

Unit – 1

Computer Networks:

- A Computer Network means an interconnected collection of autonomous computers that can share and exchange information.
- Two computers are said to be interconnected if they are able to exchange information.
- It is an interconnection of various computers to share software, hardware and data through a communication medium between them.
- Basically, The Computer Network is a collection of computers, printers and other equipment, which are connected together so that they can communicate with each other.

Uses of Computer Networks:

- **Network for Companies:**
 - **Computer Networks are useful to the organization for:**
 - Resource Sharing
 - High Reliability
 - Saving Money
 - Providing a powerful communication medium
- **Network for People:**
 - **Computer Networks offer following services to an individual:**
 - Access to remote information
 - Person to person communication
 - Resource Sharing
 - Interactive Entertainment
 - Exchanging Information

Applications of Computer Networks:

- **Communication Medium:** The most widely used network application is its use as a communication medium. It is possible for everyone to send and receive e-mails.
- **Sharing:** A Major applications of network is that it facilitates distinct types of sharing:
 - Sharing of Peripherals
 - Sharing of Data and Information
- **Access to remote database:** Another area of network application is access to remote database. Airline reservation, hotel booking, railway reservation etc. are easy for anyone sitting anywhere in the world.
- **Financial Services:** It depending on computer networks include foreign exchange and investment services, electronic funds transactions (EFT) etc.

- **Information Services:** There may be corporate information systems such as marketing information system, customer information system, product information system etc. Computer networks also facilitate decision making.
- **Tele Conferencing:** Tele Conferencing allows conferences to occur without the participants being in the same place.
- **Entertainment:** Its applications include video on demand interactive films and games, live television where audience participate in quiz shows etc.
- **Marketing and Sales:** Computer networks are used extensively in both marketing and sales organizations. Marketing professionals use them to collect, exchange and analyze data relating to customer needs.
- **Business Applications:** Now a days, business affairs rely on computer networks and internet works. To monitor production, inventories, to make payments etc. computers are extensively in use.

Advantages of Computer Networks:

- **Resource Sharing:** The networking of computers allows to share resources with others on the network. This permits to share software and peripherals such as printers, plotters, scanners and so on.
- **Easier Backups:** It means making copy of data for future use. In Business or office work, backup data is very important and valuable.
- **Communication:** Organizations today are widely dispersed over in the world. They need to exchange information and data. The computer network allows easy communication through email, internet telephony, teleconferencing etc. This allows the communication between various organizations to cooperate with each other in performing certain task rapidly.
- **Interactive Entertainment:** Computer network provides many types of games and entertainment. The real time interactive games like flight simulators are also becoming popular.
- **Cost Reduction:** Sharing of hardware and software resources leads to the reduced equipment costs. Also cost of transfer of data/documents over long distances using computers connected on network is much cheaper than other means of data transfer like speed cost, telegram etc.
- **Increased Reliability:** It is another advantage due to which networking is more popular. The provision of alternate resources leads towards high reliability of data as there are multiple existence of same data at more than one locations.

Disadvantages of Computer Networks:

- **Data Security:** Unauthorized Personnel can access the information if network security is weakly implemented.
- **Expensive:** They are expensive to purchase and maintain.

- **Crashes:** On a server-based network, if the server crashes, work gets disrupted. If proper precautions are not taken to ensure regular backups, the crash may result in the loss of critical data.
- **Privacy:** If the network is poorly implemented, improper communication may take place. This may lead to a situation in which the private or important e-mails can be read by other users and this result in loss of privacy.
- **Viruses:** The virus on one system in a network can affect the whole computer network. Viruses are easily spread over networks. To overcome this problem costs more time, money and administrative effort.

