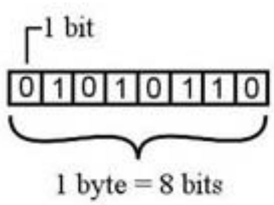
COMPUTER ORGANIZATION AND ARCHITECTURE
UNIT –III
TOPIC- DATA REPRESENTATION-BASICS, DATA TYPES

Basics

Bit: The most basic unit of information in a digital computer is called a bit.
A bit is the smallest data unit that a computer uses in computation.
All the computation tasks done by the computer systems are based on bits.A bit represents a binary digit in terms of 0 or 1. The computer usually uses bits in groups. It's the basic unit of information storage and communication in digital computing.

Byte: In 1964, the designers of the IBM System/360 main frame computer established a convention of using groups of 8 bits as the basic unit of addressable computer storage. They called this collection of 8 bits a byte. Half of a byte(4-bits) is called a nibble.

A byte is a fundamental addressable unit of computer memory and storage. Bytes are used to determine file sizes, storage capacity, and available memory space



Byte Value	Bit Value
1 Byte	8 Bits
1024 Bytes	1 Kilobyte
1024 Kilobytes	1 Megabyte
1024 Megabytes	1 Gigabyte
1024 Gigabytes	1 Terabyte
1024 Terabytes	1 Petabyte
1024 Petabytes	1 Exabyte
1024 Exabytes	1 Zettabyte
1024 Zettabytes	1 Yottabyte
1024 Yottabytes	1 Brontobyte
1024 Brontobytes	1 Geopbytes

Conversion of Bits and Bytes

• **Word:** Computer words consist of two or more adjacent bytes that are sometimes addressed and almost always are manipulated collectively.
• The word size represents the data size that is handled most efficiently by a particular architecture. Words can be 16 bits, 32 bits, 64 bits.

Data types

The data types found in the registers of digital computers may be classified as being one of the following categories:

(1) Numbers used in arithmetic computations,

(2) Letters of the alphabet used in data processing. and

(3) Other discrete symbols used for specific purposes.

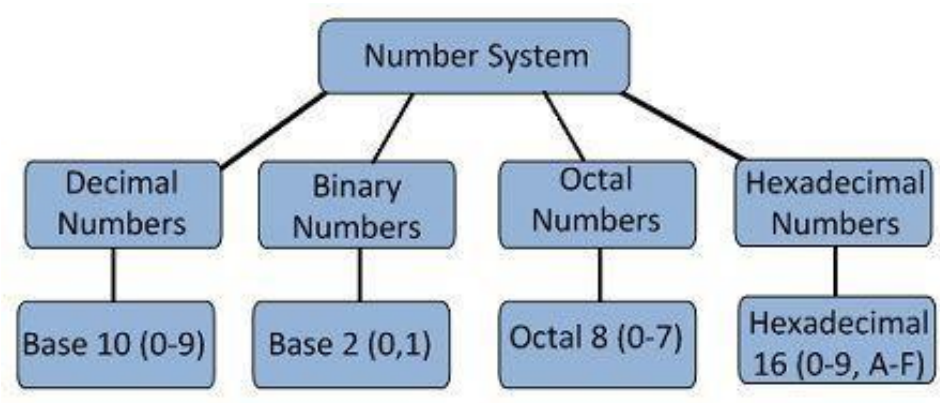
All types of data, except binary numbers, are represented in computer registers in binary coded form. This is because registers are made up of flip-flops and flip-flops are two-state devises that can store only l's and 0's. The binary number system is the most natural system to use in a digital computer. But sometimes it is convenient to employ different number systems, especially the decimal number system, since it is used by people to perform arithmetic computations.

Number System

Number systems are the technique to represent numbers in the computer system architecture.

Computer architecture supports following number systems.

- **Binary number system**
- **Octal number system**
- **Decimal number system**
- **Hexadecimal(hex) number system**



1.Binary Number System

A Binary number system has only two digits **0 and 1**. Every number (value) represents with 0 and 1. The base of binary number system is 2, because it has only two digits.

2.Octal number system

Octal number system has only eight (8) digits from **0 to 7**. Every number (value)represents with0,1,2,3,4,5,6 and 7.The base of octal number system is 8, because it has only 8 digits.

3. Decimal number system

Decimal number system has only ten (10) digits from **0 to 9**. Every number (value) represents with 0,1,2,3,4,5,6,7,8 and 9.The base of decimal number system is 10, because it has only 10 digits.

4.Hexa decimal number system

A Hexadecimal number system has sixteen (16) alphanumeric values from**0 to 9** and **A to F**. Every number (value) represents with 0,1,2,3,4,5,6, 7,8 ,9,A,B,C,D,E and F. The base of hexadecimal number system is 16, because it has 16 alphanumeric values. Here **A is 10**, **B is11**, **C is 12**, **D is 13**, **E is 14** and **F is 15**.

