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Course : COM 219

Exam ID : 22EBH44K

I will not collaborate, give or receive any help on this exam .

I will not help anyone after I have submitted the exam

Signature: Sylvia Le.

START TIME :
21h23' EST - 12/20/20
9h23' GMT+7:00 - 12/21/20

END TIME
20h44' EST - 12/21/20
8h44' GMT+7:00 - 12/22/20

Question 1

a) Suppose a memory chip of capacity C use in total x transistors

After 2 year, this chip will have in total 2x transistors, so it's like having 2 memory chips connect together to form 1 single chip (ignore extra gates that are not used for memory func)

→ In 2 years, the capacity will also double .

Capacity at year 0 = C

Capacity at year 20 = $C \times 2^{time/2} = C \times 2^{10}$

→ Ratio $\text{Capacity}_{now} / \text{Capacity}_{before} = \frac{C \times 2^{10}}{C} = 2^{10} = \boxed{1024}$

→ Capacity has increase 1024 times.

b)

#Level	#instr (= n+1)
5	6
4	5
3	4
2	3
1	–

+) Average instruction execution time at lv 1 :
$$\frac{3 \times 50 + 5 \times 50}{100} = 4 \text{ cycles}$$

+) Number of lv 1 instruction, for each lv 5 instruction:
$6 \times 5 \times 4 \times 3 = 360$ instructions

+) Program execution time, in cycle :
$$\underbrace{360 \times 4}_{\text{1 lv 6 instruction execution time}} \times 10000 = 14400000 \text{ cycles}$$

+) Cycle time $= \frac{1}{200MHz} = 5$ ns

→ Program execution time : $14400000 \times 5ns = \boxed{0,072s}$

c) $n = 6$

$T = 5ns \rightarrow f = \frac{1}{5ns} = 200 MHz$

Latency = instr. completion time = $nT = 6 \times 5 = \boxed{30 ns}$

Bandwidth = $\frac{1000}{T} = \frac{1000}{5} = \boxed{200 \text{ MIPS}}$

⊛ Without pipelining, but same latency: Bandwidth 2 = $\frac{1000}{\text{Latency}} = \frac{1000}{30} = 33.33$ MIPS

Ratio of processor bandwidth : $\frac{BW_{pipe}}{BW_{none}} = \frac{200}{33.33} = \boxed{6}$

d) + cache access time = $c \rightarrow$ memory access time = $8c$

+ new hit ratio is 25% than old $\rightarrow h_{new} = 1.25 h_{old}$

+ Old access time $T_1 = c + (1-h)8c$

New access time $T_2 = c + (1 - 1.25)8c$

+ $\frac{T_1}{T_2} = 2 \leftrightarrow \frac{c + (1-h)8c}{c + (1-1.25h)8c} = 2$

$\leftrightarrow 2c + 16c(1 - 1.25h) = c + 8c - 8hc$

$\leftrightarrow 2c + 16c - 20hc = c + 8c - 8hc$

$\leftrightarrow 12hc = 9c$

$\leftrightarrow 12h = 9$

$\leftrightarrow h = \boxed{0.75}$

e)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Correct must be 0	P_1 1		1		0		0		1		1		0		0		1		1		1
Correct must be 1		P_2 0	1			1	0			1	1			0	0			0	1		
				P_4 1	0	1	0					1	0	0	0					0	1
								P_8 0	1	1	1	1	0	0	0						
Correct must be 1																P_{16} 0	1	0	1	0	1

1	0	1	1	0	1	0	0	1	1	1	1	0	0	0	0	1	0	1	0	1
P_1	P_2	m_{15}	P_4	m_{14}	m_{13}	m_{12}	P_8	m_{11}	m_{10}	m_9	m_8	m_7	m_6	m_5	P_{16}	m_4	m_3	m_2	m_1	m_0
		1		0	1	0		1	1	1	1	0	0	0		1	0	0	1	0

- According to the table :
  + # message bit : 16
  + # check bit : 5

Parity bits 1, 2, 16 are incorrect

→ The bit must be correct = $1 + 2 + 16 = 19$

→ Correct bit 19 to 0

The data bits are now : 1010.1111.0001.0010

f) +) Convert 2584 to binary

#		Result	Remainder
1	2584	1292	0
2	1292	646	0
3	646	323	0
4	323	161	1
5	161	80	1
6	80	40	0
7	40	20	0
8	20	10	0
9	10	5	0
10	5	2	1
11	2	1	0
12	1	0	1

