

# COMPUTER NETWORKS

DR. G. ANANDHI

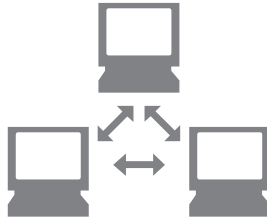
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# 1. Introduction to Computer Networks

## 1.1 Network Model

1.1.1 Physical Topology

## 1.2 Categories of Network

1.2.1 Local Area Network

1.2.2 Metropolitan Area Network

1.2.3 Wide Area Network

1.2.4 Personal Area Network

1.2.5 Campus Area Network

## 1.3 The OSI Model

1.3.1 Physical Layer

1.3.2 Data Link Layer

1.3.3 Network Layer

1.3.4 Transport Layer

1.3.5 Session Layer

1.3.6 Presentation Layer

1.3.7 Application Layer

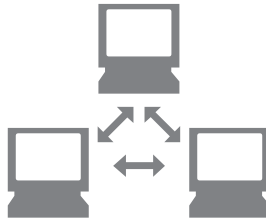
## 1.4 TCP/IP Protocol Architecture

1.4.1 Physical and Data link layers

1.4.2 Network Layer

1.4.3 Transport Layer

1.4.4 Application Layer



# I. INTRODUCTION TO COMPUTER NETWORKS

Data communication is the process of using computing and communication technologies to transfer data from one place to another through a transmission media.

A computer network is a collection of computer systems and other computing hardware devices that are linked together through communication channels to allow communication and resource-sharing among many users.

Effectiveness of data communication depends on four fundamental characteristics:

- a. Delivery: System must deliver data to correct destination.
- b. Accuracy: System must deliver the data accurately.
- c. Timeliness: System must deliver the data in a timely manner.
- d. Jitter: Refers to the variation in the packet arrival time.

Data communication system has five components:

- i. Message: This is the information to be communicated.
- ii. Sender: It is the device that sends data message.
- iii. Receiver: It is the device that receives the message.
- iv. Transmission Media: It is the physical path through which message is sent from sender to receiver.
- v. Protocol: It is a set of rules that govern data communications.

## Data Flow

Communication between two devices can be simplex, half-duplex or full-duplex. This is diagrammatically explained in Fig 1.

1. Simplex: Communication is unidirectional. One device on the link can transmit and the other can only receive.
2. Half-Duplex: Each station can transmit as well as receive data, but at different times. When one device sends the data, other one receive and vice versa.
3. Full-Duplex: Both stations can transmit and receive data at the same time.

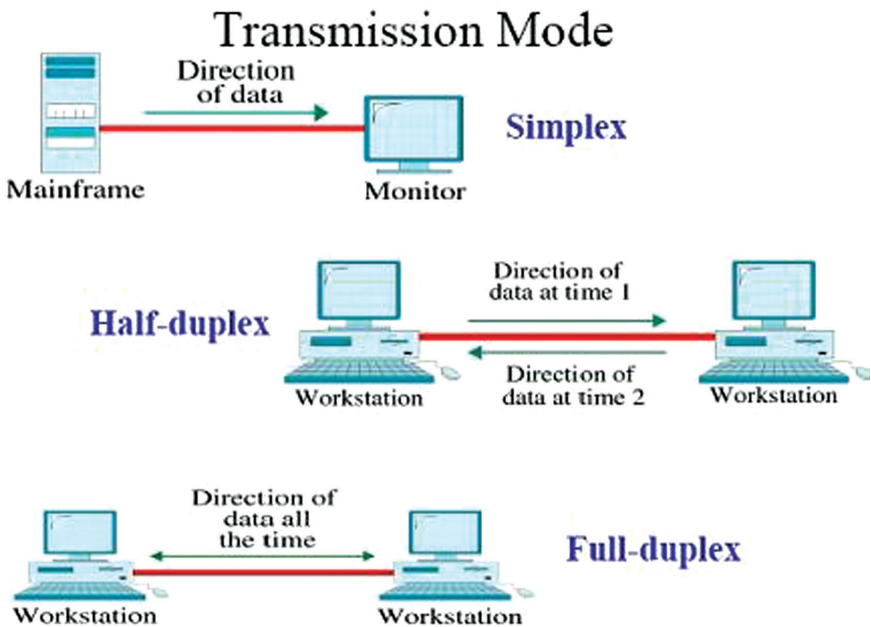


Fig 1: Communication Modes

## 1.1 Network Model

### 1.1.1 Physical Topology

Physical Topology is the way in which network is laid-out physically. There are four basic topologies:

## Computer Networks

1. **Mesh:** According to Fig 2, every device has a separate point-to-point link to other device.

