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COMPUTER NETWORKS

Module 1: Introduction to Networking

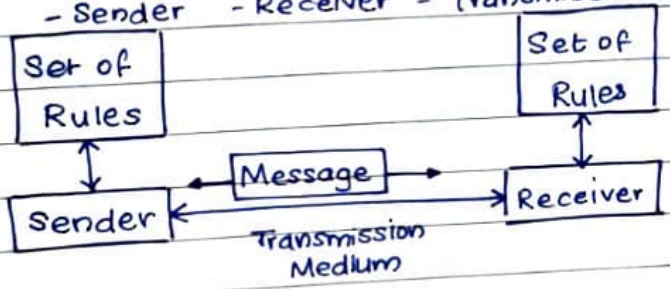
A network is a collection of computers or hardware devices that are connected together physically or logically using special hardware or software in order to exchange information.

* Data Communication

- Data communication is a process of exchanging data or information. In computer networks, data communication is in between two or more devices over a transmission media.
- Communication system consists of:
  Hardware: senders, receivers, transmission media.
  Software: set of protocols that need to be satisfied.

* Components of Data Communication

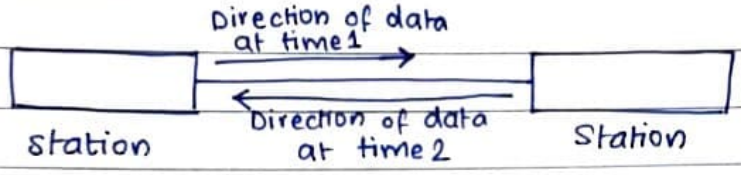
- Message - Sender - Receiver - Transmission Medium - Protocols



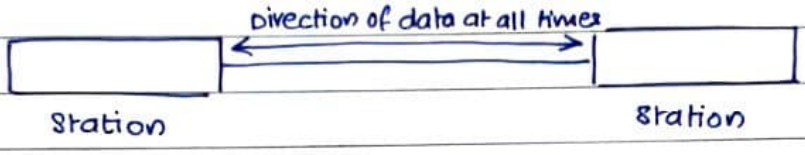
* Data Flow

1. Simplex

2. Half Duplex

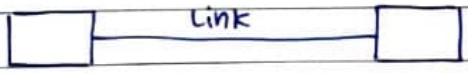


3. Full Duplex



* Networking
* Network criteria
- Performance:
  Can be measured in terms of:
  - Transit Time
  - Response Time
- Reliability: Frequency of failures, time required to recover from failures and network robustness ion catastrophe
- Security: Protect data from damage, securing data from unathorized access, recovery from breaches and data.

* Types of Connections
- Point-to-Point:
  - Provides a dedicated link between two devices.
  - Entire link capacity is shared between the two devices



- Multipoint:
  - Link is shared between two more than two devices.
  - Capacity of channel is shared
  - Capacity is shared either timely or spatially

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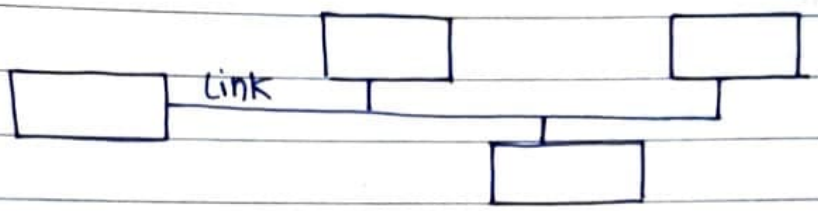

*** Physical Topology

- Topology is a geometric representation of all the links and the linking devices to one another.
- Physical topology refers to a way in which the physical network is laid out physically.
- Four basic Topologies:
  - Mesh
  - Star
  - Bus
  - Ring

1. Mesh Topology:

- Every device has a dedicated point to point link to every other device.
- Every device in the network must have (n-1) I/O ports.
- Link carries traffic only between the two devices it connects.
- Total no of links in fully connected mesh network with n nodes is n(n-1).
- In case of communication in both direction: n(n-1)/2 duplex node links

* Advantages:
- Robust
- Privacy and Security
- No traffic problems
- Fault identification and isolation is easy.

* Disadvantages:
- Expensive: Hardware Cost
- Bulk wiring
- Installation and reconnection is difficult.

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2. Hub Star Topology:

- Star topology used in LANs.
- Each device has a dedicated point to point link with a central controller called as hub.
- Devices are not directly linked to eachother.
- Star topology does not allow direct traffic between devices.

* Advantages:

- Less expensive than mesh
- Easy fault identification
- Robustness
- Reconfiguration and installation is easy.

* Disadvantages:

- Dependency on single point controller.
- Each node is linked to hub - more cabling is required.

