UNIT 1 BASICS OF DATA COMMUNICATION

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1.0 INTRODUCTION

This is the first unit of our course on Fundamentals of Computer Networks. It will introduce you to some of the basic concepts of data communication and computer networking. In other words, though this unit we would like to explain the "What, Why, When, How, Where" of data communication. In the beginning, you will be introduced with the concept of communication and "communication system". Once you understand the communication system and its components, we think other areas will be simpler for you. Different forms of data communication are further introduced to you in this unit. Next, we will discuss about various modes of communications. This unit will eventually cover an introduction to computer networking, networking protocols and standards, those are necessary for any effective communication. In the end of our unit, we will discuss various applications of data communication and computer networking.

1.1 OBJECTIVES

After going through this unit, you should be able to:

- Know the concept of communication system
- Understand the communication system and its components
- Differentiate between analog and digital Communication
- Know data communication modes
- Differentiate between synchronous and asynchronous transmission
- Differentiate among Simplex, half-duplex, full duplex communication
- Understand the need of protocols and standards
- Know the functions of OSI layers
- Understand the concepts of encapsulation and End-to-end argument
- Know the different protocol design issues

- Know the applications of computer network

1.2 CONCEPT OF COMMUNICATION SYSTEM

Before we discuss about "communication system" and its components, let us understand "communication". Can you define it, what definition will come first in your mind? When we asked some students, answers were like:

- Delivery of message
- Proper way of passing a signal to the intended user
- Right message, to right person, at right time through right way.

So many "rights"! and all seems to be 'Right'. Let me inform you about some definitions of communication:

- " Communication is transfer of information from one person to another, whether or not it elicits confidence. But the information transferred must be understandable to the receiver – G.G. Brown.
- The imparting or exchanging of information by speaking, writing, or using some other medium.-Oxford Dictionary

After going though these definitions, I am sure now we can list the components required for some communication:

- **Sender**: who is trying to send a message to the receiver?
- **Message or Signal**: the message is the actual content for communication
- **Communication Medium**: The medium is what the message is transmitted on. The phone system, it is wire. Television and radio use air
- **Receiver**: The receiver is the target of the message.

There is something missing in this list, can you guess? That is encoding and decoding. Try to conceptualize a discussion with your friend. While talking with your friend you encode your message in a speaking language and on the other side your friends (receiver) decodes your language and understand the message. In the same way, if you are talking to your friend over telephone, it is not possible to actually transmit voice across the wire for any distance. The telephone set converts the sound into electrical pulses, which can be transmitted by wires. The decoder takes the encoded message and converts it to a form the receiver understands, in continuation of our previous example phone system convert electrical pulses into voice.

Let's see a block diagram for a communication system as depicted in the Figure 1.

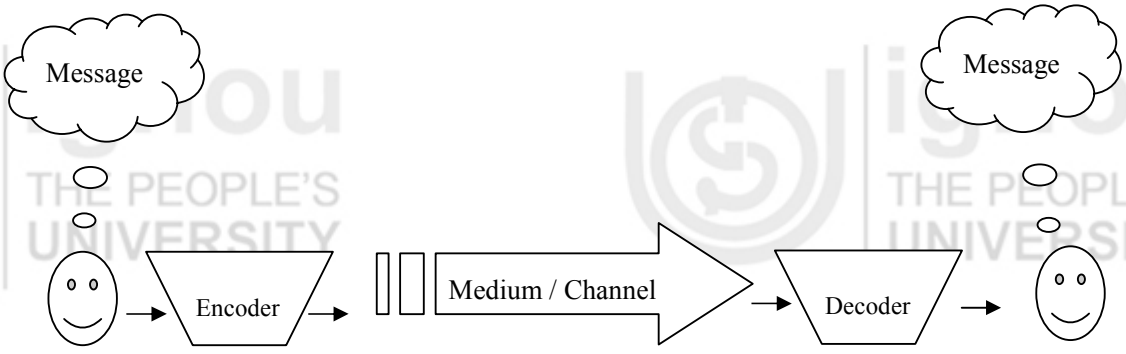

Figure 1: Block Diagram of Communication System

Now, can you try to explore some communication systems around us? Ok, let's list some:

- Human communications operate through speech, signs, gestures, body language, etc. Note that the communication mediums are air and light.
- Telephone system are a kind of communications system which we use in day to day basis, it is a collection of individuals, telephone handsets for transforming voice into electrical signals), wires (communication medium), some controlling and call management devices, Telephone exchange, etc. Remember that the components of a communications system serve a common purpose, are technically compatible, use common procedures, respond to controls, and operate in unity.
- A radio or television communication system is composed of several communications subsystems that give exterior communications capabilities. These are also known as public broadcasting systems, because they broadcast the messages/signals in the air and any one in the coverage area with a receiver can receive the signals. Such systems comprises of a large transmitting station for converting and transmitting the audio/video into the air, and on the other side if signals are public can be decoded and converted again into the same audio/video.

By now, you must be curious to know the mechanism used for converting a message (text, video, audio, etc) into some electrical signals. How does it function in a system?

Let us understand the communication from the technical or mathematical point of view, C.E. Shannon [Claude Elwood Shannon (April 30, 1916 – February 24, 2001) was an American mathematician, electronic engineer, and cryptographer known as "the father of information theory".] had worked on some of the fundamentals in the communication, like:

- How the symbols of communication are transmitted between sender and receiver?
- How the meaning is conveyed through the transmitted symbols?
- What is the effect of the received meaning?

