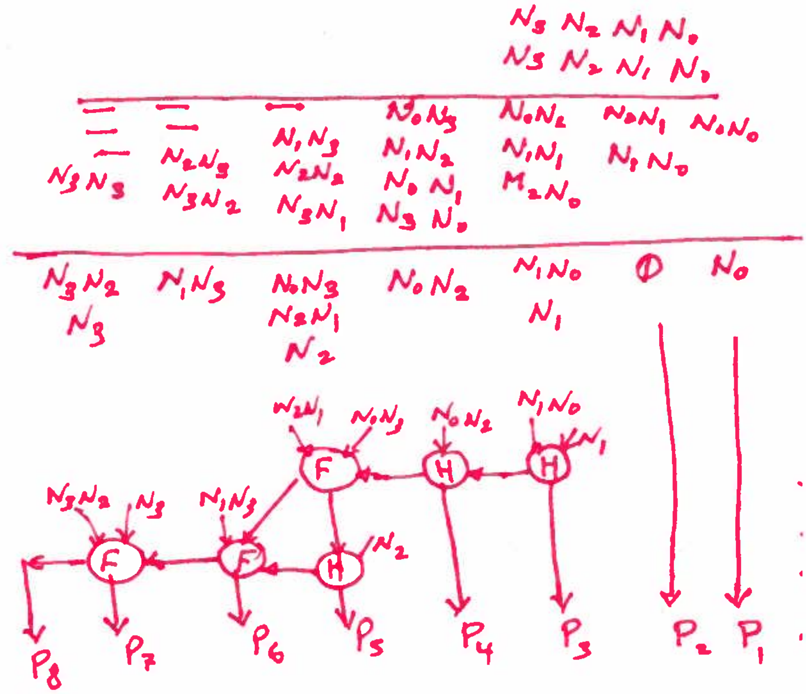
CoEN 6501 Midterm 2014

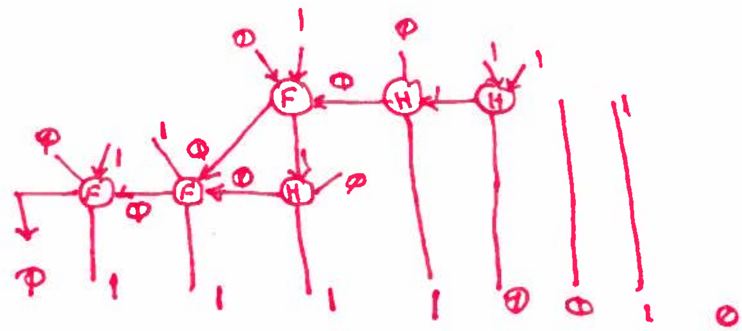
Q1 - $N = N_3 N_2 N_1 N_0$



Area = 3 Half Adders + 3 Full Adder + AND Gate

Delay = $3\,t_{ha} + 3t_{fa}$ + AND gate delay

Implementation of 1011



$P = 011110010_2 = 242_{10}$

Check $11 * 11 = 121 \times 2 = 242_{10}$

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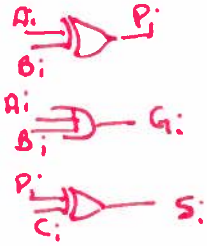
Q2) let $P_i = A_i \oplus B_i$