$\rightarrow (2584)_{10} = (00001010\ 00011000)_2$

+) If read as big endian, new binary is : 00011000 00001010

Read as two complement: $2^{12} + 2^{11} + 2^{3} + 2^{1} = 6154_{10}$

g) For system B: number of data bits = 8, we have:

$m + r + 1 \leq 2^r$

$\Leftrightarrow 9 + r \leq 2^r \rightarrow r = 4$

Effective bandwidth = total data bits transferred - check bits

$\rightarrow$ for system A: $BW_A = 8$

$\rightarrow$ for system B: $BW_B = 8 - 4 = 4$

$\rightarrow$ Ratio of effective bandwidth: $\frac{BW_A}{BW_B} = \frac{8}{4} = \boxed{2}$

h) Assume each drive has capacity x of price a.

+) System 1 = 2 groups of RAID 1 that joined together to make up a RAID 0

- Each RAID 1 group has : $10/2 = 5$ drives

- RAID 1 keep an exact copy on all drives

→ Capacity of a RAID 1 group : x

→ Total effective disk size $= 2x$

- Cost of 10 drives $= 10a$

→ Unit cost $= \frac{10a}{2x} = \frac{5a}{x}$

+) System 2 = Data is distributed, but 2 drives are used for parity

→ Effective disk size $= (10-2) \times$ capacity

$= 8x$

- Cost of 10 drives $= 10a$

→ Unit cost $= \frac{10a}{8x} = \frac{5a}{4x}$

⇒ Ratio of cost per byte : $\frac{C_1}{C_2} = \frac{5a}{x} : \frac{5a}{4x} = \boxed{4}$

Question 2

a)

a_1	a_0	b_1	b_0	m_3	m_2	m_1	m_0
0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	0
0	0	1	0	0	0	0	0
0	0	1	1	0	0	0	0
0	1	0	0	0	0	0	0
0	1	0	1	0	0	0	1
0	1	1	0	0	0	1	0
0	1	1	1	0	0	1	1
1	0	0	0	0	0	0	0
1	0	0	1	0	0	1	0
1	0	1	0	0	1	0	0
1	0	1	1	0	1	1	0
1	1	0	0	0	0	0	0
1	1	0	1	0	0	1	1
1	1	1	0	0	1	1	0
1	1	1	1	1	0	0	1

Binary multiplication:

		a_1	a_0
×		b_1	b_0
		a_1b_0	a_0b_0
	a_1b_1	a_0b_1	0
C_2	$a_1b_1 + C_1$; carry $= C_2$.	$a_1b_0 + a_0b_1$; carry $= C_1$	a_0b_0

$\Rightarrow m_0 = a_0b_0$

$m_1 = a_1b_0 + a_0b_1$

$m_2 = a_1b_1 + C_1$

$m_3 = C_2$

Boolean functions

$m_3 = a_1a_0b_1b_0$

$m_2 = a_1a_0'b_1b_0' + a_1a_0'b_1b_0 + a_1a_0b_1b_0'$

$= a_1a_0'b_1(b_0' + b_0) + a_1a_0b_1b_0'$
distribution

$= a_1a_0'b_1 + a_1a_0b_1b_0'$
invese, identity

$= a_1b_1(a_0' + a_0b_0')$ distribution $= a_1b_1(a_0' + b_0')$ distribution $= a_1a_0'b_1 + a_1b_1b_0'$ distribution

$m_1 = a_1'a_0b_1b_0' + a_1'a_0b_1b_0 + a_1a_0'b_1'b_0 + a_1a_0'b_1b_0 + a_1a_0b_1'b_0 + a_1a_0b_1b_0'$

