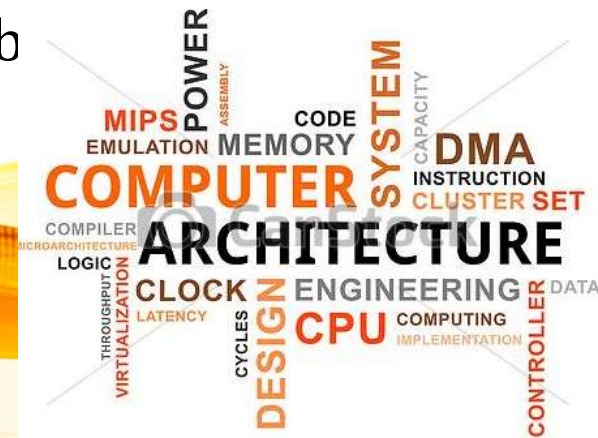


UNIT II

ARITHMETIC OPERATIONS

Addition and subtraction of signed numbers – **Design of fast adders** –
Multiplication of positive numbers - Signed operand multiplication- fast
multiplication – Integer division – Floating point numb



Recap the previous Class



Binary Adders

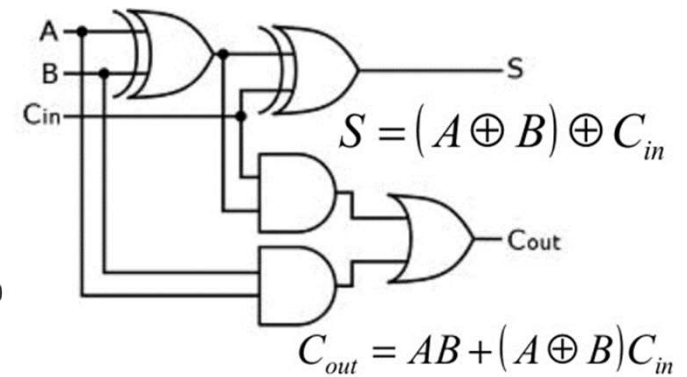
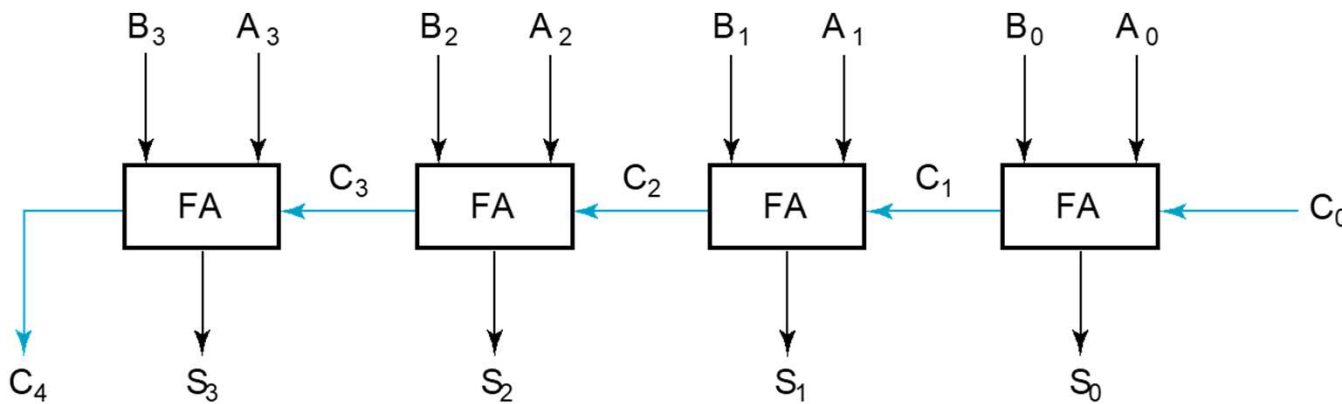
Note:

carry out of cell i becomes carry in of cell $i + 1$

| Description | Subscript 3 2 1 0 | Name |
|-------------|----------------------|------|
| Carry In | 0 1 1 0 | Ci |
| Augend | 1 0 1 1 | Ai |
| Addend | 0 0 1 1 | Bi |
| Sum | <u>1 1 1 0</u> | Si |
| Carry out | 0 0 1 1 | Ci+1 |