According to Shannon, following are the essential elements of communication also shown in the Figure 2 below:

1. Information source: Source that produces a message
2. Transmitter: An element that functions on the message to generate a signal which can be delivered through a medium/channel
3. Communication Channel: that is a medium over which the signal (carrying the information that composes the message) is sent.
4. Receiver: An element that intercept the signal and converts it back into the message
5. Destination: It can be a person/machine, for whom / which the message is intended.

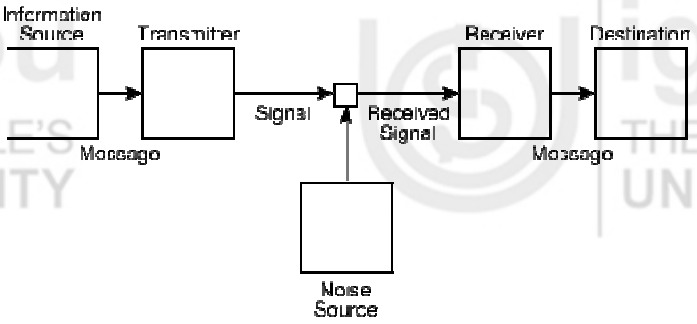

Figure 2: Shannon's diagram of a general communications system

Here, the noise is considered as an error or undesired disturbance that occurs during the transmission (before receiver and after transmitter), from natural and sometimes man-made sources.

1.3 ANALOG AND DIGITAL COMMUNICATION

We all have heard these terms several times, like analog signal, digital signal, digital TV, analog radios, etc. In this section, we will explore the basic definitions and differences of analog and digital communication. Two main types of signals encountered in practice are analog and digital. The figure 3 shows analog, discreet and digital signals, digital signals outcome from approximating an analog signal by its values at particular time moments. Digital signals are discrete and quantized, while analog signals possess neither property.

Technically, if we observe the elements and processes of any communication system, you may notice that all the components and processes of a communication system should be aligned, compatible and work as a unit. Try to remember our example where telephone system is converting voice into electrical signal, in this case receiver instrument must be compatible and convert the electrical signal or voice signal in the similar way, otherwise your message will never be delivered.

Here, we have to address one important point that is how does the message is being converted? We have two options one is analog and another is digital.

- As you may know that an analog is something continuous, which is having time varying feature (variable). Analog signal is a representation of some time varying quantity. For example, Human voice can be considered as an analog signal. In analog signals data are represented by continuously variable, measurable, physical quantities, such as current, voltage, or pressure.
- A digital signal is a physical signal that is a representation of a sequence of discrete values, for example of a bit stream. In digital technology, generally a signal is converted into a bit form represented by a series of "1"s and "0"s. Please note here that "1"s and "0"s are nothing but two states usually represented by some measurement of an electrical property: Voltage is the most common, but current is used in some logic families. A threshold is designed for each logic family.

Figure 3: Analog, Discrete and Digital Clocks

In a communication system, data signals are propagated from one point to another by means of electrical signals. An analog signal (Figure 4a) is a continuously varying voltage signal that may be propagated over a variety of media. A digital signal (Figure 4b) is a sequence of discrete values for example any bit stream.

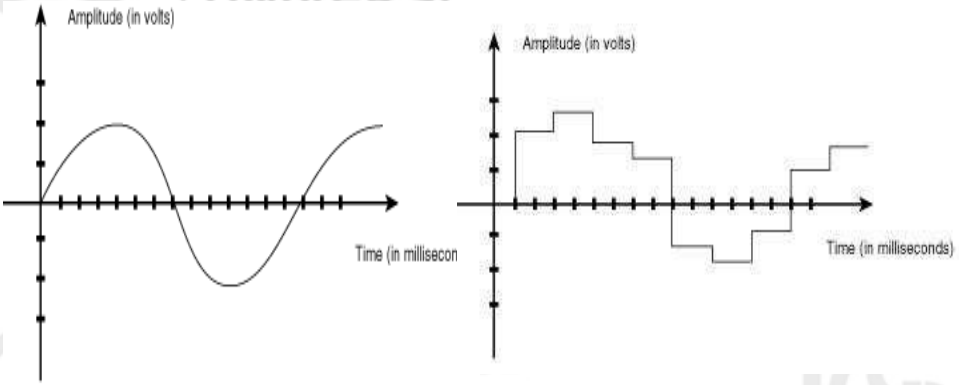

Figure 4 a): Analog Signal **Figure 4 b): Digital Signal**

Analog and **digital** signals are used to transmit information, usually through electric signals. In both these systems, the information, such as any text, audio or video, is transformed into electric signals. Let us see some of the differences between analog and digital systems below in table 1.

Table 1: Comparison between Analog and Digital system

Analog	Digital
Signals are records waveforms as they are. Signal occupies the same order of spectrum as the analog data.	Converts analog waveforms into set of numbers and records them. The numbers are converted into voltage stream for representation. In case of binary it is converted in 1's and 0's.
In analog systems electronic circuits are used for transformation of signals.	In this transformation is done using logic circuits.
About Noise analog signals are more likely to get affected and results in reducing accuracy	Digital signals are less affected, because noise response are analog in nature
Analog signal is a continuous signal which transmits information as a response to changes in physical phenomenon.	Digital signals are discrete time signals generated by digital modulation.
Data transmission is not of high quality	Data transmission has high quality.
Analog devices are not very precise.	Digital systems are very precise.