3. Bus Topology:

- It is a multi-point connection.
- A long cable wire acts as the backbone of all to link all devices in the network.
- Nodes are connected to by bus drop lines and taps.
- proplines: It is a connection running between the device and main cable.
- A tape is a connector that splices into the main cable to create contact with metallic core.

* Advantages:

- Less cabling compared to bus star and mesh.
- Ease of installation.

* Disadvantages:

- Reconfiguration and fault isolation
- Limited cable length & no.of nodes connected.
- Difficult to add new devices
- If backbone has a fault, all transmission stops.

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4. Ring Topology:

- Each devices has a dedicated point-point connection with only the two devices on the either side of it.
- Each device incorporates as a ring.
- A signal is passed along the ring connection from one device to another until it reaches its destination.

* Advantages:

- Easy configuration and installation.
- Easy to add and deleting connections.
- Fault isolation is simplified

* Disadvantages:

- Unidirectional traffic
- Breakdown in ring disables entire network.

* Types of Networks:

1. Local Area Network (LAN):

- A local area network (LAN) is a computer network that spans over a small area.
- LAN is usually privately owned and links devices in a single office, building or campus.
- LAN extends ~~upto~~ from 1km to 10km
- LANs are distinguished from other networks by their transmis-n media and topology.
- LANs allows resources to be shared between their personal computers and work stations.
- One of the computers is given a large capacity of disk drive and may become a server to clients.
- Speed: 100 to 1000 Mbps.

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Metropolitan Area Network (MAN):

MAN usually covers an area inside a town or a city.

MAN is specially designed for those who need high connectivity normally to the internet, and have endpoints spread over the city or a part of city

MAN uses guided or ~~non~~ unguided media.

MAN extends upto 30-40Km

Speed: 34-165 Mbit/s

eg: cable TV Network

Wide Area Networking (WAN):

WAN provides long-distance transmission of audio, data, images and video information over a large geographical location that may comprise a country, a continent or even the whole world.

Internet is WAN.

WAN is a group of computers or network devices which are connected and not restricted over a geographical location.

WAN speed varies based on geographical location of servers.

WAN connects several LANS.

Speed : 100 Mbps to 1000 Mbps

WAN uses guided or unguided media.

* Switching:

~~An~~ Internet is a switched network in which a switch is used to connect two links together.

Two types of switched networks:

- Circuit-switched network
- Packet-switched network

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Network Models:

* Design issues for layering:
  - Addressing: How to identify sender and receiver? who am I going to talk to?
  - Logic Channels: usually at least 2. One for normal mode and one for urgent transmission
  - Rules for data transfer: Simplex, Half duplex, full duplex.
  - Large messages: what to do when messages are very small (compared to packet)? Procedures for disassembling, transmitting and reassembling.
  - Error Control: All about communicating along imperfect channels and error correction in such cases.
  - Reconstituting messages: Out of order messages need to be numbered.
  - Multiplexing: One connection per communication or many one connection.
  - Routing: what to do when there are multiple paths between communicating machines.

*	connection-oriented services	connection-less services
-	COS is related to telephone system.	- CLS is related to postal system.
-	COS is preferred by long and steady communication	- CLS is preferred by bursty communication.
-	COS requires authentication.	- CLS does not require authentication.
-	COS is highly reliable.	- CLS is not reliable.
-	COS is necessary.	- CLS is not compulsory.
-	COS is feasible	- CLS is not feasible.
	Congestion is not possible	- Congestion is possible
	Packets follow same route.	- Packets do not follow same route.
	Has a bandwith of high range	- Has a bandwith of low range
-	eg: TCP	- eg: UDP

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- Connection Oriented Services:
- Long messages
- Reliable network service
- Requires session connection
- virtually links all between the end systems through a network
- High overhead and places greater demands on BW

eg: email.

- Connection less services:
- Short messages
- No reliability
- Less overhead
- No session connection required
- Does not maintain state information

eg: walkie-talkie.

* Reliable and un-reliable services:

- Reliable services:
- If application needs reliability, then reliability transport protocols must be used. These include STP or SCTP.
- It means a slow and more complex service

- Unreliable services:
- If the application does not require reliability, because it uses its own flow and error control mechanism and it needs fast service and nature of service does not demand flow and error control, then the UDP can be used.

★ OSI Model

Over the past couple of decades, many of the networks that were built used different hardware and software implementations, as a result they were incompatible and it became difficult for networks using different specifications to communicate with each other.