Table of the Numbers Systems

Number system	Base	Used digits	Example
Binary	2	0,1	$(11110000)_2$
Octal	8	0,1,2,3,4,5,6,7	$(360)_8$
Decimal	10	0,1,2,3,4,5,6,7,8,9	$(240)_{10}$
Hexadecimal	16	0,1,2,3,4,5,6,7,8, 9, A, B, C, D, E, F	$(F0)_{16}$

Number Conversions

To convert Number system from **Decimal Number System** to **Any Other Base** is done with just two steps:

a) Divide the Number (Decimal Number) by the base of target base system in which you want to convert the number: Binary (2), octal (8) and Hexadecimal (16)).

b) Write the remainder from step 1 as a Least Signification Bit (LSB) to Step last as a Most Significant Bit (MSB).

Decimal to Binary conversion

Steps:
1. Divide the decimal number by 2 and store remainders in array.
2.Divide the quotient by 2.
3.Repeat step 2 until we get the quotient equal to zero.

4. Equivalent binary number would be reverse of all remainders of step 1

For example:

a.$(149)_{10}$

2	**149**	1
2	**74**	0
2	**37**	1
2	**18**	0
2	**9**	1
2	**4**	0
2	**2**	0
2	**1**	1
	0	

Therefore,$(149)_{10}=(10010101)_2$

To Convert fractional Part to binary

1. Multiply the fractional decimal number by 2.
2.Integral part of resultant decimal number will be first digit of fraction binary number.
3.Repeat step 1 using only fractional part of decimal number and then step 2.

- Repeat this procedure unless and until the fractional part happens to be 0.
- If the fractional part doesn't terminate to 0, then one needs to find the result of the fraction up to as many places as required.

Example:

a.Here,$(0.55)_{10}$

0.55x2= 1.1	1
0.1x2=0.2	0
0.2x2=0.4	0
0.4x2=0.8	0
0.8x2=1.6	1
0.6x2=1.2	1

Therefore,$(0.55)_{10}=(0.100011)_2$

Decimal to Octal Conversion

Result

Decimal Number is:$(12345)_{10}$

8	12345		1	LSB
8	1543		7	
8	192		0	
8	24		0	
	3		3	MSB

Octal Number is $(30071)_8$

Decimal to Hexa decimal Conversion

Example: Convert 1228_{10} into hex.

Divide by 16	Quotient	Remainder	Hex Value
1228 ÷ 16	76	12	C
76 ÷ 16	4	12	C
4 ÷ 16	0	4	4

Therefore, $1228_{10} = 4CC_{16}$

Binary to Decimal Conversion

- Multiply each bit by2^n,where n is the “weight” of the bit
- The weight is the position of the bit, starting from 0 on the right
- Add the results.

Example1:(101011)2=(?)10=(43)10

$$(101011)_2=(1x2^5)+(0x2^4)+(1x2^3)+(0x2^2)+(1x2^1)+(1x2^0)$$

$$=32+0+8+0+2+1$$

$$=(43)_{10}$$

Example2:Convert(111.101)2

$$(111.101)_2=(1x2^2)+(1x2^1)+(1x2^0)+(1x2^{-1})+(0x2^{-2})+(1x2^{-3})$$

$$=4+2+1+0.5+0+ 0.125$$

$$=(7.625)_{10}$$

Binary to Octal conversion

Example 1: Convert 1010101_2 to octal

Solution:

Given binary number is 1010101_2

First, we convert given binary to decimal

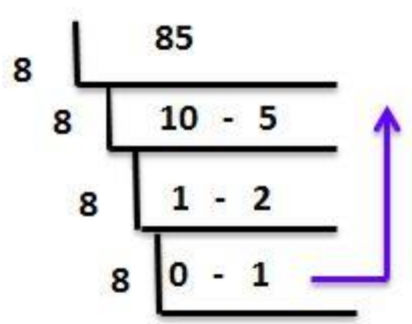
$1010101_2 = (1 * 2^6) + (0 * 2^5) + (1 * 2^4) + (0 * 2^3) + (1 * 2^2) + (0 * 2^1) + (1 * 2^0)$

= 64 + 0 + 16 + 0 + 4 + 0 + 1

= 64 + 21

010101_2= 85 (Decimal form)

Now we will convert this decimal to octal form



Therefore, the equivalent octal number is 125_8.

Binary to Hex Converter

To convert binary number to hexadecimal is an easy method. We have to group the given binary number in pair of 4 and then find the equivalent hexadecimal number from the below table.

Binary	Hex
0000	0
0001	1
0010	2
0011	3
0100	4
0101	5
0110	6

0111	7
1000	8
1001	9
1010	A
1011	B
1100	C
1101	D
1110	E
1111	F

Example: Convert 1001001_2 into a hexadecimal number.

Solution: 1001001_2

= 0100 1001

= 49_{16}