + 2.3\text{ W} + 7.0\text{ W})} = 158$$

b. $$\frac{14\text{ KW}}{(79\text{ W} + 2.3\text{ W} + 2 \times 7.0\text{ W})} = 146$$

c. $$\text{MTTF} = \frac{\dfrac{1}{9 \times 10^6} + 8 \times \dfrac{1}{4500} + \dfrac{1}{3 \times 10^4} = \dfrac{8 \times 2000 + 300}{9 \times 10^6} = \dfrac{16301}{9 \times 10^6}}{\dfrac{1}{\text{Failure rate}} = \dfrac{9 \times 10^6}{16301} = 522\text{ hours}}$$

1.6 a. See Figure L.1.

	Sun Fire T2000	IBM x346
SPECjbb	213	91.2
SPECweb	42.4	9.93

Figure L.1 Power/performance ratios.

b. Sun Fire T2000

c. More expensive servers can be more compact, allowing more computers to be stored in the same amount of space. Because real estate is so expensive, this is a huge concern. Also, power may not be the same for both systems. It can cost more to purchase a chip that is optimized for lower power consumption.

1.7 a. 50%

b. $$\frac{\text{Power new}}{\text{Power old}} = \frac{(V \times 0.50)^2 \times (F \times 0.50)}{V^2 \times F} = 0.5^3 = 0.125$$

c. $$= \frac{.70}{(1 - x) + x/2}\ ;\ x = 60\%$$

d. $\frac{\text{Power new}}{\text{Power old}} = \frac{(V \times 0.70)^2 \times (F \times 0.50)}{V^2 \times F} = 0.7^2 \times 0.5 = 0.245$

Case Study 3: The Cost of Reliability (and Failure) in Web Servers

1.8 a. 14 days × \$1.4 million⁄day = \$19.6 million
\$4 billion – \$19.6 million = \$3.98 billion

b. Increase in total revenue: 4.8/3.9 = 1.23

In the fourth quarter, the rough estimate would be a loss of 1.23 × \$19.6 million = \$24.1 million.

c. Losing \$1.4 million × .50 = \$700,000 per day. This pays for \$700,000/\$7,500 = 93 computers per day.

d. It depends on how the 2.6 million visitors are counted.

If the 2.6 million visitors are not unique, but are actually visitors each day summed across a month: 2.6 million × 8.4 = 21.84 million transactions per month. \$5.38 × 21.84 million = \$117 million per month.

If the 2.6 million visitors are assumed to visit every day: 2.6 million × 8.4 × 31 = 677 million transactions per month. \$5.38 × 677 million = \$3.6 billion per month, which is clearly not the case, or else their online service would not make money.

1.9 a. $\text{FIT} = 10^9 / \text{MTTF}$
$\text{MTTF} = 10^9 / \text{FIT} = 10^9 / 100 = 10{,}000{,}000$

b. $\text{Availability} = \frac{\text{MTTF}}{\text{MTTF} + \text{MTTR}} = \frac{10^7}{10^7 + 24} = \text{about } 100\%$

1.10 Using the simplifying assumption that all failures are independent, we sum the probability of failure rate of all of the computers:

$$\text{Failure rate} = 1000 \times 10^{-7} = 10^{-4} = \frac{10^5}{10^9}\ \text{FIT} = 10^5\text{, therefore MTTF} = \frac{10^9}{10^5} = 10^4$$

1.11 a. Assuming that we do not repair the computers, we wait for how long it takes for 3,334 computers to fail.

$$3{,}334 \times 10{,}000{,}000 = 33{,}340{,}000{,}000 \text{ hours}$$

b. Total cost of the decision: \$1,000 × 10,000 computers = \$10 million

Expected benefit of the decision: Gain a day of downtime for every 33,340,000,000 hours of uptime. This would save us \$1.4 million each 3,858,000 years. This would definitely not be worth it.