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LESSON NO. 2.1 Author: Arun Sharma
Converted into SLM by: Dr. Vishal Singh

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NUMBER SYSTEMS

2.1.1 Objectives

- *What is Number System?*
- *Categories of number system*
- Types of Number Systems
- *Method of conversion between number bases*

Since the early days of human civilisation, people have been using their fingers, sticks and other things for counting. It all started perhaps, with the need to figure out the assets a person had. As daily activities became more complex, numbers became more important in trade, time, distance and in all other spheres of human life. It became apparent that we needed more than our fingers and toes to keep track of the number in our daily routine. Furthermore, ever since people discovered that it was necessary to count objects, they have been looking for easier ways to count them. Signs and symbols gained popularity for number representation. The early forms were straight lines or groups of lines.

In 3400 BC, the ancient Egyptians started using special symbols for writing the numbers. This was a major advancement because it reduced the number of symbols required. However, it was difficult to represent large or small numbers by using such a graphical approach.

2.1.2 Number Systems

A number system defines a set of values used to represent *quantity.* We talk about the number of people attending a class, the number of modules taken by each student and use numbers to represent grades achieved by students in tests. Quantifying values and items in relation to each other is helpful for us to make sense of our environment.

Number systems have been around for thousands of years. We can see the remnants of several systems in our present day civilisation. The common system is the existing system based on number ten. Although, today the most common number system in use is the Arabic system, the number systems can be categorised in two broad categories:

- Non-Positional Number Systems
- Positional Number Systems

2.1.2.1 Non-Positional Number Systems In ancient times, people used to count on their fingers. When the fingers became insufficient for counting, stones, pebbles or sticks were used to indicate the values. This method of counting is called the *non-positional number system.* It was very difficult to perform arithmetic with such a number system, as it had no symbol for zero. The most common non-positional number system is the Roman Number System. In this number system, only a few characters are used to represent the numbers. The characters, which are used in this number system are I, V, X, L (for fifty), C (for hundred), etc. Moreover, since it is very difficult to perform the addition or any other arithmetic operations in this system, as a result no logical or positional techniques are used in this system.

2.1.2.2 Positional Number Systems

In positional number systems, the value of each digit in a number is defined not only by the symbol but also by the symbol's position. Positional number systems have a base or radix. The first positional number system was invented by the Babylonians. They used a base 60 system. The positional number system, which is being used nowadays is called the *decimal number system.* This system is base 10 system, that is, it contains 10 digits (0, 1, 2, 3... 8, 9). Apart from the decimal number system, there are some other positional number systems such as *binary number system, octal number system* and

hexadecimal number system each having a radix of 2, 8 and 16, respectively. However, the principles which are applied to the decimal number system are also applicable for the other positional number systems.

2.1.2.3 Base (or Radix) of System

In the number system, the base or radix tells the number of symbols used in the system. In the earlier days, different civilisations were using different radixes. The Egyptians used the radix 2, the Babylonians used the radix 60 and Mayans used 18 and 20. In contrast, modern computers use the radix 2 because they recognise only two symbols, which are represented in digital circuits as 0s and 1s.

Radix of the system is always expressed in decimal numbers. The base or radix of the decimal system is 9A. This implies that there are 10 symbols: 0, 1, 2, 3, 4, 5, 6, 7, 8 and 9A. Similarly, the system using three symbols 0, 1, 2 will be of base 3; four symbols will be of base 4 and so forth.

The base of a number system is indicated by a subscript (decimal number) and this will be followed by the value of the number.

For example:

$(7592)_{10}$ is of base 10 number system.

$(214)_8$ is of base 8 number system.

$(123)_{16}$ is of base 16 number system.

2.1.3 Computer and Numbers

We apply numbers everyday, and knowing how numbers work enables us to know how a computer manipulates and stores numbers.

For a computer, everything is a number whether it may be numbers, alphabets, punctuation marks, its own instructions, etc. Let us understand with the help of an example. Consider the word 'words' which always appears on the computer screen (for us) as a series of alphabetic characters. However, for the computer, it is a combination of numbers. To the computer it appears as:

0111 0111 0110 1111 0111 0010 0110 0100 0111 0011

(w o r d s)

Eventually, the number systems that are generally used by the computers are:

- Decimal System
- Binary System
- Octal System
- Hexadecimal System

Table 9A.1 Types of Number Systems

Number System	Radix Value	Set of Digits.	Example
Decimal	r = 10	(0, 1,2,3,4,5,6,7,8,9)	$(25)_{10}$
Binary	r = 2	(0, 1)	$(11001)_2$
Octal	r = 8	(0, 1,2,3,4,5,6, 7)	$(31)_8$

Hexadecimal	r = 16	(0, 1,2,3,4,5,6,7,8,9, A, B, C, D, E, F)	$(19)_{16}$

The important thing about the number systems is that each system is just a different method for representing the quantities. Moreover, the quantities do not change but the symbols used to represent those quantities are changed in each number system.

2.1.3.1 Decimal Number System

The primary number system used is a base ten number system or *decimal number system.* The decimal system is the system which we use everyday while counting. The name is derived from the Latin word *Decem,* which means ten. This number system includes the ten digits from 0 through 9A. These digits are recognized as the symbols of the decimal system. Each digit in a base ten number represents units ten times the units of the digit to its right.

Starting at the decimal point and moving to the left, each position is represented by the base (radix) value (10 for decimal) raised to a power. The power starts at 0 for the position just to the left of the decimal point. The power is incremented for each position that continues to the left.

10^3 10^2 10^1 10^0

where,

10^3 = 10 x 10 x 10 = 1000
10^2 = 10 x 10 = 100
10^1 = 10 = 10
10^0 = 1

Moving to the right of the decimal point is just like moving to the left except that we will need to place a minus sign in front of each power.

$.10^{-1}$ 10^{-2} 10^{-3}

Consider the number 9735. In the first column of the following table, we write 9735 in the expanded notation. In the second column we write the same sum but express 9000 as 9 x 1000, 700 as 7 x 100, 30 as 3 x 10, and 5 as 5 x 1. In the third column, again we write the same numbers, but express 1000, 100, 10 and 1 as powers of 10.

9735	9000 + 700 + 30 + 5	Is Equivalent to	9 x 1000 7 x 100 3 x 10 5 x 1	Is Equivalent to	9×10^3 7×10^2 3×10^1 5×10^0

So, 9735 = $(9 \times 10^3) + (7 \times 10^2) + (3 \times 10^1) + (5 \times 10^0)$.

2.1.3.2 Binary Number System

In the early stages of computer development, the problem of storing data was the

most difficult problem. Consequently, before organising a device that could hold data with the available technology, it was necessary to reduce the data to its most fundamental state.

Computers do not use the ten digits of the decimal system for counting and arithmetic. Their CPU and memory are made up of millions of tiny switches that can be either in the ON or OFF states. Two digits, 0 and 1 are used to refer for the two states of ON and OFF, respectively.

Suppose we have two tiny switches, they can represent the following four patterns:

Switch1	**Switch2**	**Pattern**
OFF	OFF	1
OFF	ON	2
ON	OFF	3
ON	ON	4

The pattern shown in the above table is not drawn randomly. They have some logical order. According to the above table, if we replace each 'ON' switch with 'l' and each 'OFF' with '0' then we get a number system called *binary number system.* With this kind of system, it is very easier for the hardware to represent the data since it has to deal with only two numbers (0 and 1). Accordingly, most of the modem computer systems are operating by using this system.

The place value of the binary number system is based on the number two. In this system, we have the one's place, the two's place, the four's place, the eight's place, the sixteen's place and so on. Each place in the number represents two times (2x's) the place to its right.

The weight of each binary bit of a binary number depends on its relative position within the number. In other words, the weight of a digit in any positional number system depends on its relative position within the number and the base of the number system.

In the binary number system with base 2, the weight of nth bit of the number from Right Hand Side (RHS) is n^{th} bit x 2^{n-1}

The weighted values for each position is determined as follows:

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	2^{-1}	2^{-2}
125	64	32	16	8	4	2	1	.5	.25

Table 9A.2 Decimal Binary Comparison

Decimal	**Binary**

0	0
1	01
2	10
3	11
4	100
5	101
6	110
7	111
8	1000
9	1001
10	1010

The problem with binary system is that it takes a large number of digits to represent numerical values. Binary is not efficient in representing fractional values. It cannot represent these values accurately and needs many digits to even come near to approximation.

2.1.3.3 Octal Number System

The octal number system with its 8 digits, '0', '1', '2', '3', '4', '5', '6' and '7' is a base-eight system. The table below shows the weighting for the octal number system up to 3 decimal places before and 2 decimal places after the *octal* point (**.**).

Octal Weights	8^3	8^2	8^1	8^0	·	8^{-1}	8^{-2}
Values	512	64	8	1	·	0.125	0.015625

The octal or base 8 number system is commonly used with computers. With reference to the above table, we find that one octal digit is the equivalent value of three binary digits. The following example of the conversion of octal $(225)_8$ to binary and vice versa will further illustrate this conversion.

Binary and Octal Comparison

Octal to Binary

2	2	5

Binary to Octal

010	010	101

010	010	101	2	2	5

This system is a positional notation number system. Just as the decimal system that uses powers of 10 and the binary system uses powers of 2, the octal system uses powers of 8 to determine the digit of a number's position.

Table 9A.3 Octal Number System

Binary Number	Decimal Number	Octal Number
000	0	0 (0×8^0)
001	1	1 (1×8^0)
010	2	2 (2×8^0)
011	3	3 (3×8^0)
100	4	4 (4×8^0)
101	5	5 (5×8^0)
110	6	6 (6×8^0)
111	7	7 (7×8^0)
1000	8	10 ($1 \text{ X } 8^1 + 0 \times 8^0$)
1001	9	11 ($1 \text{ X } 8^1 + 1 \times 8^0$)
1010	10	12 ($1 \times 8^1 + 2 \times 8^0$)

2.1.3.4 Hexadecimal Number System

Hexadecimal is another number system that works exactly like the decimal and binary number systems except that the base is 19A. Just as the decimal number represents a power of 10, each hexadecimal number represents a power of 19A. To represent the decimal numbers, this system uses 0 to 9 numbers and A to F characters to represent 10 to 15, respectively.

The largest hexadecimal digit F is equivalent to binary 1111. Thus, in other words, a single hexadecimal can represent a combination of 4 bits. Since, a byte consists of 8 bits, so a byte can be represented by exactly two hexadecimal digits. For example, consider a binary number 01101111.

Now, split the above number into two parts as shown below:

0110 1111

We see that,

0110 (binary) = 6 (hex)
1111 (binary) = F (hex)
Thus, this number is $6F_{hex}$ or $6F_{16}$

Table 9A.4 Decimal-Hexadecimal-Binary Comparisons

Decimal	Hex	Binary
0	0	0000
1	1	0001
2	2	0010
3	3	0011
4	4	0100
5	5	0101
6	6	0110
7	7	0111
8	8	1000
9	9	1001
10	A	1010
11	B	1011
12	C	1100
13	D	1101
14	E	1110
15	F	1111

Self Check Exercise-I

Q.1 What is the difference between positional and non-positional number system?

Ans:.....

.....

.....

Q.2 What is Binary number system?

Ans:.....

.....

.....

2.1.4 Conversion Between Number Bases

We have discussed earlier that internally computer uses binary numbers for data representation whereas externally it uses decimal numbers. However, any number in one number system can be represented in any other number system. Let us see the various methods which can be used to convert numbers from one base to another.

2.1.4.1 Conversion of Decimal to Binary

The method, which is used for the conversion of decimal into binary, is often called as the remainder method. This method involves the following steps:

1. Begin by dividing the decimal number by 2 (the base of binary number system).
2. Note the remainder separately as the rightmost digit of the binary equivalent
3. Continually repeat the process of dividing by 2 until the quotient is zero and keep writing the remainders after each step of division (these remainders will either be 1 or 0).
4. Finally, when no more division can occur, write down the remainders in reverse order (last remainder written first).

Example 1: Determine the binary equivalent of $(36)_{9A.}$

2	36	**Remainder**
2	18	0
2	9	0
2	4	1
2	2	0
2	1	0
	0	1

Least Significant Bit (LSB)

Most Significant Bit (MSB)

Taking remainders in reverse order, we have 100100. Thus, the binary equivalent of $(36)_{10}$ is $(100100)_2$.

Example 2: Determine the binary equivalent of $(671)_{9A.}$

2	671	**Remainder**
2	335	1
2	167	1
2	83	1
2	41	1
2	20	1
2	10	0
2	5	0
2	2	1
2	1	0
	0	1

Least Significant Bit (LSB)

Most Significant Bit (MSB)

Taking remainders in reverse order, we have 1010011111. Thus, the binary equivalent of $(671)_{10}$ is $(1010011111)_2$.

In every number system, we will number each bit as follows:

- The first bit from the right in a binary number system is bit position zero.
- Each bit to the left is given as the next successive bit number.

Here, bit at position zero is usually referred to as the LSB (least significant bit). The first bit from the left is typically called the MSB (most significant bit). In the above examples 1 and 2, the LSB and the MSB are indicated. The intermediate bits are referred by their respective bit numbers.

2.1.4.2 Conversion of Binary to Decimal

In the binary to decimal conversion, each digit of the binary number is multiplied by its weighted position, and each of the weighted values is added together to get the decimal number. Consider the following examples:

Example 1: Determine the decimal equivalent of $(11010)_2$.

Binary Number	1	1	0	1	0
Weight of Each Bit	2^4	2^3	2^2	2^1	2^0
Weighted Value	2^4 x 1	2^3 x 1	2^2 x 0	2^1 x 1	2^0 x 0
Solved Multiplication	16	8	0	2	0

Sum of weight of all bits = 16 + 8 + 0 + 2 + 0 = 26

Thus, the decimal equivalent of $(11010)_2$ is $(26)_{9A.}$

Example 2: Determine the decimal equivalent of $(10110011)_{2.}$

Binary Number	1	0	1	1	0	0	1	1

Weight of Each Bit	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Weighted Value	$2^7 \times 1$	$2^6 \times 0$	$2^5 \times 1$	$2^4 \times 1$	$2^3 \times 0$	$2^2 \times 0$	$2^1 \times 1$	$2^0 \times 1$
Solved Multiplication	128	0	32	16	0	0	2	1

Sum of weight of all bits = 128 + 0 + 32 + 16 + 0 + 0 + 2 + 1
= 179

Thus, the decimal equivalent of $(10110011)_2$ is $(179)_{9A.}$

2.1.4.3 Conversion of Decimal to Octal

To convert a decimal number into its octal equivalent, the same procedure is adopted as in decimal to binary conversion but the decimal number is divided by 8 (the base of the octal number system).

Example 1: Determine the octal equivalent of $(359)_{10}$.

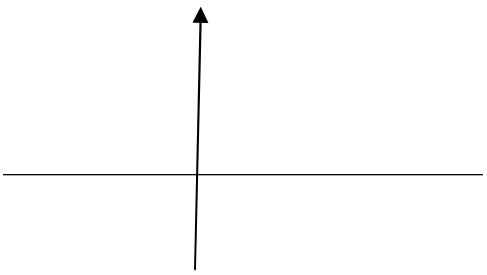
8	359	**Remainder**	
8	44	7	**Least Significant Bit (LSB)**
8	5	4	↑
8	0	5	**Most Significant Bit (MSB)**

Taking remainders in reverse order, we get 547. Thus, the octal equivalent of $(359)_{10}$ is $(547)_8$.

Note: *Here, in the octal base conversion, the concept of LSB and MSB is similar to that of the binary conversions.*

Example 2: Determine the octal equivalent of $(432267)_{10}$.

8	432267	**Remainder**	
8	54033	3	**Least Significant Bit (LSB)**
8	6754	1	
8	844	2	
8	105	4	



8	13	1	
8	1	5	
8	0	1	**Most Significant Bit (MSB)**

Taking remainders in reverse order, we get 1514213. Thus, the octal equivalent of $(432267)_{10}$ is $(1514213)_8$.

2.1.4.4 Conversion of Octal to Decimal

In the octal to decimal conversion, each digit of the octal number is multiplied by its weighted position and each of the weighted values is added together to get the decimal number.

Example 1: Determine the decimal equivalent of $(456)_8$.

Octal Number	4	5	6
Weight of Each Bit	8^2	8^1	8^0
Weighted Value	$8^2 \times 4$	$8^1 \times 5$	$8^0 \times 6$
Solved Multiplication	256	40	6

Sum of weight of all bits = 256 + 40 + 6
= 302
Thus, the decimal equivalent of $(456)_8$ is $(302)_{10}$.

Example 2: Determine the decimal equivalent of $(127662)_8$.

Octal Number	1	2	7	6	6	2
Weight of Each Bit	8^5	8^4	8^3	8^2	8^1	8^0
Weighted Value	$8^5 \times 1$	$8^4 \times 2$	$8^3 \times 7$	$8^2 \times 6$	$8^1 \times 6$	$8^0 \times 2$
Solved Multiplication	32768	8192	3584	384	48	2

Sum of weight of all bits = 32768 + 8192 + 3584 + 384 + 48 + 2
= 44978
Thus, the decimal equivalent of $(127662)_8$ is $(44978)_{10}$.

2.1.4.5 Conversion of Binary to Octal

The conversion of an integer binary number to octal is accomplished by the following steps:

1. Break the binary number into 3-bit sections starting from the LSB to the MSB.
2. Convert the 3-bit binary number to its octal equivalent.

For whole numbers, it may be necessary to add a zero as the MSB in order to complete a grouping of three bits.

Note: *By adding a zero, the MSB will not change the value of the binary number.*

Example 1: Determine the octal equivalent of $(010111)_2$.

Binary Number	010 (MSB)	111 (LSB)
Octal Number	2	7

The octal equivalent of $(010111)_2$ is $(27)_8$.

Example 2: Determine the octal equivalent of $(1010111110110010)_2$.

Binary Number	001 (MSB)	010	111	110	110	010(LSB)
Octal Number	1	2	7	6	6	2

The octal equivalent of $(1010111110110010)_2$ is $(127662)_8$.

Note: In the above example, we have added two 0's in the MSB so as to complete the required grouping of 3-bits.

2.1.4.6 Conversion of Octal to Binary

Since it is easier to read large numbers in octal form than in the binary form, the primary application of octal numbers is representing binary numbers. Besides, each octal digit can be represented by a three bit binary number; it is very easy to convert from octal to binary. The following steps are involved:

1. Convert the decimal number to its 3-bit binary equivalent.
2. Combine the 3-bit sections by removing the spaces to get the binary number.

Example 1: Determine the binary equivalent of $(231)_8$.

Octal Number	2	3	1
Binary Coded Value	010	011	001

Combining the 3-bits of the binary coded values, we have 010011001.

Thus, the binary equivalent of $(231)_8$ is $(010011001)_2$.

Example 2: Determine the binary equivalent of $(453267)_8$.

Octal Number	4	5	3	2	6	7
Binary Coded Value	100	101	011	010	110	111

Combining the 3-bits of the binary coded values, we have 100101011010110111.
Thus, the binary equivalent of $(453267)_8$ is $(100101011010110111)_2$.

2.1.4.7 Conversion of Decimal to Hexadecimal

To convert a decimal number into its hexadecimal equivalent, the same procedure is adopted as decimal to binary conversion but the decimal number is divided by 16 (the base of the hexadecimal number system).

Example 1: Determine the hexadecimal equivalent of $(5112)_{10}$.

16	5112	**Remainder**	
16	319	8 = 8	**Least Significant Bit (LSB)**
16	19	15 = F	↑
16	1	3 = 3	↑
16	0	1 = 1	**Most Significant Bit (MSB)**

Taking remainders in the reverse order, we have 13F8. Thus, the hexadecimal equivalent of $(5112)_{10}$ is $(13F8)_{110}$.

Note: *Here in the hexadecimal conversion, the concept of LSB and MSB is similar to that of the binary and octal conversions.*

Example 2: Determine the hexadecimal equivalent of $(584666)_{10}$.

16	584666	**Remainder**	
16	36541	10 = A	**Least Significant Bit (LSB)**
16	2283	13 = D	↑
16	142	11 = B	↑
16	8	14 = E	↑

16	0	8 = 8	**Most Significant Bit (MSB)**

Thus, the hexadecimal equivalent of $(584666)_{10}$ is $(8EBDA)_{110.}$

2.1.4.8 Conversion of Hexadecimal to Decimal

In the hexadecimal to decimal conversion, each digit of the hexadecimal number is multiplied by its weighted position and each of the weighted values is added together to get the decimal number.

Example 1: Determine the decimal equivalent of $(B14)_{110.}$

Hexadecimal Number	B = 11	1	4
Weight of Each Bit	16^2	16^1	16^0
Weighted Value	256 x 11	16 x 1	1 x 4
Solved Multiplication	2816	16	4

Sum of weight of all bits = 2816 + 16 + 4
= 2836
Thus, the decimal equivalent of $(B14)_{16}$ is $(2836)_{10}$.

Example 2: Determine the decimal equivalent of $(8AFE2B)_{110.}$

Hexadecimal Number	8	A=10	F=15	E=14	2	B =11
Weight of Each Bit	16^5	16^4	16^3	16^2	16^1	16^0
Weighted Value	1048576 x 8	65536xl 0	4096 x 15	256 x 14	16x 2	1 x 11
Solved Multiplication	8388608	655360	61440	3584	32	11

Sum of weight of all bits = 8388608 + 655360 + 61440 + 3584 + 32 + 11
= 9109035
Thus, the decimal equivalent of $(8AFE2B)_{16}$ is $(9109035)_{10.}$

2.1.4.9 Conversion of Binary to Hexadecimal

The conversion of an integer binary number to hexadecimal is accomplished by the following steps:

1. Break the binary number into 4-bit sections starting from the LSB to the MSB.

2. Convert the 4-bit binary number to its hexadecimal equivalent.

For whole numbers, it may be necessary to add a zero as the MSB in order to complete a grouping of four bits.