$G_i = A_i \cdot B_i$

$S_i = P_i \oplus C_i$



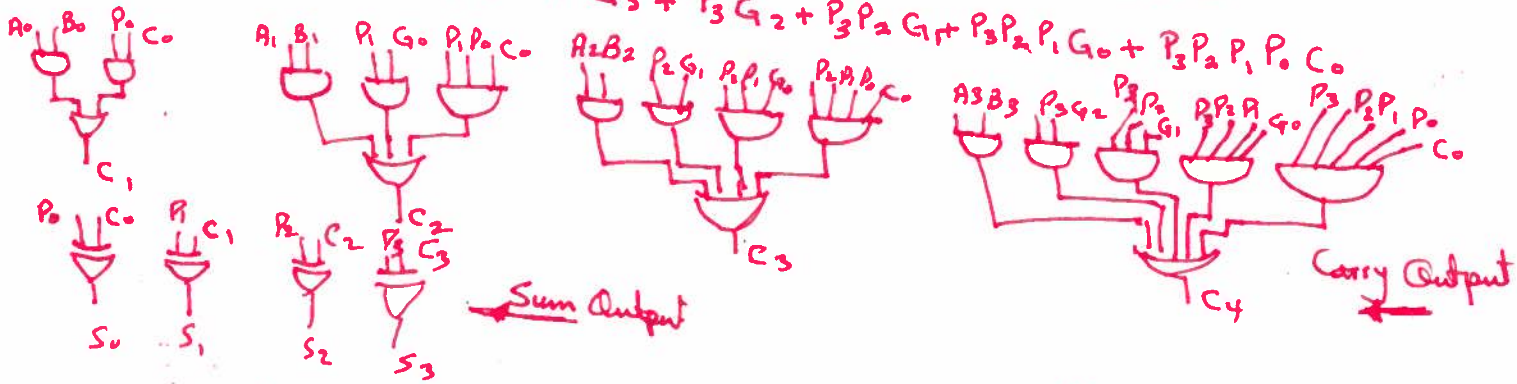
& $\underline{C_{i+1} = G_i + P_i C_i}$

$i=0$ $\quad C_1 = G_0 + P_0 C_0 = A_0 B_0 + P_0 C_0 = G_0 + P_0 C_0$

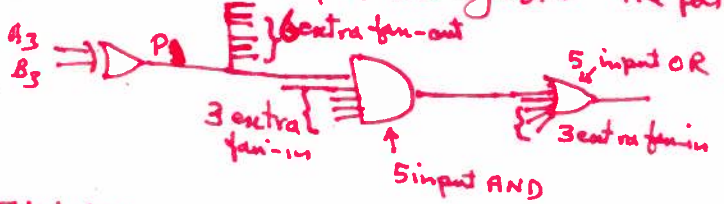
$i=1$ $\quad C_2 = G_1 + P_1 C_1 = A_1 B_1 + P_1 (G_0 + P_0 C_0) = G_1 + P_1 G_0 + P_1 P_2 C_0$

$i=2$ $\quad C_3 = G_2 + P_2 C_2 = G_2 + P_2 G_1 + P_2 P_1 G_0 + P_2 P_1 P_0 C_0$

$i=3$ $\quad C_4 = G_3 + P_3 C_3 = G_3 + P_3 G_2 + P_3 P_2 G_1 + P_3 P_2 P_1 G_0 + P_3 P_2 P_1 P_0 C_0$



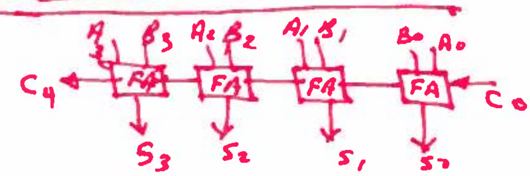
Delay associated with C_4 is the highest. The path is shown below



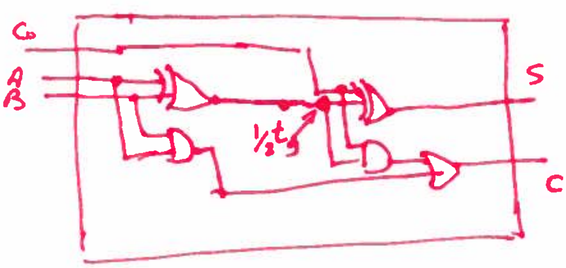
← Critical Path

Total Delay $= \underbrace{3}_{\text{gate}} + \underbrace{[\text{illegible}]}_{\text{fan-out}} + \underbrace{3 \times 1/3}_{\text{fan-in}} + \underbrace{3 \times 1/3}_{\text{fan-in}} = 8.0\, \tau_g$

In Comparison the 4-bit Carry Ripple Adder



Total Delay = 4 full Adder



T_{FA} delay $= 3\tau_g + \frac{1}{2}\tau_g = 3.5\, \tau_g$

Total Delay $= 4 * 3.5 = 14.0\, \tau_g$

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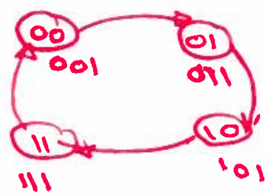
You may design a 8-state FSM with don't cares or go for a 4-state FSM with decoder for the output which is the simplest as we follow:

state diagram



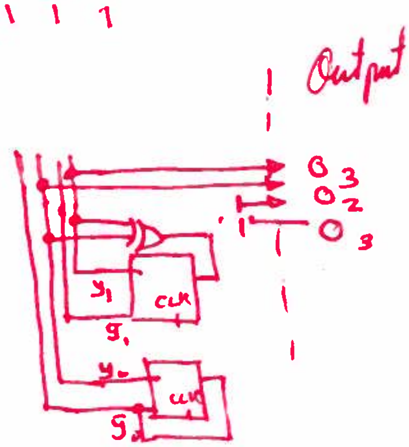
states $y_1 y_0$	Next state y_1^+ y_0^+	$O_3 O_2 O_1$ Output
0 0	0 1	0 0 1
0 1	1 0	0 1 1
1 0	1 1	1 0 1
1 1	0 0	1 1 1

From state table directly the next states and the outputs can be read as:

$y_1^+ = y_1 \oplus y_0$ $O_3 = y_1$

$y_0^+ = \bar{y}_0$ $O_2 = y_0$

$O_1 = 1$



Alternatively you might want to design a 8 bit FSM with don't care states. Assuming states 000, 010, 100, 110 never happen.

$y_2 y_1 y_0$	$y_2^+ y_1^+ y_0^+$
0 0 0	X X X
0 0 1	0 1 1
0 1 0	X X X
0 1 1	1 0 1
1 0 0	X X X
1 0 1	1 1 1
1 1 0	X X X
1 1 1	0 0 1

Giving $y_2^+ = y_1 \oplus y_1$,

$y_1^+ = \bar{y}_1$

$y_0 = 1$