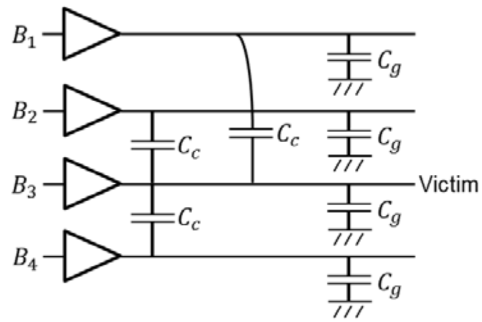
Homework Assignment 7

(Due Apr. 6th at the beginning of the class)

1. [Wire Coupling, **10 points**] Calculate effective capacitance for the victim net and transition patterns in the following figure.



Transition patterns ($B_1B_2B_3B_4$)	Effective cap. of the victim net
0000 → 0010	$C_g + 3C_C$
1101 → 0010	$C_g + 6C_C$
0101 → 1010	$C_g + 4C_C$
0011 → 1100	$C_g + 4C_C$
0100 → 1111	$C_g + C_C$
1010 → 0101	$C_g + 4C_C$

2. [Coupling Minimization, **20 points**] Encode 25 using the FPF-CAC Encoding algorithm in the lecture note (m=7). Show all the details, i.e., v, f_k, d_k, r_k, etc. at each step.

$(f_8, f_7, f_6, f_5, f_4, f_3, f_2, f_1) = (21, 13, 8, 5, 3, 2, 1, 1)$

1. MSB: $v = 25 \geq f_{7+1} = f_8 = 21$

   $d_m = d_7 = 1$

   $r_m = r_7 = v - f_7 = 25 - 13 = 12$

2. k = 6

   $r_{k+1} = r_7 = 12 < f_{k+1} = f_7 = 13$

   $r_{k+1} = r_7 = 12 \geq f_6 = 8$

   $d_k = d_6 = d_{k+1} = d_7 = 1$

   $r_k = r_6 = r_7 - f_6 * d_6 = 12 - 8*1 = 4$

3. k = 5

   $r_{k+1} = r_6 = 4 < f_{k+1} = f_6 = 8$

   $r_{k+1} = r_6 = 4 < f_5 = 5$

   $d_k = d_5 = 0$

   $r_k = r_5 = r_6 - f_5 * d_5 = 4 - 0 = 4$

4. k = 4

   $r_{k+1} = r_5 = 4 < f_{k+1} = f_5 = 5$

$r_{k+1} = r_5 = 4 \geq f_4 = 3$
$d_k = d_4 = d_{k+1} = d_5 = 0$
$r_k = r_4 = r_5 - f_4 * d_4 = 4 - 0 = 4$

5. $k = 3$
   $r_{k+1} = r_4 = 4 \geq f_{k+1} = f_4 = 3$
   $d_k = d_3 = 1$
   $r_k = r_3 = r_4 - f_3 * d_3 = 4 - 2*1 = 2$
6. $k = 2$
   $r_{k+1} = r_3 = 2 \geq f_{k+1} = f_3 = 2$
   $d_k = d_2 = 1$
   $r_k = r_2 = r_3 - f_2 * d_2 = 2 - 1*1 = 1$
7. LSB: $d_1 = r_2 = 1$

Answer: **1100111**

3. [Buffer Insertion, **30 points**] In the second buffer insertion problem in the lecture note (pp. 34 – 37), we did not take the buffer delay into account. However, the buffer delay is not negligible in reality. Suppose the Elmore delay of a buffer is d. Find N, the number of buffers to insert.

$$\tau_{all} = R_{DR}(C_{wire} + N \cdot C_{in}) + R_{wire} \cdot C_{in} + d \cdot N + \frac{R_{wire} \cdot C_{wire}}{2L^2}({s_1}^2 + {s_2}^2 + \cdots + {s_N}^2)$$

$$\frac{\partial \tau_{all}}{\partial s_k} = 2 \cdot s_k - 2s_N = 0 \;\; => \;\; \boldsymbol{s_1 = s_2 = \cdots = s_N}$$

$$\tau_{all} = R_{DR}(C_{wire} + N \cdot C_{in}) + R_{wire} \cdot C_{in} + d \cdot N + \frac{R_{wire} \cdot C_{wire}}{2N}$$

$$\frac{\partial \tau_{all}}{\partial N} = R_{DR} \cdot C_{in} + d - \frac{R_{wire} \cdot C_{wire}}{2N^2} = 0$$

$$\boldsymbol{N = \sqrt{\frac{R_{wire} \cdot C_{wire}}{2(R_{DR} \cdot C_{in} + d)}}}$$