Need of Networking:

- File Sharing
- Load Sharing
- Peripheral Sharing
- Fast Communication
- Accuracy
- High Reliability
- Backups
- To enable different computers to communicate
- Low cost of Data Transfer

Different Types of Computer Networks:

- a. **LAN (Local Area Network):** It refers to two or more up to several hundred computers and variety of computing equipment, linked via some communication lines, to exchange information speedily, within a small well-defined area. For Example: University, Campus etc.
 - **Characteristics of LANs:**
 - Small Area
 - Single Owner
 - Reliability and Stability
 - Physically Secured
 - Flexibility
 - Low cost data transmission
 - Data and Resource Sharing
 - **Advantages of LANs:**
 - Sharing Resources
 - High Speed Exchange
 - Data Transaction
 - Centralized Backup
 - Easy and Economical Communication

- Good Security
- **Disadvantages of LANs:**
 - Limited Area
 - Adds Complexity
- b. **WAN (Wide Area Network):** It connect computers and smaller networks to large networks over greater geographic areas, including different continents. These computers may be linked by means of cables, optical fibers or satellites. The purpose of WAN was to connect multiple systems in an efficient and economical way so that it can be shared by a large number of users.
 - **Characteristics of WANs:**
 - Geographically Expansive
 - Centralizing Information
 - Remote Access
 - **Functions of WAN:**
 - Remote data
 - Facilitating Communication
- c. **MAN (Metropolitan Area Network):** A Network that expands into a metropolitan area and exhibits high data rates, high reliability and low data loss is called a metropolitan are network (MAN).
 - **Characteristics of MANs:**
 - Intermediate Size
 - High Speed Network
 - Interconnects LANs
 - Connects Whole City

Network Design Issues:

- **Identifying and Justifying a Network:** In the Network Design, Identifying and Justifying a network is necessary. The networks are capable of handling various data types and support a wide and ever-growing range of applications.
- **Scope:** The scope of a network is bounded on one side by the communication facilities offered by the common carriers and on the other side by the applications.
- **Manageability:** A Network comprising of many different facilities and with complex and specialized control procedures may be cost effective, it may be difficult to own.
- **Scalability:** Another significant issue in general network design is the scalability – the scalability of the network to meet future demands based on projected traffic volumes etc.
- **Link Topology:** The topological optimization of a network involves selecting the specific links interconnecting nodes.

Network Protocols: A Network Protocol is the set of rules that governs communications between computers on a network.

These rules include guidelines that regulate the following characteristics of a network:

- Access Method
- Allowed Physical Topologies
- Types of Cabling and
- Speed of Data Transfers

Various Types of Protocols:

- **TCP/IP:** TCP/IP is the industry standard suite of protocol that enables enterprise networking and connectivity in a heterogeneous environment. It is the protocol commonly used for interoperability between various types of computers, and can be used to access the Internet and its resources.
- **Ethernet:** It is the most widely used protocol. Ethernet uses an access method called CSMA/CD (Carrier Sense Multiple Access/Collision Detection). This is a system where each computer listens to the cable before sending anything through the network.
- **Token Ring:** The Token Ring protocol was developed by IBM in the mid-1980s. The access method used involves token-passing. In Token Ring, the computers are connected so that the signal travels around the network from one computer to another in a logical ring.
- **FDDI:** Fiber Distributed Data Interface (FDDI) is a network protocol that is used primarily to interconnect two or more local area networks, often over large distances.
- **ATM:** Asynchronous Transfer Mode (ATM) is a network protocol that transmits data at a speed of 155 Mbps and higher. ATM works by transmitting all data in small packets of a fixed size; whereas other protocols transfer variable length packets.

Connection-Oriented Service:

- It means establishing a dedicated connection between communicating entities before any data can be exchanged.
- The Connection establishment may be at the physical or the logical level and involves some form of signaling.
- The Service users undergo the following sequence of operations:
 - Establish a connection
 - Use the connection i.e. exchange of user data
 - Release or clear the connection

Connectionless Service:

- A Connectionless service is that which does not require a connection to be established before the exchange of data.
- Information is transferred by using independent data units.
- An example of a connectionless service is the postal mail.

