Number System

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- Conversion of Numbers from one Radix to Another Radix
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What is Number System ?

- A system for representing number of certain type.
- Example:

–There are several systems for representing the –counting numbers.

– These include the usual base “10” or decimal system : 1,2,3 ,.....10,11,12,..99,100,...

Common Number System

System	Base	Symbols	Used by humans?	Used in computers?
Decimal	10	0, 1, … 9	Yes	No
Binary	2	0, 1	No	Yes
Octal	8	0, 1, … 7	No	No
Hexa-decimal	16	0, 1, … 9, A, B, … F	No	No

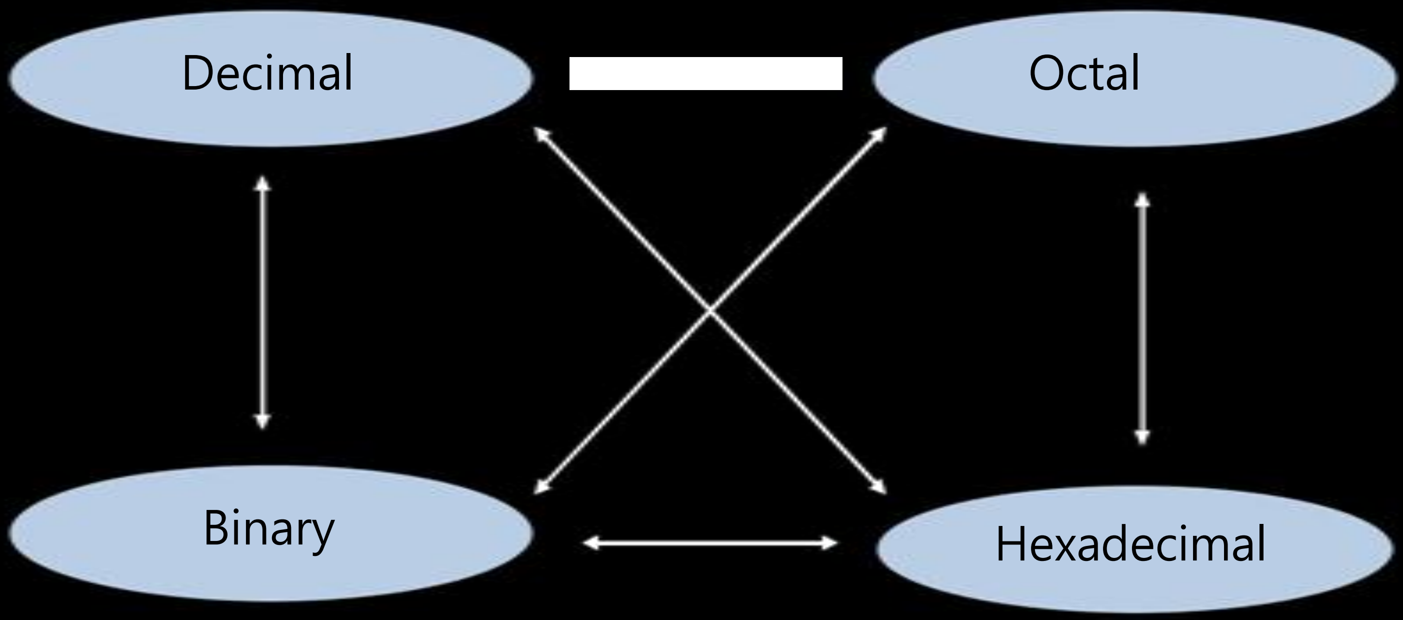
Counting

Decimal	Binary	Octal	Hexa-decimal
0	0	0	0
1	1	1	1
2	10	2	2
3	11	3	3
4	100	4	4
5	101	5	5
6	110	6	6
7	111	7	7

Counting

Decimal	Binary	Octal	Hexa-decimal
8	1000	10	8
9	1001	11	9
10	1010	12	A
11	1011	13	B
12	1100	14	C
13	1101	15	D
14	1110	16	E
15	1111	17	F

Conversion Among Bases



Binary to Octal

- Group into 3's starting at least significant symbol (if the number of bits is not evenly divisible by 3, then add 0's at the most significant end)
- write 1 octal digit for each group

e.g.: $(1010101)_2$ to $(\ )_8$

001	010	101
↓	↓	↓
1	2	5

Answer = 125_8

Octal to Binary

- For each of the Octal digit write its binary equivalent

e.g.: $(257)_8$ to $(\ )_2$

2 5 7

010 101 111

Answer = $(010101111)_2$

Binary to Hexadecimal

- Group into 4's starting at least significant symbol (if the number of bits is not evenly divisible by 4, then add 0's at the most significant end)
- write 1 hex digit for each group.

e.g.: $(1010111011)_2$ to $(\ )_{16}$

10 1011 1011

↓ ↓ ↓

2 B B

Answer = $(2BB)_{16}$

Hexadecimal to Binary

- For each of the Hex digit write its binary equivalent (use 4 bits to represent).