### Advantages:

- i) Each connection has its data load to remove traffic problems using dedicated links.
- ii) It is robust.
- iii) It has security or privacy.

### Disadvantages:

- i) More cables are required.
- ii) Installation is difficult.
- iii) Hardware is expensive.

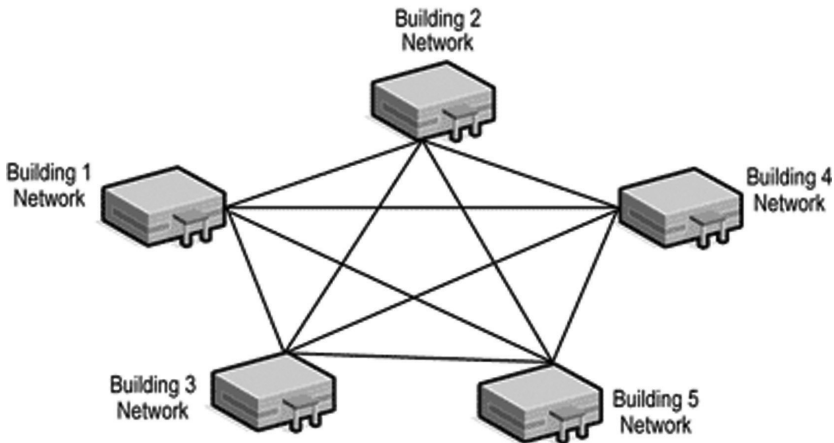


Fig 2: Mesh Topology

2. **Bus:** This is multipoint. One cable links all devices. This is demonstrated in Fig 3.

### Advantages:

- i) Easy Installation.
- ii) Redundancy is eliminated.

### Disadvantages:

- i) A fault stops all the transmission.
- ii) Difficult for fault isolation and reconnection.

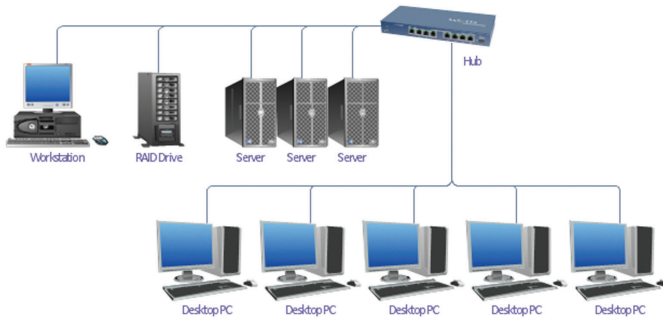


Fig 3: Bus Topology

3. **Star:** Each device has a point-to-point link using hub. As per Fig 4, unlike mesh this does not allow traffic between devices.

**Advantages:**

- i) It is less expensive, requires one I/O port and one link to connect any number of devices.
- ii) Easy to install and reconfigure.
- iii) Robustness.

**Disadvantages:**

- i) If the hub goes down the whole system is dead.

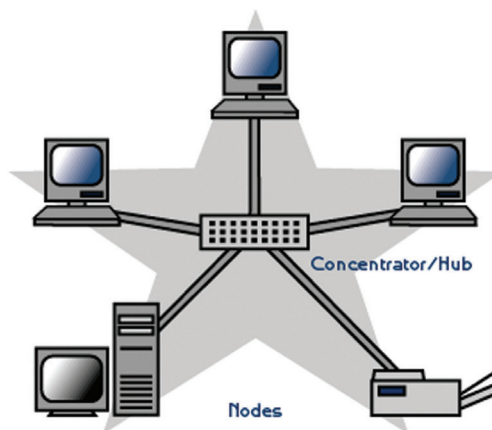


Fig 4: Star Topology

## Computer Networks

4. **Ring:** Every device is dedicated to point-to-point connection with two devices. Each device is incorporated with a repeater as per Fig 5.

