Computer Organization and Logic Design

Arithmetic Number Systems

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Lec 4-5

Arithmetic in the Binary System

Binary Addition

1- ***Binary Addition:*** The four basic rules for adding binary digits (bits) are as follows.

0+0=0 Sum of 0 with a carry 0

0+1=1 Sum of 1 with a carry 0

1+0=1 Sum of 1 with a carry 0

1+1=0Sum of 0 with a carry 1

1+1+1=1 sum of 1 with a carry 1

Binary Addition

Example9:

Add the binary numbers

$0011\ 0010_2$ + $0011\ 0111_2$:

Solution:

$$
\begin{array}{rcccccccc}
 & & {\scriptstyle 1} & {\scriptstyle 1} & & {\scriptstyle 1} & {\scriptstyle 1} & & \\
 & 0 & 0 & 1 & 1 & 0 & 0 & 1 & 0 \\
+ & 0 & 0 & 1 & 1 & 0 & 1 & 1 & 1 \\
\hline
 & 0 & 1 & 1 & 0 & 1 & 0 & 0 & 1
\end{array}
\qquad
\begin{array}{l}
= 50 \\
= 55 \\
\hline
= 105
\end{array}
$$

Binary Addition

Example10:

Add the binary numbers

111111+111111

Solution:

111111

111111

111110

Binary Subtraction

2- The four basic rules for subtracting are as follows

.

0-0=0

1-1=0

1-0=1

0-1=2

Binary Subtraction

Example 11:

Subtract:

10010110_00101100

Solution:

10010110

00101100

01101010

Binary Multiplication

Binary multiplication uses just three order-independent facts:

*0 x 0 = 0

*1 x 0 = 0

*1 x 1 = 1

Example 12:

Multiply 1010 * 1111

1010
× 11111

1010
+ 10100
+ 101000
+ 1010000
+ 10100000

10011000

Arithmetic in octal system

Octal Addition

Addition of the octal number is carried out in the same way as the decimal addition is performed. The steps are given below:

1. First, add the two digits of the unit column of the octal number in decimal.
2. This process is repeated for each larger significant digit of the octal number.
3. During the process of addition, if the sum is less than or equal to 7, then it can be directly written as an octal digit.
4. If the sum is greater than 7, then subtract 8 from the digit and carry 1 to the next digit position.
5. Note that in this addition the largest octal digit is 7.

Example :

(i) 267+514= 1003 octal

Solution

Starting from the right:

- **7 + 4 = 11 → 11 ÷ 8 = 1 remainder 3 → write 3 and carry 1.**
- **6 + 1 = 7 + 1 (carry) = 8 → 8 ÷ 8 = 1 remainder 0 → write 0 and carry 1.**
- **2 + 5 = 7 + 1 (carry) = 8 → 8 ÷ 8 = 1 remainder 0 → write 0 and carry 1.**
- **Finally, write the last carry.**

(ii) 4775+3662=10657

Solution: Step-by-Step Solution:

1. Rightmost digits:

5 + 2 = 7 → 7 < 8 → write 7, no carry.

2. Next digits:

7 + 6 = 13

13 ÷ 8 = 1 remainder 5 → write 5 and carry 1.

3. Next digits:

7 + 6 = 13 + 1 (carry) = 14

14 ÷ 8 = 1 remainder 6 → write 6 and carry 1.

4. Leftmost digits:

4 + 3 = 7 + 1 (carry) = 8

8 ÷ 8 = 1 remainder 0 → write 0 and carry 1.

5. Finally:

Write the last carry 1 at the leftmost position

Hexadecimal Addition:

Use the following steps to perform hexadecimal addition:

1. Add one column at a time.
2. Convert to decimal and add the numbers.

3a. If the result of step two is 16 or larger subtract the result from 16 and carry 1 to the next column.

3b. If the result of step two is less than 16, convert the number to hexadecimal.

Example 7:

Add: **AC5A9+ED694= 169C3D HEXA**

Solution:

Start from the rightmost digit:

1. First column (rightmost):

9 + 4 = 13

13 in hexadecimal is D.

→ Write D. (No carry)

2. Second column:

A + 9 = 10 + 9 = 19

19 ÷ 16 = 1 remainder 3

→ Write 3 and carry 1.

3. Third column:

5 + 6 = 11

11 + 1 (carry) = 12

12 in hexadecimal is C.

→ Write C. (No carry)

4. Fourth column:

C + D = 12 + 13 = 25

25 ÷ 16 = 1 remainder 9

→ Write 9 and carry 1.

5. Fifth column (leftmost):

A + E = 10 + 14 = 24

24 + 1 (carry) = 25

25 ÷ 16 = 1 remainder 9

→ Write 9 and carry 1.

6. Finally:

Write the last carry 1 at the beginning

Thank you