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Introduction

Network is the interconnection of a set of devices capable of communication.

There may be 2 kinds of devices in the network

1. Host:- also called end system. (desktop, laptop, cell phone)
2. Connecting Devices:- connects to other devices(modem, router, switch)

Network Criteria

1. Performance(evaluated by throughput and delay)
2. Reliability(evaluated by frequency of failure)
3. Scalability(Adding processing capacity)
4. Security(protecting data from unauthorized access)

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Introduction

Application of Computer Networks

1. Business Application
   a) Resource Sharing
   b) High Reliability
   c) Saving Money
2. Home Application
   a) Access to Remote Information(WWW)
   b) Person to Person communication
   c) Interactive Entertainment(Live TV, Games)

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Merits

- Allows File Sharing/ Resource Sharing
- Inexpensive System
- Flexible to be Used
- Increase in Storage Capacity of the Software

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Demerits

- **Security Difficulties(Hacking)**
- **Presence of Computer Viruses and Other Malwares**

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Network Models

- There are several classification for networks
- Classification based on Scale(size)
- Classification based on Topology
- Classification based on Architecture

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Network Models : Based on Scale

- According to the scale(size) of the networks is classified into following

1. PAN (Personal Area Network)
2. LAN (Local Area Network)
3. CAN (Campus Area Network)
4. MAN (Metropolitan Area Network)
5. DAN (Desert Area Network)
6. CAN* (Country Area Network)
7. WAN (Wide Area Network)
8. GAN (Global Area Network)

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Personal Area Network(PAN)

- Used for data transmission among devices such as computers, mobile phones, PDA etc.
- Within few meters like 10 meters only
- Medium : Bluetooth, Infrared
- Only very few connections will be available

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Local Area Network(LAN)

- It is a computer network that spans a relatively small area
- Most LANs are confined to a single building or group of buildings
- One LAN can be connected to other LANs over any distance via telephone lines and radio waves (WAN)
- Medium: optical fibers, coaxial cables, twisted pair, wireless.
- Low latency (except in high traffic periods).
- High speed networks (0.2 Mb/sec to 1Gb/sec).
- Speeds adequate for most distributed systems

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Campus Area Network(CAN)

- Computer network that links the buildings and consists of two or more local area networks (LANs) within the limited geographical area
- It can be the college campus, enterprise campus, office buildings, military base, industrial complex
- CAN is one of the type of MAN (Metropolitan Area Network) on the area smaller than MAN
- The Campus networks usually use the LAN technologies, such as Ethernet, Token Ring, Fibber Distributed Data Interface (FDDI), Fast Ethernet, Gigabit Ethernet, Asynchronous Transfer Mode (ATM)

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Metropolitan Area Network(MAN)

- Metropolitan Area Network, are data networks designed for a town In terms of geographic breadth
- MANs are larger than local area networks (LANs), but smaller than wide-area networks s)
- MANs are usually characterized by very high-speed connections using fiber optical cable or other digital media

Features:

- Generally covers towns and cities (50 kms)
- Medium: optical fibers, cables.
- Data rates adequate for distributed computing applications.

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Metropolitan Area Network

- MAN is usually **not** privately **owned** by an organization (Like banks, MNC)
- Access to a MAN is usually trough a network provider who sells the service to the users
- MAN often acts as a **high speed network** to allow sharing of regional resources
- It is also frequently used to provide a shared connection to other networks using a link to a WAN

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Country Area Network(CAN*)

- It’s wide area network which is limited to country
- It consist of more than one MAN
- It may be extended up to thousands kms
- It is more public network owned by some public organization or governments
- Example: In Nepal NTC have CAN*
-

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Wide Area Network(WAN)

- A computer network that spans a relatively large geographical area
- WAN consists of two or more local-area networks (LANs).
- Computers connected to a wide-area network are often connected through public networks, such as the telephone system
- They can also be connected through leased lines or satellites
- The largest WAN in existence is the **Internet**

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Global Area Network(GAN)

- A global area network (GAN) refers to a network composed of different interconnected networks that cover an unlimited geographical area.
- The term is loosely synonymous with Internet, which is considered a global area network.

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Topology

Topology :- Physical inter connection between different node

Node:- End device in computer network(Laptop, mobile, desktop, PDA, tablet etc.)

Various Topologies are:-

- Bus
- Ring
- Star
- Mesh
- Tree
- Hybrid

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Bus

- In this system there are 8 nodes connected to network using common connection also called bus
- All communication is done with help of bus.

