CENG3420 Homework 1

Due: Feb. 19, 2021

Solutions

All solutions should be submitted to the blackboard in the format of **PDF/MS Word**.

Q1 (15%) We have a technology process to manufacture a specific processor. Suppose we use 30cm-diameter wafer for a die. A die is 2 cm on each side.

1. Find the maximum number of dies on the wafer.

2. If the defects per unit area is 0.02, and the cost per wafer is approximately \$7000. Find the yield and the cost per die. (Can we apply the empirical equation?) p.s. accurate to 2 decimal places

3. We can increase our yield since we have incorporated the new technology to manufacture the processor. If the maximum number of dies per wafer is increased by 10% and the corresponding defects per unit area is reduced by 10%, find the yield and the cost per die. p.s. accurate to 2 decimal places

A1 These are suggested solutions.

1. 176

$$\text{Dies per wafer} \approx \frac{\text{Wafer area}}{\text{Die area}} \tag{1}$$

According to the equation 1, Dies per wafer $= \frac{\pi \times (\frac{30}{2})^2}{2 \times 2} \approx 176.71$, so we can manufacture 176 dies on the wafer.

2. %92.46, \$43.02

$$\text{Cost per die} = \frac{\text{Cost per wafer}}{\text{Dies per wafer} \times \text{yield}} \tag{2}$$

$$\text{Yield} = \frac{1}{(1 + \frac{(\text{Defects per area} \times \text{Die area})}{2})^2} \tag{3}$$

We use the euqation 2 to cacluate the cost per die and we use the equation 3 to calculate the yield. The yield is $1/(1 + \frac{0.02 * 2 * 2}{2})^2 \approx 0.9246$, and the cost per die is $\frac{7000}{176 * 0.9246} \approx 43.02$

3. %93.76, \$38.48

Because the maximum number of dies per wafer is increased by 10%, so that it is round(176.71×1.1) = 194.39. The defects per unit area is reduced by 10%, and that is $0.02 \times 0.9 \approx 0.018$. The new area of a die is $\pi \times \frac{\frac{30}{2}^2}{194.39} \approx 3.64$, and according to the equation 3, the yield is $\frac{1}{1 + \frac{0.018 * 3.64}{2}}^2 \approx 0.9376$. According to the equation 3, the cost per die is $\frac{7000}{194 * 0.9376} \approx 38.48$

Q2 (10%) Draw the gate schematic for the function $Y = \overline{(A + B + C) \cdot D}$.

A2 As shown below.
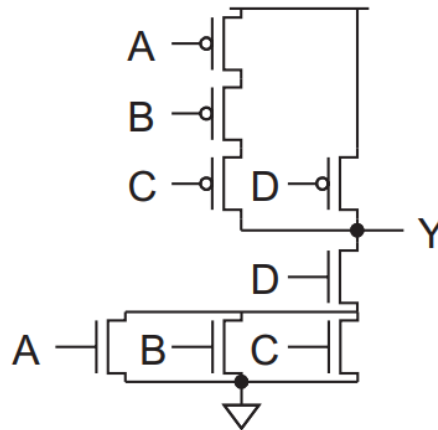
Q3 (10%) We develop a new processor which can reduce 20% of the capacitive load compared with the previous generation. The new processor can adjust the voltage to reduce the power dissipation. In this way, the new processor can reduce the average voltage by 10%, which results in a 15% shrink in frequency comapred with the previous generation. Find how much the dynamic power dissipation ratio between the new processor and the previous generation?
p.s. accurate to 2 decimal places

A3 0.55

$$\text{Power} = \frac{1}{2} \times \alpha \times \text{Capacitive load} \times \text{Voltage}^2 \times \text{Frequency switched} \qquad (4)$$

According to the equation 4, the power ratio between the new one and the old one is $0.8 \times 0.9^2 \times 0.85 \approx 0.55$

Q4 (10%) Assume `a0=0xBA, a1=0xDC`. Find the value of `a2` after the following instructions, respectively.

```
1.      xor a2, a0, a1
        ori a2, a2, 3

2.      slli a2, a0, 3
        andi a2, a2, 0x1F

3.      srai  a2, a0, 3
        and a2, a2, a1
```