Note: *By adding a zero, the MSB will not change the value of the binary number.*

Example 1: Determine the hexadecimal equivalent of $(11001011)_2$.

Binary Number	1100	1011
Decimal Number	12	11
Hexadecimal Number	C (MSB)	B (LSB)

The hexadecimal equivalent of $(11001011)_2$ is $(CB)_{110.}$

Example 2: Determine the hexadecimal equivalent of (1010111110011011001)2.

Binary Number	0010	1011	1100	1101	1001
Decimal Number	2	11	12	13	9
Hexadecimal Number	2 (MSB)	B	C	D	9 (LSB)

The hexadecimal equivalent of $(10101111110011011001)_2$ is $(2BCD9)_{110.}$

Note: *In the above example, we have added two 0s in the MSB so as to complete the required grouping of four bits.*

2.1.4.10 Conversion of Hexadecimal to Binary

Converting a hexadecimal (base 16) number to a binary (base 2) number is a precise process. Since a single digit in a hexadecimal number corresponds directly to a 4-digit binary number, so in order to convert the hexadecimal number into its binary equivalent, the following steps are involved:

1. Convert each hexadecimal digit to its 4-bit binary equivalent.
2. Combine the 4-bit sections by removing the spaces to get the binary number.

Example 1: Determine the binary equivalent of $(5AF)_{110.}$

Hexadecimal Number	5	A	F
Binary Coded Value	0101	1010	1111

Combining the 4-bits of the binary coded values, we have 010110101111.
Thus, the binary equivalent of $(5AF)_{16}$ is $(010110101111)_2$.

Example 2: Determine the binary equivalent of $(86DB45C)_{110.}$

Hexadecimal Number	8	6	D	B	4	5	C
Binary Coded Value	1000	0110	1101	1011	0100	0101	1100

Combining the 4-bits of the binary-coded values, we have 10000110110110110100010111100.

Thus, the binary equivalent of $(86DB45C)_{16}$ is $(10000110110110110100010111100)_2$.

2.1.4.11 Conversion of Octal to Hexadecimal

Octal and hexadecimal have certain relations with binary. The first digit in octal corresponds to the first three digits in its binary equivalent and so on. The same is true for hexadecimal and this time each digit represents four binary digits. This makes the conversion of octal to hexadecimal and vice versa quite easy. This conversion involves the following steps:

1. Convert each octal digit to 3-bit binary form.
2. Combine all the 3-bits binary numbers.
3. Divide the binary numbers into the 4-bit binary form by starting the first number from the right bit to the first number from the left bit.
4. Finally, convert these 4-bit blocks into their respective hexadecimal symbols.

Example 1: Determine the hexadecimal equivalent of $(2327)_8$.

Octal Number	2	3	2	7
Binary Coded Value	010	011	010	111

Combining the 3-bit binary blocks, we have 010011010111.

Dividing the group of binary numbers into the 4-bit binary blocks and by converting these blocks into their respective hexadecimal symbols, we have:

0100 1101 0111

4 D 7

Thus, the hexadecimal equivalent of $(2327)_8$ is $(4D7)_{110.}$

Example 2: Determine the hexadecimal equivalent of $(5473261)_8$.

Octal Number	5	4	7	3	2	6	1
Binary Coded Value	101	100	111	011	010	110	001

Combining the 3-bit binary blocks, we have 101100111011010110001.

Dividing the group of binary numbers into the 4-bit binary blocks and by converting these blocks into their respective hexadecimal symbols, we have:

0001 0110 0111 0110 1011 0001

1 6 7 6 B 1

Thus, the hexadecimal equivalent of $(5473261)_8$ is $(1676B1)_{110.}$

***Note**: We have added three 0's in the MSB in order to get the desired grouping of bits.*

2.1.4.12 Conversion of Hexadecimal to Octal

This conversion follows the same steps of octal to hexadecimal conversion except that each hexadecimal digit is converted into 4-bit binary form and then after grouping of all the 4-bit binary blocks, it is converted into the 3-bit binary form. Finally, these 3-bit binary forms are converted into octal symbols.

Example 1: Determine the octal equivalent of $(2B6)_{110.}$

Hexadecimal Number	2	B	6
Binary Coded Value	0010	1011	0110

Combining all the 4-bit binary blocks, we have 001010110110.

Dividing the group of binary numbers into the 3-bit binary blocks and by converting these blocks into their respective octal symbols, we have:

001 010 110 110
1 2 6 6

Thus, the octal equivalent of $(2B6)_{16}$ is $(1266)_8$.

Example 2: Determine the octal equivalent of $(5DE247)_{110.}$

Hexadecimal Number	5	D	E	2	4	7
Binary Coded Value	0101	1101	1110	0010	0100	0111

Combining all the 4-bit binary blocks, we have 010111011110001001000111.

Dividing the group of binary numbers into the 3-bit binary blocks and by converting these blocks into their respective octal symbols, we have:

010 111 011 110 001 001 000 111
2 7 3 6 1 1 0 7

Thus, the octal equivalent of $(5DE247)_{16}$ is $(27361107)_8$.

2.1.5 Summary

Number systems have been around for thousands of years. It defines a set of values used 10 represent the quantity and other special characters. Number systems basically are of two types: non-positional and positional number systems.

In a non-positional number system, special symbols or characters are used to indicate the value. It is very difficult to perform arithmetic with such a number system, as it has no symbol for zero. In a positional number system, the value of each digit in a number is defined by the symbols but also by the symbol's position. These symbols are called as *digits*.

The positional number system, which is being used nowadays, is called as the

decimal number system. Apart from this number system, there are some other positional number systems such as binary number system, octal number system, and hexadecimal number system.

The base or radix of the number system tells the number of symbols or digits used in the system. The base of the decimal number system is 10, of binary number system is 2, of octal number system is 8 and of hexadecimal number system is 110. The primary number system used in our day-to-day life is the decimal number system. This number system includes ten digits (0, 1, 2, 3, 4, 5, 6, 7, 8 and 9).

The modem computer systems are operating by using the binary number system. This system is based on the number two and deals with only two numbers: 0 and 1. In the hexadecimal number system, each hexadecimal number represents a power of 110. To represent the decimal numbers, this system uses 0 to 9 numbers and A to F characters to represent 10 to 15 numbers, respectively.

Every number system can be converted into another number system such as decimal to binary and vice versa, decimal to octal and vice versa, decimal to hexadecimal and vice versa, binary to octal and vice versa and so on. However, the method of each conversion is different from one another.

2.1.6 Keywords

Number System: It is a way to represent or express numbers.

Radix: The base of a system of numbers.

Binary: It is a system where numbers and values are expressed 0 or 1.

Octal: A number system with its base as eight and uses digits from 0 to 7.

2.1.7 Short Answer Type Questions

Q.1 What is number system?

Q.2 Define octal number system.

Q.3 Define hexadecimal number system.

2.1.8 Long Answer Type Questions

Q.1 How positional and non-positional number systems are different from each other? Give examples.

Q.2 Give the reasons as to why the binary number system is utilized for modern electronic digital computers.

Q.3 What is a radix or base of the system? With the help of this system, brief the various types of number systems.

Q.4 Explain how a decimal number is converted into binary, octal and hexadecimal number and vice versa. Give an example of each conversion.

Q.5 With an appropriate example, explain the conversion of:

a. Binary to octal and vice versa
b. Binary to hexadecimal and vice versa
c. Octal to hexadecimal and vice versa

2.1.9 Suggested Readings

1. Computer Fundamentals By Pradeep K. Sinha and Priti Sinha (BPB Publications)

2. Fundamentals of Information Technology By Shiv Kumar Anand and Harmohan Sharma (Kalyani Publishers)
3. Fundamentals of Information Technology by V.Rajaraman (PHI, New Delhi).
4. Digital Design by M. Morris Mano (Pearson Education)
5. Computer Fundamentals, Architecture & Organisation by B.Ram, New Age International.
6. The Number System by Hugh Thurston
7. Multiple Base Number System : Theory and Applications by Vissil Dimitrov, C & C Press

LESSON NO. 2.2 Author: Arun Sharma
Converted into SLM by: Dr. Vishal Singh

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COMPUTER CODES & COMPUTER ARITHMETIC

2.2.1 Objectives

1. *Represent decimal numbers using the BCD*
2. *Understand the difference between BCD and straight binary*
3. *Represent decimal numbers using the excess 3 code*
4. *Understand the purpose of ASCII code and EBCDIC code*
5. *Understanding Gray code*

In today's technology, the binary number system is used by the computer system to represent the data in the computer understandable format. Numeric data (consists of only numbers 0, 1,2….. 9) is not the only form of data, which is handled by the computer. Alphanumeric data (it is a string of symbols of the letters A, B, C……. Z or the digits 0,1,2…….9) and some special characters such as =, -, +, *, /, (,), etc. are also required to be processed by the computer.

There are lots of ways to represent numeric, alphabetic and special characters in computer's internal storage area. In computers, the code is made up of fixed size groups of binary positions. Each binary position in a group is assigned a specific value; for example 8, 4, 2, or 1. In this way, every character can be represented by a combination of bits that is different from any other combination. Moreover, data can also be arranged in a way that's very simple and easy to decode or transmitted with varying degrees of redundancy for error detection and correction. The following are the most commonly used coding systems:

- Binary Coded Decimal (BCD)
- Excess-3 code
- American Standard Code for Information Interchange (ASCII)
- Extended Binary Coded Decimal Interchange Code (EBCDIC)
- Gray code

2.2.2 BCD

Binary Coded Decimal (BCD) is a method of using binary digits to represent the decimal digits 0 to 9. A decimal digit is represented by four binary digits. The BCD coding is the binary equivalent of the decimal digit. BCD system was developed by the IBM (International Business Machines) corporation. With BCD, each digit of a number is converted into its binary equivalent rather than converting the entire decimal number to its binary form. Similarly, letters and special characters can be coded in the binary form.

Let us determine the BCD value for the decimal number 5319. Since there are four digits in our decimal number, there are four bytes in our BCD number. They are:

Thousands-Hundreds	Tens-Units
53	19
0 1 0 1 0 0 1 1	0 0 0 1 1 0 0 1

Binary code decimal digits (0-9) are represented using 4-bits. The valid combinations of bits and their respective values are shown in Table 9B.1

Decimal Code	BCD Digit
0	0000
1	0001
2	0010
3	0011

4	0100
5	0101
6	0110
7	0111
8	1000
9	1001

Table 9B.1 Binary Coded Decimal

One of the advantages of the BCD system is that there is no limit to the size of a number. For adding another digit, we just have to add a new 4-bit sequence. In contrast, numbers represented in binary format are generally limited to the largest number, which can be represented by 8, 16, 32 or 64 bits. Moreover, this is a fast way to convert numbers from decimal to binary. However, this coding is not sufficient for business purposes as it can represent only 16, that is, 2^4 symbols.

The later version of BCD used a 6-bit code. These BCD codes defined six-bit words, which allowed representing a maximum of 64, that is, 2^6 symbols. Computers using BCD codes could work only with upper case letters and 0 to 9 numbers and few characters. However, the modern computers do not use BCD numbers as they have to process names and other non-numeric data.

2.2.3 EXCESS-3 CODE

The Excess-3 is a digital code that is formed by adding 3 to each decimal digit and then converting the result to 4-bit binary. Since no definite weights can be assigned to the four digit positions, Excess-3 is an unweighted code.

For instance, to form the Excess-3 representation of 4, first 3 is added to 4 yielding 7, and equivalent binary is 019B.

The Excess-3 code for the decimal 7 is

```
  7
 +3
----
 10      ⟶  1010
----
```

The Excess-3 code for each decimal digit is found by the same procedure, and the entire code is shown in the following table 9B.2

Decimal	BCD	Excess-3

0	0000	0011
1	0001	0100
2	0010	0101
3	0011	0110
4	0100	0111
5	0101	1000
6	0110	1001
7	0111	1010
8	1000	1011
9	1001	1100

Table 9B.2 Excess-3 code

Notice that ten of a possible 16 code combinations are used in the Excess-3 code. The six invalid combinations are 0000, 000 1, 00 1 0, 110 1, 1110 and 119B.

Convert 136 to Excess-3 code.

First add 3 to each digit in the decimal number and then convert each resulting sum to its equivalent binary code

1	3	6	
+3	+3	+3	
4	6	9	
↓	↓	↓	
0100	0110	1001	Excess-3 for 136_{10}

2.2.4 ASCII

For the data representation, there is another 8-bit code known as the *American Standard Code for Information Interchange* (ASCII). This code was originally designed as a 7-bit code. Several computer manufacturers cooperated to develop this code for transmitting and processing data. Later on, IBM developed a new version of ASCII called as ASCII-8. They made use of all eight bits providing 256 symbols. Nevertheless, IBM had not changed the original set of 128 codes so that the original instructions and data could still work with the new character set. ASCII is commonly used in the transmission of data through data communication and is used almost exclusively to represent the data internally in the microcomputers. In ASCII, rather than breaking letters into three

groups, upper case letters are assigned codes beginning with hexadecimal value 41 and continuing sequentially through hexadecimal value 5A. Similarly, lower case letters are assigned hexadecimal values of 61 through 7 A.

The decimal values 1 to 9 are assigned the zone code 0011 in ASCII. Table 9B.3 of ASCII coding chart shows upper case and lower case alphabetic characters and numeric digits 0 to 9. The standard ASCII code defines 128 character codes (from 0 to 127), of which, the first 32 are control codes (nonprintable) and the other 96 are representable characters.

Table 9B.3 ASCII Coding Chart

Value	Character	Value	Character	Value	Character	Value	Character
0		32		64	@	96	'
1	☺	33	!	65	A	97	A
2	☻	34	“	66	B	98	B
3	♥	35	#	67	C	99	C
Value	**Character**	**Value**	**Character**	**Value**	**Character**	**Value**	**Character**
4	♦	36	$	68	D	100	D
5	♣	37	%	69	E	101	E
6	♠	38	&	70	F	102	F
7	•	39	‘	71	G	103	G
8	◘	40	(	72	H	104	H
9	○	41	)	73	I	105	I
10	◙	42	*	74	J	106	I
11	♂	43	+	75	K	107	K
12	♀	44	,	76	L	108	I
13	♪	45	-	77	M	109	M
14	♫	46	.	78	N	110	N
15	☼	47	/	79	O	111	O
16	►	48	0	80	P	112	P
17	◄	49	1	81	Q	113	Q

18	↕	50	2	82	R	114	R
19	‼	51	3	83	S	115	S
20	¶	52	4	84	T	116	T
21	§	53	5	85	U	117	U
22	▬	54	6	86	V	118	V
23	↨	55	7	R7	W	119	W
24	↑	56	8	88	X	120	X
25	↓	57	9	89	Y	121	Y
26	→	58	:	90	Z	122	Z
27	←	59	;	91	[	123	{
28	∟	60	<	92	\	124	|
29	↔	61	=	93	]	125	}
30	▲	62	>	94	^	126	~
31	▼	63	?	95	_	127	⌂

Value	**Character**	**Value**	**Character**	**Value**	**Character**	**Value**	**Character**
128	Ç	160	á	192	└	224	A
129	ü	161	í	193	┴	225	ß
130	é	162	ó	194	┬	226	Γ
131	â	163	ú	195	├	227	Π
132	ä	164	ñ	196	─	228	Σ
133	à	165	Ñ	197	┼	229	Σ
134	å	166	ª	198	╞	230	µ
135	ç	167	º	199	╟	231	T
136	ê	168	¿	200	╚	232	Φ
137	ë	169	⌐	201	╔	233	Θ
138	è	170	¬	202	╩	234	Ω

139	ï	171	½	203	╦	235	Δ
140	î	172	¼	204	╠	236	∞
141	ì	173	¡	205	═	237	Φ
142	Ä	174	«	206	╬	238	E
143	Å	175	»	207	╧	239	∩
144	É	176	░	208	╨	240	≡
145	æ	177	▒	209	╤	241	±
146	Æ	178	▓	210	╥	242	≥
147	ô	179	│	211	╙	243	≤
148	ö	180	┤	212	╘	244	⌠
149	ò	181	╡	213	╒	245	⌡
150	û	182	╢	214	╓	246	÷
151	ù	183	╖	215	╫	247	≈
152	ÿ	184	╕	216	╪	248	°
153	Ö	185	╣	217	┘	249	·
154	Ü	186	║	218	┌	250	·
155	¢	187	╗	219	█	251	√
Value	**Character**	**Value**	**Character**	**Value**	**Character**	**Value**	**Character**
156	£	188	╝	220	▄	252	^{n}
157	¥	189	╜	221	▌	253	^{2}
158	Pts	190	╛	222	▐	254	■
159	*f*	191	┐	223	▀	255	

Example: Determine the binary coding of 'words' in the ASCII form.

0111 0111 0110 1111 0111 0010 01100110 0111 0011

(w o r d s)

The corresponding ASCII codes for 'words' are:

119 111 114 100 115

(w o r d s)

2.2.5 EBCDIC

EBCDIC or *Extended Binary Coded Decimal Interchange Code* uses 8 bits for each character, it is possible to represent 256 different characters or bit combinations. This provides a unique code for each decimal value 0 to 9 (for a total of 10), each upper case and lower case letter (for a total of 52) and for a variety of special characters. Since it is an 8-bit code, each group of the eight bits makes up one alphabetic, numeric or special character and is called a *byte.*

In EBCDIC, the bit pattern 1100 is the zone combination (zone and digit) used for the alphabetic characters A through 1, 1101 is used for the characters J through R, and 1110 is the zone combination used for characters S through Z. The bit pattern 1111 is the zone combination used when representing decimal digits. For example, the code 11000001 is equivalent to the letter A; the code 1111 0001 is equivalent to the decimal digit 1. Other zone combinations are used when forming special characters. The concepts and advantages of ASCII are identical to those of EBCDIC. The important difference between the two coding systems lies in the 8-bit combinations assigned to represent the various alphabetic, numeric and special characters. While using ASCII 8-bit code, we notice that the selection of bit patterns used in the positions differs from those used in EBCDIC. For example, let us look at the characters DP3 in both EBCDIC and ASCII to see how they compare.

Character	**D**	**P**	**3**
EBCDIC	1100 0100	1101 0111	1111 0011
ASCII	0100 0100	0101 0000	0011 0011

Table 9B.4 EBCDIC Codes

ALPHABETIC CHARACTERS							
UPPER CASE				**LOWER CASE**			
Prints as	**EBCDIC**			**Prints as**	**EBCDIC**		
	In Binary		**In Hexadecimal**		**In Binary**		**In Hexadecimal**
	Zone	**Digit**			**Zone**	**Digit**	
A	1100	0001	C1	a	1000	0001	81

B	1100	0010	C2	b	1000	0010	82
C	1100	0011	C3	c	1000	0011	83
D	1100	0100	C4	d	1000	0100	84
E	1100	0101	C5	e	1000	0101	85
F	1100	0110	C6	f	1000	0110	86
G	1100	0111	C7	g	1000	0111	87
H	1100	1000	C8	h	1000	1000	88
I	1100	1001	C9	i	1000	1001	89
J	1101	0001	D1	J	1001	0001	91
K	1101	0010	D2	k	1001	0010	92
L	1101	0011	D3	1	1001	0011	93
M	1101	0100	D4	m	1001	0100	94
N	1101	0101	D5	n	1001	0101	95
0	1101	0110	D6	0	1001	0110	96
P	1101	0111	D7	p	1001	0111	97
Q	1101	1000	D8	q	1001	1000	98
R	1101	1001	D9	r	1001	1001	99
S	1110	0010	E2	s	1010	0010	A2
T	1110	0011	D3	t	1010	0011	A3
U	1110	0100	E4	u	1010	0100	A4
V	1110	0101	E5	v	1010	0101	A5
W	1110	0110	E6	w	1010	0110	A6
X	1110	0111	E7	x	1010	0111	A7
Y	1110	1000	E8	Y	1010	1000	A8
Z	1110	1001	E9	z	1010	1001	A9

NUMERIC CHARACTERS							
0	1111	0000	FO	5	1111	0101	F5
1	1111	0001	F1	6	1111	0110	F6
2	1111	0010	F2	7	1111	0111	F7
3	1111	0011	F3	8	1111	1000	F8
4	1111	0100	F4	9	1111	1001	F9

2.2.6 GRAY CODE

Gray code is an unweighted code, meaning that the bit positions in the code groups do not have any specific weight assigned to them. The Gray code exhibits only one bit in the code group change when going from one step to the next. Gray code is not suited for arithmetic operations.

Table 9B.5 shows the Gray code representation for the decimal numbers 0 through 15, together with the straight binary code. If we examine the Gray code groups for each decimal number, it can be seen that in going from one decimal number to the next only one bit of the Gray code changes.

Decimal	Binary	Gray Code
0	0000	0000
1	0001	0001
2	0010	0011
3	0011	0010
4	0100	0110
5	0101	0111
6	0110	0101
7	0111	0100
8	1000	1100
9	1001	1101
10	1010	1111
11	1011	1110

12	1100	1010
13	1101	1011
14	1110	1001
15	1111	1000

Table 9B.5 Gray code

For example, in going from 3 to 4, the Gray code changes from 0010 to 0110, with only the second bit from the left changing, while the binary code changes from 0011 to 0100, a change of three bits. This is a principal characteristic of the Gray code.