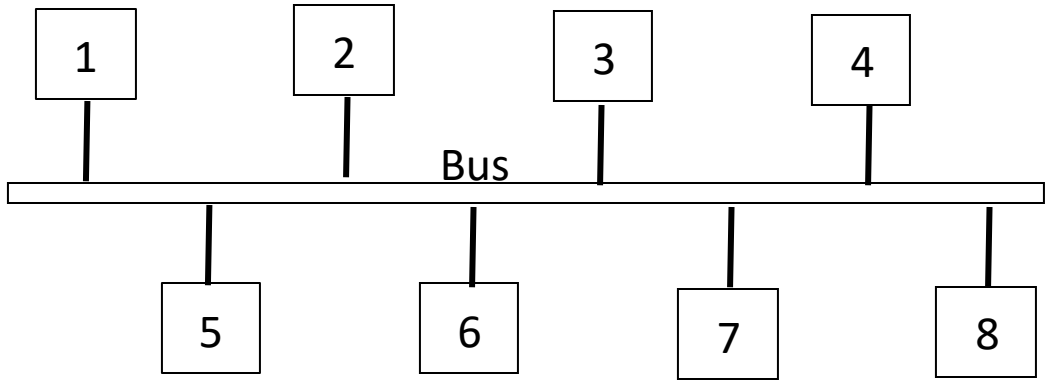
Advantage:

Less expensive

Disadvantage

Only one connection at a time

Figure : Bus Topology



Consider if node 1 is communicating with 5 other node have to wait for data transfer till 1-5 finished the communication is completed

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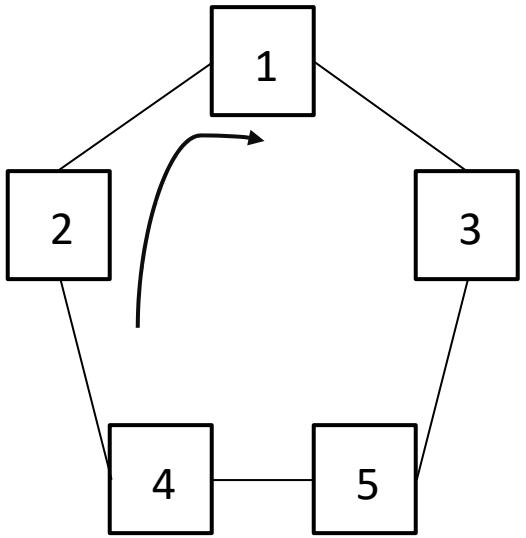
Ring

- Data travels in circular fashion from one computer to another on the network.
- Typically FDDI, SONET or Token Ring technology are used to implement a ring network
- Data access based on token
- Only one way data transfer
- Data passed through intermediate nodes to destination



Consider if data transfer from node 1 to 2, It will pass through 3,5,4 and reaches 2

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Ring

Advantages

- A central server is not required for the management
- Traffic is unidirectional and the data transmission is high-speed.
- Comparison to a bus, a ring is better at handling load.
- Easier configuration and fault detection
- Less expensive than a star topology.

Disadvantage

- Failure of a single node in the network can cause the entire network to fail.
- Less secured because of intermediate nodes
- Lower speed because of intermediate nodes

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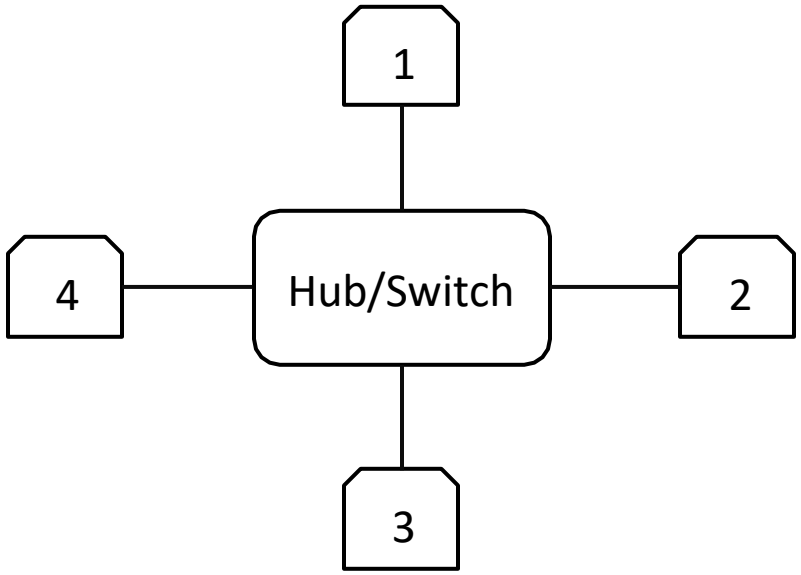
Star

- All computers/devices connect to a central device called hub or switch.
- Each device requires a single cable
- Point-to-point connection between the device and hub.
- Most widely implemented
- Hub/Switch is the single point of failure



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Star

Advantages

- Due to its centralized nature, the topology offers **simplicity of operation**
- **Isolation** of each device in the network
- Adding or removing network nodes is easy, and can be done without affecting the entire network
- Due to the centralized nature, it is easy to detect faults in the network devices
- As the analysis of traffic is easy, the topology poses lesser security risk

Disadvantage

- Network operation depends on the functioning of the central hub. Hence, central hub failure leads to failure of the entire network
- Also, the number of nodes that can be added, depends on the capacity of the central hub
- The setup cost is quite high.