Can you explore the reasons why digital signals are seems to be better? Let us see why digital communication having high quality? Because, digital devices decode and reconstruct data, due to which loss of quality of data as compared to analog devices is much higher. But analog signal are affected by noise. While amplifying the signal noise also gets amplified. Therefore it becomes difficult to filter out noise from the signal and the message gets corrupted. Digital signal are least affected by noise. And further

computer advancement has enabled use of error detection and error correction techniques to remove disturbances artificially from digital signals and improve quality. Now days, digital signals has been most proficient in cellular phone industry. Analog phones have become superfluous even though sound clarity and quality was better.

☛ Check Your Progress 1

1. List the essential elements of communication system. Also, draw and explain the Shannon model of communication system.

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2. Write any four differences between analog and digital communication.

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1.4 DATA COMMUNICATION MODES

In this section, we will learn about some modes of data communication used in computer networking. Because we are going to study computer networking, we assume all data communication is digital. Digital communications is the physical transfer of data/bits over a communication channel. As you may know, data are represented as an electromagnetic signal, such as an electrical voltage, radio-wave, microwave, or infrared signal. The channel or medium could be air (for wireless/mobile communication), copper wires, or optical-fibers. Remember, the data transmitted can be pure digital messages generated from a digital-data source, like a computer or a keyboard. However, it may also be an analog signal such as a human voice over phone call, which could be digitalized.

Serial and parallel transmission

In digital communication, serial transmission of data refers to sequential transmission of bits, where a group of bits over a single channel represents a character. It requires less processing and fewer chances for error. The start and stop of a communication is specified by LSB (lowest significant bit) and MSB (most significant bit) as shown in the Figure 5.

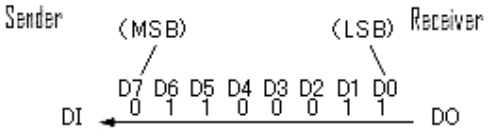

Figure 5: Serial Communication

Parallel transmission refers to simultaneous transmission of the bits over two or more separate channels. Here, we can transmit multiple bits simultaneously as given in Figure 6, which allows for higher data transfer rates than that can be achieved with serial

transmission. For example, for internal data communication in a computer system this method of parallel transmission is used. Parallel data transmission is less reliable for long distances because error correction is not very simple and economical in this case.

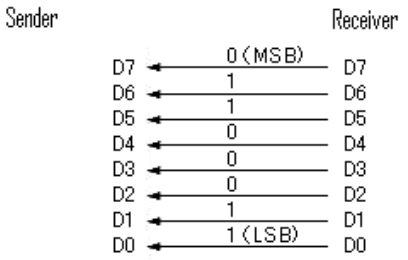

Figure 6: Parallel data transmission

In serial transmission, the byte plus the parity bit are transmitted one bit after another in a continuous line. In parallel transmission, 8 bits (a byte) plus a parity bit are transmitted at the same time over nine separate paths. Thus, parallel transmission is generally faster than serial transmission.

1.4.1 Synchronous and Asynchronous Transmission

Synchronous transmission means both receiver and sender has an agreement (or aware) about timing for the sending data, so that both sender and receiver can coordinate (synchronize) their data signals. Asynchronous means "not synchronous", or no coordination between sender and receiver before transmission. Can you try to explore some examples of Synchronous and asynchronous communication that occurs in your day to day life?

The asynchronous transmission uses start and stop bits to signify the beginning bit. For example, if sender wants to send some data "**11100001**", it will be appended with the start and stop bit and look like "1 **11100001** 0". Where, we have assumed that '0' is start bit and '1' is stop bit. Asynchronous transmission works well where the characters are transferred at irregular intervals e.g. data entry from the keyboard.

Asynchronous transmission has some advantages and disadvantages, like:

- Each individual character is complete unit, hence if there is an error in a character, other sequence of characters are not affected. However, Error in start and stop bit(s) may cause serious problems in data transfer.
- Doesn't require synchronization of both communication sides.
- It is cost effective
- The speed of transmission is limited.
- Large relative overheads, a high proportion of the transmitted bits are uniquely used for control purposes

In case of synchronous transmission, we do not use any start and stop bits, but instead of that clock signal end (clock is built into each end of transmission) is being used for synchronizing the data transmission at both the receiving and sending. A constant stream of bits is sent between the sender and receiver. As clock synchronization may disturbed the possibility of error increases in synchronous transmission. Synchronous transmission has following advantages and disadvantages:

- In comparison to asynchronous communication it has higher speeds, because the system has lesser possibility of error. But, if an error takes place, the complete set of data is lost instead of a single character.
- Serial synchronous transmission is principally used for high-speed communication between computers but is unsuitable where the characters are transferred at irregular intervals.
- It is gives lower overheads and thus, greater throughput.
- Process is more complex
- It is not very cost effective as hardware are more expensive

1.4.2 Simplex, Half-Duplex, Full Duplex Communication

The data transmission mode on the channel, can be classified into three ways simplex, half-duplex and full-duplex as given below in Figure 7.

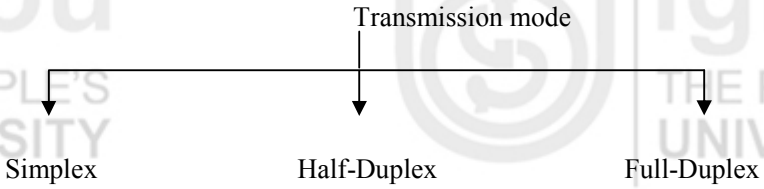

Figure 7: Transmission mode

In simplex transmission *(*Figure 8a), signals are transmitted in only one direction; one station is a transmitter and the other is the receiver. In the half-duplex operation (Figure 8b), both stations may transmit, but only one at a time. In full-duplex operation (Figure 8c), both stations may transmit simultaneously. In the latter case, the medium is carries signals in both directions at same time.