### Advantages:

- i) Easy to install and reconfigure.
- ii) Fault isolation is simplified.

### Disadvantages:

- i) Any fault or damage in the ring can disable the entire network.

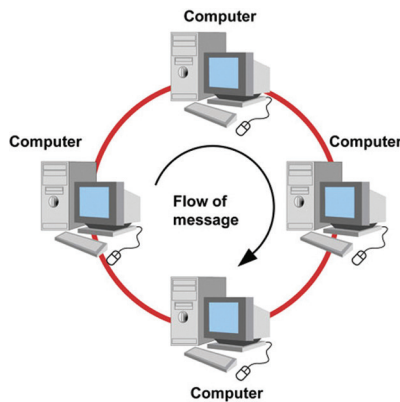


Fig 5: Ring Topology

5. **Hybrid:** A main star topology with each branch connecting to several stations in a bus topology. Fig 6 shows the hybrid topology.

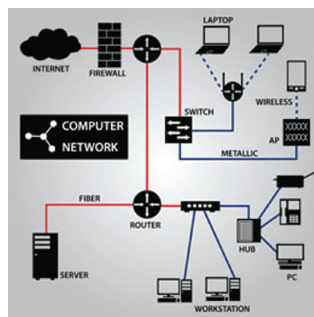


Fig 6 Hybrid Topology

## 1.2 Categories of Networks

### 1.2.1 Local Area Network (LAN)

It links the devices in a building, office or campus. Size is limited to few kilometers. Speeds are normally 100 or 1000 Mbps and the data rates are 4 to 16 megabits per second (Mbps) range. Resources to be shared are hardware, software or data. LAN topologies are bus, ring and star. These are called enterprise networks. Access point (AP), wireless router relays packets between wireless computers and Internet. IEEE 802.11 called Wi-Fi is a type of LAN. IEEE 802.3 called Ethernet uses the topology of switched Ethernet. In virtual LAN, each port is tagged with a color which forwards packets. If two or more packets are collided, computer has to wait for a random time, classic Ethernet solves this problem. Fig 7 is a diagrammatic representation of LAN.

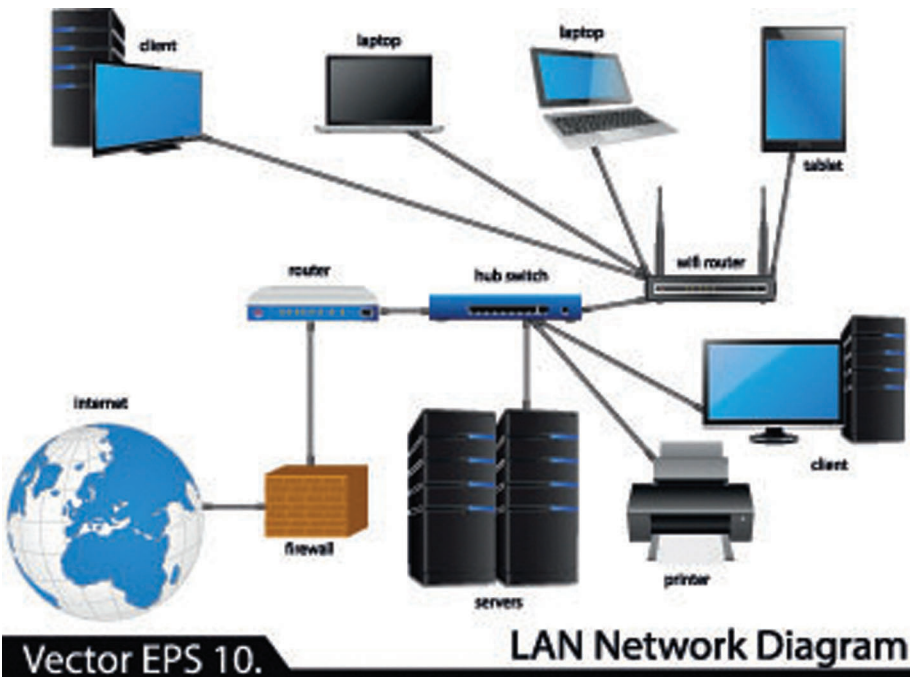


Fig 7: Local Area Network (LAN)

### 1.2.2 Metropolitan Area Network (MAN)

The size of this network is between LAN and WAN as per Fig 8 and covers a small area like a town or city. It is more useful for customers who need high-speed network connectivity. IEEE 802.16 known as WiMAX is a type of MAN. Good example of MAN is the part of telephone company network which provides high-speed DSL line to the customer. Another example is cable TV network.

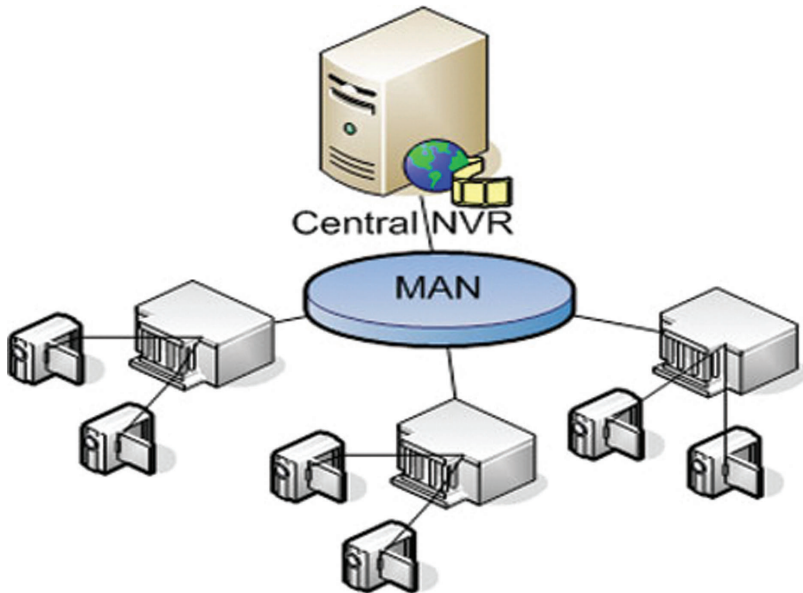


Fig 8: Metropolitan Area Network (MAN)

### 1.2.3 Wide Area Network (WAN)

This covers areas like a country, a continent or the whole world which is shown in Fig 9. Switched WAN connect end systems like router which connects to another LAN or WAN. Point-to-point WAN is a leased line from telephone which connects home computer to Internet Service Provider (ISP). Many WANs is internetwork. Leased dedicated transmission lines connect its offices to Internet. They are made as virtual links and is called Virtual Privet Network (VPN). The subnet that is run by a different company is called Network

Service provider. There may be many paths in the network that connect two routers. When the network decides which path has to be used is called routing algorithm.

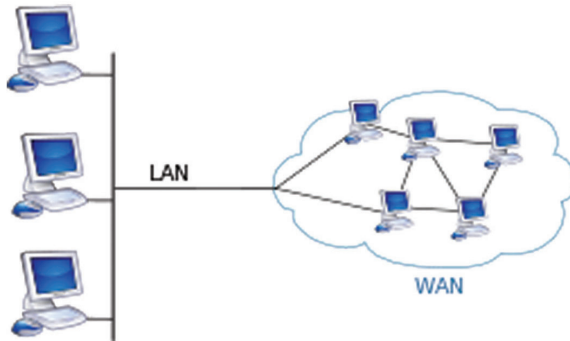


Fig 9: Wide Area Network (WAN)

### 1.2.4 Personal Area Network (PAN)

This communicates over the range of a person. Bluetooth connects the components without wires. Different kind of PAN is used in pacemakers, insulin pump, hearing aid etc. PANs are built with technologies that communicate over short ranges. Fig 10 shows a PAN.