e.g.: $(25A0)_{16}$ to $(\ )_2$

2 5 A 0

0010 0101 1010 0000

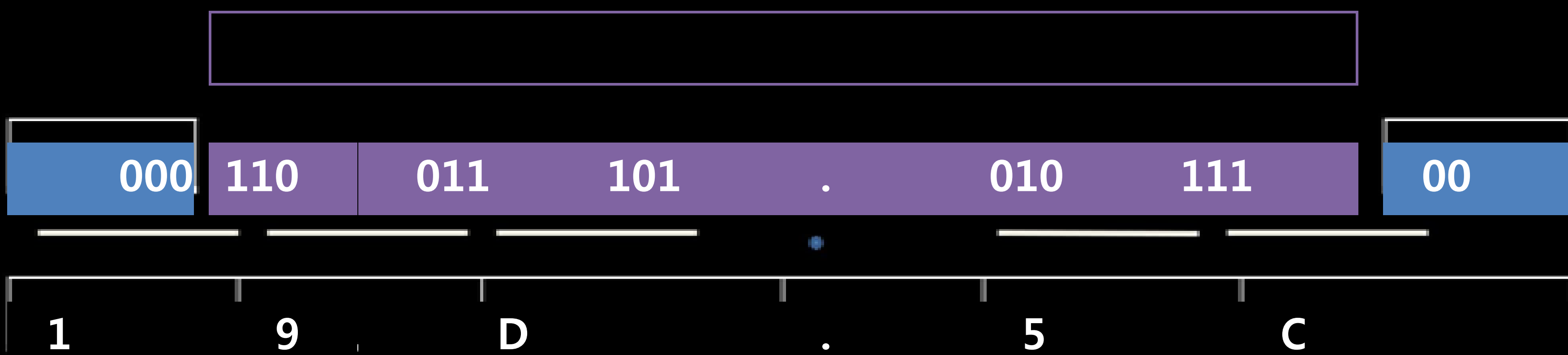
Answer = $(0010010110100000)_2$

Octal to Hexadecimal

- Steps:

1. Convert octal number to its binary equivalent
2. Convert binary number to its hexadecimal equivalent

e.g.: $(635.27)_8$ to $(\ )_{16}$



Hexadecimal to Octal

- Steps:

1. Convert hexadecimal number to its binary equivalent
2. Convert binary number to its octal equivalent

e.g.:

1010 0011 1011 . 0111 00

5 0 7 3 . 3 4

Any Base to Decimal

Converting from any base to decimal is done by multiplying each digit by its weight and summing.

e.g.:

Binary to Decimal

$= 11.75_{10}$

Decimal to Any Base

Steps:

1. Convert integer part
   (Successive Division Method)
2. Convert fractional part
   (Successive Multiplication Method)

Steps in Successive Division Method

1. Divide the integer part of decimal number by desired base number, store quotient (Q) and remainder (R)
2. Consider quotient as a new decimal number and repeat step1 until quotient becomes 0
3. List the remainders in the reverse order

Steps in Successive Multiplication Method

1. Multiply the fractional part of decimal number by desired base number
2. Record the integer part of product as carry and fractional part as new fractional part
3. Repeat steps 1 and 2 until fractional part of product becomes 0 or until you have many digits as necessary for your application
4. Read carries downwards to get desired base number

e.g.: $(125)_{10}$ to $(\ )_2$

2	125	
2	62	1
2	31	0
2	15	1
2	7	1
2	3	1
2	1	1
	0	1

Answer : $(1111101)_2$

1's Complement

The 1′s complement of a binary number is the number that results when we change all 1′s to zeros and the zeros to ones.

1	**1**	**0**	**1**	**0**	**0**	**1**	**0**
NOT OPEARATION							
0	**0**	**1**	**0**	**1**	**1**	**0**	**1**

2’s Complement

The 2’s complement the binary number that results when add 1 to the 1’s complement. It’s given as,

2’s complement = 1’s complement + 1

Example: Express 35 in 8-bit 2’s complement form.

Solution:

35 in 8-bit form is 00100011

```
  0 0 1 0 0 0 1 1
  1 1 0 1 1 1 0 0
+               1
--------------------
  1 1 0 1 1 1 0 1
```

9’s Complement

The nines' complement of a decimal digit is the number that must be added to it to produce 9. The complement of 3 is 6, the complement of 7 is 2.

Example: Obtain 9’s complement of 7493

Solution:

```
  9 9 9 9
- 7 4 9 3
  --------
  2 5 0 6   ← 9’s complement
```

10's Complement

The 10's complement of the given number is obtained by adding 1 to the 9's complement. It is given as,

10's complement = 9's complement + 1

Example: Obtain 10's complement of 7493

Solution:

```
  9 9 9 9            2 5 0 6
- 7 4 9 3      +           1
---------        ----------
  2 5 0 6            2 5 0 7   <- 10's complement
```

Binary Addition

The addition consists of four possible elementary operations:

Sr no.	Operations
0.	0+0=0
1.	0+1=1
2.	1+0=1
3.	1+1=10 (0 with carry of 1)

In the last case, sum is of two digits: Higher Significant bit is called Carry and lower significant bit is called Sum.

Binary Addition

e.g.:

		1	1	0	0
+		0	1	1	0
	1	0	0	1	0

Carry

Binary Subtraction

The subtraction consists of four possible elementary operations:

Sr no.	Operations
0.	0-0=0
1.	0-1=1(borrow 1)
2.	1-0=1
3.	1-1=0

In case of second operation the minuend bit is smaller than the subtrahend bit, hence 1 is borrowed.

Binary Subtraction

e.g.:

	0	1	0	1
-	0	1	1	0
	1	1	1	1

Binary Multiplication

Rules for Binary Multiplication are:

Sr no.	Operations
0.	0*0=0
1.	0*1=0
2.	1*0=0
3.	1*1=1

e.g.: Multiply 110 by 10

		1	1	0
	*		1	0
		0	0	0
+	1	1	0	0
	1	1	0	0

Binary Division

Rules for Binary Division are:

Sr no.	Operations
0.	0/0=0
1.	1/0=0
2.	0/1=0
3.	1/1=1

e.g.: Divide 110 by 10

```
        1 1
     ______
1 0 | 1 1 0
      1 0
     ______
      0 1 0
        1 0
     ______
        0 0
```