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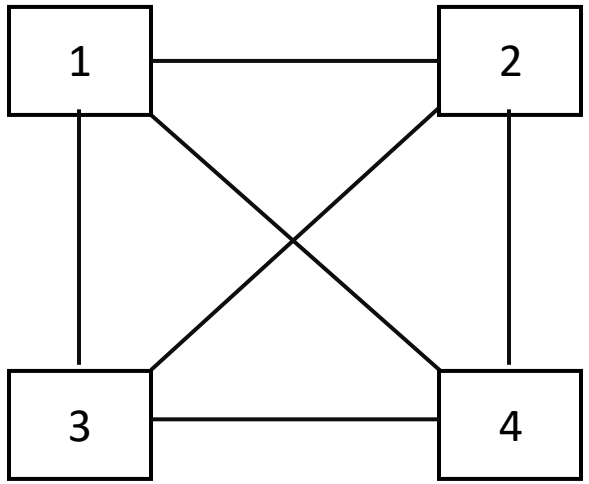
Mesh

- Each computer connects to every other.
- High level of redundancy.
- Rarely used
- Wiring is very complicate
- Cabling cost is high
- Troubleshooting a failed cable is tricky



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Mesh

Advantages

- Possible to transmit data from one node to many other nodes at the same time
- Failure of a single node does not cause the entire network to fail as there are **alternate paths** for data transmission
- It can handle heavy traffic, as there are dedicated paths between any two network nodes
- Point-to-point contact between every pair of nodes, makes it **easy to identify faults**

Disadvantages

- Many connections serve **no major purpose**
- Lot of cabling is required
- Costs incurred in setup and maintenance are **high**
- **Administration** of a mesh network is **difficult**

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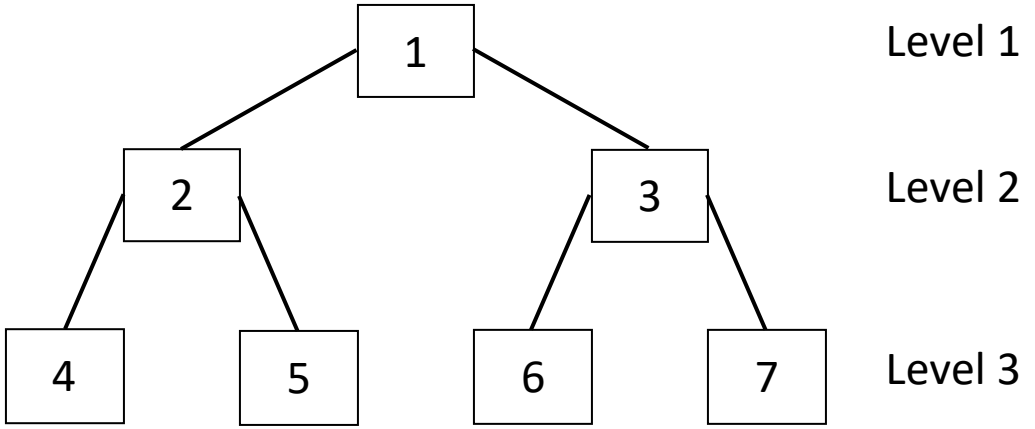
Tree

- Hierarchical structure like inverted tree
- Top node (node 1) is the root node
- It should at least have 3 levels
- Ideal for nodes that are grouped for some specific job



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Tree

Advantages

- Expansion of nodes is possible and easy
- Easily managed and maintained
- Error detection is easily done

Disadvantages

- Heavily cabled
- Costly
- If more nodes are added maintenance is difficult
- If one node fails all nodes under it will be out of the network

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Hybrid

- Two or more different types of topologies which is a mixture of two or more topologies
- For example if in an office in one department ring topology is used and in another star topology is used, connecting these topologies will result in Hybrid Topology (ring topology and star topology).

Advantages

- Effective
- Scalable
- Flexible

Disadvantages

- Complex in design
- Costly.

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Network Models : Based on Architecture

- Network architecture refers to how computers are organized in a network and how tasks are allocated between these computers
- Two of the most widely used types of network architecture are
  1. **Peer-to-Peer(P2P)**
  2. **Client/Server**

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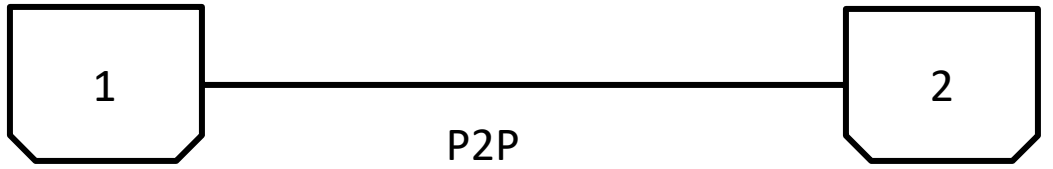
Peer to Peer(P2P)



- Tasks are allocated among all the members of the network
- No hierarchy(importance) -- All considered equal
- Does not use a central computer server that controls network activity
- All computer on the network has a special software running that allows for communications between all the computers
- One – One(1:1) relationship
- Peer-to-peer is mostly used for file sharing
- One of the earliest peer-to-peer file sharing networks was Napster
- Now **torrent** uses this way to share files

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Peer to Peer(P2P)

Advantage

1. Easy to install and configure
2. All the resources and contents are shared by all the peers
3. P2P is more reliable as central dependency is eliminated
4. No need for full-time System Administrator(No central Admin)
5. Cost comparatively very less

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Peer to Peer(P2P)

Disadvantage

1. One person (user / administrator)cannot determine the whole accessibility setting of whole network
2. Security in this system is very less viruses, spywares,trojans, etc malwares can easily transmitted over this P-2-P architecture
3. Data recovery or backup is very difficult. Each computer should have its own back-up system
4. Lot of movies, music and other copyrighted files are transferred using this type of file transfer. P2P is the technology used in torrents

