GLS UNIVERSITY

Faculty of Computer Applications & Information Technology

Number System

UNIT III

Integrated IMSCIT

Data Representation

- Computers are electronic devices powered by electricity which have only two states: on and off.
- The two digits, 0 and 1 can easily represent these two states.
- In the coding, when numbers, letters or words are represented by a specific group of symbols, it is said that the number, letter or word is being encoded.
- The group of symbols is called as a **CODE**.
- Mainly there are three types of code.

    1) Binary Codes
    2) ASCII
    3) Unicode

Binary Codes

- The digital data is represented, stored and transmitted as group of binary bits called BINARY CODE.
- The binary code is represented by the number as well as alphanumeric letter.
- Advantages of Binary Code Suitable for the computer applications.
  - Suitable for the digital communications.
  - Makes the analysis and designing of digital circuits if we use the binary codes.
  - Since only 0 & 1 are being used, implementation becomes easy.

Binary Coded Decimal (BCD) Code

- In this code each decimal digit is represented by a 4-bit binary number.
- BCD is a way to express each of the decimal digits with a binary code.
- In the BCD, with four bits we can represent sixteen numbers (0000 to 1111).
- But in BCD code only first ten of these are used (0000 to 1001).
- The remaining six code combinations i.e. 1010 to 1111 are invalid in BCD.

Decimal	0	1	2	3	4	5	6	7	8	9
BCD	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001

Binary Coded Decimal (BCD) Code

Decimal Codes	BCD Digits
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001

Example

Q) Find the BCD for the decimal value 1237.

Ans :- 1 => 0001

2 => 0010

3 => 0011

7 => 0111

Final Ans :- **0001001000110111**

Binary Coded Decimal (BCD) Code

- **Advantages of BCD Codes:**
  - It is very similar to decimal system.
  - We need to remember binary equivalent of decimal numbers 0 to 9 only.
- **Disadvantages of BCD Codes:**
  - The addition and subtraction of BCD have different rules.
  - The BCD arithmetic is little more complicated.
  - BCD needs more number of bits than binary to represent the decimal number.
  - So BCD is less efficient than binary.

ASCII

- American Standard Code for Information Interchange
- It is a 7 bit code.
- It is used for transmitting and processing data amongst different
- computers.
- Later, IBM developed new version of ASCII, known as ASCII-8.
- It consist of 256 symbols.
- The concept is same as EBCDIC only the difference is in the combinations assigned to represent the various alphabets, numeric and special characters.

Code	Description
0 to 31	Control Characters
48 to 57	0-9
65 to 90	A-Z
97 to 122	a-z
128 to 255	Extended ASCII code

ASCII Table

Dec	Hex	Oct	Char	Dec	Hex	Oct	Char	Dec	Hex	Oct	Char	Dec	Hex	Oct	Char
0	0	0		32	20	40	[space]	64	40	100	@	96	60	140	`
1	1	1		33	21	41	!	65	41	101	A	97	61	141	a
2	2	2		34	22	42	"	66	42	102	B	98	62	142	b
3	3	3		35	23	43	#	67	43	103	C	99	63	143	c
4	4	4		36	24	44	$	68	44	104	D	100	64	144	d
5	5	5		37	25	45	%	69	45	105	E	101	65	145	e
6	6	6		38	26	46	&	70	46	106	F	102	66	146	f
7	7	7		39	27	47	'	71	47	107	G	103	67	147	g
8	8	10		40	28	50	(	72	48	110	H	104	68	150	h
9	9	11		41	29	51	)	73	49	111	I	105	69	151	i
10	A	12		42	2A	52	*	74	4A	112	J	106	6A	152	j
11	B	13		43	2B	53	+	75	4B	113	K	107	6B	153	k
12	C	14		44	2C	54	,	76	4C	114	L	108	6C	154	l
13	D	15		45	2D	55	-	77	4D	115	M	109	6D	155	m
14	E	16		46	2E	56	.	78	4E	116	N	110	6E	156	n
15	F	17		47	2F	57	/	79	4F	117	O	111	6F	157	o
16	10	20		48	30	60	0	80	50	120	P	112	70	160	p
17	11	21		49	31	61	1	81	51	121	Q	113	71	161	q
18	12	22		50	32	62	2	82	52	122	R	114	72	162	r
19	13	23		51	33	63	3	83	53	123	S	115	73	163	s
20	14	24		52	34	64	4	84	54	124	T	116	74	164	t
21	15	25		53	35	65	5	85	55	125	U	117	75	165	u
22	16	26		54	36	66	6	86	56	126	V	118	76	166	v
23	17	27		55	37	67	7	87	57	127	W	119	77	167	w
24	18	30		56	38	70	8	88	58	130	X	120	78	170	x
25	19	31		57	39	71	9	89	59	131	Y	121	79	171	y
26	1A	32		58	3A	72	:	90	5A	132	Z	122	7A	172	z
27	1B	33		59	3B	73	;	91	5B	133	[	123	7B	173	{
28	1C	34		60	3C	74	<	92	5C	134	\	124	7C	174	|
29	1D	35		61	3D	75	=	93	5D	135	]	125	7D	175	}
30	1E	36		62	3E	76	>	94	5E	136	^	126	7E	176	~
31	1F	37		63	3F	77	?	95	5F	137	_	127	7F	177	