Peer-to-Peer Model:

- A Peer-to-Peer network model is simple two or more computers linked together, sharing resources such as printer, scanner or internet connection and storing files and programs on their own hard drives.
- In this type of network, each computer is responsible for:
 - Making its own resources available to other computers on the network.
 - Setting up and maintaining its own security for these resources.

Advantages of Peer to Peer Network Model:

- Useful for small business.
- Setting up of peer to peer network does not require extra environment in server hardware or software.
- Requires less expensive hardware as the resources are distributed over many computers.
- Easy set up.
- Users can control resource sharing.
- Requires simple cabling scheme.

Disadvantages of Peer to Peer Network Model:

- Not very secure.
- No central point of storage for file archiving.
- Peers cannot handle as many network connections as servers.
- Requires users to administer their own computers.
- Causes additional load on computers because of resource sharing.

Client/Server Network Model:

- In Client-Server Network, certain computers act as server and other act as clients.

- A server is the computer that makes the network resources available and provides services to other computers on their request.
- A Client is any computer on the network that requests something from a server.

Advantages of Client/Server Model:

- Centralized data storage allows users to access information and provides easy back up of critical data.
- Easy manageability of a large number of users.
- Central security is provided.
- Ability of servers to pool available hardware and software.
- Ability to share expensive equipment such as laser printers.
- Reduced network traffic.
- Reduced cost due to the ability of server to share available hardware and software.
- Centralized dedicated server provides more reliability.

Disadvantages of Client/Server Model:

- Requirement of expensive dedicated hardware.
- Requirement of professional administration.
- Complex installation and configuration as compared to a peer to peer network.
- Requirement of client computers and high speed server computers with lots of memory and disk space.

Distributed System:

- A Distributed System consists of multiple autonomous computers that communicate through a network.
- Distributed Computing Interconnects one or more personal computers/computational entities.
- It allows various services like file sharing, hardware sharing or network sharing.
- The purpose of the distributed system is to co-ordinate the use of shared resources or provides communication services to the users.

Characteristics or Features of a Distributed System:

- The System may consist of different kinds of computers and networks.
- This system uses distributed processing, in which a task is divided among multiple computers.
- A Computer Program that runs in a distributed system is called Distributed Program.

- Links and the system may change during the execution of a distributed program.
- Each node has its own central processing unit with its own memory and communication hardware.
- The nodes or computers can be of different sizes, makes and computing powers.

Advantages of Distributed System:

- Distributed Database
- Cost Efficiency
- Faster Problem Solving
- Encapsulation
- Shared Resources
- Response Time Improvement

Disadvantages of Distributed System:

- Hardware Problems
- Technical Problem
- Data Integrity and Security Issues
- Maintenance of Remote Sites

Centralized and Decentralized System:

- In a Centralized System, all processing is done at one central computer.
- In the early days of computer technology, this type of processing was justified because data processing personnel were in short supply, hardware and software were expensive, and only large organization could afford computers.
- The Main advantage of Centralized system is being able to exercise tight control on system operations and applications.
- The Main disadvantage of Centralized system is lack of responsiveness to user's needs, because the system and its users could be located far apart from each other.
- In a Decentralized System, each user, department or division has its own computer for performing processing tasks.
- A Decentralized processing system is certainly more responsive to users than a centralized processing system.
- Decentralized systems have some drawbacks, including lack of coordination among organizational units, the high cost of having many systems and duplication of efforts.

Web Based Model:

- For ensuing scalability, the world-wide web has adopted a stateless approach to client-server communication called the Web-based Model.
- In this model, each interaction between the client and the server is independent of the other interactions.
- No permanent connection is established between the client and the server and the server maintains no state information about the clients.

A Web-based Model implies the following factors:

- Changing patterns of network use and unpredictable demands for bandwidth.
- Demand for increased amount of bandwidth.
- Demand for guaranteed quality of service in terms of bandwidth and minimum delay.
- Lack of control by IT staff.

