

Simulation of Multiplication in Computer Architecture

Simulation of Basic Multiplication

This section simulates basic binary multiplication using both basic and optimized methods.

Example 1: 4-bit \times 4-bit Multiplication

Operands:

$$A = 1011_2 \quad (11_{10}), \quad B = 1101_2 \quad (13_{10})$$

Basic Multiplication Table

Iteration	Multiplier (B)	Multiplicand (A)	Product
1	1101	00001011	00001011
2	0110	00010110	00011001
3	0011	00101100	00111101
4	0001	01011000	10001111

Table 1: 4-bit \times 4-bit Basic Multiplication Simulation

Optimized Multiplication Table

Iteration	Multiplicand (A)	Product (Initial)	Action and Product (After)
1	1011	0000 1101	Add A, Shift Left \rightarrow 1011 1100
2	1011	1011 1100	No Action, Shift Left \rightarrow 0111 1000
3	1011	0111 1000	Add A, Shift Left \rightarrow 1111 0010
4	1011	1111 0010	Add A, Shift Left \rightarrow 1000 1111

Table 2: 4-bit \times 4-bit Optimized Multiplication Simulation

Example 2: 4-bit \times 3-bit Multiplication

Operands:

$$A = 1011_2 \quad (11_{10}), \quad B = 101_2 \quad (5_{10})$$

Basic Multiplication Table

Iteration	Multiplier (B)	Multiplicand (A)	Product
1	0101	00001011	00001011
2	0010	00010110	00010111
3	0001	00101100	00111011

Table 3: 4-bit \times 3-bit Basic Multiplication Simulation

Optimized Multiplication Table

Iteration	Multiplicand (A)	Product (Initial)	Action and Product (After)
1	1011	0000 0101	Add A, Shift Left \rightarrow 1011 0100
2	1011	1011 0100	No Action, Shift Left \rightarrow 0110 1000
3	1011	0110 1000	Add A, Shift Left \rightarrow 1000 1101

Table 4: 4-bit \times 3-bit Optimized Multiplication Simulation

Iteration	Multiplier (12-bit, B)	Multiplicand (20-bit, A)	Product (20-bit)
1	110101101011	000000000010101101	000000000010101101
2	011010110101	000000000101011010	000000001000111111
3	001101011010	000000001010110100	000000101000011001
4	000110101101	000000010101101000	000010100000101001
5	000011010110	000000101011010000	001001110001010011
6	000001101011	000001010110100000	010110001010110011
7	000000110101	000010101101000000	101100111011100011
8	000000011010	000101011010000000	111000011110011011
9	000000001101	001010110100000000	111111110001010111
10	000000000110	010101101000000000	111010101111111111
11	000000000011	101011010000000000	111101011011111111
12	000000000001	010110100000000000	110010101011111111

Table 5: 8-bit \times 12-bit Basic Multiplication Simulation with 20-bit Product and Multiplicand

Practice Problems

Solve the following problems step-by-step using the specified multiplication methods. Show intermediate iterations in tabular format for clarity.

1. Multiply $A = 1001_2$ and $B = 1010_2$ using both basic and optimized methods.
2. Multiply $A = 111_2$ and $B = 101_2$ using basic multiplication.
3. Simulate $A = 1100_2$ and $B = 0110_2$ using optimized multiplication.
4. Multiply $A = 101101_2$ and $B = 1101_2$ using both methods.
5. Multiply $A = 10001011_2$ and $B = 10110110_2$ using optimized multiplication.
6. Find the product of $A = 11111111_2$ and $B = 1111_2$ using basic multiplication.
7. Verify $A = 11001_2 \times B = 1001_2$ using basic and optimized methods.
8. Multiply $A = 101011_2$ and $B = 110111_2$ and verify your result.
9. Use basic multiplication for $A = 10000001_2$ and $B = 11111000_2$.
10. Use optimized multiplication for $A = 10001010_2$ and $B = 10111101_2$.