Unicode

- It is a 16 bit universal character coding standard for the representation of text which includes numbers, text and symbols.
- The Unicode consortium based in California developed the new unicode standard.
- It uses 32 bit to represent a symbol in the data.
- It is capable of representing approximately 1 million characters.
- It can uniquely represent any character or symbol present in any language like Chinese, Japanese, etc.
- In addition to the letters; mathematical and scientific symbols are also separated in Unicode codes.
- The main advantage of Unicode is that it is compatible with ASCII.
- The first 256 characters are same as ASCII

Number System

1. Binary
2. Decimal
3. Octal
4. Hexa-decimal

Number System

- A number system is defined as a set of values to represent ‘quantity’.
- For example, a number of students in a class, no. Of assignments, no. of marks obtained, etc.
- The number system is divided into two categories:
  - Non-positional number system
  - Positional number system

Non-Positional Number System

- In olden days people use this type of number system for simple calculations like additions and subtractions.
- The non-positional number system consists of different symbols that are used to represent numbers.
- Roman number system is an example of the non-positional number system i.e. I=1, V=5, X=10,L=50.
- Every system varies by country and it depends on symbols and values set by the people of that country.
- For example, the Egyptians use Hieroglyphics, and the Greeks use a numeral system.

Non – Positional Number System

- When we type some letters or words, the computer translates them in numbers as computers can understand only numbers.
- A computer can understand the positional number system where there are only a few symbols called digits.
- These symbols represent different values depending on the position they occupy in the number.
- The value of each digit in a number can be determined using –

1)The digit

2)The position of the digit in the number

3)The base of the number system (where the base is defined as the total number of digits available in the number system)

Positional Number System

- This type of number system are:
  - Decimal number system
  - Binary number system
  - Octal number system
  - Hexadecimal number system

- The total number of digits present in any number system is called its Base or Radix.
- Every number is represented by a base (or radix) x, which represents x digits.
- The base is written after the number as subscript such as $512_{(10)}$. It is a Decimal number as its base is 10.

Types of Number Systems

Number System	Base	Set of Digits	Example	Largest Digit
Decimal	10	(0,1,2,3,4,5,6,7,8,9)	$(13)_{10}$	9
Binary	2	(0,1)	$(1001)_{2}$	1
Octal	8	(0,1,2,3,4,5,6,7)	$(47)_{8}$	7
Hexadecimal	16	(0,1,2,3,4,5,6,7,A,B,C,D, E,F)	$(27B)_{16}$	F(15)

Positional Number System

- To determine the quantity that the number represents, the number is multiplied by an integer power of x depending on the position it is located and then finds the sum of the weighted digits.
- Example:
- Consider a decimal number $512.45_{(10)}$
  - which can be represented in equivalent value as:

  - $5x10^2 + 1x10^1 + 2x10^0 + 4x10^{-1} + 5x10^{-2}$

Decimal Number System

- The number system that we use in our day-to-day life is the decimal number system.
- Decimal number system has base 10 as it uses 10 digits from 0 to 9.
- In decimal number system, the successive positions to the left of the decimal point represent units, tens, hundreds, thousands, and so on.
- Each position represents a specific power of the base (10).
- For example, the decimal number 1234 consists of the digit 4 in the units position, 3 in the tens position, 2 in the hundreds position, and 1 in the thousands position.
- Its value can be written as: 1234

  = (1 x 1000)+ (2 x 100)+ (3 x 10)+ (4 x 1)

  = 1000 + 200 + 30 + 4

  = 1234

Short of Decimal Number System

- Base = 10
- It includes (0,1,2,3,4,5,6,7,8,9)
- Operations :
  - 1. Addition (+)
  - 2. Substraction (-)
  - 3. Multiplication (*)
  - 4. Division (/)

Short of Decimal Number System

- It can be used for both integer and floating point values.
- The (.) is used to represent floating point values.
- The value of each number represented in a decimal system can be determined by :

  1) Multiply the power value associated with each digit in a given number with the digit itself.

  2) Add all these values toget the final result.

  - The value that comes before the decimal point, is called integer value and after the decimal point, is called fraction value.

Short of Decimal Number System

Example : 1234.56

It can be computed as :

$= (1 * 10^3 + 2 * 10^2 + 3 * 10^1 + 4 * 10^0 + 5 * 10^{-1} + 6 * 10^{-2})$

$= 1000 + 200 + 30 + 4 + 0.5 + 0.06$

$= 1234.56$

Binary Number System

- Characteristics of the binary number system are as follows –
- Uses two digits, 0 and 1
- Also called as base 2 number system
- Each position in a binary number represents a 0 power of the base (2).
- Example 20
- Last position in a binary number represents a x power of the base (2).
- Example 2x where x represents the last position - 1.
- Example
- Binary Number: 10101_2

Binary Number System

- Binary number system is used to define a number in binary system.
- Binary system is used to represent a number in terms of two numbers only, 0 and 1.
- The binary number system is used commonly by computer languages like Java, C++.
- As the computer only understands binary language that is 0 or 1, all inputs given to a computer are decoded by it into series of 0's or 1's to process it further. In this lesson we will learn how to convert a decimal number to its binary number and the conversion of binary number to decimal number.
- "Bi" in Binary means "two". Hence, this draws back the line to the representation of a number in terms of 0 and 1 only. It is possible to express decimal numbers in terms of a binary number system easily. Decimal numbers and binary numbers have different notations. A decimal number is represented with a base of 10 while a binary number is represented with a base of 2.