OSI Reference Model:

- The International Standards Organization (ISO) developed the Open System Interconnection (OSI) reference model.
- OSI model is the most widely used model for networking.
- OSI model is a seven layer standard.
- Each layer performs a well-defined function.

Layers of OSI Model:

a. Physical Layer:

- It is the lowest layer of the OSI model.
- This layer transmits raw bits over a communication channel.

Major Functions and Services of Physical Layer:

- Establishment and termination of a connection to a communications medium.
- Defines data encoding i.e. how 0's and 1's are changed to signals.
- Defines the transmission rate i.e. the number of bits transmitted per second.
- Deals with network connection types, including multipoint and point to point connections.
- Protocols of physical layer are: IEEE 802 IEEE 02.2

b. Data Link Layer:

- It provides error-free communication lines between computers that are directly connected.
- It groups zeroes and ones into frames.

- A Frame is a series of bits that forms a unit of data.
- It is responsible for providing reliable transfer of information across the physical link and it sends frames.
- Error free service is provided by breaking bit stream into frames and adding extra bit for error detection.
- This layer is also responsible for flow control to prevent flooding of nodes and to manage speed difference between a fast sender and slow receiver.
- The data link layer constructs the frames and performs error checking.

Major Functions and Services of Data Link Layer:

- It alerts upper layer protocols that a transmission error has occurred.
- It groups bits into frames and ensures their correct delivery.
- It consists of the data link layer specification that often defines how devices are to be physically connected like bus or a ring topology.
- It interoperates certain processes which carry out error control, flow control, access control and the associated link management functions.
- It defines how devices are addressed at the data link layer.
- It transfers data from one node to another node.

c. Network Layer:

- The Network Layer is a complex layer that controls the operation of the communication subnet.
- It specifies the intra-network operations and different types of addressing and routing services.
- The main functions of network layer are packet routing, accounting and congestion control.
- Logical and Service addressing are provided from network layer.

Main functions and Services of Network Layer:

- It manages traffic with the help of packet switching, routing and controlling the congestion of data.
- It determines the route from the source to the destination computer.
- It is responsible for addressing messages and translating logical addresses and names into physical addresses.

d. Transport Layer:

- It is responsible for reliable end to end data transfer between source and destination.
- The Transport Layer performs the service of accepting data from session layer, splits it up into smaller units, if needed, passes these to network layer and ensures that the pieces arrive correctly at the other end.
- It also provides facility for end-to-end error recovery and flow control.

Major Function or Services of Transport Layer:

- It is responsible for providing reliable and transparent transfer of data between source and destination points.
- It provides flow control, sequence numbering and message acknowledgement.
- It determines what type of service to provide to the session layer and ultimately the users of the network.

e. Session Layer:

- The Session Layer adds mechanisms to establish, maintain, synchronize and manage communication between network entities.
- It provides services to manage who can transmit data at a particular time.

Major Functions or Services of Session Layer:

- It provides the synchronization to the data.
- This layer is responsible for regulating communication between source and destination.
- This layer controls dialogues between two processes; determining which one can transmit and which one can receive and at what point of time during communication.

f. Presentation Layer:

- It is responsible for data compression, data encryption and data decryption.
- It translates or formats data to adapt to the needs of application layer and nodes at both the receiving and sending ends of communication process.

Major Functions or Services of Presentation Layer:

- The main responsibility of this layer is data compression.
- It reduces the size of data in order to achieve faster transmission over the network.
- For the security, it encrypts and decrypts data whenever required.
- Data Encryption is the conversion of data into an encoded form that cannot be read by an unauthorized person.
- It translates data i.e. it converts the data from one protocol to another so that it can be transferred between dissimilar platforms or operating systems.

g. Application Layer:

- It provides access to OSI environment for users.
- It also provides distributed information services.
- The application layer provides a variety of protocols that are commonly needed to the application processes running on separate computers on behalf of user tasks.
- The protocols include electronic mail, remote job entry and file transfer.