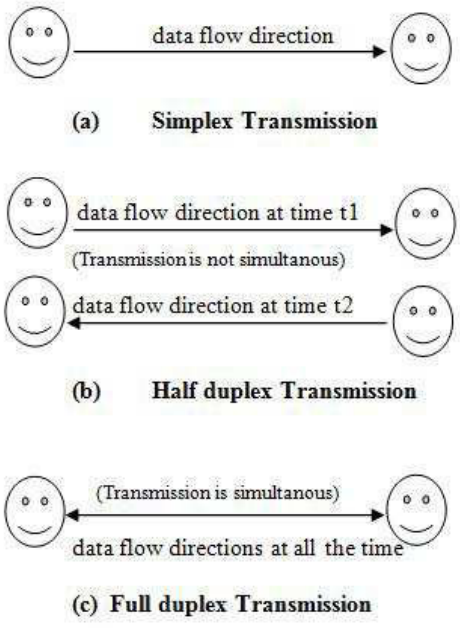

Figure 8(a) (b) (c): Directions of data transmission in Simplex 8(a), half-duplex 8(b), full duplex 8(c) communication

Simplex Transmission

Simplex transmission is one-way transmission. As the name implies, is simple in term of process and hardware. It is also called unidirectional because the signal travels in **only**

one direction. For example, Radio or TV broadcasting system, which are always in one direction from Radio/TV station to our radio or TV sets.

Half-Duplex Transmission

In half-duplex transmission data transmission can be take place in both directions, but not at the same time. This means that only one side can transmit at a time. For example, walky-talky devices used by security agencies are half-duplex as only one person can talk at one time.

Full-Duplex Transmission

Full-duplex (also known as Duplex) transmission can take place in both directions at the same time. For example, telephone or mobile conversation is an example of full-duplex communication, where both sender and receiver can hear each other at the same time.

☞ **Check Your Progress 2**

1. Differentiate between Synchronous and asynchronous transmission.

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   ……

2. Give an example of each communication system based on:

   - Simplex communication,
   - half-duplex communication,
   - full duplex communication

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1.5 NETWORKING PROTOCOLS AND STANDARDS

All modes of communication described above follow some 'set of rules' or protocol. Protocol is set of rules that governs communication between the entities engaged in conversation, for example in railways, if a green colour flag is shown a train can start, and if red colour flag is shown train will stop, this is a set of rule and we can say it is a protocol. When we write a letter or talk to someone we follow protocol(s). In case of computer communication also both sender computer and receiver computer should agree on some set of rules like communication language/syntax, scheme of acknowledgement, rules for data control, error control, and other mechanism. Thus, we can say that the conversation is governed by some set of rules known to both the parties. This set of rules is called protocol and it necessary for proper and disciplined conversation/communication.

Problems in Computer Communication

When protocols are implemented for computer communication, we encounter some challenges due to the infrastructure and machines used in computer network may not be compatible and aligned with one another. The concept of Internetworking though, highly desirable, is not easily achievable. Let us see one simple example to understand the compatibility problem, any two networks, cannot directly communicate by connecting a wire between the networks. For example, one network could represent a binary 0 by-5 volts, another by +5 volts. Similarly, one could use a packet size of 128 bytes, whereas other could use 256 byte packets. The method of acknowledgement or error detection

could be different. There could be many such differences. The incompatibility issues are handled at two levels:

i) **Hardware Issues**

At the hardware level, an additional component called router is used to connect physically distinct networks. A router connects to the network in the same way as any other computer. Any computer connected to the network has a Network Interface Card (NIC), which has the address (network id+ host id), hard coded into it. A router is a device with more than one NICs. Router can connect incompatible networks as it has the necessary hardware (NIC) and protocols.

ii) **Software Issues**

The routers must agree about the way information would be transmitted to the destination computer on a different network, since the information is likely to travel through different routers, there must be a predefined standard to which routers must confirm. Packet formats and addressing mechanism used by the networks may differ. One approach could be to perform conversion and reconversion corresponding to different networks. But this approach is difficult and cumbersome. Therefore, the Internet communication follows one protocol suite, the TCP/IP. The basic idea is that it defines a packet size, routing algorithms, error control, flow control methods universally.

It would be unwise to club all these features in a single piece of software ─ it would make it very bulky. Therefore, all these features are logically sub-grouped and then the sub-groups are further grouped into groups called layers. Each layer has an interface with the adjacent layers, and performs specific functions.

1.5.1 Layering

Since it is difficult to deal with complex set of rules, and functions required for computer networking, these rules and functions are divided into logical groups called layers. Each layer can be implemented interdependently with an interface to other layers providing with services to it or taking its services like data, connection and error control functions are grouped together and make a layer. A. Speech in telephone conversation is translated, with electrical segments and vice-versa. Similarly in computer system the data or pattern are converted into signals before transmitting and receiving. These function and rules are grouped together and form a layer.

1.5.2 OSI Reference Model

The OSI model is based on a proposal developed by the International Standards Organization as a first step towards international standardization of the various communication functions and services. Here, communication functions are grouped into logical layers. The model is called the ISO - OSI (International Standard Organisation - Open Systems Interconnection) Reference Model because it deals with connecting open systems — that is, systems that follow the standard are open for communication with other systems, irrespective of a manufacturer. Its main objectives were to allow manufacturers of different systems to interconnect equipment through standard interfaces globally. Allow software and hardware to integrate well and be portable on different systems. The OSI model has seven layers shown in Figure 9. The principles that were applied to arrive at the seven layers are as follows:

1. Each layer should perform a well-defined function.

2. The function of each layer should be chosen with an eye toward defining internationally standardized protocols.

3. The layer boundaries should be chosen to minimize the information flow across the interfaces.

4. A layer serves the layer above it and is served by the layer below it.

The set of rules for communication between entities in a layer is called protocol for that layer. The seven layers of ISO OSI reference model as shown in the Figure 9 are following:

i) Physical Layer

ii) Data Link Layer

iii) Network Layer

iv) Transport Layer

v) Session Layer

vi) Presentation Layer

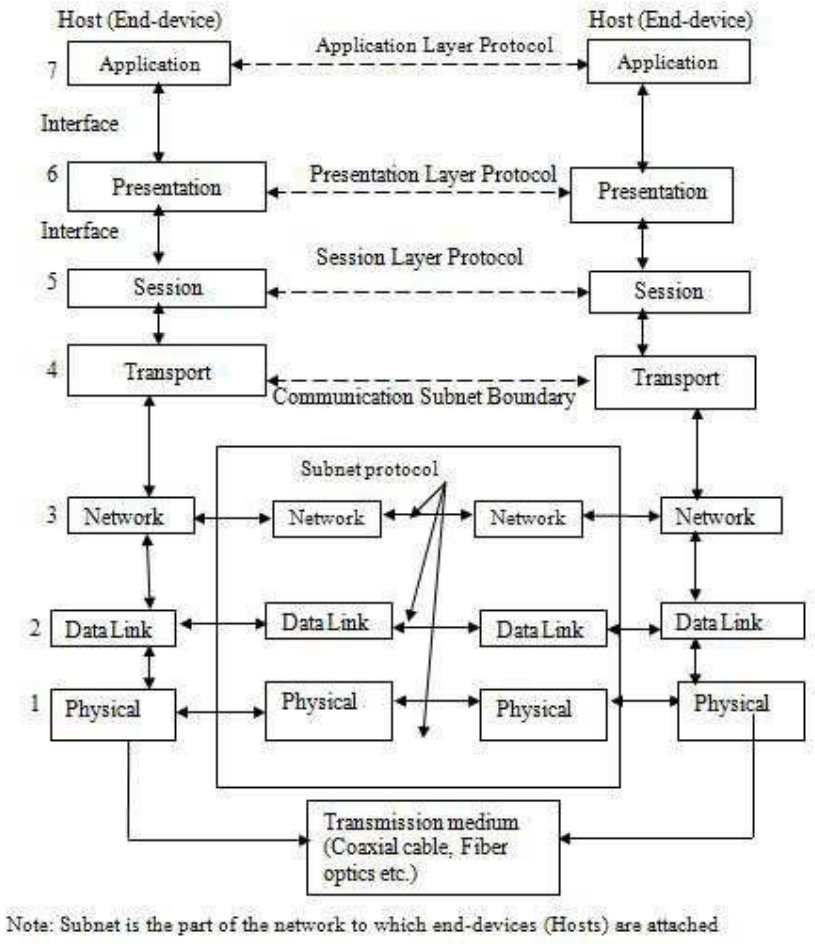

Figure 9: OSI Reference Model

a) **The Physical Layer**

Physical Layer defines functional, electrical and mechanical specifications of signaling, cables, and connectors options that physically link two nodes on a network.

b) **The Data Link Layer**

The main task of data link layer is to provide error free transmission. It accomplishes this task by having the sender configure input data into data frames, transmit the frames sequentially, between network devices and process the acknowledgement frames sent back by the intermediate receiver. The data link layer creates and recognises frame boundaries. This can be accomplished by attaching special bit patterns to the beginning and end of the frame. Since these bit patterns can accidentally occur in the data, special care is taken to make sure these patterns are not incorrectly interpreted as frame boundaries.

c) **The Network Layer**

The network layer ensures that each packet travels from its sources to destination (both in different networks) successfully and efficiently. A key design issue is determining how packets are routed from source to destination. Routes can be based on static tables that are "wired into" the network and rarely changed. They can also be determined at the start of each conversation, for example, a terminal session. Finally, they can be highly dynamic, being determined anew for each packet, to reflect the current network load. When a packet has to travel from one network to another to reach its destination, many problems can arise. The addressing mechanism is used by the second network may be different from the first one. The second network may not accept the packet at all because it is too large. The protocols may differ, and so on. It is up to the network layer to overcome all these problems to allow heterogeneous networks to be interconnected.

d) **The Transport Layer**

The basic function of the transport layer is to accept data from the session layer, split it up into smaller units if need be, pass these to the network layer, and ensure that the pieces all arrive correctly at the other end. Furthermore, all this must be done efficiently, and in a way that isolates the upper layers from the inevitable changes in the hardware technology.

Transport Layer provides location and media independent end-to-end data transfer service to session layer.

e) **The Session Layer**

The main tasks of the session layer are to provide:

- Session Establishment
- Session Release – Orderly or abort
- Synchronization
- Data Exchange
- Expedited Data Exchange.

The session layer allows users on different machines to establish sessions between them. A session allows ordinary data transport, as does the transport layer, but it also provides enhanced services useful in some applications. A session might be used to allow a user to log into a remote timesharing system or to transfer a file between two machines.
One of the services of the session layer is to manage dialogue control. Sessions can allow traffic to go in both directions at the same time, or in only one direction at a time. If traffic can only go one way at a time (analogous to a single railroad track), the session layer can help in keeping track of whose turn it is.

A related session service is token management. For some protocols, it is essential that both sides do not attempt the same operation at the same time. To manage these activities, the session layer provides tokens that can be exchanged. Only the side holding the token may perform the desired operation.

Another session service is synchronization. Consider the problem that might occur when trying to do a 2 hour file transfer between two machines with a one hour mean time between crashes. After each transfer was aborted, the whole transfer would have to start over again and would probably fail again the next time as well. To eliminate this problem, the session layer provides a way to insert markers after the appropriate checkpoints.

f) **The Presentation Layer**

Unlike all the lower layers, which are just interested in moving bits reliably from here to there, the presentation layer is concerned with the syntax and semantics of the information transmitted.

A typical example of a presentation service is encoding data in a standard agreed upon format. Most user programs do not exchange random binary bit strings, they exchange things such as people's names, dates, amounts of money and invoices. These items are represented as character strings, integers, floating-point number, and data structures composed of several simpler items. Different computers have different codes for representing character strings (e.g., ASCII and Unicode), integers (e.g., one's complement and two's complement), and so on. In order to make it possible for computers with different representations to communicate, the data structure to be exchanged can be defined in an abstract way, along with a standard encoding to be used. The presentation layer manages these abstract data structure and converts from the representation used inside the computer to the network standard representation and back. It also performs the task of encryption and decryption.

g) **Application Layer**

Application Layer supports functions that control and supervise OSI application processes such as start/maintain/stop application, allocate/deallocate OSI resources, accounting, check point and recovering. It also supports remote job execution, file transfer protocol, message transfer and virtual terminal.

1.5.3 Encapsulation

Encapsulation is a technique of implementing layered architecture of a communication system. In OSI model we have separated all the communication functions/services into seven layers. We know that a layer serves the layer above it and is served by the layer below it, so to make it possible encapsulation techniques is followed for sending/receiving data between and through layers. In encapsulation we add some control information or "Header/Trailer" to a Data Unit by a communications protocol. This data along with header/trailer is known as Protocol Data Unit (PDU). This header/trailer actually creates an envelope for the PDU which has its address and addressee.

The Figure 10 shows the header associated with each of the N layers of some communication model. When a packet of data (we are saying it as PDU because packets is relevant to some protocol at some layer) is passed by any layer, attach a header (control information) of its layer and passes the packet (along with header) to the layer below. Each layer appends a new header to the PDU received from upper layer. Each layer considers the PDU of upper layer as data, and does not worry about headers in the PDU. This process continues until the packet reaches the lowest layer, which is the communication channel.

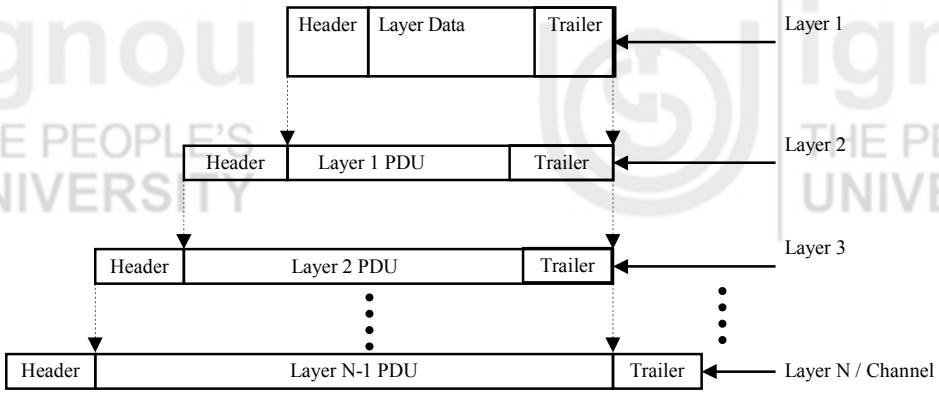

Figure 10: Encapsulation

This lowest layer is considered as physical layer by OSI model, which also add its control information. As you know that physical layer is final end or beginning of any side of communication. It converts PDU+control information into a series of bits and sends it across a cable or telecommunications circuit to the destination. Generally, due to this physical layer add control information at both ends of PDU for management point of view. At the receiver side, the Layer N of receiver reassembles the series of bits to form a packet and forwards the packet for processing by the upper (N-1) layer. This removes the N-1 layer header, and passes it to the next upper layer. The processing continues until finally the original packet data is sent to the program/application running at Layer 1.

1.5.4 End-To-End Argument

Assume we want to transfer some important file or information from a machine available on a network to a machine on other network. In case of a reliable communication we will establish a connection. If connection is available we send the data. Before accepting the data we will ensure the reliability of data at each step or each layer. But at the final stage at receiver (application layer) reliability check have to be performed. If we have to perform a final reliability check at application layer, can we say that we do not require reliability checks at lower layers? Is there any need to implement reliability at lower layers? Yes, it can be implemented but only for improving the performance in case the link quality is poor.

The end-to-end principle states that application-specific functions must be implemented in the end hosts of a network instead of intermediary nodes, provided these functions are "completely and correctly" implemented at the end hosts. The basic concept behind the end-to-end principle is that for two processes communicating with each other via some communication channel, the reliability obtained from that means cannot be expected to be absolutely associated with the reliability requirements of the processes. To be specific we can say, obtaining a very high 'reliability' requirements of communicating processes in a small network is more costly than obtaining that 'reliability' by end-to-end acknowledgements and retransmissions.

A system should consider only functions that can be completely and correctly implemented within it. We needs to be careful before implementing a functionality that we believe that is useful to an application at a lower layer. If the application can implement a functionality correctly, implement it a lower layer only as a performance enhancement. If implementation of function in higher levels is not possible due to technological/economic reasons then it may be placed at lower levels.