2.2.6.1 Binary-to-Gray Conversion

To convert from a binary number to a Gray code number, apply the following steps:

1. The most significant digit (left-most) in the Gray code is the same as the corresponding digit in the binary number.
2. Going from left to right, add each adjacent pair of binary digits to get the next Gray code digit. Disregard carries.

For example, let us assume the binary number 11010 to convert to Gary code

Step-1 The left-most Gray digit is the same as the left most binary digit

1 1 0 1 0 Binary

↓

1 Gray

Step-II Add the left-most binary digit to the adjacent one and discard carry

[1 + 1] 0 1 0 Binary

↓

1 0 Gray

Step-III Add the next adjacent pair

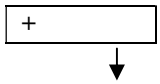
1 [1 + 0] 1 0 Binary

↓

1 0 1 Gray

Step-IV Add the next adjacent pair

1 1 [0 1] 0 Binary



1 0 1 1 Gray

Step- V Add the last adjacent pair

1 1 0 1 + 0 Binary

1 0 1 1 1 Gray

The conversion is now complete and the Gray code equivalent to binary 11010 is 1019B.

2.2.6.2 Gray-to-Binary Conversion

To convert from Gray code to binary, a similar method is used with little difference. The following steps apply:

1. The left-most significant digit in the binary code is same as the corresponding digit in the Gray code.
2. Add each binary digit generated to the Gray digit in the next adjacent position. Disregard carries.

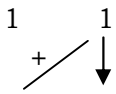
For example, the conversion of the Gray code number 11011 to binary is as follows:

Step-I The left most Gray digit is the same.

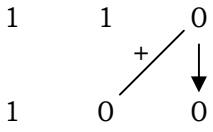
1 1 0 1 1 Gray

1 Binary

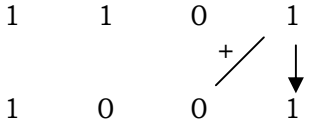
Step-II Add the last binary digit just generated to the Gray digit in the next position. Discard carry.



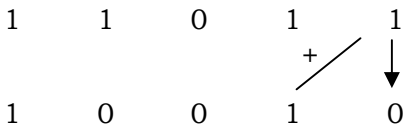
Step-III Add the last binary digit generated to the next Gray code.



Step-IV Add the last binary digit generated to the next Gray digit



Step- V Add the last adjacent pair



The conversion is now complete and the Binary equivalent to Gray 11011 is 10010.

Self Check Exercise-I

Q.1 Define BCD.

Ans:……

……

Q.2 What is Gray Code?

Ans:……

……

2.2.7 Binary Arithmetic

Everything that is stored in or manipulated by the computer is a number. The computer only understands the numbers 1 and 0. Therefore, every number has to be

converted to binary (0s and 1s) digits. The basic arithmetic operations of the binary number system are:

- Addition
- Subtraction

2.2.7.1 Binary Addition

Binary addition is carried out in the same way as the decimal addition is performed. In decimal addition, the unit column is added first, then the tens column, the hundreds, and so on. If the sum is greater than or equal to ten, the least significant digit is written as a partial sum and a carry of 1 is added to the sum of the next column. This process is repeated for each larger significant digit. These steps are also followed in the binary addition. The addition table of the binary arithmetic is very simple because this system has only two digits. As a result, there are only four outcomes or rules of the binary addition. These are listed below:

Table 9B.1 Addition of Binary Numbers

INPUT		**OUTPUT**	
X	**Y**	**SUM(S)**	**CARRY(C)**
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

In the table above, the results of the four addition operations between the two binary digits are divided between the 'sum' and the 'carry' part. The first three outcomes are the simple arithmetic operations but in the fourth operation, a *'carry-over'* condition occurs. This has been performed in the same manner as in decimal arithmetic according to which 1 is carried to the next higher column. However, since 1 is the largest possible digit in the binary system, any value which will be greater than 1 requires the digit to be carried over.

For instance, 10 plus 10 in the binary system requires addition of two 1s in the second position. Here, 1 + 1 = 0 plus a carry of 1. Hence, in the binary addition the sum of 10 + 10 is 100.

Example 1: Add the binary numbers 1111 and 1010 and check the answer with the help of decimal addition.

Binary **Decimal**

1 1

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

```
   1  5
+  1  0
---------
   2  5
```

According to the last step of the above binary addition, 1 + 1 + 1 = 10 + 1= 11 = 1 + carry of 1 into higher column.

Example 2: Calculate the sum of 110011, 10010, 1100 and 101 and check the answer with the help of decimal addition.

Binary

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

Decimal

```
    1
    +
    5   1
    1   8
    1   2
+       5
-------------
    8   6
```

Example 3: Add the binary fractional numbers 11.10 and 10.10 and check the result with the help of decimal addition.

Binary

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

Decimal

```
    1
    +
    3 . 5
  + 2 .
5 -------
    6 . 0
```

Example 4: Calculate the sum *of* 11010.0100, 1001.01,001.11, and 10.1010 and check the answer with the help *of* decimal addition.

Binary

```
    1     1  1  1  1
    +     +  +  +  +
    1  1  0  1  0.0  1  0  0
       1  0  0  1.0  1
          0  0  1.1  1
 +              1  0.1  0  1  0
-------------------------------
    1  0  0  1  1  1.1  1  1  0
```

Decimal

```
    1  1  1
    +  +  +
    2  6.2  5
       9.2  5
       1.7  5
 +     2.6  2  5
-----------------
    3  9.8  7  5
```

2.2.7.2 Binary Subtraction

Subtraction is generally simple in comparison to addition since only two numbers are involved and the upper value representation is greater than the lower value representation. In binary subtraction, the problem *of* 'borrow' is similar to that in decimal. If the subtrahend bit is equal to or smaller than the minuend bit, then perform the subtraction, otherwise borrow one from its left most neighbour. If its neighbour is zero, then proceed to the left until a borrow can be performed. For the left most bit, a borrow is made from the outside.

We can construct a subtraction table (as shown in Table 2.6 below) that has two parts - the three cases *of* subtracting without borrow, and the one case *of* the involvement *of* a borrow digit, no matter how far to the left is the next available binary digit. Like the binary addition, binary subtraction also follows four rules for the operation. These rules are discussed below:

Table 9B.2 Subtraction *of* Binary Numbers

INPUT		**OUTPUT**	
X	**Y**	**Difference(D)**	**Borrow(B)**
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

The rules, given in the above table, can be explained by the following example *of* subtraction:

		1				
		~~1~~0	10		10	
	~~1~~	~~0~~	~~0~~	~~1~~	~~0~~	1
-	0	0	1	0	1	1
	0	1	1	0	1	0

The following steps are involved:

a. First, for the least significant bit (the right most bit), 1 - 1 is 0.

b. For the next bit, 0 - 1 cannot be computed since the subtrahend is smaller than the minuend. Borrow 1 from the third bit to form the binary number 10 (decimal 2) and do the subtraction. The operation is 10 - 1 = 1 which in the decimal number system is 2 - 1 = 1.

c. For the third bit, since we borrowed 1 for the second bit, we have 0 - 0 that is 0.

d. For the fourth bit again, we cannot perform the subtraction. However, the fifth bit in the minuend is zero, so we must borrow from the sixth bit. This makes the fifth bit 10 (decimal 2). Borrowing 1 from the fifth bit makes it 1 and the fourth bit becomes 10 (decimal 2). Now the subtraction in binary is 10 - 1 = 1 which is the result of the fourth bit.

e. For the fifth bit, we now have 1 - 0 = 1.

f. Since we borrowed 1 from the sixth bit for the fourth bit, so for the sixth bit, the subtraction is 0 - 0 = 0.

Example 1: Find the binary difference of (1101-10110) and check the answer with the help of decimal subtraction.

Binary

		10		
	1	~~1~~	~~0~~	1
-	1	0	1	1
	0	0	1	0

.:

Decimal

	1 3
-	1 1
	0 2

Note: *Here, we borrowed* 1 *from 3rd-column because of the difference 0-1 in the 2nd-column.*

Example 2: Calculate the binary difference of (11100011-10101000) and check the answer with the help of binary subtraction.

Binary

```
          1 1
          0
          0  10 10
  1  1    1  0  0  0  1  1
- 1  0    1  0  1  0  0  0
-------------------------
  0  0    1  1  1  0  1  1
```

Decimal

```
    2  2  7
- 1  6  8
---------
       5  9
```

2.2.8 Octal Arithmetic

In the computer, everything that is stored in or manipulated is in a form of binary number. Nevertheless, the octal number system is also a common system, which has been used with the computers. The essential arithmetic operations of the octal number system are:

- Addition
- Subtraction

2.2.8.1 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 a octal digit.
4. If the sum is greater than 7, then subtract 8 from that particular digit and carry 1 to the next digit position.

Note: *In this addition, we should remember that the largest octal digit is 7 instead of 9.*

Example 1: Add the octal numbers 26 and 17.

```
  1(Carry)
  2    6
  1    7
-------
  4   13
      8        (modification)
-------
  4    5
```

Thus, the resultant octal sum is 45.

Example 2: Add the octal numbers 5647 and 1425.

```
  5  6  4  7
```

+ 1	4	2	5	
7	10	7	12	
	-8		-8	(modification)
7	2	7	4	

Thus, the resultant octal sum is 7274.

2.2.8.2 Octal Subtraction

In the octal subtraction, the method, which we have adopted, is similar to that of binary subtraction method. The only difference lies in the carry part. During octal subtraction, instead of 1, we will borrow 8 and the rest of the steps are similar to that of binary subtraction.

Example 1: Subtract $(677)_8$ from $(770)_{9B.}$

8+6=14

6	~~6~~	8	(Borrow)
~~7~~	~~7~~	~~0~~	
- 6	7	7	
0	7	1	

Thus, the difference is $(71)_{9B.}$

Note: *Here, we borrowed 8 from the 2nd column for the difference 0-7 and 8 from the 3rd column for the difference* 6-7.

Example 2: Subtract $(2761)_8$ from $(6357)_{9B.}$

5	8+2=10	8+5=13	
~~6~~	~~3~~	~~5~~	7
2	7	6	1
3	3	7	6

Thus, the difference is $(3376)_{9B.}$

2.2.9 Hexadecimal Arithmetic

The hexadecimal number system is extensively used in the memories of the computer system and in the computer instructions. The basic arithmetic operations that are to be performed are listed below:

- Addition
- Subtraction

2.2.9.1 Hexadecimal Addition

The addition operation performed with the hexadecimal numbers is analogous to the decimal addition except with a few differences that are discussed in the following steps:

1. First add the unit column of the hexadecimal digits in decimal.
2. This process is repeated for each larger significant digit of the hexadecimal

number.

3. During the process of addition, observe if the sum is 15 or less, then it can be directly expressed as a hexadecimal digit.
4. If the sum is greater than 15, then subtract 16 from that particular digit and carry 1 to the next digit position.

Example 1: Add the hexadecimal numbers $(76)_{16}$ and $(45)_{16}$.

```
      7   6
+     4   5
-----------
     11  11
-----------
      -   -      (modification)
-----------
      B   B
```

The hexadecimal sum is $(BB)_{16}$.

Note: *In the above example, since the decimal sums are less than* 15 *so they are expressed directly in the hexadecimal form.*

Example 2: Add the hexadecimal numbers $(A27E9)_{16}$ and $(6FB43)_{16}$.

```
      1   1   1   1
      A   2   7   E   9
+     6   F   B   4   3
-------------------------
  1  17  18  19  18  12
     -16 -16 -16 -16   -      (modification)
-------------------------
  1   1   2   3   2  12
  1   1   2   3   2   C      (Hex Form)
```

The hexadecimal sum is $(11232C)_{16}$.

2.2.9.2 Hexadecimal Subtraction

The hexadecimal subtraction is based on the same principles as that of binary subtraction. In this subtraction, 16 will be used as borrow instead of 1. The rest of the steps are similar to the binary subtraction.

Example 1: Subtract $(75)_{16}$ from $(527)_{16}$.

```
          4
      16+2=18      (Borrow)
      5   2   7
+         7   5
-----------------
      4  11   2
      4   B   2      (Hex Form)
```

The hexadecimal difference is $(4B2)_{16}$.

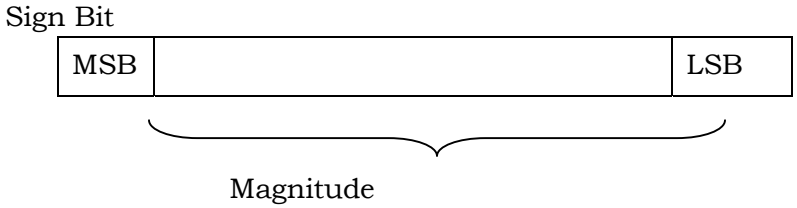
Example 2: Subtract $(lF65)_{16}$ from $(7E2CA)_{16}$.

```
                13    16+2=18 (Borrow)
      7    E    2    C    A
-          1    F    6    5
-------------------------------
      7   12    3    6    5
      7    C    3    6    5        (Hex Form)
```

The hexadecimal difference is $(7C365)_{16}$.

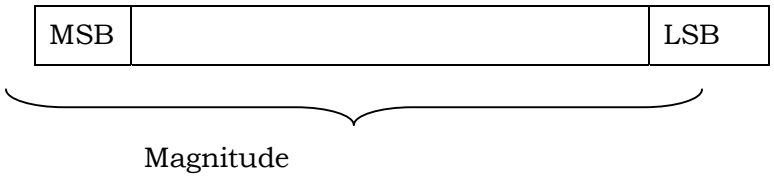
2.2.10 Signed and Unsigned Numbers

An n-bit signed binary number consists of two parts. A part denoting the sign of the number and a part denoting the magnitude of the number, The MSB is always a sign bit which denotes the sign of the number and the convention is that 0 and 1 denote '+' and '-', respectively. The remaining (n-l) bit denotes the magnitude of the number. The 8-bit sign-magnitude system ranges from -127 to +127.



In some applications, all data is either positive or negative, for example, smallest 8-bit number is 00000000 and largest is 11111111. Therefore, it ranges from 0 to 255. Here, positive and negative sign are not included with these numbers. All the bits in the binary number are used to represent magnitude of the corresponding decimal number.

There are certain restrictions in unsigned binary number. With 8-bit unsigned arithmetic, all magnitude must be between 0 and 255. Therefore, each number being added or subtracted must be between 0 and 255 and answer must fall in the range of 0 to 255. If the magnitude is greater than 255, one should use 16-bit arithmetic.



So far, we have considered all binary numbers as unsigned numeric values. However, we can also use signed binary numbers. Whether a number is a signed number or an unsigned number depends solely on how we treat the number in our operation. We assign a bit, the MSB, as a sign bit that helps us to place a minus sign in a binary position.

The rules for signed and unsigned binary numbers are simple:

- In an unsigned number, the MSB is a weighted position bit.

- In a signed number, the MSB (the sign bit) is 0 for a positive number.
- In a signed number, the MSB (the sign bit) is 1 for a negative number.

2.2.10.1 Complements

The complement of a number is the number which when added to the original will make it equal to a multiple of the base number system.

The complement of a number can be used as a representation of that number as a *negative* and as a *positive* number that represents a negative. It is a method, which can be used to make the subtraction easier for machines. Consequently, complements are used in the digital computers for simplifying the subtraction operation and for the logical operation.

For every base 'r' system, there are two types of complements: rs complement and (r-l)s complement. For decimal r = 10, we have 9s and l0s complement.

For binary r = 2, we have 1s and 2s complement.

For octal r = 8, we have 7s and 8s complement.

For hexadecimal r = 16, we have 15s and 16s complement.

2.2.10.2 Negative Binary Numbers - the 1s Complement

Positive numbers are same in both sequences, but we need to define the negative numbers in the system. All the negative numbers have the binary MSB = 1, which is helpful in identifying the sign of the number. Indeed, the binary MSB is commonly known as the *sign bit.* This bit is useful in differentiating between positive and negative numbers. In addition, the sign bit allows us to divide the counting sequence evenly between positive and negative numbers.

To form the negative of any number, first complement all the bits of the number. This result is known as the *one's complement* of the original number. This requires us to change every logic 1 bit in a number to logic 0 and every logic 0 bit to a logic 1. For instance, let us find the 1 s complement of 0011 0110 in binary.

Number Format	D7	D6	D5	D4	D3	D2	D1	D0
Unsigned Number	0	0	1	1	0	1	1	0
1s Complement	1	1	0	0	1	0	0	1

2.2.10.3 Negative Binary Numbers - the 2s Complement

We do not just place 1 in the MSB of a binary number to make it negative. We must take the 2s complement of the number. Taking the 2s complement of the number will cause the MSB to become 1.

To obtain the 2s complement of a number, there is a two-step process:

1. Take the 1 s complement of the number by changing every logic 1 bit in the number to logic 0 bit and change every logic 0 bit to logic 1 bit.
2. Add 1 to the 1's complement of the binary number. Now, we have the 2s complement of the original number. Here, we can notice that the MSB has become 1.

1s complement and 2s complement of 0011 0110 in binary is shown in the following table:

Number Format	D7	D6	D5	D4	D3	D2	D1	D0
Unsigned Number	0	0	1	1	0	1	1	0
1s Complement	1	1	0	0	1	0	0	1
2s Compliment	1	1	0	0	1	0	1	0

If we are using signed binary numbers and the MSB is already logic 1, it means the value is the 2s complement of the number.

2.2.10.4 Representation of signed numbers using 2s complement

We have discussed *that* the signed numbers can be represented by taking out the 2s complement of the original number. However, this representation varies between positive and negative numbers.

If the number is positive, the magnitude remains in its binary form and a sign bit of 0 is placed in front of the MSB.

Example 1: Represent + $(12)_{10}$ in 2s complement form.

Binary Number		1	1	0	0
1s Complement		0	0	1	1
2s Compliment		0	1	0	0
With Sign Bit	**0**	0	1	0	0

If the number is negative, the magnitude is represented in its 2s complement form and a sign bit 1 is placed in front of the MSB.

Example 2: Represent - $(14)_{10}$ in 2s complement form.

Binary Number		1	1	1	0
1s Complement		0	0	0	1
2s Compliment		0	0	1	0
With Sign Bit	**1**	0	0	1	0

2.2.10.5 Addition-subtraction of signed numbers using 2s complement addition

The addition of signed binary numbers represented in the radix complement form is similar to the unsigned case. However, when the 2s complement of a number is added to any other binary number, it will be equivalent to its subtraction from that number. As a result, subtraction of the signed numbers by 2s complement method is performed by using the following steps:

1. Convert both the numbers into the binary equivalent form.
2. Find the 2s complement form of the number, which is subtracting, that is, subtrahend.
3. Add this 2s complement number to the minuend.
4. If there is carry of **1,** ignore it from the result to obtain the correct result.
5. If there is no carry, recomplement the result and attach the negative sign to the obtained result.

Example 1: Add $(27)_{10}$ and $(-11)_{10}$ using complementary representation for the negative value.
Binary form of $(27)_{10} = (011011)_2$ and of $(11)_{10} = (001011)_2$

Hence, the result is $(010000)_2$ or $(16)_{10}$.

Note: *Here, carry* is 1, *so ignore it and the result* is *(010000)2.*

Example 2: Subtract $(25)_{10}$ from $(42)_{10}$.

Binary form of $(25)_{10} = (011001)_2$ and of $(42)_{10} = (101010)_2$

Get the 2s complement of the $(011001)_2$

Here, ignore the carry 1 and the result is $(010001)_2$ or $(17)_{10}$.

2.2.11 Summary

The binary coding schemes are used to represent the internal storage area of the computers. In binary coding, every character is represented by a combination of bits. The most commonly used computer coding systems are BCD, ASCII and EBCDIC.

BCD (Binary Coded Decimal) is a method that represents the decimal digits with the help of binary digits. It is a 6-bit code, which can represent a maximum of 64 different characters.

The Excess-3 is a digital code that is formed by adding 3 to each decimal digit. Excess-3 is an unweighted code.

ASCII is a 8-bit code and is exclusively used to represent the data internally in the microcomputers. It can represent 128 different characters.

EBCDIC or Extended Binary Coded Decimal Interchange Code uses 8 bits for each character and can represent 256 different characters. It provides a unique code for

each decimal value 0 through 9 and for a variety of special characters.

Gray code is an unweighted code. Gray code is not suited for arithmetic operations.

All the computers perform the arithmetic operations in the binary mode. The basic arithmetic operations that have been performed by all the number systems are addition and subtraction.

The rules of binary addition are as follows:

0 + 0 = 0
0 + 1 = 1
1 + 0 = 1
1 + 1 = 0 plus a carry of 1 to next higher column

The rules of binary subtraction are as follows:

0 - 0 = 0
1 - 0 = 1
1 - 1 = 0
0 - 1 = 1 with a borrow from the next column

The *complement* of a number is the number which when added to the original will make it equal to a multiple of the base number system. The complement of a number can be used to represent a number as a *negative* and a *positive* number. The addition and subtraction of the signed numbers is dependent on the 2s complement of the numbers and whenever the 2s complement of a number is added to any other binary number, it will be equivalent to its subtraction from that number.

2.2.12 Keywords

BCD: It is a numerical representation scheme in which each decimal digit is encoded using four binary digits.

ASCII: It is a 7-bit code capable of representing 2^7 or 128 number of different characters.

EBCDIC: It is an eight-bit encoding scheme that standardizes how alphanumeric characters, punctuation and other symbols are interpreted by a computer's operating system (OS) and applications.

2.2.13 Short Answer Type Questions

Q.1 What is the purpose of the binary coding system?

Q.2 Why computers have deigns to use the binary number system?

2.2.14 Long Answer Type Questions

Q.1 Briefly explain the terms: BCD, ASCII and EBCDIC.