Major Functions or Services of Application Layer:

- It provides services for electronic mail.
- It provides the mechanism for remote file access and transfer.
- It provides user interfaces and support for services.

TCP/IP Reference Model:

- Transmission Control Protocol / Internet Protocol is the protocol that makes possible the communication between different types of machines on different types of networks.
- It was developed by the United States Development of Defence Advanced Research Projects Agency (ARPA).
- ARPA originally created TCP/IP to connect military networks together.
- It is the most widely used protocol for interconnecting computers and it is the protocol of the Internet.

Goals of TCP/IP Model:

- The network should connect multiple networks together.
- The connection should withstand till the source and destination machines are functioning.
- The architecture should be so flexible that it should be able to transfer data among different hardware or software platforms.

Layers of TCP/IP Model:

a. Application Layer:

- This is the highest level layer in the TCP/IP Model which is on the top of the transport layer.
- This layer includes all processes and services that use the transport layer to deliver data.
- The Protocols contained in the layer are FTP, SMTP etc.

b. Transport Layer:

- It provides end-to-end transfer service.
- It is the layer above the internet layer in the TCP/IP model.
- It is designed to allow peer entities on source and destination machines to communicate with each other, just as in the OSI transport layer.
- Two end-to-end transport protocols have been defined here.
- These are Transmission Control Protocol (TCP) and User Datagram Protocol (UDP).
- TCP provides a reliable flow of data between two communicating machines.

- UDP provides an unreliable flow of data between two communicating machines.

c. Internet Layer:

- It provides the means through which a host can send packets onto a network and then have them travel independently to their destination.
- The Internet Network level protocols IP (Internet Protocol) and ICMP (Internet Control Management Protocol) handle machine to machine communications.
- The Internet Layer provides the Addressing and Fragmentation services.

d. Data Link Layer:

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e. Physical Layer:

- It is the lowest layer of the TCP/IP model.
- This layer transmits raw bits over a communication channel.

Network Topology:

- Topology refers to the physical or logical layout of the network.
- It can be determined by the configuration of connections between nodes.
- Network Topology refers to the geometrical arrangement and connection of nodes in the network.
- A node is an active device connected to the network like a computer or a printer.

Various Types of Network Topologies:

a. Bus Topology:

- In bus topology, all devices on network are connected to a single continuous cable called a bus.
- This long cable acts as a backbone to link all the devices in a network.
- This cable has terminator at each end.

- Bus topology uses multipoint cabling i.e. multiple devices are connected by means of connectors.

Advantages of Bus Topology:

- The reduction in physical lines.
- A wide range of equipment can be attached to the LAN without any problem.
- It is easy to use and understand, reliability is higher in very small networks.
- Low cabling cost.
- The failure of a node does not affect others.
- The backbone can be extended by using repeater.

Disadvantages of Bus Topology:

- The performance may decrease as numbers of nodes are increased.
- Failure of backbone affects failure of all devices on the network.
- Low reliability.
- The fault detection is very difficult.
- Each connection between two cables weakens the electrical signal.

b. Star Topology:

- In this topology, a device known as hub is placed in the center of network and all nodes are connected to the central hub and communicate through it.
- A star network consists of several devices connected to one centralized computer.
- Any communication between the stations must pass through the central node.
- Device can be easily plugged to the central node, as when required.
- The routing function is performed by HUB, which centrally controls communication between any two nodes by establishing a logical path between them.
- HUB manages and controls all functions of the network.
- It is considered as a central controller.

Advantages of Star Topology:

- In this topology, there is minimum data traffic along the cable and thus it provides the optimum performance.
- A broken connection between a node and a hub does not affect the rest of the network.
- Networking management is easy.
- Fault detection is easy.
- It is easy to modify and add new nodes to a start network without disturbing the rest of the network.