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Client/Server(Tiered)

- Computing system in which one powerful workstation serves the requests of other systems
- Server :- Provides services to clients
- Client :- Accept services from server
- Server is central device for managing files , and other resources.
- If server is down all communication among the clients will be down
- **Features of Servers :-**
    1. They have large storage capacity.
    2. They are able to provide information to many computers simultaneously, therefore have large RAM
    3. Its processor speed is high, as it may have to execute multi-tasking too

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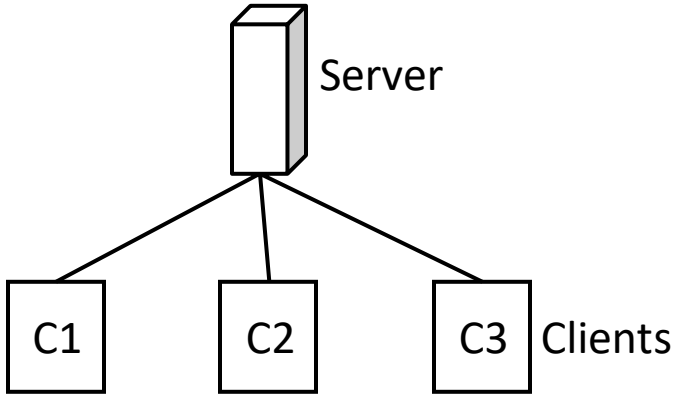
Client/Server

Advantages

1. Centralization
2. Proper Management
3. Back-up and Recovery possible
4. Upgradation and Scalability in Client-server set-up
5. Accessibility
6. Security



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Client/Server

Disadvantages

1. Congestion in Network(Too many requests at same time)
2. Cost : It is very expensive to install and manage this type of computing
3. Client-Server architecture is not as robust as a P2P and if the server fails, the whole network goes down.
4. You need professional IT people to maintain the servers and other technical details of network.

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Active Networks(ANTS)

- Allows packets flowing through a telecommunications network to dynamically modify the operation of the network
- Dynamic modification is mainly for improving the performance of the system
- Real time /Rapid changes in network is allowed
- Usually network packets consist of data only but in ANTS packets consist of code and data
- Application customized code to be executed in network

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Internet, Intranet & Extranet

- Internet:- Connections between different network/LAN. There will be outside connection. It is public network
- Intranet:- Connection inside a network/LAN. No outside connection
- Extranet:- Connects 2 or more intranet but not private. It is used to connect between 2 branches of company or connection between company and client.

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Reference Model

- 2 important reference models **OSI reference model** & **TCP/IP reference model**
- Also called Protocol Architecture or Layered Architecture
- Mainly define the protocols of communication in layered architecture

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Protocol ???

- Protocol means rule
- In computer networking Protocol means rules for establishing communication between 2 devices
- Consists of a set of rules that govern data communications
- determines what is communicated, how it is communicated and when it is communicated
- **Key Elements**
  1. Syntax
  2. Semantics
  3. Timing

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Syntax, Semantics and Timing

Syntax

- Structure or format of the data
- Indicates how to read the bits - field delineation
- Syntax should be same in sender and receiver for to communicate

Semantics

- Interprets the meaning of the bits
- Knows which fields define what action
- Interpretation of the syntax should be same

Timing

- When data should be sent and what
- Speed at which data should be sent or speed at which it is being received

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ISO/OSI Reference Model

- ISO- International Organisations for Standard
- OSI- Opens System Interconnections
- Stats developing in late 1970s
- Approved by 1984
- The term “Open” in Open System Interconnections denotes **“to communicate with any 2 systems”**
- There are 7 layers in OSI Reference model
- It is also called OSI layered architecture /OSI Protocol architecture

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ISO/OSI Reference Model

- The process of breaking up the functions or tasks of networking into layers reduces complexity.
- Each layer provides a service to the layer above it in the protocol specification.
- Each layer communicates with the same layer's software or hardware on other computers.
- The lower 4 layers are concerned with the flow of data from end to end through the network
- The upper Three layers of the OSI model are orientated more toward services to the applications

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ISO/OSI Reference Model- 7 Layers

- Layer 7 –Application Layer
- Layer 6 –Presentation Layer
- Layer 5 –Session Layer
- Layer 4 –Transport Layer
- Layer 3 –Network Layer
- Layer 2 –Data Link Layer
- Layer 1 –Physical Layer