Q.2 Encode these binary number in BCD

- 45
- 247
- 1029

Q.3 Perform the binary addition

- 1010 + 1101

- 111011 + 101011
- 1010110 + 1011010

Q.4 Add the binary numbers 1011 and 101 in both decimal and binary forms.

Q.5 Subtract 0110111_2 from 1101110_2

Q.6 Subtract 011011_2 from 110111_2

2.2.15 Suggested Readings*:*

1. Computer Fundamentals By Pradeep K. Sinha and Priti Sinha (BPB Publications)
2. Fundamentals of Information Technology By Shiv Kumar Anand and Harmohan Sharma (Kalyani Publishers)
3. Fundamentals of Information Technology by V.Rajaraman (PHI, New Delhi).
4. Digital Design by M. Morris Mano (Pearson Education)
5. Computer Fundamentals, Architecture & Organisation by B.Ram, New Age International.
6. Code : the sudden language of computer hardware and software by Charles Petzold

DATA COMMUNICATION AND COMPUTER NETWORK

2.3.1 Objectives

In this lesson we will learn computer networks and its types. We will also study about various types of transmission media and network topologies.

2.3.2 Introduction

We have entered in the era of communication technology. The dynamic world today needs fast communication channels to move data frequently from one place to another.

To move data quickly from one place to another, the concept of networking has been introduced. In networking, the computers in different parts of the world are connected to each other to share data. Therefore, when a number of computers are connected with each other in such a way that they can share the information, the system is called Network. A network allows computers users to share computer equipment, programs, messages and the information

Computer Network :- **A computer network is a group of computer systems and other computing hardware devices that are linked together through communication channels to facilitate communication and resource sharing among a wide range of users**. A network consists of following elements:

(i) **Nodes (Workstations)**: The different terminals attached to the network sharing the resources of the network are called nodes. When we attach a computer to the network it becomes the workstation of a network.

(ii) **Server**: We designate a particular node as a main or central node, which is at a well known and a fixed address to provide service to the network as a whole. The node providing the service is known as the server.

(iii) **Network Interface Unit**: The interpreter which helps in the communication between the server and different nodes is called a Network Interface Unit. The network interface unit is a device that is attached to the server and all the workstations to maintain the connection between them. Each network interface unit has a unique node address.

2.3.3 Need for Networking

1. **To share computer files**: Networks enable users to share files with others. For example, a person sitting on one computer can send the file to other in sharing mode.
2. **To share computer equipment**: Printers and hard-disk drives can also be shared. Networks enable users to share such equipment by networking.
3. **Increasing speed and accuracy:** Messages can be send through networks with high speed and more accuracy
4. **Cost effectiveness:** The cost of transfer of documents using computers connected on networks is cheaper than other conventional methods like telegrams.
5. **Team Work:** Different computers on a network can be connected together and the users can work together as a group. Software packages have been developed for group working in Data Base Management systems (DBMS) and graphic applications.
6. **High reliability:** All files could be replicated (copied) on two or three machine, so if one of them is unavailable (due to hardware failure), the other backup can be used.

Self Check Exercise-I

Q.1 Define Computer Network

Ans:……
……

2.3.4 Types of Computer Networks

There are three types of computer networks:

1. Local Area Network (LAN)
2. Metropolitan Area Network (MAN)
3. Wide Area Network (WAN)

2.3.4.1 Local Area Network (LAN)

A local area network is relatively smaller and privately owned network with the maximum span of 10 km. to provide local connectivity within a building or small geographical area. In private offices this type of Networking is very popular and effectively used. They are widely used to connect personal computers and workstations in corporate offices and factories to share resources and exchange information. LANs often use a transmission technology consisting of a single cable to which, the entire machines are attached as shown in figure. Traditional LANs run at speeds of 10 to 100 Mbps, have low delay and make very few errors.

Features of LAN

i) Limited Geographic Limits :A LAN is designed for a small area. Generally it spans a single often, workgroup floor in a building or in a campus etc. LAN uses different protocols or rules for information transmission.

(ii) Limited number of users : Most LAN supports less numbers of users usually around five or ten, More users can be supported by connecting different LAN'S together, which gives better results than making one big-network of the nature of LAN.

(iii) Reliability and Stability :LANs tend to be very Reliable Failures on a LAN are mostly due to wrong or improper installation. Monitoring software that comes along with a LAN provides a number of useful programs like error detection, prevention of transmission loss and excellent security features.

(iv) Flexibility : Major development in LANs today is flexibility they offer earlier versions would support only one type of desktop computers. Today advanced LANs however can support different types of Computers. This flexibility also extends to operating systems & storage media.

(v) Expandable : Most LANs can be expanded easily. More nodes (Terminals) can be added. Also LANs can have more servers on same network and a user at a terminal can connect to one or many servers and work comfortably.

(vi) Security & Administration :A LAN administrator is one who supervises the operation of a LAN. He takes care of tasks like adding or deleting users, creating Passwords, Providing authorizations and other resources like printers and backing up data. All these tasks can be performed without much difficulty since both hardware and software are quite easy to manage today.

2.3.4.2 Wide Area Network

WAN provides no limit of distance. A WAN provides long distance transmission of data, voice, image and video information over large geographical area that may comprise a country, a continent or even the whole world. In fact in WAN, the data is transmitted via a satellite or through the telephone lines. All the big organizations, which want to make a central data base to be used by all the branches, use WAN.

Railway, Airlines and Banking companies are examples of such network as they have a central database that is used by all the terminals. As a result you can operate your bank account from anywhere in India or get your reservation from any place to any other place for train journey or air flight.

Features of WAN

1. **Remote Data and Job Entry:** It is possible to enter data of the sales and transactions at the point-of-sale terminals using WANs. It is also possible to centralize this data in a computer for processing or reporting purposes. For example, Super markets in different cities connected through WANs can send all sales data from their remote sale centre and the central purchase and distribution centre can monitor all the sale figures on a day to daybasis.
2. **Centralizing Information:** It is often convenient for a business to centralize regional and national information. For example, auto-parts dealers can help in locating rare-auto parts using a centralized computer file of inventory items. WANs enable such dealers to query centralized databases.
3. **Facilitating Communications:** Corporations in advanced countries often use WANs to facilitate employee communications, to save on long-distance phone calls and letter writing, to cut costs on the preparation of written documents. To overcome the time lags involved in the conventional means of extracting information between different branches. Computer conferencing, in which users communicate with each other through their computer systems, is another possible function of WANs.

2.3.5 Elements of computer network

1. Servers

One of the major benefits of implementation of LAN is sharing expensive resources such as Laser printer, hard disk etc. This is achieved through providing servers on the LAN. Server may be dedicated or non-dedicated. A dedicated server is a computer that controls one or more resources. A non-dedicated server is a computer that can be used

as a stand-alone pc while in the background it serves the LAN. Three major categories of servers used in LAN are

(a) File Server: It is used to share storage space for files. Besides providing storage spaces for files in a LAN environment, it is used for taking periodical backup and also to provide gateway to other servers within and between LANs.

(b) Printer Server: It is used to handle printing works of all workstation connected in the network.

(c) Modem Server: In LAN environment modem is also required to get connected to other network or simply to use a telephone. A modem server is used to share this expensive resource by all connected work stations in a network ring.

2. Work Station

A workstation is a computer and it has its own local O.S. like DOS, Windows etc. depending on machine type. A work station's main job is to execute program files retrieved from network. In distributed processing environment, processing burden is shared by server and workstation.

3. Network Interface Units (NIU)

Network interface units connect each device in the LAN network to shared transmission device. NIU is also used for to implement LAN protocols (rules) and for device attachments.

4. Hub

There are two types of Hub

(a) Active Hub: An active hub is a powered distribution point with active devices which drive nodes up to 1 kilometer away. Active hubs can be cascaded to connect 8 connections to which passive hubs, file servers or another active hub can be connected. The maximum distance covered by an active hub is about approximately 2000 ft.

(b) Passive hub: As the name suggests it is a passive distribution point which does not use power or active devices in a network to connect up to 4 nodes within a very short distance. The maximum distance covered by a passive hub is about 300 ft.

5. Shared Resources

Shared Resources include storage devices attached to server, optical disk drives, printers, plotters, modems and other equipment that can be used by everyone on network. Sharing hardware not only reduces cost by making duplicate purchases redundant, but LAN can access a wide variety of equipment.

6. Modem

Computer generates digital data which is unsuitable for long distance communication. So for this purpose this data must be converted to analog data. It is the modulation which performs this conversion of data from digital to analog. The converted data in the form of analog signals can travel without any noise over long distances. This

data when reaches its destination is converted back to digital data with the help of demodulation. Thus demodulation converts analog signals to original digital data. Modem is device which converts the analog into digital signal & vice-versa. Modems are already used for transmission of data over telephone lines.

7. Bridges

Bridges are used to connect two LANs that use identical LAN protocols over a wide area. The bridge acts as an address filter which picks up packets from one LAN that are intended for a destination on another LAN and passes these packets on the network. **If** the distance between the two LANs is large, the user would require two identical bridges at either end of the communication link

8. Routers

Routers can be used to connect networks that many not be similar. Ro provide connectivity between two LANs or two WANs overlarge geographical distances. For large Wide Area Networks spanning thousands of kilometers the normal practice is to put network routers at suitable locations to min link costs for leased lines and provide adequate reliability from link fail Networks and other system are then connected to the nearest router

9. Gateways

Gateways are used to connect two dissimilar LANs. The term gateway routers are used interchangeably, though there is a slightly difference the two. A gateway is required to convert data packets from one format to another before forwarding it, as it connects two dissimilar elements

Self Check Exercise-II

Q.2 What is Server?

Ans:.....

.....

Q.3 What is Router?

Ans:.....

.....

2.3.6 Transmission Media

Cable is the medium through which information usually moves from one network device to another. There are several types of cable which are commonly used with computer network transmission. In some cases, a network will utilize only one type of cable, other networks will use a variety of cable types. The type of cable chosen for a network is related to the network's topology, protocol and size. Understanding the characteristics of different types of cable and how they relate to other aspects of a

network is necessary for the development of a successful network. The following sections discuss the types of cables used in networks and other related topics.

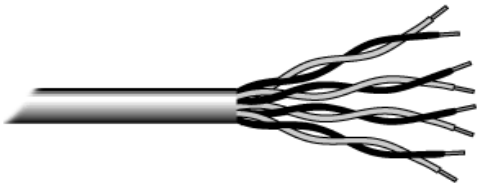
1. Twisted Pair Cable
2. Coaxial Cable
3. Fiber Optic Cable
4. Wireless transmission

2.3.6.1 Twisted Pair Cable

It consists of two insulated copper wires arranged in a regular spiral pattern to minimize the electromagnetic interference between adjacent pairs. It is of two types.

a) Unshielded Twisted Pair (UTP) Cable

Unshielded twisted pair (UTP) is the most popular and is generally the best option for telephone networks.



The quality of UTP may vary from telephone-grade wire to extremely high-speed cable. Each pair is twisted with a different number of twists per inch to help eliminate interference from adjacent pairs and other electrical devices.

- Ordinary telephone wire
- Cheapest
- Easiest to install
- Suffers from external electromagnetic interference (EM)

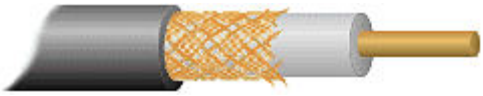
b) Shielded Twisted Pair (STP) Cable

A disadvantage of UTP is that it may be disturbed to radio and electrical frequency interference. Shielded twisted pair (STP) is suitable for environments with electrical interference; however,

- The pair is wrapped with metallic foil or braid to insulate the pair from electromagnetic interference.
- More expensive.
- Harder to handle (thick, heavy).

2.3.6.2 Coaxial Cable

Coaxial cabling has a single copper conductor at its center. A plastic layer provides insulation between the center conductor and a braided metal shield. The metal shield helps to block any outside interference from lights, external devices and other computers.



Coaxial cable

Characteristics of Coaxial Cable

- Most versatile medium
- Used in Television transmission
- Aerial to TV
- Used in Cable TV
- Long distance telephone transmission
- Can carry 10,000 voice calls simultaneously
- Short distance computer systems links
- Used in Local area networks

Advantage and Disadvantage of Coaxial Cable

- Supports Analog and Digital Transmission
- Amplifiers on higher bandwidth.
- Can transmit on higher frequency, Up to 600MHz.
- up to 10,800 voice conversations
- much less susceptible to interference than twisted pair
- high attenuation rate makes it expensive over long distance
- It is bulky

2.3.6.3 Fiber Optic Cable

Fiber optic cabling consists of a center glass core surrounded by several layers of protective materials. It transmits light rather than electronic signals eliminating the problem of electrical interference. This makes it ideal for certain environments that contain a large amount of electrical interference. It has also made it the standard for connecting networks between buildings, due to its immunity to the effects of moisture and lighting. Fiber optic cable has the ability to transmit signals over much longer distances than coaxial and twisted pair. It also has the capability to carry information at vastly greater speeds. This capacity broadens communication possibilities to include services such as video conferencing and interactive services.

But it is difficult to install and connect the fiber optics.

Characteristics of Fiber optics

- Greater capacity
- Data rates of hundreds of Gbps
- Smaller size & weight
- Lower attenuation
- Electromagnetic isolation
- Greater repeater spacing
- More distance in km.

Advantages and Disadvantages of Fiber optics

- Immunity to environmental interference
- Highly secure due to tap difficulty and lack of signal radiation
- Used in Telephone Exchange and Internet connectivity.
- Expensive over short distance
- Requires highly skilled installers
- Adding additional nodes is difficult

2.3.6.4 Wireless transmission

All networks are not connected with cabling, some networks are wireless. Wireless network use high frequency radio signals, infrared light beams or lasers to communicate between the computers. Each computer and file server on a wireless network has some sort of transceiver/antenna to send and receive the data. For longer distance, wireless communications can also take place through cellular telephone technology satellite, microwave transmission etc. Wireless networks are also beneficial in older buildings where it may be difficult or impossible to install cables.

The two most common types of infrared communications used in wireless transmission are line-of-sight and broadcast. Line-of-sight communication means that there must be a direct line between the computer and the transceiver. If a person walks

within the line-of-sight while there is a transmission, the information would need to be sent again.

Infrared communication is a broadcast of infrared transmissions sent out in multiple directions that bounces off walls and ceilings until it eventually hits the receiver. Networking communications with laser are virtually the same as line-of-sight infrared networks. Wireless LANs have several disadvantages. They provide poor security and are susceptible to interference from lights and electronic devices. They are also slower than LANs using cabling.

2.3.7 Network Topologies

It is the logical arrangement of computes in a network. The various rules / methods to connect the computers in networking are known as **Topology**. The choice of topology depends upon the following factors:

1. Cost
2. Availability of physical communication line.
3. Reliability of the entire system.
4. Number of cables required.
5. Expandability of the system.
6. Transmission delays.
7. Maximum distance.
8. Maximum number of nodes.

2.3.7.1 Star Topology

Star Topology is forerunner of all other topologies. Here, Server acts as heart of LAN and all PCs are connected individually to it. It is topology upon which our telephone network is built. Every communication from every user's station goes through the Central Computer before reaching it destination. Control Computer is very powerful and takes care of all networking responsibilities. This network is cheapest of all. To connect five systems we just need four cables. But failure chances are more if Central Computer Trips, whole network will go down. Sometimes Star-Shaped LAN is built with duplicate Central Computers as it allows rapid recovery from failure. But this will add to cost of Networking.

Merits

1. Cheaper media of Networking.
2. Less number of Cables required.
3. Transmission delays between two nodes do not increase by adding new nodes to the network.
4. If any node fails, the remaining portion of the network is unaffected.

Demerits

1. Central Computer must be very powerful.

2. If the host computer fails, the entire network fails.

2.3.7.2 Ring Topology

Ring Topology avoids dependence on Central Computer. Each node on ring can send a message to other terminal with a unique-address. A node receives data from one of its adjacent node. The only decision a node has to take is whether the data is for its use or not. If it is addressed to it utilizes it. Otherwise it passes it on to the next node. Every Data Unit in ring contains source & destination address.

Merits

1. It is a True Distributed Data processing system.
2. More reliable than STAR because communication is not dependent on host computer.

Demerits

1. Addition of New Node increases the communication delays.
2. Complicated control software.

2.3.7.3 Bus Topology

All the PCs are connected to same cable in one stream. At one end is server and last terminal at the other end is called Terminator**.** As with ring structure, Bus Network has also a unique address. If geographic coverage needs to be expanded, repeaters which interconnect two buses are required. In Bus topology, least length of physical Transmission medium is used. Coverage can be increased by extending the bus through use of repeaters. The Bus Topology is one of most popular topology. One reason for popularity is that, its wiring requirements are comparatively simple and growth is obtained easily & quickly.

Merits

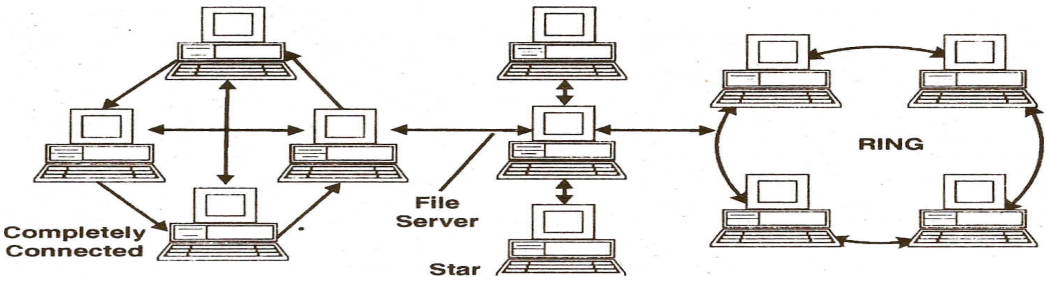
1. Less number of cables required.
2. Easy to expand.
3. Nodes can be added without distributing the rest of network.

Demerits

1. If the communication line fails, the entire system breaks down.

2.3.7.4 Hybrid Topology

A hybrid topology is simply a combination of two or more than two topologies. The exact shape configuration of the network depends on the needs and the over organizational structure of the company involved. In some cases, the hybrid topology may have components of star, ring and completely connected networks topology as shown in following figure



2.3.7.5 Complete connected Topology

A fully connected network, complete topology or full mesh topology is a network topology in which there is a direct link between all pairs of nodes. In a fully connected network with *n* nodes, there are *n(n-1)/2* direct links. Networks designed with this topology are usually very expensive to set up, but provide a high degree of reliability due to the multiple paths for data that are provided by the large number of redundant links between nodes

2.3.8 Summary

A network is a collection of computers connected to each other. The network allows computers to communicate with each other and share resources and information. Computer networks may be classified according to the network topology upon which the network is based. All networks are made up of basic hardware building blocks to interconnect network nodes, such as Network Interface Cards (NICs), Bridges, Hubs, Switches and Routers. In addition, some method of connecting these building blocks is required, usually in the form of cable which are discussed in this lesson.

2.3.9 Keywords

Computer Networks: It is a system that connects two or more computing devices for transmitting and sharing information.

LAN: A local area network (LAN) is a collection of devices connected together in one physical location, such as a building, office or home.

WAN: WAN stands for Wide Area Network. It is a computer network that covers a large geographical area consisting of two or more LANs or MANs.

Topology: Network topology refers to the arrangement of different elements like nodes, links and devices in a computer network.

2.3.10 Short Answer Type Questions

Q1 Define LAN.

Q2 What is MAN?

Q3 What is WAN?

2.3.11 Long Answer Type Questions

Q1 What is computer networking? What are its advantages?

Q2 Differentiate between LAN and WAN?

Q3 Write different elements of computer network?

Q4 Compare different transmission media?

Q5 Describe various Network topologies?

Q6 Differentiate between Bridges and Routers?

2.3.12 Suggested Readings

1. "Computer network protocol standards and interface", Black UD, Prentice Hall.
2. "Computer Networks", Tanenbaum, Pearson Education India.
3. "Data Communication and Networking" ,Forouzan, Tata McGraw Hill Ltd.

B.A.I (Computer Science) **PAPER : BCSB1101T**
(SEM- I) **FUNDAMENTALS OF IT**
LESSON NO. 2.4 **AUTHOR : DR AMARDEEP SINGH**
Converted into SLM by: Dr. Vishal Singh
Last Updated on April, 2024

INTERNET AND ITS APPLICATIONS

2.4.1 Objectives

In this lesson we will study Internet and its concepts. We will also learn about various standards and protocols linked with the Internet.

2.4.2 Introduction

As we approach a new millennium, the Internet is revolutionizing in our society, our economy and our technological systems. No one knows for certain how far, or in what direction, the Internet will evolve. But no one should underestimate its importance. The Internet, as an integrating force, has melded the technology of communications and computing to provide instant connectivity and global information services to all its users at very low cost.

The Internet is formed by the global interconnection of hundreds of thousands of otherwise independent computers, communications entities and information systems. The Internet, sometimes called simply "the Net," is a worldwide system of computer networks i.e. a network of networks in which users is at any one computer. The Internet uses a portion of the total resources of the currently existing public telecommunication networks. The procedures by which computers communicate with each other are called

"protocols." While this infrastructure is steadily evolving to include new capabilities, the protocols initially used by the Internet are called the "TCP/IP" or (Transmission Control Protocol/Internet Protocol), named after the two protocols that formed the principal basis for Internet operation.

The size, scope and design of the Internet allow users to:

- connect easily through ordinary personal computers and local phone numbers.
- exchange electronic mail (E-mail) with friends and colleagues with accounts on the Internet.
- post information for others to access and update it frequently.
- access multimedia information that includes sound, photographic images and even video and
- access diverse perspectives from around the world.