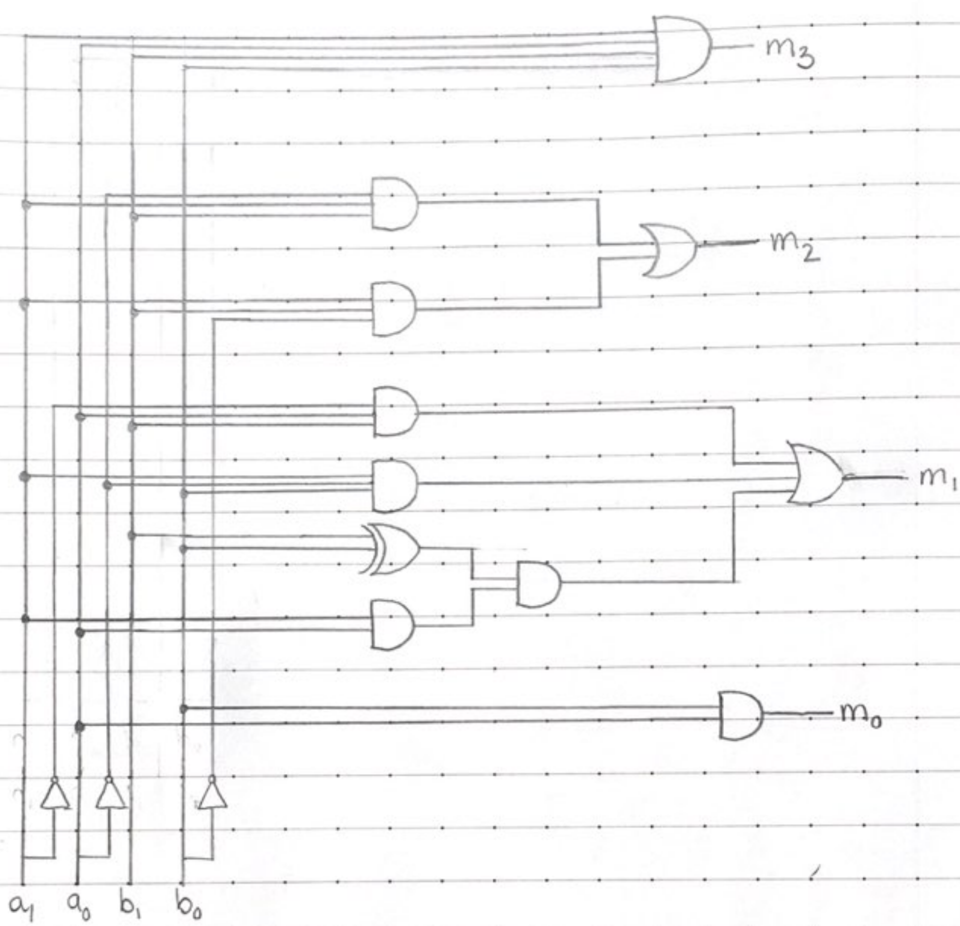
$= a_1'a_0b_1 + a_1a_0'b_0 + a_1a_0(b_1 \oplus b_0)$
distribution, inverse, identity; distibution, XOR definition

$m_0 = a_1'a_0b_1'b_0 + a_1'a_0b_1b_0 + a_1a_0b_1'b_0 + a_1a_0b_1b_0$

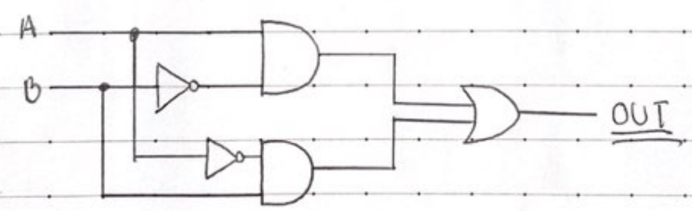
$= a_1'a_0b_0 + a_1a_0b_0$
distribution, inverse, identity.

$= a_0b_0$
distribution, inverse, identity

(2-a)



The XOR gate used can be substituted by this, I didn't draw in since there might not be enough space



b) Use a_0, b_1, b_0 as select line

a_1 will provide input.

$a_0 b_1 b_0$	m_3	m_2	m_1	m_0
000	0	0	0	0
001	0	0	a_1	0
010	0	a_1	0	0
011	0	a_1	a_1	0
100	0	0	0	0
101	0	0	a_1	1
110	0	a_1	1	0
111	a_1	0	$\overline{a_1}$	1

4 output value → 4 MUX. The MUX for m_1: