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University of California

Los Angeles

Computer Science Department

CSM51A/EEM16 Midterm Exam

Winter Quarter 2016

February 8th 2016

This is a closed book exam. Absolutely nothing is permitted except pen, pencil and eraser to write your solutions. Any academic dishonesty will be prosecuted to the full extent permissible by university regulations.

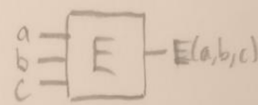
Time allowed 100 minutes.

Problem (possible points)	Points
1 (20)	20
2 (20)	20
3 (20)	20
4 (20)	18
5 (20)	20
Total (100)	98

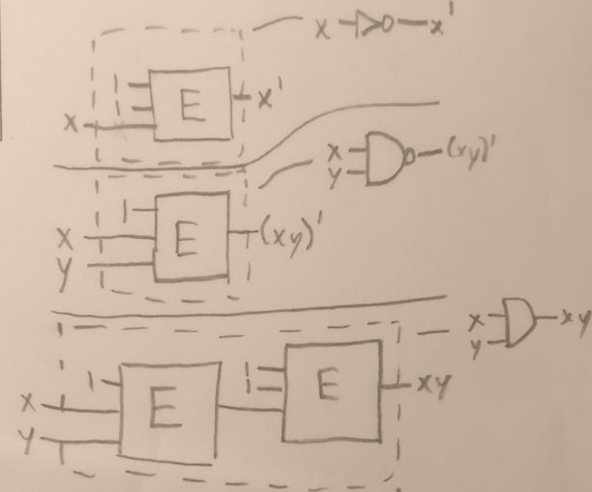
Problem 1 (20 points)

Use only the "E" gate defined below to implement Boolean function:
F=w'xy'+wxz+w'x'z+wx'y'z'
You may also use constants 0 and 1 as inputs.

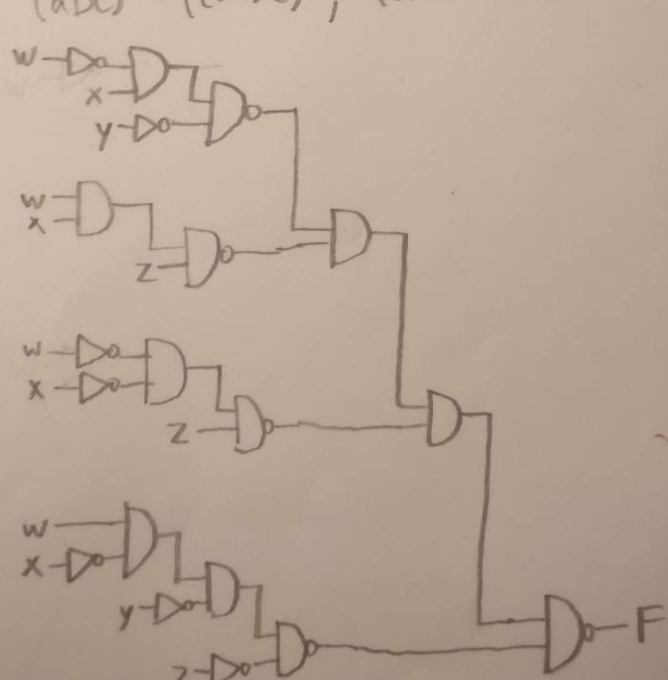
a	b	c	E(a,b,c)
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	0



For this problem I will define more traditional gates with the E gate and use the traditional gates in my final solution.



$(abc)' = ((ab)c)'$, $(abcd)' = (((ab)c)d)'$



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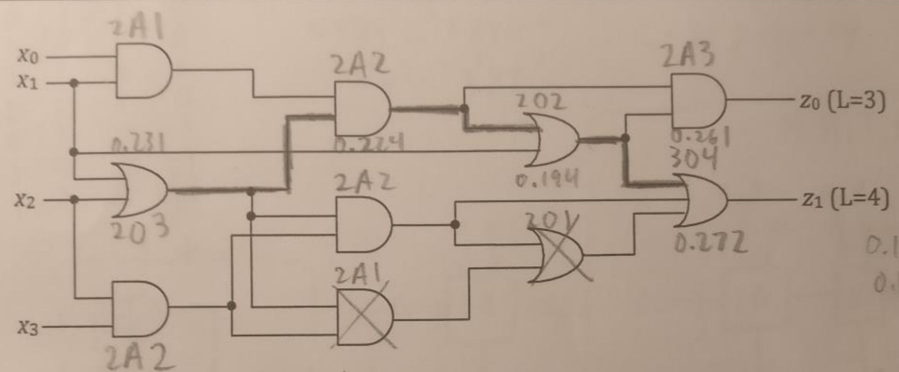
Problem 2 (20 points)

Given the network below, calculate the critical path delay. Consider L → H delay when calculating the critical path.