1.5.5 Protocol Design Issues

For communication to take place, protocols have to be agreed upon. Data are sent and received on communicating systems to establish communications. Protocols should therefore specify rules governing the transmission. In general, the following issues should be addressed for designing these protocols:

- Data formats: The format of data should be well defined, how the bit strings are divided in fields and in which format. Here, the packet size and format, PDU format, header size and format should be defines properly for proper communication. Let us assume a postal system, in which we specify, where the address of sender/ receiver should be written. Different kind of letters are represented by different methods like speed post, telegraph, registered post, book post, post card, etc.
- Address formats: Addresses are used to recognize both the sender and the proposed receiver. Mostly, addresses (also a bit string) are stuffed in the header field of the packet, to find whether the packet/data are intended for someone or not. The rules explaining the purpose of the address value are called an addressing scheme. For example, in the postal system, the method and sequence of writing an address is well formulated like name, father's name, house number, street, city, country, pin code, etc.
- Address mapping. Sometimes protocols need to map addresses of one scheme on addresses of another scheme. When the address formats are different than mapping is needed. For example, physical address of a computer need to be mapped with network address of a computer.
- Routing. When systems are not directly connected, intermediary systems along the route to the intended receiver(s) need to forward messages on behalf of the sender. In the postal system, we can see the post offices are selecting and sorting the letter according to the given addresses.
- Acknowledgements Scheme: In connection-oriented communication (communication systems where connection is not established before communication like email or SMS), acknowledgement of correct reception of packets is required. Acknowledgements are sent from receivers back to their respective senders, in the same way of registered posts. connection-oriented communication ensure the reliability by acknowledgement.
- Data Loss and damage: There is a possibility that data is lost or get corrupted (changed from 0 to 1 or vice versa). To address the data loss, protocols may implement acknowledgement scheme. Protocols may use timeout mechanism, in which if data is not received within a time frame sender is requested to retransmit the data. If data is corrupted, different error correction and detection mechanisms can be used.
- Sequence control: In this we wants to ensure that the packets (chunk of bits) are received in a correct sequence or not. The packets are sent on the network individually, so some packets may get lost or delayed or take different routes to their destination on some types of networks. As a result pieces may arrive out of sequence. necessary scheme should be implemented for retransmissions and reassemble the packets in right order to get the original message.
- Flow control is needed when the sender transmits faster than the receiver can process the transmissions. Flow control can be implemented by various schemes, which you will study further in the course.

1.6 APPLICATIONS OF COMPUTER NETWORKING

The main reason is that each computer network is designed with a specific purpose. Due to advancement in Computer Networks field we are now moving from personalized

computing to network computing. Therefore, its application is increasing every day. For example, a computer network in an office is used to connect computers in a smaller area, and it provides fast communication between the office persons/machines. The following is the list of some general application of computer network:

Resource sharing

Using networks we can share any resource, CPU processing power, peripherals like printers, scanners, etc, information like files and data and even software. This sharing is done by communicating the machine through whom we want to share.

Personal communication

There are many examples available with us for personal communication through computer networks, like email, chatting, audio/video conferencing, etc

Information Broadcasting and Search

This is also a mostly used application like website, blogs, social networking website, search engines, etc. Computer network provide us tremendous opportunity for information broadcasting, display, searching and information retrieval. Apart from these commonly used applications of computer networks we have following specific applications of computer networking.

Some Specific end applications

- Campus-wide computing and resources sharing
- Collaborative research and development
- Integrated system for design + manufacturing + inventory
- Electronic commerce, publishing and digital libraries
- Multimedia communication (tele-training, etc.)
- Health-care delivery (remote diagnosis, telemedicine)
- Video-on-demand.
- On-line learning.

☞ Check Your Progress 3

1. Explain the need of layering in the data communication protocols stack.

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2. List and explain any two functions of each OSI layer.

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1.7 SUMMARY

We hope you must have understood the concept of communication and communication system. As we discussed communication system is comprised of Information Source, Transmitter, Communication Channel, Receiver and the Destination. The information could be sent in the various forms like analog and digital. The concept of analog and digital transmission deals with form in which information is available and the way it is transmitted. Analog data is represented by continuous signals. The other type of signal is digital, which uses a bit steam. In this unit we have studied various modes and mechanism of communication like synchronous and asynchronous communication, simplex, half and full duplex communication. We studied that in simplex the data/signals are transmitted in one direction by a station i.e., by the sender, in half duplex the transmission can be done in one direction at a time whereas in full duplex the transmission can take place in both directions simultaneously. Further, in the unit we have explored the computer networking systems, its difficulties in data communication and the need of protocols and standards for these systems. We have also studied the details of OSI reference model and functions of OSI layers. In the end of this unit we have discussed different protocol design issues and listed some of the applications of computer networks. In the next unit, you will be introduced with various modulation techniques and there advantages. These modulation techniques are used to convert the message signal into a different form(s) so that it can be communicated through computer networks.

1.8 REFERENCES/FURTHER READING

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1.9 SOLUTIONS/ANSWERS

☛ Check Your Progress 1

1. Following are the essential elements of communication system.
   a) Information source: Source that produces a message
   b) Transmitter: An element that functions on the message to generate a signal which can be delivered through a medium/channel
   c) Communication Channel: that is the medium over which the signal (carrying the information that composes the message) is sent.
   d) Receiver: An element converts the signal back into the intended message.

e) Destination: It can be a person/machine, for whom / which the message is intended.