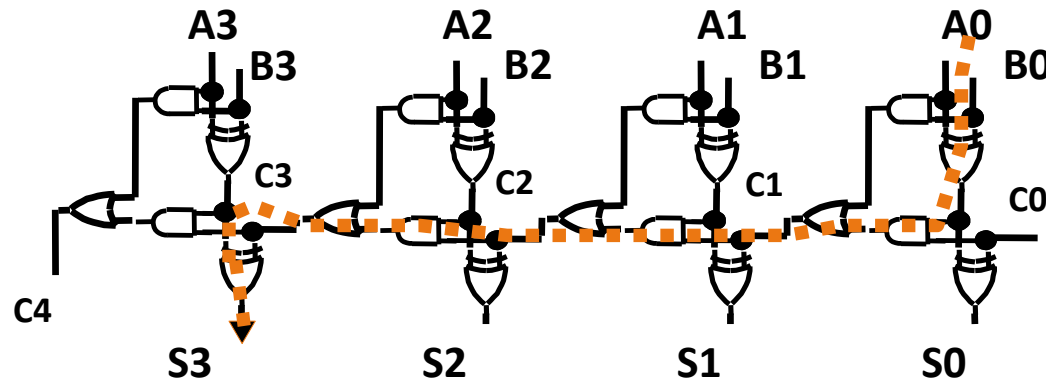
4 bit Ripple carry Adder

- A four-bit Ripple Carry Adder made from four 1-bit Full Adders



Carry Propagation & Delay

- One problem with the addition of binary numbers is the length of time to propagate the ripple carry from the least significant bit to the most significant bit.
- The gate-level propagation path for a 4-bit ripple carry adder



Carry Lookahead Adder

$$S_i = x_i \oplus y_i \oplus c_i$$

$$C_{i+1} = x_i y_i + x_i c_i + y_i c_i$$

Factorizing

$$C_{i+1} = x_i y_i + (x_i \oplus y_i) c_i$$

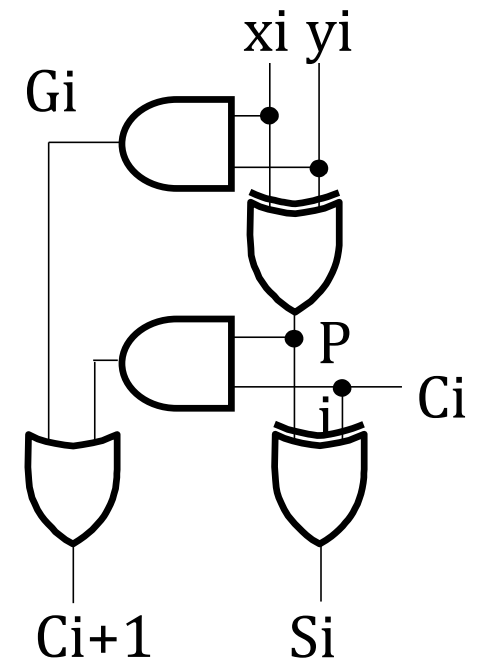
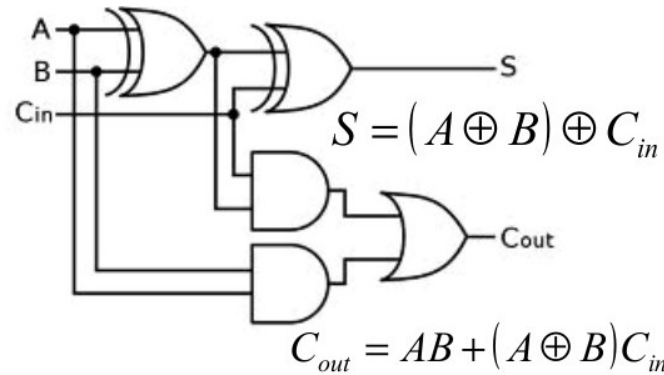
We can write

$$C_{i+1} = G_i + P_i c_i$$

Where

$$G_i = x_i y_i$$

$$P_i = x_i \oplus y_i$$



These two signal conditions are called **generate**, denoted as **G_i**, and **propagate**, denoted as **P_i** respectively