Gate	Fan-in	t_{pLH}	t_{pHL}
AND	2	$0.15 + 0.037L$	$0.16 + 0.017L$
AND	3	$0.20 + 0.038L$	$0.18 + 0.018L$
OR	2	$0.12 + 0.037L$	$0.20 + 0.019L$
OR	3	$0.12 + 0.038L$	$0.34 + 0.022L$



12
0.037
x 3
111

13
0.038
x 4
152

304
0.12+0.038(4)
0.12+0.152
0.272

202
0.12+0.037(2)
0.12+0.074
0.194

2A2
0.15+0.037(2)
0.15+0.074
0.224

203
0.12+0.037(3)
0.12+0.111
0.231

2A3
0.15+0.037(3)
0.15+0.111
0.261

CRITICAL PATH = 304+202+2A2+203 =
= 0.272 + 0.194 + 0.224 + 0.231
= 0.466 + 0.455
= $\boxed{0.921}$

466
455
921

20

Problem 3 (20 points)

Four 4-bit numbers A,B,C, and D are given as inputs. E=A+B, F=C+D. Design a system that outputs the larger number between E and F. If E=F, output either E or F. You can use any type of gates to implement your design.

ONE BIT ADDER

x	y	c_i	z	c_o
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

Z

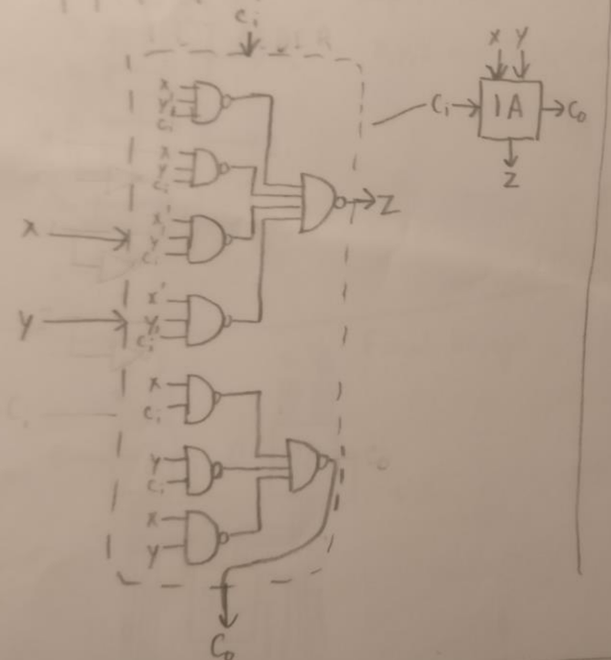
	0	1	0	1
x	1	0	1	0

$z = xy'c_i' + xyc_i + x'y'c_i + x'yc_i'$

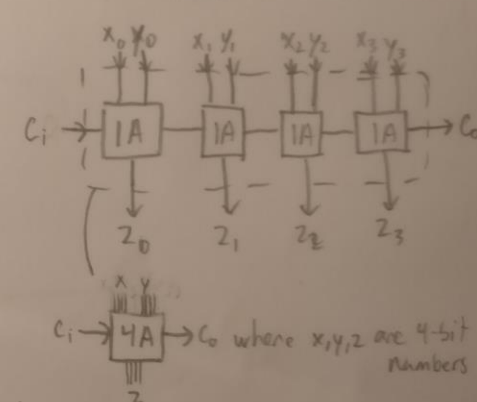
C_o

	0	0	1	0
x	0	1	1	1

$C_o = xc_i + yc_i + xy$



4 BIT ADDER



$c_i \to$ 4A $\to C_o$ where x,y,z are 4-bit numbers

ONE BIT COMPARITOR

x	y	g_i	g_o
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	0
1	1	1	1

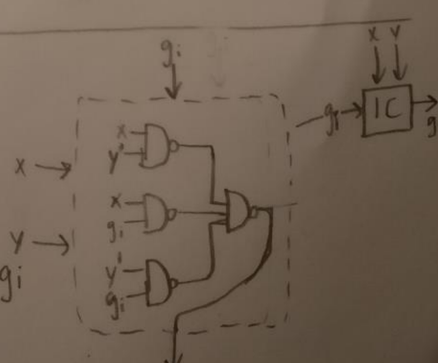
g=1 when x≥y

g=0 when x<y

g_o

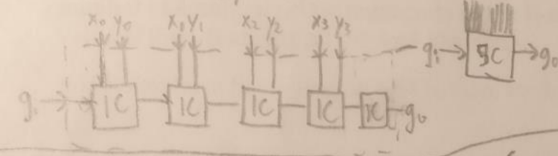
	0	1	0	0
x	1	1	1	0

$g_o = xy' + xg_i + y'g_i$



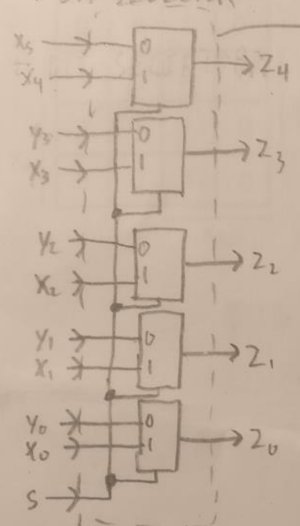
Problem 3) Extra Page

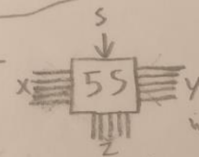
5 BIT COMPARITOR



where x, y are 5-bit numbers

5 BIT SELECTOR





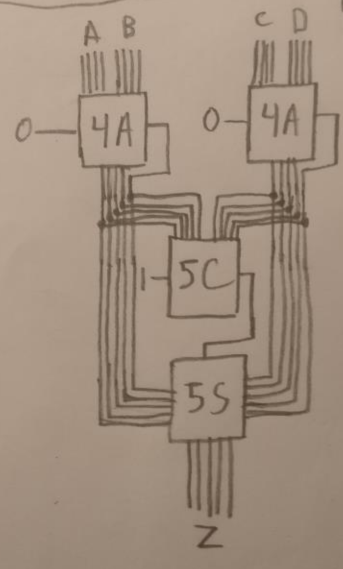
where x, y, z are 5-bit numbers

$z = x$ if $s = 1$

$z = y$ if $s = 0$

x, y, z are 5-bit numbers

Final Design



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Problem 4 (20 points)

For a K-map, M denotes the number of prime implicants of the K-map, and N denotes the number of essential prime implicants of the K-map. Draw a 4×4 K-map that has the largest value of P=M-N among all the 4×4 K-maps.

