CS M51A F14 MDE

MULTIPLIER DESIGN: AN EXAMPLE —

4-BIT × 3-BIT MULTIPLICATION

$p = x \cdot y \qquad x \in \{0, \dots, 15\} \quad y \in \{0, \dots 7\}$

$\qquad\qquad\qquad p \in \{0, \dots, 105\}$

$x = (x_3, x_2, x_1, x_0) \qquad y = (y_2, y_1, y_0)$

$p = (p_6, p_5, \dots, p_0)$

$$p = x \cdot y = x \sum (y_2 2^2 + y_1 2^1 + y_0 2^0)$$
$$= \sum (x \cdot y_2 \cdot 2^2 + x y_1 2^1 + x y_0 2^0)$$

$x = 1001 = 9 \qquad y = 110 = 6$

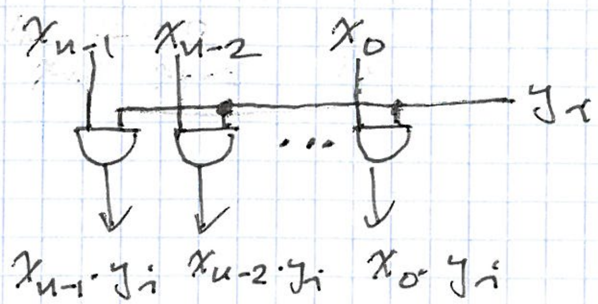
$$\begin{array}{lr} & (1\ 0\ 0\ 1) \times 0 \cdot 2^0 \\ + & (1\ 0\ 0\ 1) \times 1 \cdot 2^1 \\ + & (1\ 0\ 0\ 1) \times 1 \cdot 2^2 \end{array} \qquad \begin{array}{c} \text{PARTIAL PRODUCTS} \\ P_0 \\ P_1 \\ P_2 \end{array}$$

$$\Downarrow$$

$$\left.\begin{array}{rcccccc} & & & 0 & 0 & 0 & 0 \\ & & 1 & 0 & 0 & 1 & \\ + & 1 & 0 & 0 & 1 & & \\ \hline & 1 & 1 & 0 & 1 & 1 & 0 \end{array}\right\} = 54 \quad \text{ALIGNED BIT-MATRIX OF PARTIAL PRODUCTS}$$

2 STEPS;

1. OBTAIN BIT-MATRIX; SIMPLE IN RADIX 2



2. ADD ROWS TO OBTAIN THE PRODUCT

- TWO BASIC APPROACHES

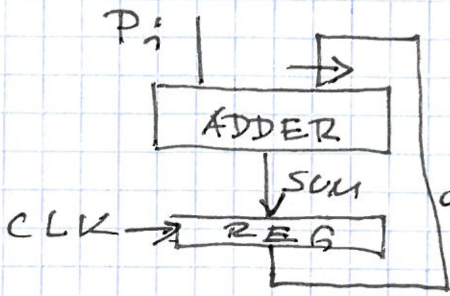
a) – SEQUENTIAL

b) – COMBINATIONAL

(*) LINEAR ARRAY OF ADDERS

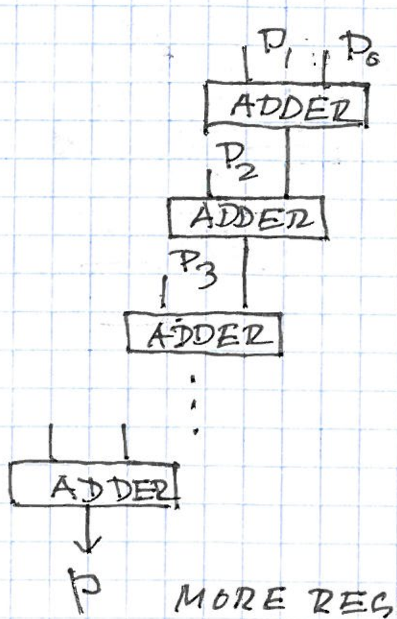
(**) TREE OF ADDERS

a)



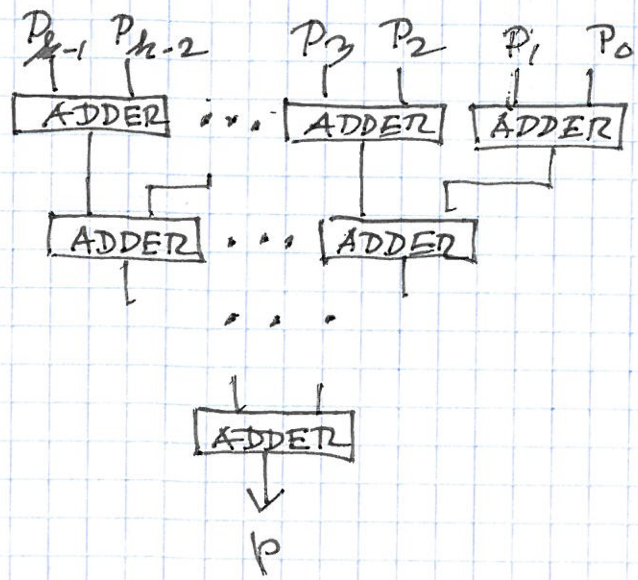
SHIFT RIGHT TO ALIGN P_i AND THE SUM OF PARTIAL PRODUCTS

b)