Carry Lookahead Adder

- In the ripple carry adder:
 - G_i , P_i , and S_i are local to each cell of the adder
 - C_i is also local each cell
- In the carry lookahead adder, in order to reduce the length of the carry chain, **C_i is changed to a more global function spanning multiple cells**
- Defining the equations for the Full Adder in term of the P_i and G_i :

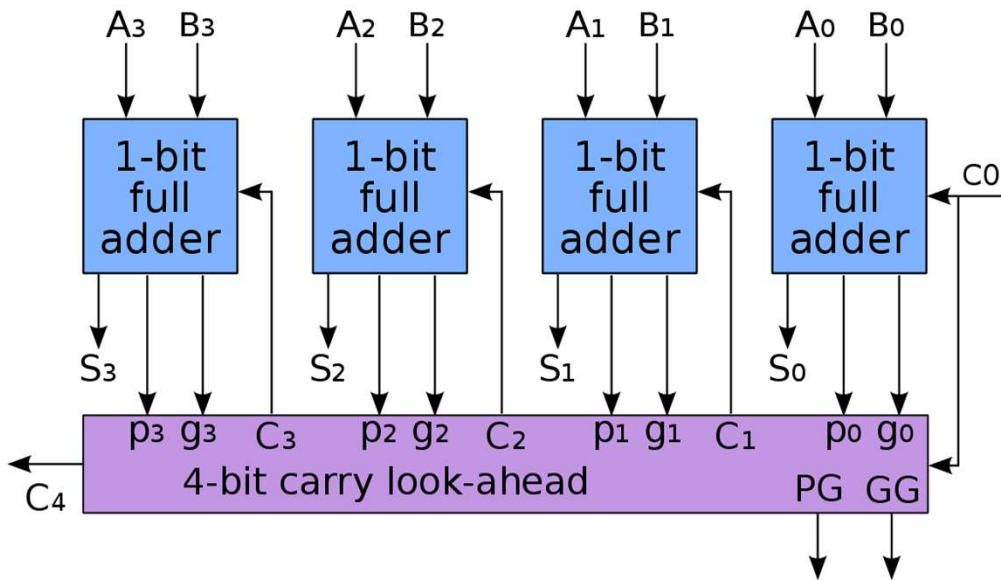
$$P_i = A_i \oplus B_i$$

$$G_i = A_i B_i$$

$$S_i = P_i \oplus C_i$$

$$C_{i+1} = G_i + P_i C_i$$

Carry Lookahead Adder



$$C_1 = G_0 + P_0 C_0$$

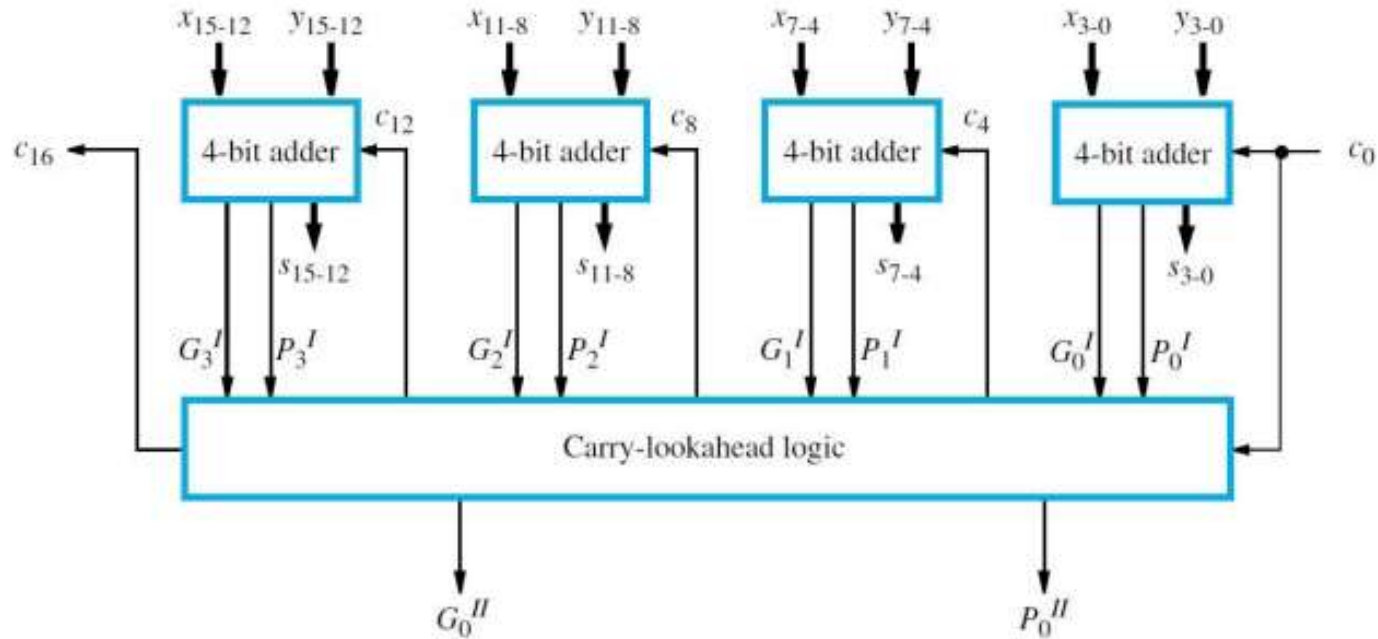
$$C_2 = G_1 + P_1 C_1 = G_1 + P_1(G_0 + P_0 C_0) \\ = G_1 + P_1 G_0 + P_1 P_0 C_0$$

