Solutions to Case Studies and Exercises

Chapter 1 Solutions

Case Study 1: Chip Fabrication Cost

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

b. It is fabricated in a larger technology, which is an older plant. As plants age, their process gets tuned, and the defect rate decreases.

1.2 a. $\text{Dies per wafer} = \frac{\pi \times (30/2)^2}{1.5} - \frac{\pi \times 30}{\text{sqrt}(2 \times 1.5)} = 471 - 54.4 = 416$

$$\text{Yield} = \left(1 + \frac{0.30 \times 1.5}{4.0}\right)^{-4} = 0.65$$

$$\text{Profit} = 416 \times 0.65 \times \$20 = \$5408$$

b. $\text{Dies per wafer} = \frac{\pi \times (30/2)^2}{2.5} - \frac{\pi \times 30}{\text{sqrt}(2 \times 2.5)} = 283 - 42.1 = 240$

$$\text{Yield} = \left(1 + \frac{0.30 \times 2.5}{4.0}\right)^{-4} = 0.50$$

$$\text{Profit} = 240 \times 0.50 \times \$25 = \$3000$$

c. The Woods chip

d. Woods chips: 50,000/416 = 120.2 wafers needed
Markon chips: 25,000/240 = 104.2 wafers needed

Therefore, the most lucrative split is 120 Woods wafers, 30 Markon wafers.

1.3 a. $\text{Defect – Free single core} = \left(1 + \frac{0.75 \times 1.99/2}{4.0}\right)^{-4} = 0.28$

No defects = $0.28^2 = 0.08$
One defect = $0.28 \times 0.72 \times 2 = 0.40$
No more than one defect = $0.08 + 0.40 = 0.48$

b. $\$20 = \frac{\text{Wafer size}}{\text{old dpw} \times 0.28}$

$\$20 \times 0.28$ = Wafer size/old dpw

$$x = \frac{\text{Wafer size}}{1/2 \times \text{old dpw} \times 0.48} = \frac{\$20 \times 0.28}{1/2 \times 0.48} = \$23.33$$

Case Study 2: Power Consumption in Computer Systems

1.4 a. $.80x = 66 + 2 \times 2.3 + 7.9$; $x = 99$

b. $.6 \times 4\text{ W} + .4 \times 7.9 = 5.56$

c. Solve the following four equations:

seek7200 = .75 × seek5400
seek7200 + idle7200 = 100
seek5400 + idle5400 = 100
seek7200 × 7.9 + idle7200 × 4 = seek5400 × 7 + idle5400 × 2.9

idle7200 = 29.8%

1.5 a. $$\frac{14\text{ KW}}{(66\text{ W} + 2.3\text{ W} + 7.9\text{ W})} = 183$$

b. $$\frac{14\text{ KW}}{(66\text{ W} + 2.3\text{ W} + 2 \times 7.9\text{ W})} = 166$$

c. 200 W × 11 = 2200 W
2200/(76.2) = 28 racks
Only 1 cooling door is required.

1.6 a. The IBM x346 could take less space, which would save money in real estate. The racks might be better laid out. It could also be much cheaper. In addition, if we were running applications that did not match the characteristics of these benchmarks, the IBM x346 might be faster. Finally, there are no reliability numbers shown. Although we do not know that the IBM x346 is better in any of these areas, we do not know it is worse, either.

1.7 a. $(1 - 8) + .8/2 = .2 + .4 = .6$

b. $$\frac{\text{Power new}}{\text{Power old}} = \frac{(V \times 0.60)^2 \times (F \times 0.60)}{V^2 \times F} = 0.6^3 = 0.216$$

c. $$1 = \frac{.75}{(1 - x) + x/2}\text{; } x = 50\%$$

d. $$\frac{\text{Power new}}{\text{Power old}} = \frac{(V \times 0.75)^2 \times (F \times 0.60)}{V^2 \times F} = 0.75^2 \times 0.6 = 0.338$$

Exercises

1.8 a. $(1.35)^{10}$ = approximately 20

b. $3200 \times (1.4)^{12}$ = approximately 181,420

c. $3200 \times (1.01)^{12}$ = approximately 3605

d. Power density, which is the power consumed over the increasingly small area, has created too much heat for heat sinks to dissipate. This has limited the activity of the transistors on the chip. Instead of increasing the clock rate, manufacturers are placing multiple cores on the chip.

e. Anything in the 15–25% range would be a reasonable conclusion based on the decline in the rate over history. As the sudden stop in clock rate shows, though, even the declines do not always follow predictions.