The Internet is a large common space, accessible to everyone around the world. As in any public space, it should be taken appropriate precautions to protect yourself against fraudulent people and processes. Internet security analysis is broken down into a consideration of threats and corresponding defenses. For most threats there is a defense. The short course advises you to ensure you always use a firewall, virus protection and to use encryption when necessary.

2.4.3 The Evolution of the Internet

The internet is a global system of interconnected computer networks that uses the TCP/IP net work protocols to facilitate data transmion and exchange. The Internet was the result of some visionary thinking by people in the early 1960s that saw great potential value in allowing computers to share information on research and development in scientific and military fields. The Internet, then known as ARPANET was brought online in 1969 under a contract let by the renamed Advanced Research Projects Agency (ARPA) which initially connected four major computers at universities in the southwestern US (UCLA, Stanford Research Institute, UCSB, and the University of Utah). The early Internet was used by computer experts, engineers, scientists and librarians. There was nothing friendly about it. There were no home or office personal computers in those days, and anyone who used it, whether a computer professional or an engineer or scientist or librarian, had to learn to use a very complex system. The Internet matured in the 70's as a result of the TCP/IP architecture first proposed by Bob Kahn at BBN. As the commands for e-mail, FTP, and telnet were standardized, it became a lot easier for non-technical people to learn to use the nets. It was not easy by today's standards by any means, but it did open up use of the Internet to many more people in universities in particular. Other departments besides the libraries, computer, physics, and engineering departments found ways to make good use of the nets to communicate with colleagues around the world and to share files and resources.

While the number of sites on the Internet was small, it was fairly easy to keep track of the resources of interest that were available. But as more and more universities and organizations and their libraries connected, the Internet became harder and harder to track. There was more and more need for tools to index the resources that were available. In 1989 another significant event took place in making the nets easier to use. This protocol, which became the World Wide Web in 1991, was based on hypertext a system of embedding links in text to link to other text, which you have been using every time you selected a text link while reading these pages. Since the Internet was initially funded by the government, it was originally limited to research, education and government uses. Commercial uses were prohibited unless they directly served the goals of research and education. This policy continued until the early 90's, when independent commercial networks began to grow. It then became possible to route traffic across the country from one commercial site to another without passing through the government funded NSFNet Internet backbone. Wireless has grown rapidly in the past few years and travelers search for the wi-fi "hot spots" where they can connect while they are away from the home or office. Many airports, coffee bars, hotels and motels now routinely provide these services, some for a fee and some for free.

2.4.4 The Internet Architecture

The Internet's architecture is described in its name, a short from of the compound word "inter-networking". This architecture is based in the very specification of the standard TCP/IP protocol, designed to connect any two networks which may be very different in internal hardware, software, and technical design. Once two networks are interconnected, communication with TCP/IP is enabled end-to-end, so that any node on the Internet has the near magical ability to communicate with any other no matter where they are. This openness of design has enabled the Internet architecture to grow to a global scale. An individual's access to the Internet is often from home over a modem to a local Internet service provider who connects to a regional network connected to a national network. At the office, a desktop computer might be connected to a local area network with a company connection to a corporate Intranet connected to several national Internet service providers. In general, small local Internet service providers connect to medium-sized regional networks which connect to large national networks, which then connect to very large bandwidth networks on the Internet backbone. Most Internet service providers have several redundant network cross-connections to other providers in order to ensure continuous availability.

The companies running the Internet backbone operate very high bandwidth networks relied on by governments, corporations, large organizations, and other Internet service providers. Their technical infrastructure often includes global connections through underwater cables and satellite links to enable communication between countries and continents. Each communication packet goes up the hierarchy of Internet

networks as far as necessary to get to its destination network where local routing takes over to deliver it to the addressee. In the same way, each level in the hierarchy pays the next level for the bandwidth they use, and then the large backbone companies settle up with each other. Bandwidth is priced by large Internet service providers by several methods, such as at a fixed rate for constant availability of a certain number of megabits per second, or by a variety of use methods that amount to a cost per gigabyte. Due to economies of scale and efficiencies in management, bandwidth cost drops dramatically at the higher levels of the architecture.

In order to work properly, the architecture required a global addressing mechanism (or Internet address) to enable computers on any network to reference and communicate with computers on any other network in the federation. Internet addresses fill essentially the same role as telephone numbers do in telephone networks. The design of the Internet assumed first that the individual networks could not be changed to accommodate new architectural requirements; but this was largely a pragmatic assumption to facilitate progress. The networks also had varying degrees of reliability and speed. Host computers would have to be able to put disordered packets back into the correct order and discard duplicate packets that had been generated along the way.

A key architectural construct was the introduction of gateways and routers between the networks to handle the disparities such as different data rates, packet sizes, error conditions and interface specifications. The gateways would also check the destination Internet addresses of each packet to determine the gateway to which it should be forwarded. These functions would be combined with certain end-end information transmission.

2.4.5 The Domain Name System

The Internet evolved as an experimental system during the 1970s and early 1980s. It then flourished after the TCP/IP protocols were made mandatory on the ARPANET and other networks in January 1983; these protocols thus became the standard for many other networks as well. Indeed, the Internet grew so rapidly that the existing mechanisms for associating the names of host computers to Internet addresses (known as IP addresses) were about to be stretched beyond acceptable engineering limits. Most of the applications in the Internet referred to the target computers by name. These names had to be translated into Internet addresses before the lower level protocols could be activated to support the application. The designers of the DNS also developed seven generic "top level" domains, as follows:

- Education- EDU
- Government – GOV
- Military – MIL
- International – INT
- Network – NET

- (non-profit) Organization – ORG
- Commercial – COM
- Information – info
- Mobile devices - .mobi
- business - .biz
- museums - .museum
- individuals - .name
- Cooperatives - .coop
- Asia-pacific region - .asia
- travel and tourism industry - .travel

The Domain Name System (DNS) was and continues to be a major element of the Internet architecture, which contributes to its scalability. It also contributes to controversy over trademarks and general rules for the creation and use of domain names, creation of new top-level domains and the like.

The growth of Web servers and users of the Web has been remarkable, but some people are confused about the relationship between the World Wide Web and the Internet. The Internet is the global information system that includes communication capabilities and many high level applications. The Web is one such application. The existing connectivity of the Internet made it possible for users and servers all over the world to participate in this activity. Electronic mail is another important application. As of today, over 90 million computers take part in the Internet and about 8.6 million web sites were estimated to be accessible on the net. Virtually every user of the net has access to electronic mail and web browsing capability. Email remains a critically important application for most users of the Internet, and these two functions largely dominate the use of the Internet for most users.

Self Check Exercise-I

Q. 1 Define Internet.

Ans:.....

.....

.....

Q. 2 What is Domain Name System? Give examples.

Ans:.....

.....

.....

2.4.6 The Internet Standards Process

Each distinct version of an Internet standards-related specification is published as part of the "Request for Comments" (RFC) document series. This archival series is the official publication channel for Internet standards documents and other publications of the IESG, IAB and Internet community. RFCs can be obtained from a number of Internet hosts using anonymous FTP, gopher, World Wide Web, and other Internet document-retrieval systems. The RFC series of documents on networking began in 1969 as part of the original ARPA wide-area networking (ARPANET) project. RFCs cover a wide range of topics in addition to Internet Standards, from early discussion of new research concepts to status memos about the Internet. RFC publication is the direct responsibility of the RFC Editor, under the general direction of the IAB.

At present, the standards efforts for Internet are carried out primarily under the auspices of the Internet Society (ISOC). The Internet Engineering Task Force (IETF) operates under the leadership of its Internet Engineering Steering Group (IESG), which is populated by appointees approved by the Internet Architecture Board (IAB) which is now part of the Internet Society.

There are other bodies with considerable interest in Internet standards or in standards that must inter work with the Internet. Examples include the International Telecommunications Union Telecommunications standards group (ITU-T), the International Institute of Electrical and Electronic Engineers (IEEE) local area network standards group (IEEE 801), the Organization for International Standardization (ISO), the American National Standards Institute (ANSI), the World Wide Web Consortium (W3C), and many others.

The goals of the Internet Standards Process are:

- technical excellence.
- prior implementation and testing.
- clear, concise and easily understood documentation.
- openness and fairness and
- timeliness.

As Internet access and services are provided by existing media such as telephone, cable and broadcast, interactions with standards bodies and legal structures formed to deal with these media will become an increasingly complex matter. The intertwining of interests is simultaneously fascinating and complicated, and has increased the need for thoughtful cooperation among many interested parties.

The Internet can now be accessed virtually anywhere by numerous means. Mobile phones, data cards, handheld game consoles and cellular routers allow users to connect to the Internet from anywhere there is a cellular network supporting that device's technology. Within the limitations imposed by the small screen and other limited facilities of such a pocket-sized device, all the services of the Internet, including email

and web browsing, may be available in this way. Service providers may restrict the range of these services and charges for data access may be significant, compared to home usage.

2.4.7 The Internet security

Use of a good password is your first security defence. You should always use a password on any computer that others can access, so that no one can access your private information, use your account and impersonate you on the Internet, delete your files by mistake, etc. The most common type of password on the Internet are passwords you know, mainly alphanumeric keywords. For a reasonably secure home computer, password selection might be a less critical issue, but on networks open to the Internet there are many very real threats to administrator, network and application passwords. Many ingenious programs have been written to crack passwords at high volume, some by hackers and some as legitimate security testing tools, and are of course loose on the Internet. Many of these programs use a variety of dictionary based attacks to combine common words and word variations to try thousands of passwords as fast as the targeted system will permit. Some start by guessing a whole bunch of common passwords. Lots of people use their birthday or spouse's birthday, the name of someone from their family or friends, the name of a favorite pet, or some other high profile subject for their password. Avoid all the obvious choices, since professional hackers try these first.

If you give a site personal data like an email address, home address, phone number, birth date, or credit card number, be aware that the information can be easily cross referenced by a range of large service companies to assemble a detailed database of your buying habits, surfing patterns and interests. And it usually is. If you do give site personal information, it is a good idea to first read their Internet privacy policy to see how confidential they promise to keep it.

2.4.8 Application of Internet

1. To find general information about a subject

The Web is like a huge encyclopedia of information. The volume of information you'll find on the Web is amazing. For every topic that you've ever wondered about, there's bound to be someone who's written a Web page about it. The Web offers many different perspectives on a single topic. For example, for a selection of pages about Internet will show thousand of pages. In fact you can even find online encyclopedias. Many of these are now offering a subscription service which lets you search through the complete text of the encyclopedia. There are also many free encyclopedias that may give you a cut-down version of what you would find in a complete encyclopedia.

2. To access information not easily available elsewhere

One of the great things about the Web is that it puts information into your hands that you might otherwise have to pay for or find out by less convenient means. Online

shopping, information of product, company profile, document download, journals, books etc. can be easily accessed. It's faster and easier than writing mail and cheaper than using the telephone.

3. Communication and Social networking

The Web is generally a very friendly place. People communicate by email from strangers, and friendships are quick to form from casual correspondence. The impersonal aspect of email and chatting tends to encourage people to reveal surprisingly personal things about themselves. When you know you will never have to meet someone face-to-face, you may find it easier to tell them your darkest secrets. Cyber-friendships have often developed into real life ones too. In industries the concept of chatting is used to share the information in term of video conferencing.

4. To discuss their interests with like-minded people

Did you think you were alone in your obsession with a singer, TV programmer, author and hobby? Chances are there's and Internet group for people like you. You can share your technical, communicational, personality development skills with other people. The scientists, researchers, innovators can share their views with each other on websites and other persons can take benefit of it.

5. VoIP (Voice over Internet Protocol)

It has started from an optional two-way voice chat provided by some of the instant messaging systems that started around the year 2000. The benefit of VoIP is that it can be free or cost much less than a normal telephone call, because the Internet carries that voice traffic. VoIP is surely a cheap solution for long distance call.

7. To learn

Internet has huge knowledge of material of all the topics and subjects. You can get the on line information of any topic. Journals, Magazines, newscast letters, papers, assignments, tutorials, quizzes etc. is available on Internet. Online distance education courses can give you an opportunity to gain a qualification over the Internet.

8. To read the news

If you are in hurry to attend classes or for office work just open the internet to get the latest news on any news bulletin or news paper.

9. To find software

The Internet contains a wealth of useful downloadable shareware. Some pieces of shareware are limited versions of the full piece of software, other are time limited trials. Some shareware are free for educational institutes or for non-commercial purposes.

10.To buy things

You can do on-line shopping dealing with a reputable company for purchase of any product. Now days these type of shopping are giving good discount. The transaction of money is done mostly by credit cards. Though, transaction using such Web Sites is risky.

11.To advertise a product

Most company Web sites start up as a big advertisement for their products and services. It may be hard to see why anyone would willingly visit a 10 page advertisement but these advertisements are very useful to anyone genuinely interested in finding out about their products. Companies may also give away some information for free as an incentive for people to visit their pages.

12.To make money

A popular way to make money out of the Web is from advertising revenue. Popular sites have banners at the top of the page enticing people to click them and be taken to the advertiser's Web site. These banners are generally animated and very appealing, with mysterious messages to make users wonder where they will be taken. For each person that clicks the ad, the host site gets commission. Making money this way is only successful if the site gets lots of visitors (thousands a day); so the sites must be very useful and offer something of real value to their visitors.

13.Educational Websites

The rise of the internet has sparked new innovation into making teaching and learning much more convenient and one of the main features it presents to the college curriculum is the class website. Many classes have websites that are made specifically for the class but that's only for those who have professors who can create one ahead of time. Although, nowadays there are universal websites in which professors can just list the class under websites such as Blackboard and Web camera in which students can access it with the accounts they make under those websites. Nowadays, professors require students to create accounts in those websites because most of the time the information they put up on the website is important such as grades and homework. Overall, the convenience that class websites have put upon the class curriculum has demonstrated its effectiveness by making it easier for both professor and student.

14.Mailing System

The email is most likely one of the greatest innovations since the internet. It was become widely universal and has literally been built into the everyday lives of millions of people. The aspect of it that makes it so great is the fact that it allows instantaneous travel of information in either short distance or long distance. That convenience of it alone makes it so attractive to everyone. In the case of the college classes, not only its use is important but more towards it being required. Nowadays, most college classes require students to have email accounts and they even further enforce this during the registry process of students in the colleges as they have everyone being registered to the college create an email account under the college.

15.Webcasts

More and more technological innovations have taken place in the world of the internet and one of the most interesting ones is webcast. Webcast allows many things

like speeches, lectures and even demonstrations to be recorded and posted up online so that everyone can watch it. This brings convenience to a whole new level. In terms of its use in college classrooms, it is becoming more widely accepted and also used. Many classes, more specifically, large lectures are webcasted and students can view the lectures online. This makes it so that if they miss the lecture, they can view it anytime from anywhere there's a computer and online connection. This also makes it easier for students to enforce the material as they can re watch certain parts of the lecture over and over so they can truly learn the material. This is probably one of the most useful innovations for the college class curriculum as often times students don't go to class and this makes them make up for it.

16. File sharing

A computer file can be e-mailed to customers, colleagues and friends as an attachment. It can be uploaded to a website or FTP server for easy download by others. It can be put into a "shared location" or onto a file server for instant use by colleagues. In any of these cases, access to the file may be controlled by user authentication the transit of the file over the Internet may be obscured by encryption, and money may change hands before or after access to the file is given. The price can be paid by the remote charging of funds from, for example, a credit card whose details are also passed hopefully fully encrypted across the Internet. These simple features of the Internet, over a worldwide basis are changing the basis for the production, sale and distribution of anything that can be reduced to a computer file for transmission. This includes all manner of print publications, software products, news, music, film, video, photography, graphics and the other arts. This in turn has caused seismic shifts in each of the existing industries that previously controlled the production and distribution of these products. Internet collaboration technology enables business and project teams to share documents, calendars and other information. Such collaboration occurs in a wide variety of areas including scientific research, software development, conference planning, political activism and creative writing.

2.4.9 Summary

Internet is necessary tool to access the data, transactions, on line information, communicating the ideas, research analysis etc. The Internet provides teachers, researchers and students with countless opportunities to research and exchange information. The Internet has made it easy for government departments and agencies to communicate with other organizations and with the citizens they serve. The Internet facilitates exchanges between employees within the same company and between the company and its customers and suppliers. The Internet Protocol (IP) is the method or protocol by which data is sent from one computer to another on the Internet. The functionality of Internet is controlled by Internet architecture board which is having different standards named as protocols for different applications. Proper use of firewalls,

Anti Virus and auto protected system should be there to make smooth Internet connectivity.

2.4.10 Keywords

Internet: Internet is a vast network that connects computers all over the world.

DNS: DNS stands for Domain Name System. It is a directory service that provides a mapping between the name of a host on the network and its numerical address.

Webcast: A webcast is the simple live streaming of a presentation, meeting or physical event from a host (or hosts) to a much larger online audience.

2.4.11 Short Answer Type Questions

Q1 Define Internet?

Q2 Who is controlling the Internet facilities?

2.4.12 Long Answer Type Questions

Q1 Write a short note on history of Internet?

Q2 What is internet architecture board?

Q3 What is DNS? How the Internet standards are governed?

Q4 How internet connectivity can be made secure?

Q5 Write the applications of Internet in detail?

2.4.13 Suggested Readings

1. "Internet: The complete Reference", Young, 2002, Tata Mcgraw Hill Publishing Company Limited.
2. "Internet: The Complete Reference" 2nd Edition, 1997 by Hahan H, Tata Mcgraw Hill Publishing Company Limited.
3. "Internet Security Dictionary" by Phoha, VirV, Springer.

B.A.-I COMPUTER SCIENCE **PAPER : BCSB1101T**
(SEM- I) **FUNDAMENTALS OF IT**
LESSON NO. 2.5 **AUTHOR : DR AMARDEEP SINGH**
Converted into SLM by: Dr. Vishal Singh
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INTERNET COMPONENTS

2.5.1 Objectives

In this lesson we will study various Internet components, which are very helpful in our day to day activities. We will also learn about security threats like virus, worms etc.

2.5.2 Internet Components

The Internet, sometimes called simply "the Net," is a worldwide system of computer networks i.e. a network of networks in which users at any one computer. The main components of internet are E-mail, TELNET, WWW, Chatting, Bulletin board, Web browsers, Virus, Worms etc. Which are discussed in the following section.

2.5.2.1 WWW

World Wide Web is a type of service provided by the internet, with the help of which we can access various websites. The most widely used part of the Internet is the World Wide Web (often abbreviated "WWW" or called "the Web"). Its outstanding feature is

hypertext, a method of instant cross-referencing. In most Web sites, certain words or phrases appear in text of a different color than the rest often this text is also underlined. When you select one of these words or phrases, you will be transferred to the site or page that is relevant to this word or phrase. Sometimes there are buttons, images, or portions of images that are "clickable." If you move the pointer over a spot on a Web site and the pointer changes into a hand, this indicates that you can click and be transferred to another site.

The World Wide Web is a system of interlinked hypertext documents accessed via the Internet. With a Web browser, one can view Web pages that may contain text, images, videos and other multimedia, navigate between them using hyperlinks. Such a collection of useful, related resources, interconnected via hypertext links is named as "web" of information. The World Wide Web was created in 1989 by British scientist Tim Berners-Lee, working at the European Organization for Nuclear Research (CERN) in Geneva.

Viewing a Web page on the World Wide Web normally begins either by typing the URL of the page into a Web browser or by following a hyperlink to that page or resource. The Web browser then initiates a series of communication messages, behind the scenes, in order to fetch and display it. First, the server-name portion of the URL is resolved into an IP address using the global, distributed Internet database known as the domain name system or DNS. This IP address is necessary to contact and send data packets to the Web server.

The browser then requests the resource by sending an HTTP request to the Web server at that particular address. In the case of a typical Web page, the HTML text of the page is requested first and parsed immediately by the Web browser, which will then make additional requests for images and any other files that form a part of the page.

The five basic surfing techniques are described below:

- Surfing. You don't have to wait for a page to load to click a link, press the back button, or select a new link from your bookmarks. You can take action whenever you are ready. Jumping ahead of the browser is recommended if the link you want is already loaded but the rest of the page is lagging behind. When you click on a link as soon as it is available, you speed up and accentuate the feeling of surfing from wave to wave.
- Chains. After you click on several links and proceed through several pages, you create a chain of web sites accessible with the down-arrow beside your browser's Back button. You can click on the browser Back button to return to a previous page and read it again, and then repeatedly click forward to return to the last page without the trouble of finding the links you used last time. If you click a new link from any page, you start a new chain from that point on.

- Reloading. You can stop and then reload a page at any time if it is having problems loading or to ensure you have the latest copy of a page that updates regularly.
- Stopping. You can stop the load of any page at any time by clicking Stop on the toolbar or pressing <Esc>. The browser will display as much of the page as it loaded and all of the displayed links will be operational.
- Restarting. If a page seems to be taking a long time to load, don't hesitate to stop the connection and then select the link again. As long as the messages in the bottom border show that some parts of the page are loading then you should let it continue, but if nothing happens for more than a minute then something is likely stalled and you should stop and reload the page again.

2.5.2.2 Electronic mail (e-mail)

For many Internet users, electronic mail (e-mail) has practically replaced the Postal Service for short written transactions. Electronic mail is the most widely used application on the Net. You can also carry on live "conversations" with other computer users, using Internet Relay Chat (IRC). More recently, Internet telephony hardware and software allows real-time voice conversations. It is Short for electronic mail, which is used for the transmission of messages over communications networks. The messages can be notes entered from the keyboard or electronic files stored on disk. Most mainframes, minicomputers, and computer networks have an e-mail system. Some electronic-mail systems are confined to a single computer system or network, but others have gateways to other computer systems, enabling users to send electronic mail anywhere in the world. Companies that are fully computerized make extensive use of e-mail because it is fast, flexible and reliable.