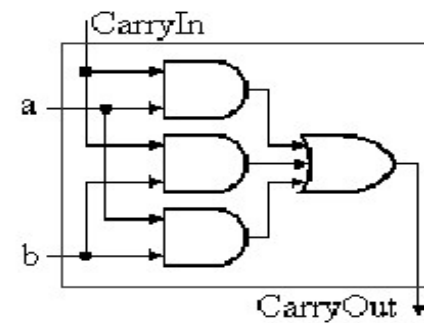
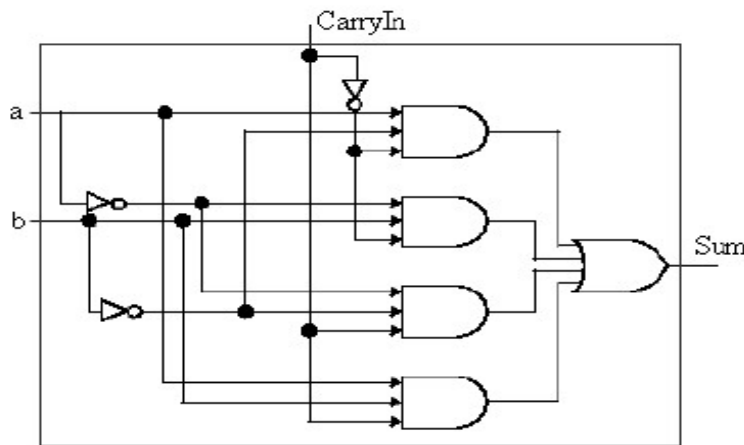
$$C_3 = G_2 + P_2 C_2 = G_2 + P_2(G_1 + P_1 G_0 + P_1 P_0 C_0) \\ = G_2 + P_2 G_1 + P_2 P_1 G_0 + P_2 P_1 P_0 C_0$$

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

$$C_{i+1} = G_i + P_i G_{i-1} + P_i P_{i-1} C_{i-1}$$

16 bit Carry Lookahead Adder





$$\text{Carryout} = (b \cdot \text{CarryIn}) + (a \cdot \text{CarryIn}) + (a \cdot b)$$

$$\text{Sum} = (a \cdot b' \cdot \text{CarryIn}') + (a' \cdot b \cdot \text{CarryIn}') + (a' \cdot b' \cdot \text{CarryIn}) + (a \cdot b \cdot \text{CarryIn})$$



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Thank You