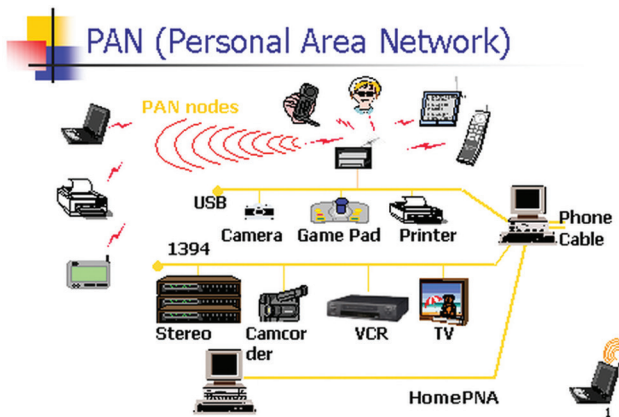


Fig 10: Personal Area Network (PAN)

### **1.2.5 Campus Area Network (CAN)**

It is a network of multiple interconnected local area networks (LAN) in a limited geographical area. CAN is smaller than a wide area network (WAN) or metropolitan area network (MAN). A CAN is a network that covers an educational or corporate campus.

#### **Advantages:**

- Cost-effective
- Wireless
- Versus cable
- Multi departmental network access
- Single shared data transfer rate (DTR)

### **Connection-oriented Versus Connectionless Service**

Connection-oriented service is designed as per the telephone system. The receiver of the call has to answer and the sender keeps talking accordingly. Connectionless service is designed as per the postal system. A packet is a message at the network layer. When the intermediate node receives a message in full before sending it on to the next node, is called store-and-forward switching. The alternate where the transmission of a message at a node starts before it is received by the node is called cut-through switching. For some applications, transit delays made by acknowledgements are unacceptable. One such application is digitized voice traffic for voice over IP. All applications do not require connections. Spammers send electronic junk-mail to many recipients. Unreliable connectionless service is called datagram service.

## **1.3 The OSI Model**

This Model is called ISO OSI (International Standards Organization Open System Interconnection). It contains seven layers. Its principles are:

- i) A layer is created with different abstraction.
- ii) Each layer should perform well-defined function.

- iii) The function of each layer is defined with internationally standardized protocols.
- iv) Layer boundaries are chosen to minimize information flow across interfaces.
- v) Number of layers should be large so that the functions does not lie in the same layer.

Fig 11 gives a detailed idea of OSI Reference Model.

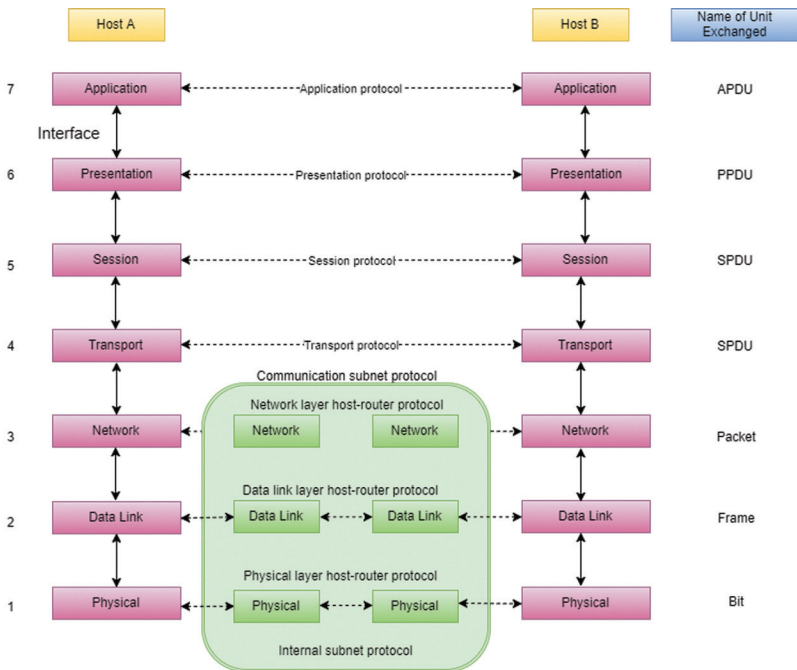


Fig 11: The OSI Reference Model

### 1.3.1 Physical Layer

This layer is concerned with transmitting raw bits over a communication channel. It deals with mechanical and electrical specification of the interfaces and transmission medium. The sender and receiver must use the same bit and must be synchronized at the bit level. It defines the characteristics of the interface between the devices and the transmission medium. Data consists of bits with no interpretation. For transmission purpose the bits should be encoded.

### **1.3.2 Data Link Layer**

It transforms raw transmission facility into a line to make free of undetected transmission errors. It accomplishes the masking of errors by breaking the input data and transmitting data frames. If the service is reliable, the receiver confirms receipt of each frame by sending acknowledgement frame. This layer also has the capacity of dividing the stream into data units called frames.

### **1.3.3 Network Layer**

Operation of subnet is controlled by this layer. Key design is to determine how packets are routed from source to destination. Too many packets in the subnet creates bottlenecks where handling congestion is the responsibility of this layer. When a packet travels from one network to another, addressing will be different in both the networks and the protocols also differ. Network layer has to overcome the problems and allow heterogeneous networks to be interconnected. Lower three layers are concerned with attaching and communicating with the network.

### **1.3.4 Transport Layer**

This layer accepts the data, splits it into smaller units and sends it to the network layer. This layer also determines the type of service to be provided to the session layer and users of the network. The most popular type of transport connection is error-free point-to-point channel that delivers messages in the order in which they were sent. Transport layer header must include service-point address (port address). This layer concerns with optimizing the use of network services and providing requested quality of service to session entities.

### **1.3.5 Session Layer**

This layer allows users on different machines to establish sessions between them. Services include dialog control, token management and synchronization. This layer allows a process to add checkpoints to a stream of data. This layer also provides the mechanism for controlling the dialogue between applications in end systems.

Message-processing application enables us to interrupt a dialogue in order to prepare a new portion of the message and then can resume the dialogue wherever it was left off.

### 1.3.6 Presentation Layer

This layer is concerned with moving bits around and also with syntax and semantics of the information transmitted. Data compression is important in the transmission of multimedia such as text, audio and video. Encryption is another services offered in this layer.

### 1.3.7 Application Layer

This layer contains a variety of protocols that are commonly needed by the users. One common protocol is HTTP (Hyper Text Transfer Protocol) where whenever a browser wants a web page, it sends the name of the page for hosting it using HTTP. Other application protocols are used for file transfer, electronic mail and network news. This layer contains management functions and useful mechanisms to support distributed applications. This layer also provides distributed database sources and access for global information about various objects and services.

## 1.4 TCP/IP Protocol Architecture

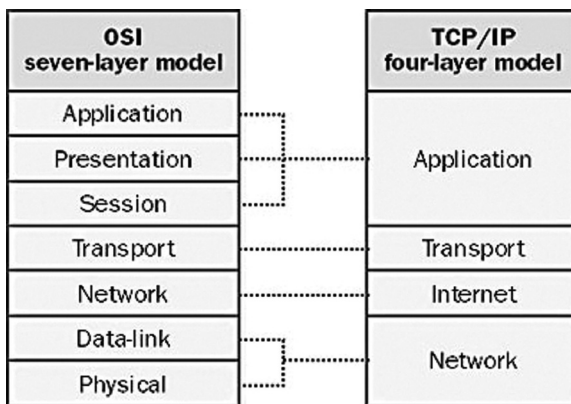


Fig 12: TCP/IP Reference Model

TCP/IP Protocol suite is defined as having four layers: host-to-network, internet, transport and application. Host-to-network layer is equivalent to the combination of physical and data link layers. Internet layer is equivalent to the network layer, and the application layer does the job of session, presentation and application layers. This model organizes the communication task into 5 independent layers. The concept of TCP/IP Reference model is shown in Fig 12.

### **1.4.1 Physical and Data link layers**

This layer is concerned with specifying the characteristics of the transmission medium, nature of signals, data rate etc. It also describes the lines (serial and classic Ethernet) must do to meet the needs of connectionless internet layer. It does not define any specific protocol.