Most e-mail systems include a text editor for composing messages, but many allow you to edit your messages using any editor you want. You then send the message to the recipient by specifying the recipient's address. You can also send the same message to several users at once. This is called broadcasting. You should copy and paste addresses into the To field instead of typing them for both ease of use and accuracy. If it is an address you will use again, then you should always enter it in your address book. If you want to send an email to more than one person at once, you can enter multiple email addresses separated with commas in any of the address fields, including the bcc field.

Sent messages are stored in electronic mailboxes until the recipient fetches them. To see if you have any mail, you may have to check your electronic mailbox periodically, although many systems alert you when mail is received. After reading your mail, you can store it in a text file, forward it to other users or delete it. Copies of mail can be printed out on a printer if you want a paper copy.

Usually, it takes only a few seconds or minutes for mail to arrive at its destination. This is a particularly effective way to communicate with a group because you can broadcast a message or document to everyone in the group at once. Although different e-

mail systems use different formats, there are some emerging standards that are making it possible for users on all systems to exchange messages. Some of the examples of Email provider are Yahoo, Google, Rediff, sify etc.

2.5.2.3 Telnet

Telnet is a user command and an underlying TCP/IP protocol for accessing remote computers. Through Telnet, an administrator or another user can access someone else's computer remotely. On the Web, HTTP and FTP protocols allow you to request specific files from remote computers, but not to actually be logged on as a user of that computer. With Telnet, you log on as a regular user with whatever privileges you may have been granted to the specific application and data on that computer. Telnet is most likely to be used by program developers and anyone who has a need to use specific applications or data located at a particular host computer.

The Telnet program runs on your computer and connects your PC to a server on the network. You can then enter commands through the Telnet program and they will be executed as if you were entering them directly on the server. This enables you to control the server and communicate with other servers on the network. To start a Telnet session, you must log in to a server by entering a valid username and password. Telnet is a common way to remotely control Web servers.

The telnet commands allow you to communicate with a remote computer that is using the Telnet protocol. You can run telnet without parameters in order to enter the telnet context, indicated by the Telnet prompt (telnet>).

2.5.2.4 Chatting

On the Internet, chatting is talking to other people who are using the Internet at the same time you are. Usually, this "talking" is the exchange of typed-in messages requiring one site as the repository for the messages (or "chat site") and a group of users who take part from anywhere on the Internet. In some cases, a private chat can be arranged between two parties who meet initially in a group chat. Chats can be ongoing or scheduled for a particular time and duration. Most chats are focused on a particular topic of interest and some involve guest experts or famous people who "talk" to anyone joining the chat.

Chats are conducted on online services by bulletin board services, and by Web sites. Several Web sites, notably America Online, Yahoo, Google Talk, Orkut etc. exist solely for the purpose of conducting chats. Chatting can also be used for simulated or virtual reality environment which helps in video conferencing for companies, education program, research etc. Videoconferencing provides students with the opportunity to learn by participating in a 2-way communication platform. Furthermore, teachers and lecturers from all over the world can be brought to classes in remote or otherwise isolated places. Students from diverse communities and backgrounds can come together to learn about one another. Students are able to explore, communicate, analyze and

share information and ideas with one another. Through videoconferencing students can visit another part of the world to speak with others, visit a company, a museum and so on, to learn.

Internet Relay Chat (IRC) is a system for chatting that involves a set of rules and conventions and client/server software. On the Web, certain sites such as Talk City or IRC networks such as the Undernet provide servers and help you download an IRC client to your PC. You can start a chat group (called a channel) or join an existing one. There is a protocol for discovering existing chat groups and their members. Depending on the type of network, nicknames can be reserved (registered) or just used during the session. Some channels encourage you to register a nickname that you always use and even offer space for a personal profile, picture, and personal home page link.

2.5.2.5 Bulletin board

Bulletin board system (BBS) is a computer or an application dedicated to the sharing or exchange of messages or other files on a network. A BBS may be accessible from a dial-up modem, Telnet or the Internet. BBS interface is a text-based. Although recent Web-based versions have a graphical, interactive user interface, the text-only interface preferred by BBS purists can often be accessed by Telnet. Most BBS are devoted to a particular subject, although some are more general in nature. Among special interests represented on BBS are dentistry, law, guns and multi-player games.

The BBS is often free, although some charge a membership or use fee. Many BBS have Web sites, and many Internet access providers have bulletin board systems from which new Internet users can download the necessary software to get connected. Despite the vastly greater reach of the Internet, the BBS is still fairly common in parts of the world where the Internet is less established and is still valued by many with Internet access for its ability to promote a sense of community.

2.5.2.6 Web Browsers

Web browser is a piece of software which provides the interface between the user and Internet. Using the Web, you have access to millions of pages of information. Web browsing is done with a Web browser. A web browser is a software application which enables a user to display and interact with text, images, videos, music, games and other information typically located on a Web page at a website on the World Wide Web or a local area network. Text and images on a Web page can contain hyperlinks to other Web pages at the same or different website. Web browsers allow a user to quickly and easily access information provided on many Web pages at many websites by traversing these links. Web browsers format HTML information for display, so the appearance of a Web page may differ between browsers.

Some of the Web browsers currently available for personal computers include Internet Explorer, Mozilla Firefox, Netscape, Google Chrome and AOL Explorer etc. Web browsers are the most commonly used type of HTTP. Although

browsers are typically used to access the World Wide Web, they can also be used to access information provided by Web servers in private networks or content in file systems.

Web browsers communicate with Web servers primarily using HTTP (hypertext transfer protocol) to fetch web pages. HTTP allows Web browsers to submit information to Web servers as well as fetch Web pages from them. Pages are located by means of a URL (uniform resource locator), which is treated as an address, beginning with http: for HTTP access. Many browsers also support a variety of other URL types and their corresponding protocols, such as gopher: for Gopher (a hierarchical hyperlinking protocol), ftp: for FTP (file transfer protocol) etc. The combination of HTTP content type and URL protocol specification allows Web page designers to embed images, animations, video, sound and streaming media into a Web page, or to make them accessible through the Web page.

Early Web browsers supported only a very simple version of HTML. The rapid development of proprietary Web browsers led to the development of non-standard dialects of HTML, leading to problems with Web interoperability. Modern Web browsers support a combination of standards and dynamic HTML and XHTML, which should display in the same way across all browsers. Currently many sites are designed using HTML generation programs such as Adobe, Dreamweaver or Microsoft FrontPage. The appearance of a particular Web site may vary slightly depending on the browser you use. Also, later versions of a particular browser are able to render more "bells and whistles" such as animation, virtual reality, sound, and music files than earlier versions.

Self Check Exercise-I

Q.1 Define WWW.

Ans:.....

.....

Q.2 What is Telnet?

Ans:.....

.....

2.5.3 Virus

It is a program or piece of code that is loaded onto your computer without your knowledge and runs against your wishes. Viruses can also replicate themselves. All computer viruses are manmade. A simple virus that can make a copy of itself over and over again is relatively easy to produce. Even such a simple virus is dangerous because it will quickly use all available memory and bring the system to a halt. An even

more dangerous type of virus is one capable of transmitting itself across networks and bypassing security systems.

Since 1987, when a virus infected ARPANET, a large network used by the Defense Department and many universities, many antivirus programs have become available. These programs periodically check your computer system for the best-known types of viruses.

A computer virus is a small program written to alter the way a computer operates, without the permission or knowledge of the user. A virus must meet two criteria:

1. It must execute itself. It often places its own code in the path of execution of another program.
2. It must replicate itself. For example, it may replace other executable files with a copy of the virus infected file. Viruses can infect desktop computers and network servers alike.

Some viruses are programmed to damage the computer by damaging programs, deleting files, or reformatting the hard disk. Others are not designed to do any damage, but simply to replicate themselves and make their presence known by presenting text, video and audio messages. Even these viruses can create problems for the computer user. They typically take up computer memory used by legitimate programs. As a result, they often cause erratic behavior and can result in system crashes. In addition, many viruses are bug-ridden and these bugs may lead to system crashes and data loss. Computer viruses of one kind or another have infected the Internet since its very first years of existence. Virus protection is now required technology for everyone that uses the Internet.

Signs that your computer might have a virus could include spontaneous startup of programs like email programs, unexplained attempts by programs on your computer to access the Internet, changes in file date stamps, unusually slow program load or run times, lots of unexplained disk activity or failure of a program or your computer to start. However, if you have an anti-virus protection running, then problems like a slow computer or lots of disk activity are most likely caused by an inefficient system configuration, not enough memory, a fragmented disk, or other benign causes, since most viruses won't give any visible signs.

Some viruses are only annoying, displaying a message, using extra memory or disk, or changing file names. However, some are destructive and will change files and erase data, and some will erase your entire hard drive. Some run silently in the background and give outside agent’s complete control of your computer without your knowledge whenever you are connected to the Internet.

2.5.3.1 Types of viruses

1. File infector viruses

File infector viruses infect program files. These viruses normally infect executable code, such as .com and .exe files. The can infect other files when an infected program is run from floppy, hard drive or from the network. Many of these viruses are memory resident. After memory becomes infected, any non infected executable that runs becomes infected. Examples of known file infector viruses include Jerusalem and Cascade.

2. Boot sector viruses

   Boot sector viruses infect the system area of a disk; that is, the boot record on floppy disks and hard disks. All floppy disks and hard disks (including disks containing only data) contain a small program in the boot record that is run when the computer starts up. Boot sector viruses attach themselves to this part of the disk and activate when the user attempts to start up from the infected disk. These viruses are always memory resident in nature. Most were written for DOS, but, all PCs, regardless of the operating system, are potential targets of this type of virus. All that is required to become infected is to attempt to start up your computer with an infected floppy disk thereafter, while the virus remains in memory, all floppy disks that are not write protected will become infected when the floppy disk is accessed. Examples of boot sector viruses are Form, Disk Killer, Michelangelo, and Stoned.

3. Master boot record viruses

   Master boot record viruses are memory-resident viruses that infect disks in the same manner as boot sector viruses. The difference between these two virus types is where the viral code is located. Master boot record infectors normally save a legitimate copy of the master boot record in a different location. Windows NT computers that become infected by either boot sector viruses or master boot sector viruses will not boot. This is due to the difference in how the operating system accesses its boot information, as compared to Windows 98/ME. Examples of master boot record infectors are NYB, AntiExe and Unashamed.

4. Multipartite viruses

   Multipartite viruses infect both boot records and program files. These are particularly difficult to repair. If the boot area is cleaned, but the files are not, the boot area will be re infected. The same holds true for cleaning infected files. If the virus is not removed from the boot area, any files that you have cleaned will be re infected. Examples of multipartite viruses include One_Half, Emperor, Anthrax and Tequilla.

5. Macro viruses

   These types of viruses infect data files. They are the most common and have cost corporations the most money and time trying to repair. Macro viruses infect Microsoft Office Word, Excel, PowerPoint and Access files. Newer strains are now turning up in other programs as well. All of these viruses use another program's internal

programming language, which was created to allow users to automate certain tasks within that program. Because of the ease with which these viruses can be created, there are now thousands of them in circulation. Examples of macro viruses include W97M.Melissa, WM.NiceDay and W97M.Groov.

Self Check Exercise-II

Q.3 What is a Virus?

Ans:.....

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2.5.4 Worms

A worm is similar to a virus by design and is considered to be a sub-class of a virus. Worms spread from computer to computer, but unlike a virus, it has the capability to travel without any human action. A worm takes advantage of file or information transport features on your system, which is what allows it to travel unaided. The biggest danger with a worm is its capability to replicate itself on your system, so rather than your computer sending out a single worm, it could send out hundreds or thousands of copies of itself, creating a huge devastating effect. One example would be for a worm to send a copy of itself to everyone listed in your e-mail address book. Then, the worm replicates and sends itself out to everyone listed in each of the receiver's address book, and the manifest continues on down the line. Due to the copying nature of a worm and its capability to travel across networks the end result in most cases is that the worm consumes too much system memory (or network bandwidth), causing Web servers, network servers and individual computers to stop responding. In recent worm attacks such as the much-talked-about Blaster Worm, the worm has been designed to tunnel into your system and allow malicious users to control your computer remotely.

Some people distinguish between general viruses and worms. A worm is a special type of virus that can replicate it and use memory, but cannot attach it to other programs. Worms are programs that replicate themselves from system to system without the use of a host file. This is in contrast to viruses, which requires the spreading of an infected host file. Although worms generally exist inside of other files, often Word or Excel documents, there is a difference between how worms and viruses use the host file. Usually the worm will release a document that already has the "worm" macro inside the document. The entire document will travel from computer to computer, so the entire document should be considered the worm.

Worms spread by exploiting vulnerabilities in operating systems. All vendors supply regular security updates. Users need to be wary of opening unexpected email, and should not run attached files or programs, or visit web sites that are linked to such

emails. Anti-virus and anti-spyware software are helpful, but must be kept up-to-date with new pattern files at least every few days. The use of a firewall is also recommended.

2.5.5 General precautions

1. Be suspicious of email attachments from unknown sources.
2. Verify that attachments have been sent by the author of the email. Newer viruses can send email messages that appear to be from people you know.
3. Do not set your email program to "auto-run" attachments.
4. Obtain all Microsoft security updates.
5. Back up your data frequently. Keep the write-protected media in a safe place preferably in a different location than your computer.
6. Specific to AntiVirus.
7. Make sure that you have the most recent virus definitions. It is recommended that you run LiveUpdate at least once per week. Symantec Security Response updates virus definitions in response to new virus threats.
8. Scan all new software before you install it. Because boot sector viruses spread by floppy disks and bootable CDs, every floppy disk and CD should be scanned for viruses. Shrink-wrapped software, demo disks from suppliers, and trial software are not exempt from this rule. Viruses have been found even on retail software.

Use caution when opening email attachments. Email attachments are a major source of virus infections. Microsoft Office attachments for Word, Excel and Access can be infected by Macro viruses. Other attachments can contain file infector. Software programs such as antivirus software are the most useful in protecting your computer from harmful viruses. These programs are used to detect and eliminate viruses. Anti-virus software can be purchased from any software vendor or downloaded off the internet. Care should be taken in the selection of anti-virus software, as some programs are not very affective in finding and eliminating viruses. Also, when downloading anti-virus software from the Internet, one should be cautioned that some websites say they are providing protection from viruses with their software, but they are really trying to install Anti Virus on your computer by disguising it as something else.

2.5.6 Summary

To know about the world wide information Internet is used. Today it is the necessary tool for daily usages. Its components and services like WWW, chatting, Email, Web Browsing are used for communicating and receiving the required information. The World Wide Web is a way of accessing information over the medium of the Internet. It is an information-sharing model that is built on top of the Internet. The Web uses the HTTP protocol, only one of the languages spoken over the Internet, to transmit data. Web services, which use HTTP to allow applications to communicate in order to exchange business logic, use the Web to share information. The Web also utilizes web browsers. Since the computers are explored to outer world through internet, there is possibility of

Viruses and worm. The types of Viruses and how to protect your desktop from malicious programs are also discussed in this lesson.

2.5.7 Keywords

WWW: The World Wide Web (WWW) is a system of interconnected public web pages accessible through the Internet

Telnet: It is a text-based network protocol that facilitates remote computer access.

Web browser: The web browser is application software to explore WWW.

Virus: A computer virus is a type of malicious software, or malware that spreads between computers and causes damage to data and software.

2.5.8 Short Answer Type Questions

Q1 What is BBS?

Q2 What is Web Browser?

Q3 Why we are using the Telnet Protocol?

2.5.9 Long Answer Type Questions

Q1 Write the functioning of E-mail?

Q2 What are the benefits of Videoconferencing?

Q3 List various Web browsers and there advantages?

Q4 Explain different types of Viruses?

Q5 How Worm is different from virus?

Q6 Write the precautions for making your Personal computer risk free?

2.5.10 Suggested Readings

1. “Internet: The complete Reference”, Young, 2002, Tata Mcgraw Hill Publishing Company Limited.
2. “Computers Today”, Sanders, D., Tata McGraw-Hill.
3. “PC Software for Windows Made Simple”, R.K.Taxali, TMH.

Advanced Trends in IT

Objectives: In this lesson we will study about advanced trends in information technology, which are very helpful in our day to day activities. We will also learn about social networking platforms like Facebook, Linkedin, Twitter etc.

2.6.1 Introduction

Emerging trends in information technology include the widespread adoption of technologies like mobile internet, Wi-Fi, 3G and 4G etc which are revolutionizing connectivity, enabling faster and more reliable communication for a wide range of devices. Various other advanced information technology trends are also discussed in this lesson

2.6.2 Mobile Internet

Mobile internet, often referred to as mobile web or wireless internet, allows users to access the internet and its resources using mobile devices such as smartphones, tablets and mobile hotspots. This technology leverages cellular networks and wireless connections to provide users with online access while on the go. Mobile internet has become an integral part of modern life, offering several key features:

1. **Everywhere Connectivity**: With mobile internet, users can connect to the web from virtually anywhere, ensuring constant access to information, communication and online services.
2. **Information Access**: It allows users to browse websites, search for information and access online content, including news, social media and entertainment, on their mobile devices.
3. **Communication**: Mobile internet supports various forms of communication, including email, instant messaging, voice and video calls and social media, keeping people connected in real-time.
4. **E-commerce and Transactions**: Users can shop online, conduct financial transactions, and access mobile banking services, making it convenient for both consumers and businesses.
5. **Navigation and Location-based Services**: Mobile internet is essential for GPS navigation, mapping applications and location-based services, facilitating travel and way finding.
6. **App Ecosystem**: It supports mobile apps, offering a wide range of services and entertainment options through app stores, enhancing the functionality of mobile devices.
7. **Work and Productivity**: Mobile internet enables remote work, document sharing and cloud-based collaboration tools, increasing productivity and flexibility in the workplace.
8. **Entertainment**: Users can stream videos, music and games on mobile devices, providing on-the-go entertainment options.

Mobile internet has significantly transformed how individuals access and interact with the digital world. It continues to evolve with the rollout of faster and more reliable mobile networks, ensuring that users can stay connected and accesses the resources they need whenever and wherever they are.

2.6.3 Global Positioning System (GPS)

GPS or Global Positioning System is a satellite-based navigation system that enables users to determine their precise location, velocity and time anywhere on Earth. It consists of a network of satellites orbiting the planet, ground stations and user devices like GPS receivers in smartphones, vehicles and various other applications.

The GPS system works by triangulating signals from multiple satellites to pinpoint the user's exact coordinates. Each satellite continuously broadcasts a signal that includes its precise location and the current time. GPS receivers use these signals to calculate the distance to each satellite and through a process known as trilateration, they determine the user's location. GPS has a wide range of applications, from providing driving directions and location-based services to guiding aircraft, supporting military operations and aiding in search and rescue efforts. It has become an indispensable tool for navigation, mapping and positioning in both everyday life and specialized fields.

2.6.4 3G

3G or third-generation is a mobile telecommunications technology that succeeded 2G (second-generation) networks. It offers faster data transfer speeds, enabling advanced mobile services beyond voice calls and text messages. 3G networks provide broadband-like connectivity and support multimedia services, including video calling, mobile internet access and mobile TV. This technology, introduced in the early 2000s, was a significant leap forward in mobile communications and laid the groundwork for the development of subsequent generations, such as 4G and 5G. While 3G networks have been succeeded by more advanced technologies, they continue to provide essential mobile connectivity in regions where newer generations may not be widely available.

2.6.5 4G

4G or fourth-generation is a mobile telecommunications standard that succeeded 3G (third-generation) networks. It represents a significant advancement in wireless communication, offering higher data transfer speeds, low latency and improved network reliability. With 4G technology, users experience faster internet access, smoother video streaming and enhanced mobile gaming. It also paved the way for a range of new applications and services, including high-definition video conferencing, mobile hotspot functionality and the widespread use of mobile apps. 4G networks are designed to handle the growing demand for mobile data, supporting the ever-increasing number of smartphones and connected devices.

Self check exercise-I

Q1. What is GPS?

Ans.....

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Q2. What is 4G?

Ans.....

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2.6.6 wi-fi

Wi-Fi or Wireless Fidelity is a technology that allows electronic devices to connect to a local area network (LAN) or the internet without the need for physical cables. It operates using radio waves to transmit data between a wireless router or access point and Wi-Fi-enabled devices like smartphones, laptops, tablets and smart home devices. Wi-Fi networks are prevalent in homes, businesses, public spaces and educational institutions, providing convenient and flexible internet connectivity.

Wi-Fi technology has evolved over the years, with various standards and frequencies, such as 2.4 GHz and 5 GHz, offering different capabilities and data transfer speeds. It enables users to browse the web, stream media, send emails and use various online services from virtually anywhere within the range of the Wi-Fi network. The convenience and mobility offered by Wi-Fi have transformed the way people work, communicate and access information, making it an integral part of modern connectivity and a fundamental component of our increasingly interconnected world.

2.6.7 Bluetooth

Bluetooth is a wireless technology standard used for short-range communication between electronic devices. It enables data exchange and connectivity between devices like smartphones, headphones, speakers and IoT devices without the need for physical cables. Bluetooth operates on radio waves in the 2.4 GHz frequency range and is characterized by its low power consumption. It facilitates various applications, such as wireless audio streaming, file sharing and device pairing. Bluetooth has evolved through different versions, each offering improved data transfer speeds and enhanced functionalities. It plays a crucial role in creating a wireless ecosystem that simplifies device interconnectivity and is widely integrated into modern consumer electronics and smart home systems.