A4 As shown below,

    1. 0x67

Q5 (15%) Assume that the variables a, b, c, d, and e are assigned to registers t0, t1, t2, t3, and t4, respectively. Given RISC-V assembly instructions:

```
        slli t2, t4, 3
        bge t0, t2, label1
        add t3, t1, t2
        j label2
label1:
        mul t3, t1, t2
label2:
        addi t3, t3, 1
```

Translate the RISC-V assembly instructions above into the corresponding C statements. **Please include comments for each instruction in your solution.**

A5
```
c = e * 8;
if (a >= c) {
d = b * c;
} else {
d = b + c;
}
d++;
```

Q6 (15%) Assume that a0 = n and a1 = rst. Given the C statement:

```
int sum(int n, int rst){
        if (n > 0)
                return sum(n-1, rst + n);
        else
                return rst;
}
```

Translate C statements above into corresponding RISC-V assembly instructions. **Please include comments for each instruction in your solution.**

A6 As shown below (assume that a0 = n and a1 = rst):

```
sum:
bne a0, zero, sum_exit
add a1, a1, a0
addi a0, a0, -1
j sum
sum_exit:
add s0, a1, zero
jr ra
```

Q7 (15%) Write down the step by step procedure to calculate 7×3 or 0111×0011. Use Multiplier0 to indicate the least significant bit of the multiplier

Iteration	Step	Multiplier	Multiplier0	Multiplicand	Product
0	Initial values	001<u>1</u>	1	0000 0111	0000 0000
1	1a: 1⇒Prod=Prod+Mcand	0011	1	0000 0111	0000 0111
	2: Shift left Multiplicand	0011	1	0000 1110	0000 0111
	3: Shift right Multiplier	000<u>1</u>	1	0000 1110	0000 0111
2	1a: 1⇒Prod=Prod+Mcand	0001	1	0000 1110	0001 0101
	2: Shift left Multiplicand	0001	1	0001 1100	0001 0101
	3: Shift right Multiplier	000<u>0</u>	0	0001 1100	0001 0101
3	1a: 1⇒Prod=Prod+Mcand	0000	0	0001 1100	0001 0101
	2: Shift left Multiplicand	0000	0	0011 1000	0001 0101
	3: Shift right Multiplier	000<u>0</u>	0	0011 1000	0001 0101
4	1a: 1⇒Prod=Prod+Mcand	0000	0	0011 1000	0001 0101
	2: Shift left Multiplicand	0000	0	0111 0000	0001 0101
	3: Shift right Multiplier	0000	0	0111 0000	0001 0101

A7

Q8 (10%) We want to compare the computers C1 and C2, which differ that C1 has the machine instructions for the floating point operations, while C2 has not (FP operations are implemented in the software using several non-FP instructions). Both computers have a clock frequency of 400 MHz. In both we perform the same program, which has the following mixture of commands:

The command type	Dynamic share of instructions in program	CPI	
		C1	C2
FP addtion	16%	6	20
FP multiplication	10%	8	32
FP division	8%	10	66
Non-FP instructions	66%	3	3

1. Find the MIPS for the computers C1 and C2.
2. Find the CPU program execution time on the computers C1 and C2 when there are 12000 instructions in the program.

A8 1.

$$CPI = \sum_{i=0}^{3} CPI_i \cdot p_i \qquad (5)$$

4

$$MIPS = \frac{frequency}{CPI \cdot 10^6} \tag{6}$$

For computer C1,

$$CPI = 0.16 \times 6 + 0.1 \times 8 + 0.08 \times 10 + 0.66 \times 3 = 4.54 \tag{7}$$

$$MIPS = \frac{400 \times 10^6}{4.54 \times 10^6} = 88.1 \tag{8}$$

For computer C2,

$$CPI = 0.16 \times 20 + 0.1 \times 32 + 0.08 \times 66 + 0.66 \times 3 = 13.66 \tag{9}$$

$$MIPS = \frac{400 \times 10^6}{13.66 \times 10^6} = 29.28 \tag{10}$$

2.

$$CPU_{time} = \frac{\text{Number of instructions}}{MIPS \times 10^6} \tag{11}$$

For computer C1,

$$CPU_{time} = \frac{12000}{88.1 \times 10^6} = 136.2\mu s \tag{12}$$

For computer C2,

$$CPU_{time} = \frac{12000}{29.28 \times 10^6} = 410\mu s \tag{13}$$