For example, in the following 4×4 K-map, M=3, N=2, P=M-N=1.

		X_0	X_0		
	0	0	0	0	
	1	1	0	0	X_2
X_3	1	1	1	0	X_2
X_3	0	0	1	0	
			X_1	X_1	

M=10 N=0

0	1	1	1
1	1	0	1
1	0	1	1
1	1	1	0

M=12, N=0, P=12

+18

20

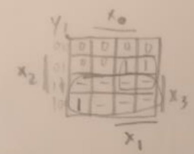
Problem 5 (20 points)

Use only multiplexers to design a system with input $x \in (0,1,2, \ldots 8)$, outputs y and z that implements the following equation

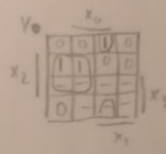
$$(x)_{10} = (yz)_3$$

In the system, x is encoded as $x_3x_2x_1x_0$ in binary. y is encoded as y_1y_0 in binary, and z is encoded as z_1z_0 in binary.
Note that the outputs y and z represent the two digits of a base-3 number.
For example, if x=7 ($x_3x_2x_1x_0$=0111), then the system will solve: $(7)_{10} = (21)_3$. Thus $y = 2$ (y_1y_0=10) and $z = 1$ (z_1z_0=01).

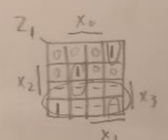
$x_3x_2x_1x_0$	y_1y_0	z_1z_0
0000	00	00
0001	00	01
0010	00	10
0011	01	00
0100	01	01
0101	01	10
0110	10	00
0111	10	01
1000	10	10
1001	--	--
⋮		
1111	--	--

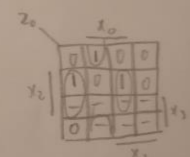


$Y_1 = x_3 + x_2x_1$



$y_0 = x_2x_1' + x_2'x_1x_0$





$Z_1 = x_3 + x_2x_1'x_0 + x_2'x_1x_0'$ $Z_0 = x_2x_1'x_0' + x_2'x_1'x_0 + x_2x_1x$

$\underline{y_1}$

$x_3 + x_2x_1$
- $x_3 = 1$
- $x_3' = x_2x_1$
  - $x_2 = x_1$
  - $x_2' = 0$

$\underline{y_0}$

$x_2x_1' + x_2'x_1x_0$
- $x_2 = x_1'$
  - $x_1 = 0$
  - $x_1' = 1$
- $x_2' = x_1x_0$
  - $x_1 = x_0$
  - $x_1' = 0$

$\underline{z_1}$

$x_3 + x_2x_1'x_0 + x_2'x_1x_0'$
- $x_3 = 1$
- $x_3' = x_2x_1'x_0 + x_2'x_1x_0'$
  - $x_2 = x_1'x_0$
    - $x_1 = 0$
    - $x_1' = x_0$
  - $x_2' = x_1x_0'$
    - $x_0 = 0$
    - $x_0' = x_1$

$\underline{z_0}$

$x_2x_1'x_0' + x_2'x_1'x_0 + x_2x_1x_0$
- $x_2 = x_1'x_0' + x_1x_0$
  - $x_1 = x_0$
  - $x_1' = x_0'$
    - $x_0 = 0$
    - $x_0' = 1$
- $x_2' = x_1'x_0$
  - $x_1 = 0$
  - $x_1' = x_0$

GATE NETWORK ON NEXT PAGE

Problem 5) Extra Page