2.6.8 Cloud Technology

Cloud technology, often referred to as cloud computing, is a paradigm that delivers various computing services over the internet. Instead of relying on local servers or personal devices to handle data and applications, cloud technology allows users to access and utilize resources hosted in remote data centers. These resources include computing power, storage, databases, networking, software and more.

Cloud technology offers several key advantages:

1. **Scalability**: Users can easily scale up or down based on their needs, without the need for significant infrastructure investments.
2. **Cost Efficiency**: Pay-as-you-go models reduce capital expenses and users only pay for the resources they use.
3. **Flexibility**: Cloud technology supports a wide range of applications and services, from web hosting and data storage to machine learning and artificial intelligence.
4. **Accessibility**: Users can access their data and applications from anywhere with an internet connection, fostering remote work and collaboration.
5. **Reliability and Redundancy**: Cloud providers ensure high availability and data redundancy, reducing the risk of data loss and downtime.
6. **Security**: Cloud providers invest in robust security measures to protect data and infrastructure.

Popular cloud providers include Amazon Web Services (AWS), Microsoft Azure and Google Cloud Platform, each offering a variety of services to cater to diverse business and individual needs. Cloud technology has transformed the way businesses and individuals manage and leverage technology resources, fostering innovation and efficiency in the digital age.

2.6.9 Virtual LAN technology

Virtual LAN (VLAN) technology is a network configuration that enables the segmentation of a physical network into multiple virtual networks or VLANs. Each VLAN operates as an independent network, even though they share the same physical infrastructure. VLANs are created to enhance network management, security and efficiency. Devices in the same VLAN can communicate as if they are on the same physical network, while communication between devices in different VLANs typically requires routing. VLANs are commonly used to isolate traffic, improve network performance and enhance security by separating devices into logical groups, such as separating guest Wi-Fi from the main network or segregating departments in an organization while using the same network infrastructure.

2.6.10 Firewall

A firewall is a network security device or software that acts as a protective barrier between a trusted internal network and untrusted external networks, such as the internet. It monitors and controls incoming and outgoing network traffic based on predetermined security rules, policies and access controls. Firewalls are designed to prevent unauthorized access, protect against cyber threats and filter potentially harmful data, such as viruses and malware. They can be implemented as hardware appliances or as software running on servers, routers or even individual devices. Firewalls are a fundamental component of network security, helping to safeguard data and maintain the integrity and confidentiality of network resources.

2.6.11E-Commerce

E-commerce, short for electronic commerce, is a business model that involves buying and selling products or services over the internet. It has transformed the way we conduct trade and has become an integral part of the modern economy. E-commerce encompasses a wide range of online activities, from online shopping platforms like Amazon and eBay to digital marketplaces and subscription-based services. Key elements of e-commerce include online storefronts, secure payment gateways, digital marketing and efficient logistics. Consumers can browse, compare and purchase products or services from the comfort of their homes, while businesses can reach a global audience and expand their market reach.

E-commerce offers numerous benefits, such as convenience, accessibility and cost-efficiency. It has also driven innovations like mobile commerce (m-commerce), where transactions occur on mobile devices and has paved the way for new business models like dropshipping and affiliate marketing. As e-commerce continues to evolve, it presents both opportunities and challenges for businesses and consumers, including data security and privacy concerns, competition and the need for effective digital marketing strategies.

2.6.12 M-Commerce

Mobile commerce, often referred to as m-commerce, is a subset of e-commerce that involves the buying and selling of products and services using mobile devices, such as smartphones and tablets. M-commerce leverages the capabilities of mobile technology to facilitate online transactions, providing users with the ability to shop, pay and conduct business activities while on the go. Key aspects of m-commerce include mobile apps, mobile-optimized websites, mobile wallets and mobile payment solutions. It enables users to browse and purchase products, make mobile payments, book travel tickets and access various services directly from their mobile devices.

M-commerce offers several advantages, including convenience, accessibility and the ability to reach a wide audience. It has transformed the retail industry, with businesses optimizing their online presence for mobile platforms and offering features like mobile loyalty programs and location-based marketing. As mobile technology continues to advance, m-commerce is expected to further expand its reach and influence in various industries, making it a pivotal part of the modern digital economy.

Self Check Exercise-II

Q1. What is Wi-Fi?

Ans.....

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Q2. What is M-Commerce?

Ans.....

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2.6.13 Nanotechnology

Nanotechnology is a multidisciplinary field that involves manipulating matter at the nanoscale, typically dealing with structures and materials at the atomic or molecular level. It focuses on designing, creating and utilizing structures, devices and systems with unique properties and applications due to their small size. Nanotechnology has diverse applications in various fields, including medicine, electronics, materials science and energy. It enables the development of novel materials, nanoelectronics, targeted drug delivery systems and efficient energy storage. The ability to engineer matter at the nanoscale opens up exciting possibilities for innovation, revolutionizing industries and potentially addressing complex challenges in science and technology.

2.6.14 Virtual reality

Virtual reality (VR) is an immersive technology that uses computer-generated environments to simulate a realistic sensory experience. It typically involves the use of headsets or other devices that provide users with a 360-degree, three-dimensional view of a virtual world. VR aims to create a sense of presence, where users feel as though they are physically present in the virtual environment.

VR technology has diverse applications, including gaming, education, healthcare, training, and entertainment. In gaming, VR provides players with an interactive and lifelike experience, while in education; it offers immersive simulations for hands-on

learning. In healthcare, VR can aid in pain management, therapy and surgical training. It's also used in architectural and industrial design for visualizing prototypes and simulating scenarios. Advancements in VR technology continue to drive innovation, making it a promising tool for enhancing user experiences and solving real-world problems in various industries.

2.6.15 BPO and KPO

Business Process Outsourcing (BPO) and Knowledge Process Outsourcing (KPO) are two distinct types of outsourcing services that organizations use to streamline their operations and enhance efficiency.

1. **BPO (Business Process Outsourcing)**: BPO involves outsourcing specific non-core, repetitive and standardized business processes or tasks to a third-party service provider. These processes can include customer support, data entry, payroll processing, human resources management and call center operations. BPO aims to reduce costs, increase operational flexibility and improve the quality of these processes while allowing the organization to focus on its core competencies.
2. **KPO (Knowledge Process Outsourcing)**: KPO, on the other hand, goes beyond standardized tasks and focuses on outsourcing more complex, knowledge-based activities. These activities often require specialized expertise, research, analysis, and problem-solving skills. KPO services can include market research, financial analysis, legal services, healthcare research and intellectual property research. KPO aims to tap into specialized knowledge and skills while reducing costs and improving accuracy.

Both BPO and KPO are valuable strategies for organizations to gain a competitive edge by optimizing their operational efficiency, reducing costs and accessing specialized skills and knowledge. The choice between BPO and KPO depends on the nature of the processes or tasks being outsourced and the specific needs of the organization.

2.6.16 Online Shopping

Online shopping, also known as e-commerce, has revolutionized the way people purchase goods and services. It offers a convenient and accessible shopping experience, allowing consumers to browse and buy products from the comfort of their homes or on the go using computers and mobile devices. Online retailers provide an extensive variety of products, often exceeding the selection found in physical stores, and shoppers can easily compare prices and find the best deals across multiple platforms. Customer reviews and product recommendations further assist in making informed purchase decisions. With the advantage of 24/7 accessibility, online shopping accommodates

diverse schedules and physical limitations, delivering products right to the customer's doorstep. Many e-commerce platforms also use data-driven personalization to offer tailored shopping experiences, making the process more engaging and efficient. While online shopping offers numerous benefits, it has raised concerns regarding security, privacy and the impact on traditional retail businesses. However, as technology and security measures continue to evolve, online shopping is poised to remain a dominant and continually improving facet of the retail landscape.

2.6.17 Social Media

Social media refers to online platforms and websites that facilitate social networking and the creation, sharing and exchange of information, ideas and content. Users can connect, communicate and interact with others, share text, images, videos and engage in various forms of online communities and social interactions. Social media is a ubiquitous and transformative phenomenon in the digital age, fundamentally altering the way people connect, communicate and share information. It encompasses a broad range of online platforms and applications that enable users to create profiles, share content and engage with others. These platforms include Facebook, Twitter, Instagram, LinkedIn and many more.

Social media's key features typically involve creating user profiles, making connections with others and sharing various forms of content, including text, photos, videos and links. Users can interact by liking, commenting, sharing and sometimes even live-streaming. These platforms have become a primary means of personal and professional communication, enabling individuals to connect with friends and family, express their thoughts and access news and entertainment.

Social media also plays a substantial role in business and marketing, providing opportunities for brand promotion, customer engagement and advertising. Additionally, it has been influential in shaping public discourse, sparking social movements, and disseminating information, both positively and negatively. The impact of social media on society, from privacy concerns to mental health implications, is a subject of ongoing debate and research. Despite its challenges, social media continues to be a significant part of contemporary culture, offering various benefits and challenges as it shapes how we communicate and engage in the digital world.

2.6.18 YouTube

YouTube, established in 2005, is a multimedia powerhouse and a cornerstone of the digital age. It is a globally recognized video-sharing platform that has transformed the way we create, share and consume video content. Acquired by Google in 2006, YouTube has become one of the most influential and widely used social media platforms globally.

Users can upload, view, like, comment on, and interact with an extensive array of videos on YouTube. Its content spans the spectrum, from user-generated vlogs, educational tutorials and music videos to professionally produced documentaries, entertainment shows and live streaming events.

YouTube's impact on popular culture, entertainment, education and information dissemination is immeasurable. It has given rise to countless content creators, influencers and internet celebrities who have cultivated large and dedicated followings. The platform's features, such as subscriptions, playlists and recommendations, offer a personalized user experience, keeping viewers engaged. Furthermore, YouTube's monetization options, including advertising revenue, channel memberships and merchandise shelf integration, have turned it into a viable career for many creators. Live streaming, premieres and community posts foster audience interaction and engagement.

Despite challenges related to content moderation, copyright issues, and algorithmic recommendations, YouTube remains a dominant force in the digital landscape, influencing trends, shaping online culture and serving as an essential platform for entertainment, education and expression.

2.6.19 Facebook

Facebook, founded in 2004 by Mark Zuckerberg and his college roommates, is one of the most influential and widely used social media platforms in the world. It has fundamentally transformed how people connect, communicate and share in the digital age. Facebook enables users to create personal profiles, connect with friends and family, and share various forms of content, including text posts, photos, videos and links. The platform's features include the News Feed, where users can see updates from their connections, as well as the ability to join or create Facebook Groups, Pages and Marketplace listings, catering to various interests, communities and commerce.

Facebook has played a pivotal role in reshaping online social interaction, but it has also faced scrutiny and challenges related to user privacy, data security and content moderation. The platform is a hub for news dissemination, event organization, business promotion and personal expression. Through acquisitions like Instagram and WhatsApp, Facebook has expanded its influence, making it a significant player in the social media and technology industry. It has introduced features such as Facebook Live, Stories, and Watch, further diversifying its offerings and keeping users engaged. Despite its achievements and controversies, Facebook remains an integral part of the digital landscape, connecting people across the globe and shaping online culture and communication.

2.6.20 Linkedin

LinkedIn, founded in 2002, is a professional networking platform and social media site that has become the premier destination for career development and business connections. It allows users to create and manage professional profiles, connect with colleagues and industry peers and engage in a wide range of professional activities. LinkedIn's primary features include the ability to showcase one's work experience, skills and qualifications, connect with others in the professional sphere and seek or post job opportunities. Users can also share updates, articles and insights related to their fields, positioning LinkedIn as a hub for business-related content and networking.

The platform has become an essential tool for job seekers, recruiters, businesses and professionals looking to expand their networks, build relationships and stay updated on industry trends. LinkedIn Premium offers additional features for more dedicated users, such as enhanced visibility and messaging options. LinkedIn's influence extends to industries like recruitment, professional development, and B2B marketing, making it a valuable resource for individuals and organizations seeking to harness the power of professional networking and personal branding.

2.6.21 Twitter

Twitter, established in 2006, is a renowned social media platform that has redefined the way people communicate, share information and engage with the world. It enables users to create accounts, post and interact with short messages known as "tweets" of up to 280 characters, making it a concise and dynamic medium for global conversation. Key features of Twitter include hashtags, which organize and categorize topics, retweets for sharing and amplifying content and likes for showing approval. The platform's real-time nature has made it a vital source for breaking news, trending topics and viral content. It empowers individuals, influencers, organizations and public figures to disseminate information, express opinions, and engage with diverse audiences.

Twitter's impact extends to politics, activism, marketing, customer service and more. It has been instrumental in shaping public discourse and social movements. Twitter also supports multimedia, enabling the sharing of images, videos and live broadcasts. The introduction of features like Twitter Moments and Twitter Spaces has expanded its functionality. Twitter remains an influential and dynamic part of the digital and social media landscape, connecting millions of users worldwide and facilitating global conversations on an array of topics in real time.

2.6.22 Google+

Google+, often referred to as Google Plus, was a social networking platform launched by Google in 2011. It was designed to compete with other social media giants like Facebook and Twitter. Google+ allowed users to create profiles, connect with friends and

acquaintances, and share content such as posts, photos and videos. One distinctive feature of Google+ was its use of "Circles," which allowed users to organize their connections into different groups, making it easy to share specific content with particular audiences. It also introduced the concept of "Hangouts" for video chats and "Communities" for discussions on various topics.

Despite Google's efforts to promote Google+, it faced challenges in gaining widespread user adoption, particularly as it entered a highly competitive social media landscape. In 2019, Google announced the discontinuation of Google+ for consumers due to low usage and security concerns, ultimately shutting down the platform in April 2019. While Google+ as a consumer social network is no longer available, Google's core services like search, Gmail, YouTube, and Google Photos continue to be widely used, and Google Workspace (formerly G Suite) incorporates collaboration features for businesses and organizations.

2.6.23 Summary

In this lesson we have discussed about wireless technologies which involve the transmission of data without physical cables or wires. Key examples include Wi-Fi, providing wireless local area network (WLAN) connectivity; Bluetooth, facilitating short-range wireless communication between devices; and cellular networks, enabling mobile communication through technologies like 3G and 4G. These technologies support the seamless exchange of information, enhancing mobility and connectivity in various domains. We have also discussed about Social media platforms, which are online spaces that enable users to create and share content, connect with others and engage in virtual communities. Examples include Facebook, a widely used platform for personal networking; Twitter, emphasizing short-form text updates; and LinkedIn, focused on professional networking and career development. These platforms play a significant role in global communication and information dissemination.

2.6.24 Keywords

GPS: It is a satellite-based navigation system in which two or more signals, received from satellites are used to determine the receiver's position on the globe.
wi-fi: It is a wireless networking technology that uses radio waves to provide wireless high-speed Internet access.
Cloud Technology: cloud technology means having the ability to store and access data and programs over the internet instead of on a hard drive.
Firewall: It is a network security device that monitors incoming and outgoing network traffic and decides whether to allow or block specific traffic based on a defined set of security rules.

2.6.25 Short Answer Type Questions

1. What is the difference between 3G and 4G?

2. Define Bluetooth
3. What is VLAN?
4. What is Nanotechnology?

2.6.26 Long Answer Type Questions

1. What is Cloud technology? What are its advantages and disadvantages?
2. Define Firewall. What are the benefits of using firewall?
3. Define E-Commerce. What are the advantages and disadvantages of E-Commerce?
4. What is Social Media? Discuss popular social media platforms in detail.

2.6.27 Suggested Readings

- "Internet: The complete Reference", Young, 2002, Tata Mcgraw Hill Publishing Company Limited.
- "Computers Today", Sanders, D., Tata McGraw-Hill.
- "PC Software for Windows Made Simple", R.K.Taxali, TMH.

Applications of IT

Objectives: In this lesson we will study about applications of information technology in various areas of our society like in business and industry, education, science and technology, entertainment etc. We will also learn about currents trends in IT like AI, Voice recognition, robots, multimedia, virtual reports etc.

2.7.1 Introduction

Information technology plays a pivotal role in various fields. In education, it facilitates remote learning, digital classrooms and access to vast online resources. Businesses leverage IT for efficient operations, communication and data management. Government

services benefit from IT in areas like e-governance, improving accessibility and transparency. Additionally, IT influences social interactions and fostering global connectivity and information sharing. In this lesson we explore all these areas in detail with reference to information technology.

2.7.2 IT in Business and Industry

Information technology (IT) plays a crucial role in today's business and industrial landscape, shaping and revolutionizing the way organizations operate, compete and innovate. Its impact is multifaceted, encompassing various aspects of business processes, decision-making, customer engagement and overall efficiency. The significant role of information technology in business and industry are following:

1. **Enhancing Communication and Collaboration**: IT facilitates real-time communication and collaboration among employees, departments and even global teams. Email, video conferencing, instant messaging and collaborative tools such as Slack and Microsoft Teams enable seamless interaction, breaking down geographical barriers. This connectivity enhances information sharing and problem-solving, leading to increased productivity and efficiency.
2. **Data Management and Analysis**: Businesses and industries generate vast amounts of data daily. IT systems help collect, store and analyze this data to extract valuable insights. Big data analytics, machine learning and data visualization tools assist in making data-driven decisions, identifying trends, and improving operational efficiency. This, in turn, leads to better strategic planning and a competitive edge.
3. **Automation and Streamlining of Processes**: IT automation, through the use of software, robotics and artificial intelligence has the power to streamline repetitive and time-consuming tasks. Automation reduces human error, increases accuracy and enhances productivity. For instance, in manufacturing, robots and automated production lines can significantly boost efficiency.
4. **Market Research and Customer Insights**: The internet and social media have opened up new avenues for market research and understanding customer behavior. Businesses can monitor online conversations, gather feedback and analyze consumer preferences through IT tools. This helps in tailoring products and services to meet market demands more effectively.
5. **E-commerce and Online Sales**: The rise of e-commerce platforms has transformed the way businesses reach and serve customers. Online marketplaces, payment gateways and digital marketing have become critical tools for expanding market reach and boosting sales. Companies can target a global audience without a physical presence in multiple locations.
6. **Supply Chain Management**: IT systems like Enterprise Resource Planning (ERP) and Supply Chain Management (SCM) software enable better management of

supply chains. Real-time tracking of inventory, orders and shipments ensures efficient operations, minimizes delays and reduces costs. This is vital for industries where the timely delivery of goods is crucial.

7. **Customer Relationship Management (CRM)**: CRM software allows businesses to manage and nurture customer relationships. It stores valuable customer data, tracks interactions and assists in tailoring marketing and support efforts to individual preferences. This personalization enhances customer satisfaction and loyalty.
8. **Security and Data Protection**: As businesses increasingly rely on IT for their operations, security and data protection have become paramount. Cyber security tools, encryption and firewalls safeguard sensitive information from cyber threats. Data breaches can be catastrophic for organizations, so IT plays a critical role in mitigating these risks.
9. **Innovation and Product Development**: IT accelerates the pace of innovation by providing tools for research, simulation, and rapid prototyping. This leads to the development of new products and services, which can give businesses a competitive advantage.
10. **Cost Reduction**: Through cloud computing and virtualization, businesses can reduce IT infrastructure and operational costs. They can also employ remote work arrangements, reducing overhead expenses like office space. This cost efficiency is especially beneficial for small and medium-sized enterprises.
11. **Globalization and Market Expansion**: IT has enabled companies to enter new markets and establish a global presence. With the help of e-commerce, digital marketing and global supply chains, businesses can tap into international markets more easily.
12. **Regulatory Compliance and Reporting**: IT systems assist in ensuring compliance with various industry regulations and reporting requirements. Automated systems can generate accurate and timely reports, reducing the risk of non-compliance and associated fines.

In conclusion, information technology has evolved into an integral component of modern business and industry. Its influence spans across various functions and sectors, enabling organizations to stay competitive, efficient and innovative. The role of IT in business and industry will continue to expand as technology advances, making it essential for companies to embrace and leverage these advancements to thrive in today's rapidly changing world.

2.7.3 IT in Education and Training

Information technology (IT) has significantly transformed the landscape of education and training, revolutionizing the way knowledge is acquired, shared and disseminated. In the digital age, IT plays a pivotal role in providing access to information, enhancing learning

experiences and preparing individuals for the challenges of the modern world. Here are some key aspects of the role of information technology in education and training:

1. **Access to Educational Resources:** IT has democratized education by providing access to a vast array of educational resources, including online textbooks, articles, videos and interactive learning materials. The internet has made it possible for learners to access these resources from virtually anywhere in the world, reducing geographical and financial barriers.
2. **E-Learning and Online Education:** E-learning platforms and online education have become increasingly popular, allowing students to pursue degrees and courses remotely. These platforms offer flexible learning options, accommodating the needs of working professionals, individuals with busy schedules and learners with diverse backgrounds.
3. **Personalized Learning:** Information technology enables personalized learning experiences through adaptive learning platforms and data-driven insights. Educational software can adapt to individual learning styles, pace and needs, helping students achieve better outcomes.
4. **Collaboration and Communication:** IT tools, such as video conferencing and collaboration platforms, facilitate communication and interaction between students, teachers and peers, regardless of their physical location. This fosters collaborative learning, group projects and peer-to-peer support.
5. **Gamification and Interactive Learning:** Gamification elements in educational software make learning more engaging and enjoyable. Interactive simulations and educational games can help students grasp complex concepts and retain information more effectively.
6. **Teacher Professional Development:** IT offers teachers opportunities for professional development through online courses and resources. Teachers can stay updated with the latest teaching methods, technologies and best practices, enhancing their instructional abilities.
7. **Assessment and Feedback:** Technology streamlines assessment processes by automating grading, providing instant feedback and allowing for the creation of online quizzes and exams. This makes it easier for educators to monitor student progress and tailor their teaching accordingly.
8. **Resource Management:** Educational institutions use IT systems for resource management, including student records, class scheduling and administrative tasks. These systems help improve organizational efficiency and reduce administrative overhead.
9. **Special Education and Inclusion:** IT assists in providing specialized education and support for students with disabilities. Assistive technologies, such as screen readers and communication devices, empower these students to participate fully in their education.