 # OSI Consider a receiver system hence Layer 1 at bottom

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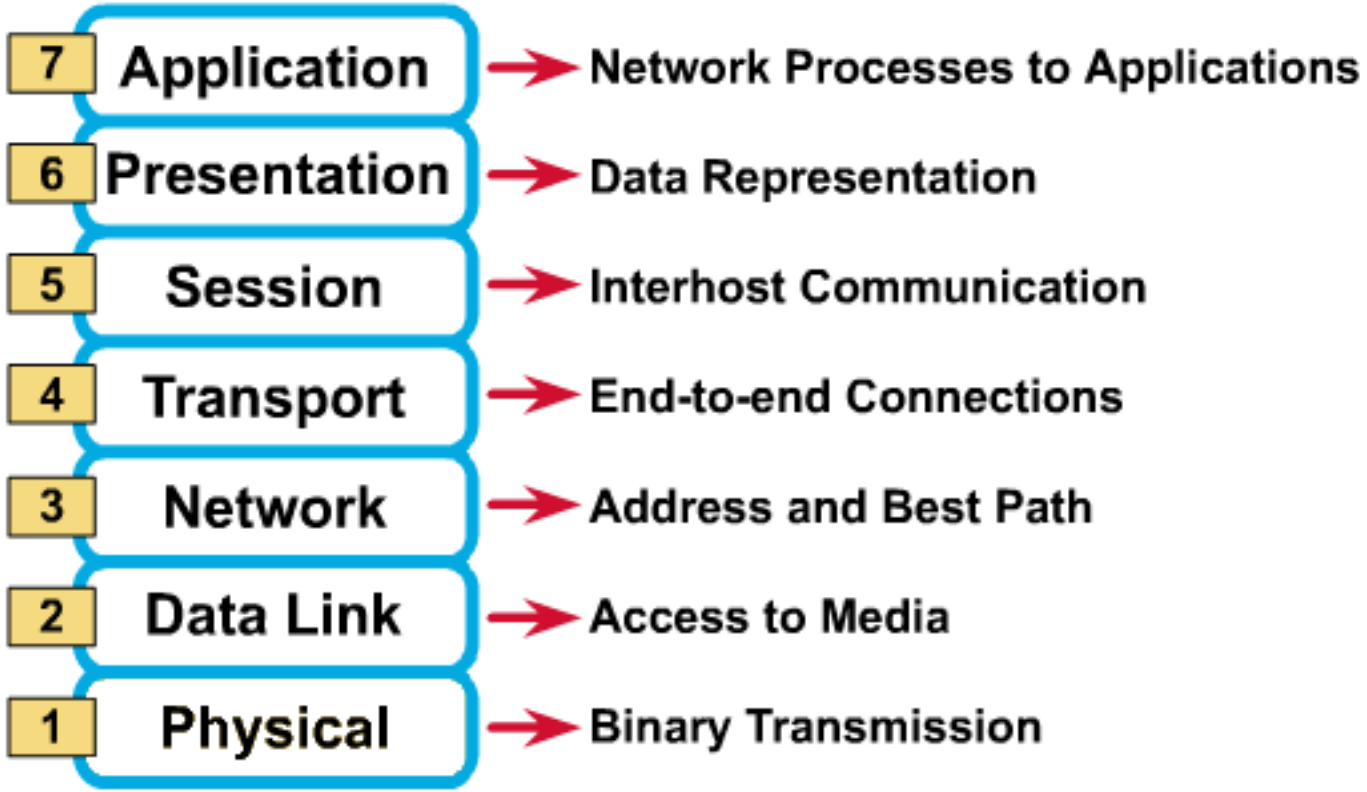
ISO/OSI Reference Model- 7 Layers



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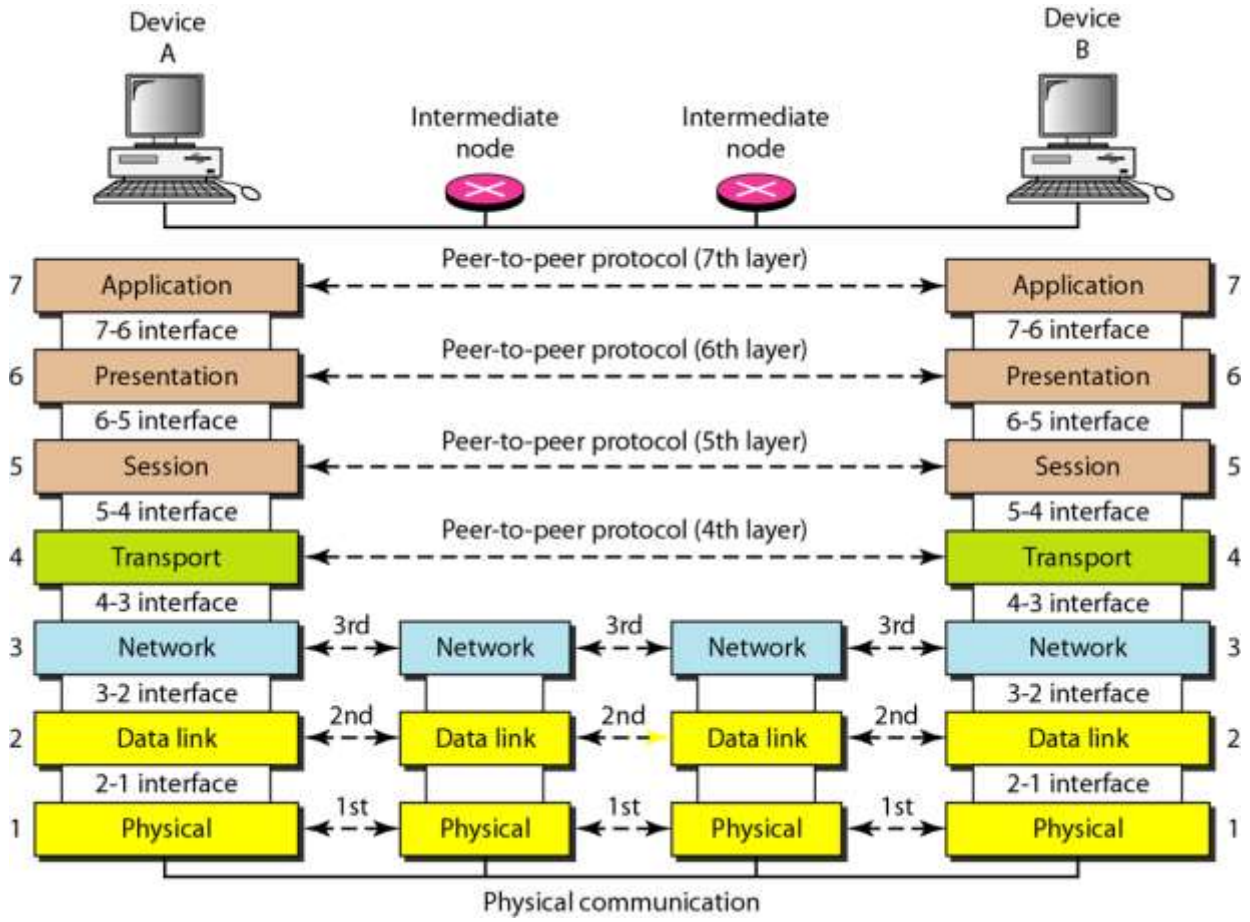
ISO/OSI Reference Model- 7 Layers