2. Binary System

Following are some terminologies used in binary system.

1) Bit (binary digit) = 0 & 1

2) Nibble = 4 bits

3) Byte = 8bits

4) Word= 16 bits / 2 bytes

5) 1KB(Kilobyte) = 1024 bytes

6) 1MB(Megabyte) = 1024 KB

7) 1 GB(Gigabyte) = 1024 MB

8) 1TB(Terabyte) = 1024 GB

9) 1PB(Petabyte) = 1024 TB

Representing Binary Number System

Example : 10110.110

It can be computed as :

$= (1 * 2^4 + 0 * 2^3 + 1 * 2^2 + 1 * 2^1 + 0 * 2^0 + 1 * 2^{-1} + 1 * 2^{-2} + 0 * 2^{-3})$

$= 16 + 4 + 2 + 0.5 + 0.25$

$= 22.75$

Representing Decimal in binary

Decimal Number	4-bit binary number
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
10	1010
11	1011
12	1100
13	1101
14	1110

Octal Number System

- Uses eight digits – 0,1,2,3,4,5,6,7
- Also called as base 8 number system
- Each position in an octal number represents a 0 power of the base (8).
- Example 80
- Last position in an octal number represents a x power of the base (8).
- Example 8x where x represents the last position - 1
- Example
- Octal Number: 125708

Octal System Example

Example : 234.56

==> It can be computed as :

= $(2 * 8^2 + 3 * 8^1 + 4 * 8^0 + 5 * 8^{-1} + 6 * 8^{-2})$

= 128 + 24 + 4 + 0.625 + 0.094

= 156.719

So , The octal value 234.56 represents the decimal value 156.719

Representing binary and decimal in octal

Decimal Number	Binary Number	Octal Number
0	0000	0
1	0001	1
2	0010	2
3	0011	3
4	0100	4
5	0101	5
6	0110	6
7	0111	7

Hexadecimal Number System

- Letters represent the numbers starting from 10.

  A = 10. B = 11, C = 12, D = 13, E = 14, F = 15

- Also called as base 16 number system
- Each position in a hexadecimal number represents a 0 power of the base (16). Example, 160
- Last position in a hexadecimal number represents a x power of the base (16).
- Example 16x where x represents the last position - 1
- Example
- Hexadecimal Number: 19FDE16
- Characteristics of hexadecimal number system are as follows:
  - Uses 10 digits - 0, 1, 2, 3, 4, 5, 6, 7, 8, 9
  - 6 letters - A, B, C, D, E, F

Decimal to Hexadecimal Conversion

You have learned how to convert hexadecimal numbers to decimal numbers. Now let us find out how we can convert a decimal number into a hexadecimal number system. Follow the below steps:

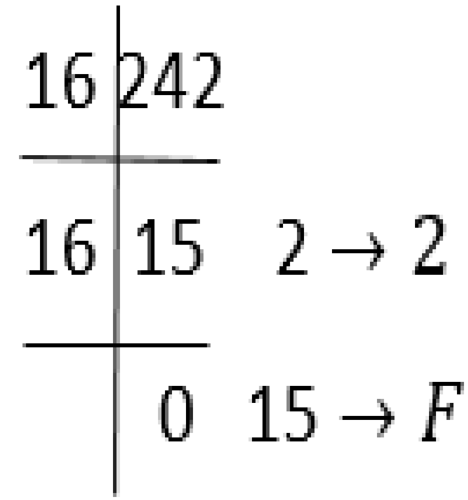
Firstly divide the number by 16

Take the quotient and divide again by 16

The remainder left will produce the hex value

Repeats the steps until the quotient has become 0

Example: Convert (242)10 into hexadecimal.



Solution: Divide 242 by 16 and repeat the steps, till the quotient is left as 0.

Therefore, (242)10 = (F2)16

4. Hexadecimal System

Example : 5A7.2C

- It can be computed as :

$= (5 * 16^2 + 10 * 16^1 + 7 * 16^0 + 2 * 16^{-1} + 12 * 16^{-2})$

$= 1280 + 160 + 7 + 0.125 + 0.047$

$= 1447.172$

- The hexadecimal number 5A7.2C represents the decimal value 1447.172

Representing decimal,binary and octal in hexadecimal

Decimal Number	Binary Number	Octal Number	Hexadecimal
0	0000	0	0
1	0001	1	1
2	0010	2	2
3	0011	3	3
4	0100	4	4
5	0101	5	5
6	0110	6	6
7	0111	7	7
8	1000	10	8
9	1001	11	9