MORE REGULAR

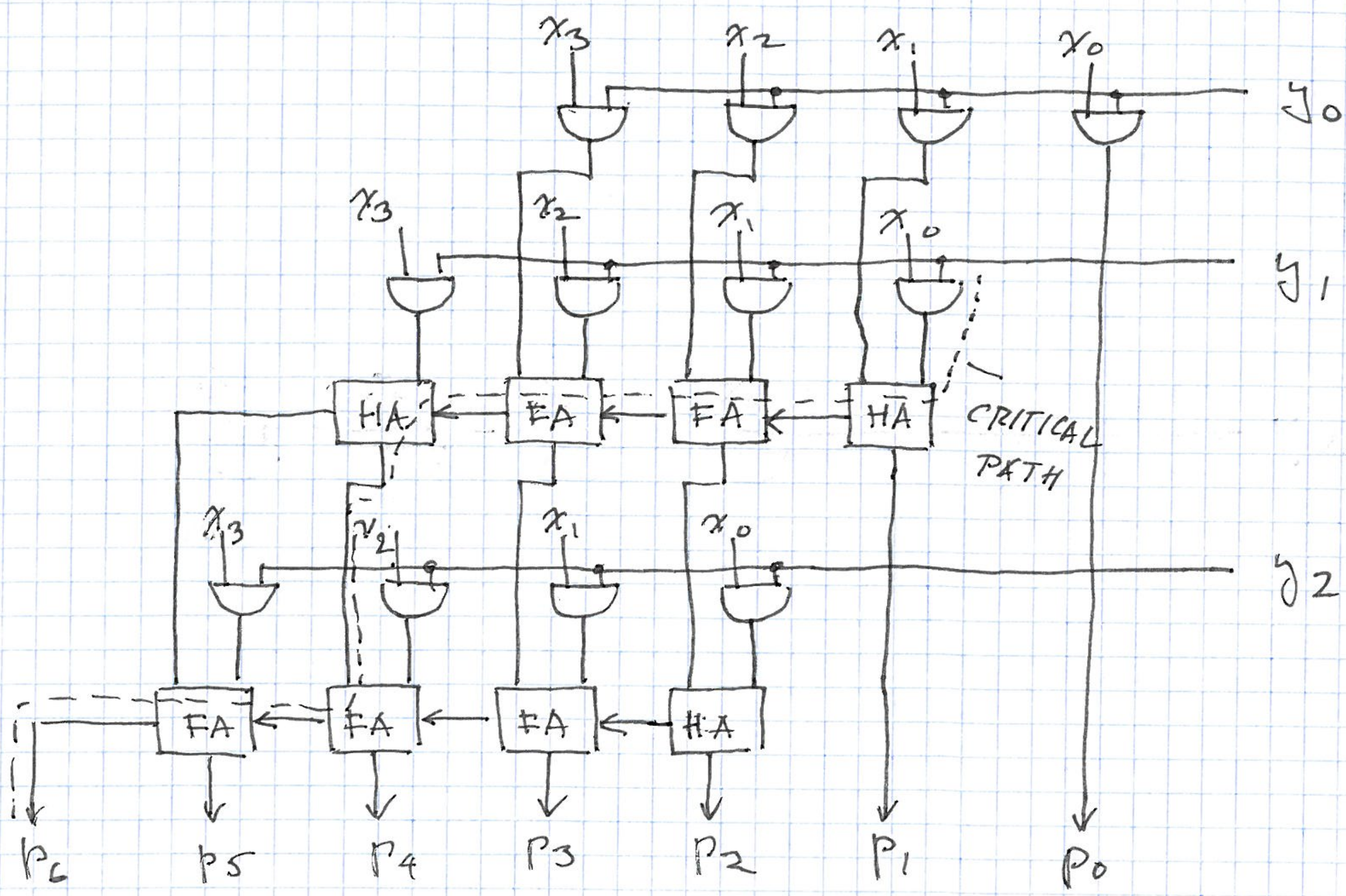
(*)



FASTER, SAME COST AS (*)

(**)

4x3 ARRAY MULTIPLIER



DELAY $T = t_{AND} + 3 \cdot t_c + t_s + 2t_c = 13t_g \quad t_s = t_c = 2t_g$

IN GENERAL FOR $n \times m$ ARRAY MULTIPLIER

$$T = t_{AND} + (n-1)t_c + (t_s + t_c)(m-2)$$

$$\approx (n + 2m - 4)2t_g$$

IF $n = m$, $T \rightarrow 3n \cdot 2t_g$

— DESIGN AND SIMULATE IN LOGISIM !