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Application Layer (Layer 7)

- The application layer is responsible for providing services to the user
- The layer relates to the services that directly support user applications, such as software for file transfers, database access, and e-mail, web browsers
- A message to be sent across the network enters and exits the OSI reference model's a at this layer.
- Protocols works in this layer are HTTP,FTP,DNS..
- HTTP(HyperText Transfer Protocol)
- FTP(File Transfer Protocol)
- DNS(Domain Name System)

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Presentation Layer (Layer 6)

- Defines the format used to exchange data among networked computers
- Acts like translator (interpreter)
- When computers from dissimilar systems—such as IBM, Apple, and Sun—need to communicate, a certain amount of translation and byte reordering must be done
- Within the sending computer, the presentation layer translates data from the format sent down from the application layer into a commonly recognized, intermediary format

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Presentation Layer (Layer 6)

- At the receiving computer, this layer translates the intermediary format into a format that can be useful to that computer's application layer
- The presentation layer is responsible for converting protocols, **translating the data, encrypting the data**, changing or converting the character set, and expanding graphics commands.
- The presentation layer also manages **data compression** to reduce the number of bits that need to be transmitted.

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Session Layer (Layer 5)

- Session is a logical connection between 2 systems
- Layer is responsible creating managing and termination of session
- Also responsible for dialogue management
- 3 Types of Dialogue
  1. Simplex : 1 Way Communication(Radio)
  2. Half Duplex : 2 Way Communication, But One at a time (Walkie-Talkie)
  3. Full Duplex: 2 Way Simultaneous Communication (Telephone)
- Also Provide Security and Check points in data

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Transport Layer (Layer 4)

- Provide a reliable mechanism for the exchange of data between two processes in different computers.
- Data from above layer is converted into smaller Data Units called segments
- Segments consist of Port number , Acknowledge number, Sequence number

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Transport Layer (Layer 4)

- Ensures that the data units are delivered error free, delivered in sequence, there is no loss or duplication of data units.
- Provides connectionless(UDP) or connection oriented service(TCP).
- Provides for the connection management.
- Multiplex multiple connection over a single channel.

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Transport Layer (Layer 4) TCP vs UDP

TCP(Transmission Control Protocol)

- Connection Oriented
- Reliable
- Have Acknowledgement
- Have Retransmission
- Have Sequence Delivery
- Have Handshaking

UDP (User Datagram Protocol)

- Connectionless
- Unreliable
- No Acknowledgement
- No Retransmission
- No Sequence delivery
- No Handshake signal

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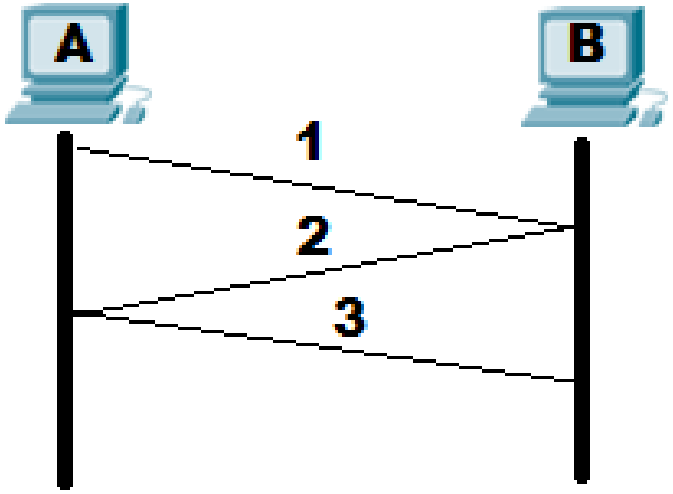
Transport Layer (Layer 4) - 2 Way Handshaking