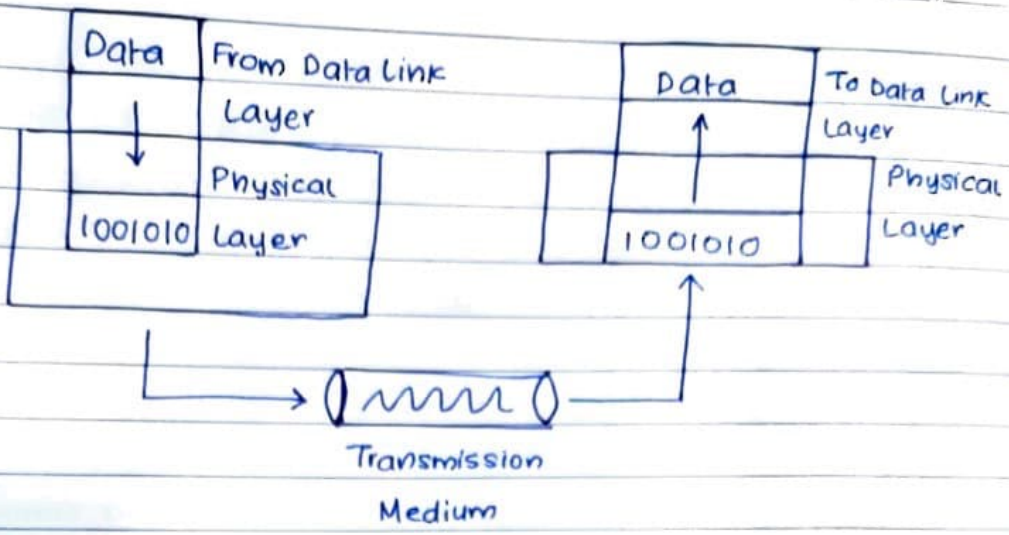
- The Open System Interconnection allows two devices to communicate with eachother irrespective of their architecture.
- OSI is a concept that describes how data communication takes place.
- It is also called as framework for design of network systems.
- It divides the process into 7 layers.

1. Physical Layer:

- Physical layer deals with the physical characteristics of the transmission medium.
- This layer simply consists of wire or media by which network signals are connected.
- Physical layer defines the connector and interface requirements as well as cable requirements for transmissions to occur.

• Functions:

- Synchronisation of bits.
- Data rate
- Physical Topology
- Conversion of bits to electrical / optical
- Line configuration: Multi-point or Point to Point
- Physical characteristics of interface and medium.



2. Data Link Layer:

- Data link layer transforms physical layer, a raw transmission to a reliable link
- Node to node delivery
- Data link layer uses MAC address to define hardware and data link address for of multiple stations to share same medium and still uniquely identify eachother.
- Concerned with flow control, network access, error notification, network topology, ordered delivery of frames.

• Functions:

- Flow control
- Access Control
- Error Control
- Framing
- Physical addressing

3. Network Layer:

- This layer establishes a route between sender and receiver.
- Responsible for delivering individual packets from source to destination
- Two systems connected on same link- no network layer.
- Two systems connected on different links- need network layer.
- Network layer addresses are also called logical addresses.
- It handles routing of data and forwarding of data.

• Functions:

- Routing: Routing packets to destination via connecting devices
- Logical addressing: Handles addresses locally.

4. Transport Layer:

- Transport layer is responsible for delivery of message from one process to another.
- If data is sent incorrectly, the transport layer has the responsibility to ask for retransmission of data.
- It is responsible for constructing stream of data segments, sending and checking for correct delivery.
- Transport layer understands relationship between the packets and makes sure the whole message arrives intact and in order.
- Acts as an interface between the bottom and top three layers.

• Functions:

- Service-Point Addressing: Port Address. Transport layer gets each packet to the correct processor on computer
- Retransmission in case of lost segment
- Segmentation and Reassembly: Message divided into segments.

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- Connection Control
- Error Control
- Flow Control

5. Session Layer:

- The services provided by the first three layers (physical, data link and network) are not sufficient for some processes.
- Session layer defines how to start, control and end conversations (sessions) between applications.
- It provides coordination of communication in an ordered manner.
- The session layer offers provisions for efficient data transfer.

• Functions:

- Dialog Control: Allows ~~sess~~ two systems to enter into a dialog.
- Synchronization: Allows to add check points to stream of data

6. Presentation Layer:

- The presentation layer ensures that the ~~ap~~ information sent out by the application layer of one system is readable to the application layer of another system.
- The presentation layer translates between multiple data formats by using a common format.
- The presentation layer allows an application to read the message.

• Functions:

- Translation: Changes data so that another computer can read it.
- Compression: Makes data smaller to move in same amount of time.
- Encryption: Encodes data to protect from interception.

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Application Layer:

Application layer enables the user, be it human or a software to access the network.

