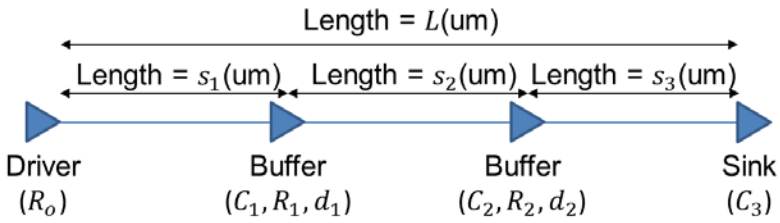
Homework Assignment 16
(Due 4:10pm, Apr. 18, email to daehyun@eecs.wsu.edu)

(1) **[Interconnect, 30 points]** Find the locations (s_1 and s_2) of the two buffers minimizing the total delay (i.e., express s_1 and s_2 as functions of $L, R_0, R_1, R_2, C_1, C_2, C_3, r, c$).



- R_0: Output resistance of the driver
- R_1, R_2: Output resistances of the first and second buffers, respectively
- C_1, C_2: Input capacitances of the first and second buffers, respectively
- C_3: Input capacitance of the sink
- r, c: Unit wire resistance (ohm/um) and capacitance (F/um), respectively
- d_1, d_2: Delays of the first and second buffers, respectively
- L: Total wire length
- Use $L = s_1 + s_2 + s_3$

Total delay $\tau = \{R_0(c \cdot s_1 + C_1) + r \cdot s_1 \cdot C_1 + 0.5rcs_1{}^2\} + \{d_1\} + \{R_1(c \cdot s_2 + C_2) + r \cdot s_2 \cdot C_2 + 0.5rcs_2{}^2\} + \{d_2\} + \{R_2(c \cdot s_3 + C_3) + r \cdot s_3 \cdot C_3 + 0.5rcs_3{}^2\}$

$$\frac{\partial \tau}{\partial s_1} = c(R_0 - R_2) + r(C_1 - C_3) + rc(s_1 - s_3) = 0$$

$$\frac{\partial \tau}{\partial s_2} = c(R_1 - R_2) + r(C_2 - C_3) + rc(s_2 - s_3) = 0$$

With $L = s_1 + s_2 + s_3$, we get the followings.

$$s_1 = \frac{L}{3} + \frac{R_1 + R_2 - 2R_0}{3r} + \frac{C_2 + C_3 - 2C_1}{3c}$$

$$s_2 = \frac{L}{3} + \frac{R_0 + R_2 - 2R_1}{3r} + \frac{C_1 + C_3 - 2C_2}{3c}$$

$$s_3 = \frac{L}{3} + \frac{R_0 + R_1 - 2R_2}{3r} + \frac{C_1 + C_2 - 2C_3}{3c}$$