- 3 way handshaking signal establish logical connection between 2 computers before data transfer
- Steps involved are:-
    1. TCP Connection Request(Syn A to B)
    2. TCP Connection Reply(Ack B to A)
    3. Data Transfer (A to B)



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Network Layer (Layer 3)

- Data units from the Transport layer is converted into packets(IP Packets)
- Each packet consist of IP Header
- IP header consist of Source IP, Destination IP and several other details regarding Packet
- IP(Internet Protocol) address helps packet to navigate from source to destination between **different network**(internetwork)
- Implements routing of packets through the network

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Network Layer (Layer 3)

- Defines the most optimum path the packet should take from the source to the destination
- Handles congestion in the network.
- Facilitates interconnection between heterogeneous networks (Internetworking).
- The network layer also defines how to fragment a packet into smaller packets to accommodate different media
- Protocol in this layer is IP(Internet Protocol)

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Data Link Layer (Layer 2)

- Packet from network layer is converted to Frames
- Frame consist of frame header
- Frame header consist of source and destination MAC(Media Access Control) Address
- Data link layer attempts to provide reliable communication over the physical layer interface
- Create and detect frame boundaries
- Implement flow control, Error control(Parity, Hamming Code)
- Supports points-to-point(unicasting) as well as broadcast communication
- Supports simplex, half-duplex or full-duplex communication

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Physical Layer (Layer 1)

- Convert the frames into bits (0/1) and transmit through medium
- Provides physical interface for transmission of information
- Defines rules by which bits are passed from one system to another
- Covers all - mechanical, electrical, functional and procedural - aspects for physical communication.
- Such characteristics as voltage levels, timing of voltage changes, physical data rates, maximum transmission distances, physical connectors, and other similar attributes are defined by physical layer specifications.

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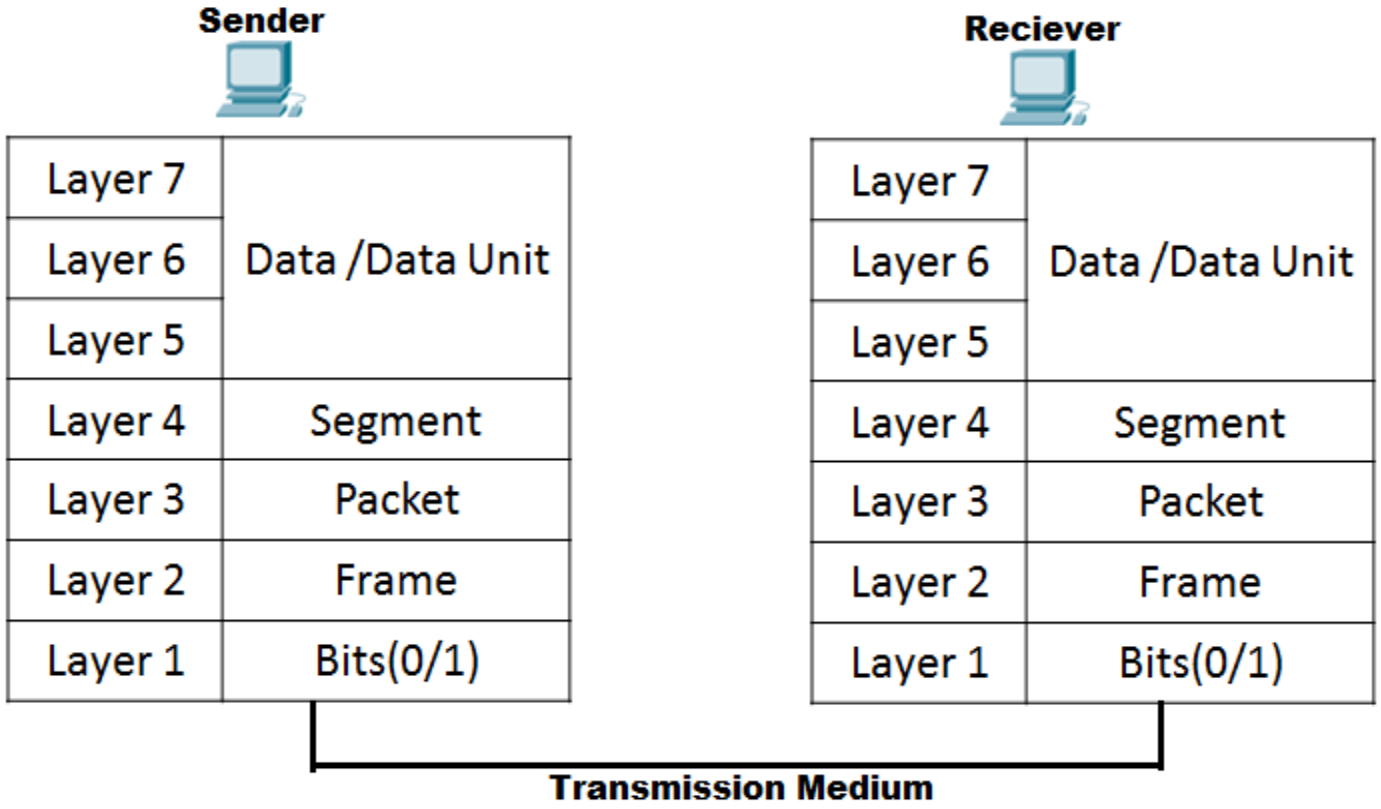
OSI Layer Working