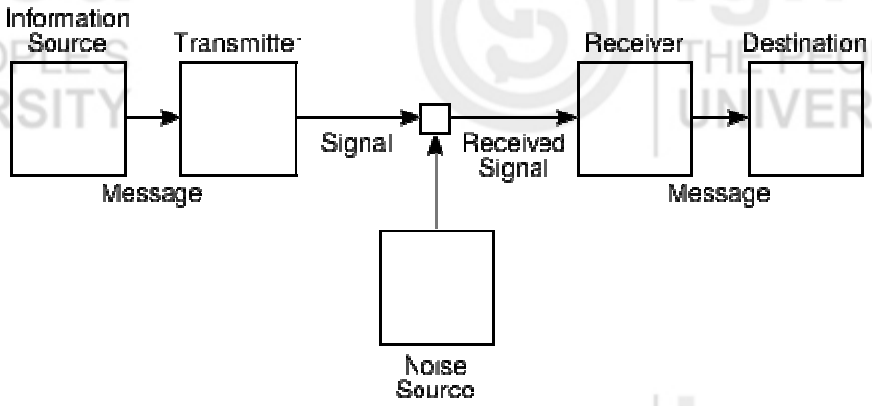

Diagram: Shannon's diagram of a general communications system

Here, the noise is considered as an error or undesired disturbance occurs during the transmission (before receiver and after transmitter), from natural and sometimes man-made sources.

2. Following are some differences between analog and digital communication:

Analog	Digital
Signals are records waveforms as they are. Signal occupies the same order of spectrum as the analog data.	Converts analog waveforms into set of numbers and records them. The numbers are converted into voltage stream for representation. In case of binary it is converted in 1's and 0's.
In analog systems electronic circuits are used for transformation of signals.	In this transformation is done using logic circuits.
About Noise analog signals are more likely to get affected and results in reducing accuracy	Digital signals are less affected, because noise response are analog in nature
Data transmission is not of high quality	Data transmission has high quality.

☞ Check Your Progress 2

1. Following are the main differences between Synchronous and asynchronous transmission.

Asynchronous transmission has following advantages and disadvantages:

- Each individual character is complete unit, hence if there is an error in a character, other sequence of characters are not affected. However, Error in start and stop bit(s) may cause serious problems in data transfer.
- Doesn't require synchronization of both communication sides.
- It is cost effective
- The speed of transmission is limited.
- Large relative overhead, a high proportion of the transmitted bits are uniquely for control purposes

Synchronous transmission has following advantages and disadvantages:

- In comparison to asynchronous communication it has higher speeds, because the system has lesser possibility of error. But, if an error takes place, the complete set of data is lost instead of a single character.
- Serial synchronous transmission is principally used for high-speed communication between computers but is unsuitable where the characters are transferred at irregular intervals.
- Lower overhead and thus, greater throughput.
- Process is more complex
- It is not very cost effective as hardware are more expensive

2. Following are the example for each:
   - Simplex communication: Radio/ Television Broadcasting System
   - half-duplex communication: walky-talky System
   - full duplex communication: Mobile or telephone system

☛ Check Your Progress 3

1. Explain the need of layering in the data communication protocol stack.

   The data communication follows protocols or protocols stack like OSI reference model. Since it is difficult to deal with complex set of rules, and functions required for computer networking, these rules and functions are divided with logical groups called layers. Each layer can be implemented interdependently with an interface to other layers providing with services to it or taking its services like data, connection and error control functions are grouped together into a layer. Speech in telephone conversation is translated, with electrical segments and vice-versa. Similarly in computer system the data or pattern are converted into signals before transmitting and receiving. These function and rules are grouped together into a layer.

2. List and explain any two functions of each OSI layer.

   The seven layers of ISO OSI reference model are:

   i) Physical Layer
   ii) Data Link Layer
   iii) Network Layer
   iv) Transport Layer
   v) Session Layer
   vi) Presentation Layer
   vii) Application Layer.

   a) **The Physical Layer**
      - Physical Layer defines electrical and mechanical specifications of cables and connectors.
      - Specify signaling options for sending control information between two nodes on a network.

   b) **The Data Link Layer**
      - The main task of the data link layer is to provide error free transmission.

- The data link layer creates and recognises frame boundaries. This can be accomplished by attaching special bit patterns to the beginning and end of the frame.

c) **The Network Layer**

- The network layer ensures that each packet travels from its sources to destination successfully and efficiently. It determining how packets are routed from source to destination.
- Addressing is another important task of this layer. The addressing used by the second network may be different from the first one. The second network may not accept the packet at all because it is too large. The protocols may differ, and so on. It is up to the network layer to overcome all these problems to allow heterogeneous networks to be interconnected.

d) **The Transport Layer**

- The basic function of the transport layer is to accept data from the session layer, split it up into smaller units if need be, pass these to the network layer, and to ensure that the pieces all arrive correctly at the other end.
- Transport Layer provides location and media independent end-to-end data transfer service to session and upper layers.

e) **The Session Layer**

- Session Establishment and Session Release – Orderly or abort
- Synchronization, Data Exchange and Expedited Data Exchange.

f) **The Presentation Layer**

- Presentation layer is concerned with the syntax and semantics of the information transmitted.
- The presentation layer manages these abstract data structure and converts from the representation used inside the computer to the network standard representation and back.

g) **Application Layer**

- Application Layer supports functions that control and supervise OSI application processes, such as start/maintain/stop application, allocate/deallocate OSI resources, accounting, check point and recovering.
- It also supports remote job execution, file transfer protocol, message transfer and virtual terminal.