10. **Massive Open Online Courses (MOOCs):** MOOCs offer access to high-quality courses from prestigious institutions and experts around the world. They provide a scalable and cost-effective way to disseminate knowledge to a broad audience.
11. **Language Learning:** IT tools and language learning apps have made language acquisition more accessible and engaging. They provide language learners with interactive exercises, pronunciation feedback and real-world language practice.
12. **Training and Workforce Development:** IT is essential for workforce training and development. Employers and organizations use e-learning platforms to train employees, share knowledge and enhance skills, ensuring a competitive workforce.
13. **Lifelong Learning:** Lifelong learning has become a necessity in the rapidly changing world. IT supports individuals in pursuing new skills, staying up-to-date in their professions and adapting to evolving industries and technologies.
14. **Research and Innovation:** IT facilitates research and innovation in the education sector. Researchers can collaborate globally, access vast databases and employ advanced analytical tools to further the understanding of educational processes and outcomes.
15. **Global Learning and Cultural Exchange:** IT allows students to engage in cross-cultural learning experiences through virtual exchanges, video conferences and international collaborations, broadening their perspectives.

In conclusion, information technology has brought about a paradigm shift in education and training. It has made learning more accessible, engaging and personalized, with a focus on preparing individuals for the challenges of the digital age. As technology continues to evolve, the role of IT in education and training will only expand, offering new opportunities for innovation, inclusivity and adaptability in a rapidly changing world. Educational institutions, educators and learners who embrace IT stand to benefit from the numerous advantages it brings to the field of education and training.

Self Check Exercise-I

Q1. List benefits of IT in Business and Industry.

Ans.....

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Q2. List key aspects of IT in Education and Training

Ans.....
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2.7.4 IT in Science and Technology

Information technology (IT) plays a fundamental and transformative role in advancing science and technology across various domains. IT has become an indispensable tool for researchers, engineers and innovators, enabling them to collect, analyze and disseminate information, as well as facilitating collaboration and innovation. Here are some key aspects of the role of information technology in science and technology:

1. **Data Collection and Analysis:** Information technology is instrumental in collecting and analyzing vast amounts of data in scientific research. Data collection tools, sensors and data storage solutions help scientists gather and manage data efficiently, enabling more comprehensive and accurate analyses.
2. **Computational Modeling and Simulations:** IT systems allow scientists and engineers to create complex computational models and simulations. These simulations help in understanding phenomena, testing hypotheses and optimizing designs without the need for costly and time-consuming physical experiments.
3. **High-Performance Computing (HPC):** Supercomputers and high-performance computing clusters are crucial for tackling large-scale scientific problems. They are used in fields like climate modeling, drug discovery and astrophysics, where immense computational power is required.
4. **Internet of Things (IoT):** IoT technology, which connects devices and sensors to the internet, has applications in various scientific domains. It enables real-time data collection and remote monitoring in fields such as environmental science, agriculture and healthcare.
5. **Big Data and Machine Learning:** IT facilitates the handling of big data through powerful machine learning algorithms. These tools help researchers discover patterns, trends and correlations in vast datasets, providing valuable insights and predictions.
6. **Genomic Sequencing and Bioinformatics:** The field of genomics relies heavily on IT for sequencing DNA and analyzing genetic data. Bioinformatics tools aid in understanding genetic information, contributing to advancements in medicine, agriculture and evolutionary biology.
7. **Scientific Visualization:** Information technology supports the creation of detailed scientific visualizations, helping researchers convey complex concepts and data in

a comprehensible manner. Visualization aids in scientific communication and decision-making.

8. **Research Collaboration:** Collaboration is essential in scientific endeavors. IT systems, including collaboration platforms and video conferencing tools, facilitate remote collaboration among researchers, even when they are dispersed globally.
9. **Access to Scientific Literature:** IT has made it easier to access scientific literature, journals, and databases. Online repositories and search engines provide scientists with quick access to a vast wealth of scientific knowledge, accelerating research and innovation.
10. **Technology Transfer and Commercialization:** IT systems play a crucial role in the transfer of technology and intellectual property from research institutions to the commercial sector. This leads to the development of new products, services, and industries.
11. **Laboratory Automation:** IT supports laboratory automation, improving the efficiency and accuracy of experiments. Automated instruments, data acquisition systems, and robotics reduce human error and enhance reproducibility.
12. **Nanotechnology and Materials Science:** Information technology contributes to the development of new materials and the study of nanoscale structures. Computer-aided design and simulations assist in optimizing the properties of materials for various applications.
13. **Space Exploration and Astronomy:** IT is integral to space exploration, enabling the collection and analysis of data from spacecraft, telescopes and satellites. It also supports navigation, communication and control systems for missions to space.
14. **3D Printing and Additive Manufacturing:** IT-driven 3D printing and additive manufacturing technologies revolutionize product development, allowing rapid prototyping, customization and the creation of complex, high-precision components.
15. **Renewable Energy and Sustainability:** IT is pivotal in the development and management of renewable energy sources, such as solar and wind power. It aids in monitoring energy production, optimizing distribution and reducing environmental impact.

In conclusion, information technology is a driving force behind scientific and technological progress. It empowers researchers, engineers, and innovators by providing them with the tools and resources needed to push the boundaries of knowledge and discovery. The role of IT in science and technology is dynamic, as it continues to evolve, enabling new frontiers of exploration and innovation. As technology advances, IT will remain a critical enabler for addressing complex scientific challenges and shaping the future of technology and scientific understanding.

2.7.5 IT and Entertainment

Information technology (IT) has had a profound impact on the entertainment industry, transforming the way content is created, distributed and consumed. The convergence of technology and entertainment has revolutionized the industry, providing new opportunities for content creators, enhancing user experiences and reshaping the business landscape. Here are some key aspects of the role of information technology in entertainment:

1. **Content Creation and Production:** Information technology has revolutionized content creation in the entertainment industry. Digital cameras, computer-generated imagery (CGI), and advanced software have enabled filmmakers, animators, and designers to produce high-quality content more efficiently and cost-effectively.
2. **Digital Editing and Post-Production:** Digital editing tools and software have streamlined the post-production process. Editors and visual effects artists can manipulate and enhance content with precision, leading to more polished and visually stunning final products.
3. **Streaming and Distribution Platforms:** The rise of streaming services like Netflix, Amazon Prime Video, and Disney+ has been facilitated by IT. These platforms use advanced algorithms and cloud infrastructure to deliver content to viewers on-demand, enabling a shift away from traditional cable and broadcast television.
4. **Personalization and Recommendation Algorithms:** IT systems use data analytics and machine learning to provide personalized content recommendations to users. This enhances the viewer's experience by offering tailored content and discovering new shows or movies based on their preferences.
5. **Virtual Reality (VR) and Augmented Reality (AR):** Entertainment is pushing the boundaries of technology with VR and AR experiences. These immersive technologies provide viewers with interactive and captivating content, from VR gaming to AR-enhanced marketing campaigns.
6. **Video Games and Gaming Industry:** The gaming industry has greatly benefited from IT innovations. High-performance gaming consoles, cloud gaming and sophisticated game engines allow for immersive, visually stunning gaming experiences, attracting millions of players worldwide.
7. **Social Media and Fan Engagement:** Social media platforms have become integral to the entertainment industry for promoting content, engaging with fans and building fan communities. Celebrities, production companies and artists use these platforms to interact with their audience and create buzz around their work.
8. **Copyright Protection and Digital Rights Management (DRM):** IT solutions help protect intellectual property and combat piracy. DRM technologies are used to

control the distribution and access to digital content while safeguarding the rights of content creators.

9. **Live Streaming and Events:** Live streaming platforms and technologies have transformed how live events, such as concerts, sports and gaming tournaments are broadcast to global audiences. Fans can watch events in real-time from anywhere, broadening the reach of live entertainment.
10. **Music and Digital Audio:** Digital technology has transformed the music industry, making it easier for artists to create, distribute and monetize their music. Streaming services, digital audio workstations and music production software have played a crucial role in this transformation.
11. **E-Sports:** Competitive video gaming, known as e-sports, has gained immense popularity. IT infrastructure, streaming platforms and online communities have fueled the growth of e-sports as a legitimate form of entertainment and competition.
12. **Interactive Experiences and Escape Rooms:** IT enables interactive and immersive entertainment experiences, such as escape rooms and interactive theater. These experiences blend the physical and digital worlds to engage participants in exciting narratives and challenges.
13. **Virtual Concerts and Performances:** During the COVID-19 pandemic, virtual concerts and performances became a lifeline for artists and a source of entertainment for audiences. IT allowed artists to perform and connect with their fans through live-streamed events.
14. **Digital Art and NFTs:** Digital art and non-fungible tokens (NFTs) have gained prominence in the art and entertainment world. These technologies provide new avenues for artists to create, sell and protect their digital creations.
15. **Data Analytics and Audience Insights:** IT tools are used to analyze audience behavior and preferences. This data-driven approach helps entertainment companies make informed decisions, target specific demographics and refine content offerings.

In conclusion, information technology has fundamentally reshaped the entertainment industry, offering new possibilities for content creation, distribution, and engagement. As technology continues to evolve, it will continue to drive innovation, shape audience experiences, and create new opportunities for content creators, marketers, and businesses in the ever-evolving landscape of entertainment. The role of IT in entertainment is dynamic, and its influence is set to grow as technology continues to advance.

Self Check Exercise-II

Q1. List benefits of IT in Science and Technology.

Ans.....

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Q2. List key aspects of IT in Entertainment

Ans.....

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2.7.6 Currents trends in IT Application

2.7.6.1 Artificial Intelligence

Artificial Intelligence (AI) is a multidisciplinary field of computer science that focuses on creating systems and machines capable of performing tasks that typically require human intelligence. These tasks include problem-solving, learning, reasoning, understanding natural language, perception and decision-making. AI has evolved significantly over the years and has found applications in various domains, transforming industries and daily life.

Key aspects of AI include:

1. **Machine Learning:** Machine learning is a subset of AI that involves training algorithms to learn from data and make predictions or decisions without explicit programming. It has found applications in image and speech recognition, recommendation systems and autonomous vehicles.
2. **Neural Networks:** Neural networks, inspired by the human brain, are a fundamental component of many AI applications. Deep learning, a subset of machine learning, involves deep neural networks with multiple layers, enabling complex tasks like image and speech recognition.
3. **Natural Language Processing (NLP):** NLP focuses on enabling computers to understand, interpret and generate human language. Chatbots, language translation and sentiment analysis are common NLP applications.
4. **Computer Vision:** Computer vision allows machines to interpret and process visual information from the world, enabling applications like facial recognition, object detection and autonomous drones.
5. **Robotics:** AI-driven robots are used in manufacturing, healthcare and various industries for tasks such as assembly, surgery and exploration. They can perform complex tasks in unstructured environments.

6. **Expert Systems:** Expert systems are AI programs designed to mimic human expertise in a specific domain. They can assist with decision-making and problem-solving, often used in healthcare and finance.
7. **Autonomous Systems:** Autonomous vehicles, drones, and industrial robots use AI for navigation and decision-making, reducing the need for human intervention.

Applications of AI:

1. **Healthcare:** AI aids in diagnosing diseases, interpreting medical images, drug discovery and personalized treatment plans. Chatbots and telemedicine also enhance patient care and accessibility.
2. **Finance:** AI is used for fraud detection, algorithmic trading, risk assessment, and customer service in the financial industry.
3. **E-Commerce and Recommendation Systems:** Online platforms use AI to analyze customer behavior and provide personalized recommendations, improving user experience and increasing sales.
4. **Customer Service:** Chatbots and virtual assistants handle routine customer inquiries, saving time and resources for businesses.
5. **Manufacturing and Industry 4.0:** AI-driven automation and predictive maintenance enhance efficiency and reduce downtime in manufacturing processes.
6. **Entertainment:** AI is used for content recommendation, game development, and enhancing visual effects in movies and video games.
7. **Transportation:** Autonomous vehicles and intelligent traffic management systems improve safety and efficiency in transportation.
8. **Education:** AI-driven platforms offer personalized learning experiences, automate administrative tasks and provide tools for teachers to enhance instruction.

Challenges and Considerations:

1. **Ethical Concerns:** AI raises ethical questions regarding privacy, bias and the potential misuse of technology. Ethical AI development and regulation are essential.
2. **Bias and Fairness:** AI systems can inherit bias from training data, leading to unfair or discriminatory outcomes. Addressing bias is a significant challenge in AI development.
3. **Data Privacy:** AI relies on large datasets, raising concerns about data privacy, security and consent. Regulations like GDPR aim to protect individuals' data rights.
4. **Accountability and Transparency:** It can be challenging to trace the decision-making processes of AI systems. Establishing accountability and transparency is

crucial, especially in critical applications like healthcare and autonomous vehicles.

5. **Job Displacement:** Automation driven by AI can potentially lead to job displacement, requiring measures to retrain the workforce for new roles.
6. **Security:** AI systems can be vulnerable to attacks and defending against adversarial attacks is a growing concern.

The Future of AI:

AI is a rapidly evolving field with a promising future. As technology advances, AI is expected to have an even greater impact on various industries and aspects of life. Research and development will continue to push the boundaries of what AI can achieve, making it an integral part of the technological landscape.

In conclusion, artificial intelligence is a transformative field with the potential to revolutionize industries and enhance human life. Its applications are wide-ranging, from healthcare and finance to entertainment and education. However, ethical considerations, bias and privacy concerns must be addressed as AI continues to progress. The future of AI holds exciting possibilities, and its continued development will shape the way we live and work in the years to come.

2.7.6.2 Voice recognition

Information technology (IT) and voice recognition are closely intertwined, with IT serving as the foundation for the development and deployment of voice recognition systems. Voice recognition, also known as automatic speech recognition (ASR), is a technology that enables computers and devices to interpret and understand human speech.

IT supports voice recognition in several key ways:

1. **Data Processing:** IT infrastructure and computational power are essential for processing the vast amount of data generated by voice recognition systems. These systems analyze audio input, extract relevant features and convert spoken words into text or commands.
2. **Machine Learning:** Machine learning algorithms, a subset of AI, play a crucial role in training voice recognition systems. IT tools are used to develop and fine-tune these algorithms, improving accuracy and performance over time.
3. **Natural Language Processing (NLP):** NLP, a subfield of AI, involves IT systems that help voice recognition understand context and language nuances, making interactions more natural and accurate.

4. **Cloud Computing:** Cloud-based IT solutions provide the necessary infrastructure for real-time voice recognition and processing, enabling applications like virtual assistants and interactive voice response (IVR) systems to function seamlessly.
5. **Integration with Devices:** IT enables the integration of voice recognition into various devices and applications, including smartphones, smart speakers, cars, and home automation systems.

Voice recognition, powered by IT, has found applications in numerous sectors, such as customer service, healthcare, automotive, and accessibility. It offers the convenience of hands-free interaction with technology, improving user experiences and accessibility for individuals with disabilities. As technology continues to advance, the integration of IT and voice recognition will likely lead to further innovations and expanded use cases in both consumer and enterprise environments.

2.7.6.3 Robots

Information technology (IT) and robots are two interconnected technological domains that have revolutionized various aspects of our lives, from industry and healthcare to daily routines. Information technology is the backbone of modern computing and communication systems, encompassing hardware, software, networks and data management. It plays a vital role in enabling robots to function effectively. Robots rely on IT for data processing, communication and control. This is particularly evident in industries where robots are used for automation and precision tasks. IT systems help robots gather and process data from sensors, making real-time decisions and communicate with other machines or humans.

Robots, in turn, have greatly benefited from advances in information technology. These advances have led to more sophisticated and capable robots, from industrial robots that can assemble products with precision to collaborative robots (cobots) that can work alongside humans. Furthermore, service robots have emerged in various domains, such as healthcare, retail and logistics, offering assistance, automating tasks and enhancing efficiency.

In the healthcare sector, robotic-assisted surgeries are made possible through the integration of IT and robotics, allowing surgeons to perform minimally invasive procedures with greater precision. In logistics and warehousing, robots equipped with IT systems manage inventory, automate order fulfillment and optimize supply chains.

In agriculture, IT-powered robots can perform tasks like precision planting and harvesting, improving crop yields and reducing the need for manual labor. Even in our homes, robotic vacuum cleaners and smart appliances are becoming more prevalent, enhancing our daily lives with convenience and automation.

The synergy between information technology and robots continues to drive innovation in various industries, improving productivity, accuracy and safety. As technology advances, the integration of IT and robotics is likely to expand into new domains, making automation and assistance more accessible and beneficial to society. However, it's crucial to address ethical and societal concerns related to automation, job displacement and privacy as these technologies become increasingly integrated into our lives.

2.7.6.4 Multimedia

Information technology (IT) and multimedia technology are closely intertwined fields that have had a profound impact on how we create, consume and share information and entertainment in the digital age. Information technology encompasses hardware, software, networks and data management systems that enable the processing, storage, and exchange of data. IT plays a pivotal role in multimedia technology by providing the infrastructure and tools to create, store and distribute multimedia content. This content includes text, images, audio, video and interactive elements.

Multimedia technology leverages IT to deliver engaging and interactive experiences. Here's how IT and multimedia technology intersect:

1. **Digital Media Creation**: Multimedia content, such as video, audio and graphics, is created and edited using IT tools. Software like Adobe Creative Suite and Final Cut Pro enable professionals to produce high-quality multimedia content.
2. **Storage and Retrieval**: IT systems manage vast multimedia databases, making it possible to store, index and retrieve multimedia files efficiently. Cloud storage and content management systems are examples of IT solutions that facilitate this.
3. **Streaming and Broadcasting**: IT infrastructure, including high-speed internet and content delivery networks, is essential for streaming multimedia content, such as music, video, and live broadcasts, to a global audience in real-time.
4. **Virtual Reality (VR) and Augmented Reality (AR)**: IT technologies power VR and AR experiences, creating immersive multimedia environments and applications.
5. **E-Learning and Training**: IT supports e-learning platforms and multimedia content for educational purposes, making learning more engaging and accessible.
6. **Gaming**: Multimedia technology is at the core of video games, with IT systems handling graphics rendering, sound processing and online gaming infrastructure.
7. **User Interfaces**: Graphical user interfaces (GUIs) and touch screens are IT-driven technologies that enable users to interact with multimedia applications and devices seamlessly.
8. **Mobile Applications**: Smartphones and tablets leverage IT to support multimedia applications for communication, entertainment and productivity.
9. **Social Media**: Social networking platforms rely on IT infrastructure for the exchange of multimedia content, from photos and videos to live streams.

10. **Advertising and Marketing**: IT supports multimedia marketing efforts, such as video ads, interactive websites and data analytics for targeted advertising.

The collaboration between IT and multimedia technology has not only transformed how we consume content but has also expanded the possibilities for creative expression and communication. It has made multimedia content more accessible, interactive and personalized, enhancing our daily lives in areas like education, entertainment and information dissemination. As both fields continue to evolve, we can expect further innovation and integration, leading to even more immersive and engaging multimedia experiences.

2.7.6.5 Virtual reports

Information technology (IT) plays a vital role in the creation, distribution and presentation of virtual reports. A virtual report is a digital document or presentation that conveys information, findings or insights electronically, and IT is the backbone that makes this possible. IT enables the creation of virtual reports through various software tools, such as word processing applications, data visualization software and multimedia editing programs. These tools help in formatting, designing and organizing the content for a clear and engaging report.

Additionally, IT facilitates the storage and sharing of virtual reports. Cloud storage, email and online collaboration platforms allow for easy distribution and accessibility of these reports. IT securities measures help protect sensitive information within these reports. Moreover, virtual reports can leverage IT to incorporate interactive elements, multimedia content and hyperlinks. This enriches the report, making it more engaging and informative for the audience.

Overall, IT is integral to the entire lifecycle of virtual reports, from their creation and distribution to their accessibility and interactivity. It streamlines the process, making it efficient, environmentally friendly and user-friendly, ultimately enhancing the effectiveness of virtual reporting in the modern digital age.

2.7.7 Summary

In this lesson we have discussed the role of Information Technology in business and industry, education and training, science and technology and in entertainment. We have also studied the current trends of Information Technology like Artificial Intelligence, Voice recognition, Robots, Multimedia and Virtual reports.

2.7.8 Keywords

Artificial Intelligence: It is the simulation of human intelligence processes by machines, especially computer systems.

Voice recognition: It is the ability of a machine or program to receive and interpret dictation or to understand and perform spoken commands.

Multimedia: It is a form of communication that uses a combination of different content forms, such as writing, audio, images, animations or video.

2.7.9 Short Answer Type Questions

1. Define Voice recognition.
2. What is Multimedia? Give ex.
3. What do you mean by Virtual reports?

2.7.10 Long Answer Type Questions

1. Discuss the role of IT in Business and Industry in detail.
2. Explain the role of IT in Education and Training.
3. Discuss the role of IT in Science and Technology in detail
4. Explain the role of IT in Entertainment.
5. What is AI? What are the benefits of AI?

2.7.11 Suggested Readings

- "Internet: The complete Reference", Young, 2002, Tata Mcgraw Hill Publishing Company Limited.
- "Computers Today", Sanders, D., Tata McGraw-Hill.
- "PC Software for Windows Made Simple", R.K.Taxali, TMH.

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