### **1.4.2 Network Layer (Internet Layer)**

This layer deals with exchange of data between an end system and the network. This layer also will route data across a network. When two devices are attached to different networks, there are certain procedures needed to allow data to traverse multiple interconnected networks. This function is done by Internet Layer. Internet Protocol (IP) at this layer provides routing function across multiple networks. It transports data as datagrams. It is a unreliable and connectionless protocol. All the mechanisms are collected in a common layer and shared by all applications. This is called host-to-host layer or transport layer. Transport Control Protocol (TCP) is the commonly used protocol to provide this functionality. Application layer contains the logic to support user applications. For each application there is a separate module. Address Resolution Protocol (ARP) allocates logical address with a physical address. Reverse Address Resolution Protocol (RARP) allows a host to discover its internet address when it knows the physical address. Internet Control Message Protocol (ICMP) is used by hosts and gateways to send notification of datagram problems to the sender. Internet Group Message Protocol (IGMP) supports simultaneous transmission of a message to a group of receivers.

### **1.4.3 Transport Layer**

This is designed to allow peer entities on the source and destination hosts to carry a conversation. TCP is a connection-oriented protocol that allows a byte stream to be delivered from one machine to the other without error. It segments the byte stream into discrete messages and passes it on to the internet layer. At the destination, receiving TCP reassembles received messages into the output stream. UDP is a connectionless protocol which is used for request-reply, client-server queries where delivery is important than accuracy especially for speech or video. Stream Control Transmission Protocol (SCTP) provides support for new applications such as voice over internet. It combines the features of TCP and UDP.

### **1.4.4 Application Layer**

This is equivalent to the combined session, presentation and application layers of OSI model. This contains all higher-level protocols. Earlier virtual terminal (TELNET), file transfer (FTP) and electronic mail (SMTP) were included. Many other protocols are added now. Domain Name System (DNS) is one for mapping onto their network addresses, HTTP for fetching pages on World Wide Web, RTP for delivering real-time media like movies and voice are also included.

## **Key Terms**

Local Area Network (LAN)

Metropolitan Area Network (MAN)

Wide Area Network (WAN)

Personal Area Network (PAN)

Campus Area Network (CAN)

Transmission Control Protocol/Internetworking Protocol (TCP/IP)

User Datagram protocol (UDP)

## Computer Networks

International Standards Organization (ISO)

Open Systems Interconnection (OSI)

Protocol Data Unit (PDU)

Address Resolution Protocol (ARP)

Domain Name System (DNS)

Stream Control Transmission Protocol (SCTP)

File Transfer Protocol (FTP)

Simple Mail Transfer Protocol (SMTP)

Hyper Text Transfer Protocol (HTTP)

Data Transfer Rate (DTR)

Virtual Private Network (VPN)

Reverse Address Resolution Protocol (RARP)

Internet Control Message Protocol (ICMP)

Internet Group Message Protocol (IGMP)

Internet Service Provider (ISP)

### Points to Remember

Computer networks are used in companies and for individuals in home and while on move. Networks are divided into LANs, MANs, WANs. LAN covers a building and works at high speed. MAN covers a city. WAN covers a country. Network topologies are the structure of the network which facilitates the general function.

Network software is built around protocols, which are the rules by which processes communicate. Protocol stacks are based on OSI model or TCP/IP model. Both have link, network, transport and application layers, but differ on other layers. Among the seven layers

of OSI model, Physical, data link and network layers are network support layers. Session, presentation and application layers are user support layers. Transport layer links network and user support layers. Physical layer coordinates functions required to transmit a bit over physical medium. Data link layer delivers data units from station to station without errors. Network layer delivers packets from source to destination across multiple network links. Transport layer delivers the entire message. Session layer maintains and synchronizes the interaction between communicating devices. Presentation layer gives interoperability between communicating devices. Application layer makes the users to access the network. Design issue includes reliability, resource allocation, growth, security etc.

### **Review Questions**

1. Identify the five components of a data communication system.
2. Define Networks. What are the characteristics of networks?
3. What is the difference between half-duplex and full-duplex transmission modes?
4. What are the factors that determine whether a communication system is LAN or WAN?
5. What are the differences between TCP and UDP?
6. Why are protocols needed?
7. What are the differences between OSI reference model and TCP/IP model?
8. What is the importance of using network topologies?
9. How are the different types of networks useful?
10. Write about connection-oriented and connectionless service.

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