1.9 a. 50%

b. Energy = ½ load × V^2. Changing the frequency does not affect energy–only power. So the new energy is ½ load × (½ V)^2, reducing it to about ¼ the old energy.

1.10 a. 60%

b. 0.4 + 0.6 × 0.2 = 0.58, which reduces the energy to 58% of the original energy.

c. newPower/oldPower = ½ Capacitance × (Voltage × .8)^2 × (Frequency × .6)/½ Capacitance × Voltage × Frequency = 0.8^2 × 0.6 = 0.256 of the original power.

d. 0.4 + 0 .3 × 2 = 0.46, which reduce the energy to 46% of the original energy.

1.11 a. $10^9/100 = 10^7$

b. $10^7/10^7 + 24 = 1$

c. [need solution]

1.12 a. 35/10000 × 3333 = 11.67 days

b. There are several correct answers. One would be that, with the current system, one computer fails approximately every 5 minutes. 5 minutes is unlikely to be enough time to isolate the computer, swap it out, and get the computer back on line again. 10 minutes, however, is much more likely. In any case, it would greatly extend the amount of time before 1/3 of the computers have failed at once. Because the cost of downtime is so huge, being able to extend this is very valuable.

c. $90,000 = (x + x + x + 2x)/4
$360,000 = 5x
$72,000 = x
4th quarter = $144,000/hr

1.13 a. Itanium, because it has a lower overall execution time.

b. Opteron: 0.6 × 0.92 + 0.2 × 1.03 + 0.2 × 0.65 = 0.888

c. 1/0.888 = 1.126

1.14 a. See Figure S.1.

b. 2 = 1/((1 – x) + x/10)
5/9 = x = 0.56 or 56%

c. 0.056/0.5 = 0.11 or 11%

d. Maximum speedup = 1/(1/10) = 10
5 = 1/((1 – x) + x/10)
8/9 = x = 0.89 or 89%

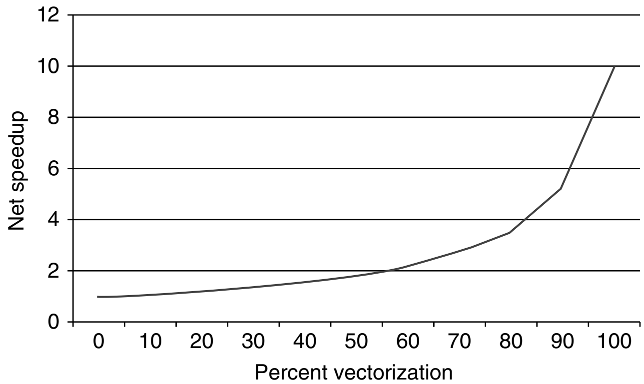

Figure S.1 Plot of the equation: y = 100/((100 – x) + x/10).

e. Current speedup: 1/(0.3 + 0.7/10) = 1/0.37 = 2.7
Speedup goal: 5.4 = 1/((1 – x) + x /10) = x = 0.91

This means the percentage of vectorization would need to be 91%

1.15 a. old execution time = 0.5 new + 0.5 × 10 new = 5.5 new

b. In the original code, the unenhanced part is equal in time to the enhanced part sped up by 10, therefore:
(1 – x) = x/10
10 – 10x = x
10 = 11x
10/11 = x = 0.91

1.16 a. 1/(0.8 + 0.20/2) = 1.11

b. 1/(0.7 + 0.20/2 + 0.10 × 3/2) = 1.05

c. fp ops: 0.1/0.95 = 10.5%, cache: 0.15/0.95 = 15.8%

1.17 a. 1/(0.6 + 0.4/2) = 1.25

b. 1/(0.01 + 0.99/2) = 1.98

c. 1/(0.2 + 0.8 × 0.6 + 0.8 × 0.4/2) = 1/(.2 + .48 + .16) = 1.19

d. 1/(0.8 + 0.2 × .01 + 0.2 × 0.99/2) = 1/(0.8 + 0.002 + 0.099) = 1.11

1.18 a. 1/(.2 + .8/N)

b. 1/(.2 + 8 × 0.005 + 0.8/8) = 2.94

c. 1/(.2 + 3 × 0.005 + 0.8/8) = 3.17

d. 1/(.2 + logN × 0.005 + 0.8/N)

e. d/dN(1/((1 – P) + logN × 0.005 + P/N)) = 0