Disadvantages of Star Topology:

- More cabling is needed as compared to Bus or Ring Topology.
- The system depends on HUB and If breaks down, the whole network would break down.
- More expensive.
- The Maintenance costs may be high.

c. Ring Topology:

- In this topology, all nodes are connected in a circular form like a chain, with each node connected to the next.
- The last node of the network connects to the first node to complete the ring.
- The ring topology is also called a loop.
- A ring may be unidirectional or bi-directional.

Advantages of Ring Topology:

- Link failure can be easily found as each device is connected to its immediate neighbors only.
- Simple to install or reconfigure.
- It introduces less signal loss as data travels along the path.

Disadvantages of Ring Topology:

- There may be large communication delays as the number of nodes increases.
- Each node on the ring must handle the data being transferred by other nodes.
- If one node fails to handle the transfer of data, then whole of network fails.
- Adding a new node can be difficult.

d. Mesh Topology:

- It is a network in which every node has a dedicated point-to-point link to all the nodes within network.
- There is no chance of data failure i.e. if one connection goes down, there are other ways to route the data to its destination.

Advantages of Mesh Topology:

- Communication between nodes is very fast.
- It is very reliable because breakdown in any one of the lines will not affect other links.
- It permits any two devices in the network to communicate directly.
- Security is maintained.

Disadvantage of Mesh Topology:

- High Cost.
- Difficult to install and reconfigure.

- Complexity increases as number of nodes increases.

Examples of Networks:

a. ATM:

- ATM stands for Asynchronous Transfer Mode.
- ATM is a connection-oriented network.
- It is network technology based on transferring data in cells of a fixed size.
- It uses packets of fixed size for the communication of data.
- These packets are called as ATM cells.
- ATM is used for efficient data transfer over high speed data networks.
- It provides real time and non-real time services.

ATM Technology:

- It provides good bandwidth and flexibility.
- It can be used effectively from desktop computers to LAN and WAN.

ATM Architecture:

- **The Physical Layer:**
 - It deals with the transmission and reception of ATM cells across a physical medium between two ATM devices.
- **The ATM Layer:**
 - This layer is common to all the services that provide the packet transfer capabilities.
 - The ATM layer deals with cells and transport of cell.
 - It also deals with establishment and release of virtual circuits.
- **ATM Adaptation Layer:**
 - It allows users to send packets larger than a cell.
 - The ATM interface segments these packets, transmits the cell individually and reassembles them at the other end.

Advantages of ATM:

- It provides flexibility for different applications.
- It has ability to connect LAN to WAN.
- It is best suited for voice, video and data communication.
- It provides scalability in speed and network size.
- It transmits data at high speed mbps.

Disadvantages of ATM:

- It is an expensive technique.
- The mechanisms are complex for achieving Quality of Service (QoS).

ATM Applications:

- Video Conferencing.
- Distance Learning.

b. Frame Relay:

- It is concept where the information is sent using data frames in a digital format.
- It uses a packet switching technology.
- Using this relay service, the data can be sent in a fast and efficient way through the internet.
- It is a cheaper way to send data from one point to another.

Frame Relay was developed to solve:

- Communication problems.
- Increased need for higher speeds.
- Increased need for large bandwidth efficiency.
- Need to connect LAN and WANs.

Advantages of Frame Relay:

- Reducing the Costs.
- It is protocol independent.

Disadvantages of Frame Relay:

- The damages frame is simple dropped.
- There is no retransmission.
- It does not provide the acknowledgement of received packets.
- It does not provide flow control.

c. X.25:

- The X.25 protocol is commonly used network protocol.
- This protocols allows computers on different public networks to communicate.

Advantages of X.25:

- Error Checking at every node.
- Provides the network at low cost.

Disadvantages of X.25:

- Delay in Transmissions.