It provides user interfaces and support, email, shared database, access to remote file, etc.

It differs from other layers in such away that it does not provide services to any other OSI layer, but rather only to applications outside the OSI model.

TCP/IP Model

- TCP/IP was developed prior to OSI model.
- It is a hierarchical protocol made up of interactive modules, each providing specific functionality, but they are not interdependent.
- Made up of 5 layers:
  - Application layer
  - Transport layer
  - Network Layer
  - Data Link layer
  - Physical layer

1) **Network Layer:**
- TCP/IP does not support any specific protocol.
- All standard and proprietary protocols are supported at this level.
- At this level, TCP supports Internetworking Protocol (IP)
- IP itself uses 4 supporting protocols:
  - ARP
  - RARP
  - ICMP
  - IGMP

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- Inter Networking Protocol

- IP is transmission mechanism used by TCP/IP
- It is unreliable and connection-less protocol
- No error checking or tracking
- Transports data in packets called as datagrams.
- Does not keep track of routes and no facility re-ordering

- Address Resolution Protocol (ARP)

- Associates logical address to physical address.
- ARP is used to find physical address when logical address is known.

- Reverse Address Resolution Protocol (RARP)

- Finds logical address when physical address is known.
- Used when computer is connected to network for the first time.

- Internet Control Message Protocol (ICMP)

- used by hosts and gateways to send notification of datagram problem to the sender.

- Internet Group Message Protocol (IGMP)

- Facilitates simultaneous transmission of message to the receipients.

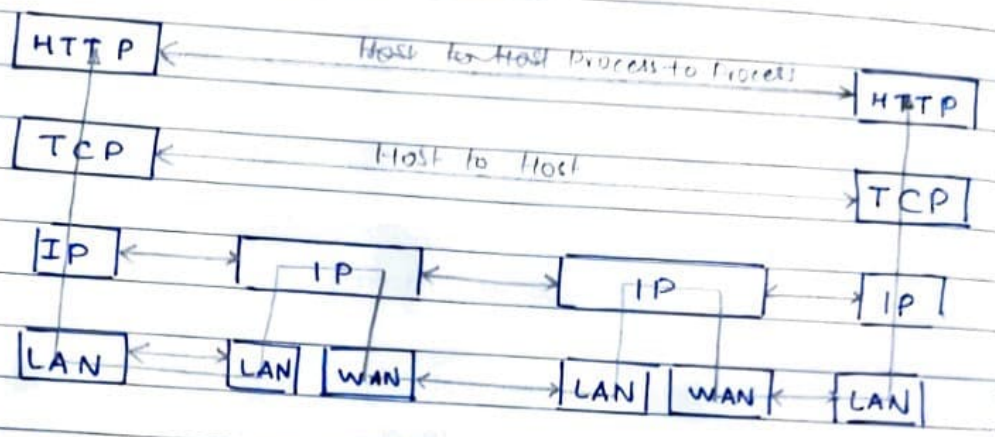
(2) Transport Layer

- IP is host to host protocol.
- Transport layer has 3 protocols:
  - User Datagram Protocol (UDP)
    - Process to process.
    - Adds only error control, address, checksum etc from upper layers to the data.
  - Transmission Control Protocol (TCP)
    - Reliable stream protocol.
    - Data is divided into segments.
    - Each segment has sequence number for reordering.
    - At the receiving end, TCP collects each datagram and reorders it based on sequence numbers.
  - Stream Control Transmission Protocol (SCTP)
    - Combines features of UDP and ~~STP~~ TCP

★ TCP vs UDP

TCP	UDP
- Reliable	- Unreliable
- Connection-oriented	- Connection-less
- Segment Sequencing	- NO sequencing.
- Acknowledge segments	- No acknowledgements.
- Segment retransmission or flow control through windowing.	- No windowing or retransmission.

* Data Flow of Internet



* Imp Points:
- Process to process: Transport layer
- Host to Host: Network Layer
- Node to Node: Data link layer.

* Difference b/w OSI and TCP/IP

	OSI	TCP/IP
-	Reference Model	- Implementation of OSI model.
-	Has 7 layers	- Has 6 layers.
-	Considered as a reference tool	- Considered more reliable
-	Theoretical Model	- Model around which Internet is developed.
-	Vertical Approach	- Horizontal approach
-	Strict boundaries for protocols	- Less strict boundaries for protocols.
-	Separate session and presentation layer.	- Combines session and presentation layer in application layer.

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	OSI	TCP/IP
-	Model was developed before protocols were developed	- Protocols were developed first and then the models.
-	Supports connection-less & connection-oriented communication in network layer.	- Supports only connection-less communication in the network layer.
-	Protocol independent standard	- Protocol dependent standard.