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TCP/IP Reference Model

- Also called Internet Reference model
- Consist of 4 layered Architecture

1. Application Layer
2. Transport Layer
3. Internetwork Layer(Internet Layer)
4. Network Access Layer (Network Interface Layer)

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TCP Layer

Application Layer

- Similar to Application Presentation and Session layer in OSI
- Application programs using the network

Transport Layer (TCP/UDP)

- Similar to Transport Layer in OSI
- Only TCP protocol works
- Management of end-to-end message transmission,
- error detection and error correction

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TCP Layer

Internetwork Layer (IP)

- Similar to Network layer in OSI
- IP Address
- Handling of packets : routing and congestion

Network Access Layer

- Similar to Datalink and physical layer in OSI
- Management of cost effective and reliable data delivery,
- access to physical networks
- Physical Media

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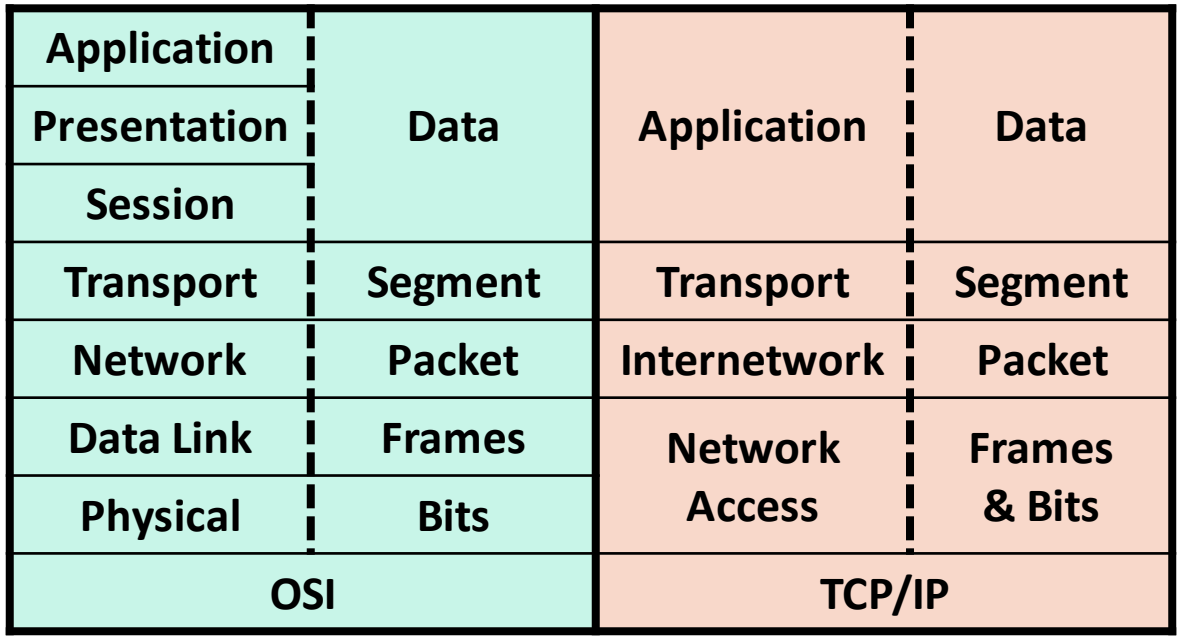
TCP/IP vs OSI



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TCP/IP Vs OSI

OSI

- 7 Layered architecture
- Designed for General Network
- Supports TC and UDP
- Designed both Functionalities of layer and protocol
- Defines functionalities of all layer
- Protocols are hidden in OSI model and are easily replaced as the technology changes.

TCP/IP

- 4 Layered architecture
- Internet only
- Supports only TCP
- More based on protocols than functions
- Only protocol
- Difficult to change the protocol in future

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Connection Oriented Services

There is a sequence of operation to be followed by the users of connection oriented service. These are:

1. Connection is established.
2. Information is sent.
3. Connection is released.

In connection oriented service we have to establish a connection before starting the communication. When connection is established, we send the message or the information and then we release the connection.

Connection oriented service is more reliable than connectionless service. We can send the message in connection oriented service if there is an error at the receivers end. Example of connection oriented is TCP (Transmission Control Protocol) protocol.

Connectionless Services

It is similar to the postal services, as it carries the full address where the message (letter) is to be carried. Each message is routed independently from source to destination. The order of message sent can be different from the order received.

In connectionless the data is transferred in one direction from source to destination without checking that destination is still there or not or if it prepared to accept the message. Authentication is not needed in this. Example of Connectionless service is UDP (User Datagram Protocol) protocol.

Difference: Connection oriented and Connectionless service

1. In connection oriented service authentication is needed, while connectionless service does not need any authentication.
2. Connection oriented protocol makes a connection and checks whether message is received or not and sends again if an error occurs, while connectionless service protocol does not guarantees a message delivery.
3. Connection oriented service is more reliable than connectionless service.
4. Connection oriented service interface is stream based and connectionless is message based.