

Introduction to Computer Networks

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Outline

- Introduction to Computer Networks
- Goals
- Applications
- Communication model
- Categories of networks
- Network Structure and Architecture

Introduction to Computer Networks

- A set of devices often mentioned as nodes connected by media link is called a Network
- A node can be a device which is capable of sending or receiving data generated by other nodes on the network like a computer, printer etc
- These links connecting the devices are called Communication channels
- Computer network is a telecommunication channel using which we can share data with other computers or devices, connected to the same network
- It is also called Data Network

Introduction to Computer Networks

- The best example of a computer network is the Internet
- A computer network does not mean a system with one Control Unit connected to multiple other systems as its slave
- That is a distributed system

Goals of Computer Networks

- **Resource Sharing:** Many organizations has a substantial number of computers in operations which are located apart
 - Ex A group of office workers can share a common printer fax, modem, scanner etc.
- **High Reliability** If there are alternate sources of supply, all files could be replicated on two or, machines
 - If one of them is not available, due to hardware failure, the other copies could be used

Goals of Computer Networks

- **Inter process Communication:** Network users, located geographically apart, may converse in an interactive session through the network
 - In order to permit this, the network must provide almost error free communications
- **Flexible access:** Files can be accessed from any computer in the network.
 - The project can be begun on one computer and finished on another.

Goals of Computer Networks

- **Security:** It refers to the protection of data from any unauthorized user or access.
- While travelling through network, data passes many layers of network, and data can be traced if attempted.
- Hence security is also a very important characteristic for Networks.
- ***Cost Reduction:*** Centralized services and efficient resource usage

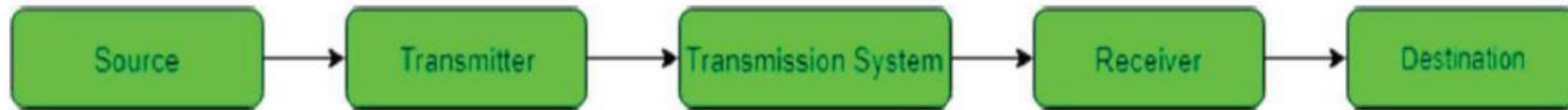
Applications of Computer Networks

- **Business:** E-commerce, online collaboration
- **Education:** E-learning, virtual labs
- **Healthcare:** Remote consultations, data sharing
- **Entertainment:** Video streaming, online gaming

Communication model

Basic Communication Model

- A Communication model is used to exchange data between two parties.
- For example: communication between a computer, server and telephone (through modem)



- **Source** : Data to be transmitted is generated by this device, example: telephones, personal computers etc.

Communication model

Basic Communication Model

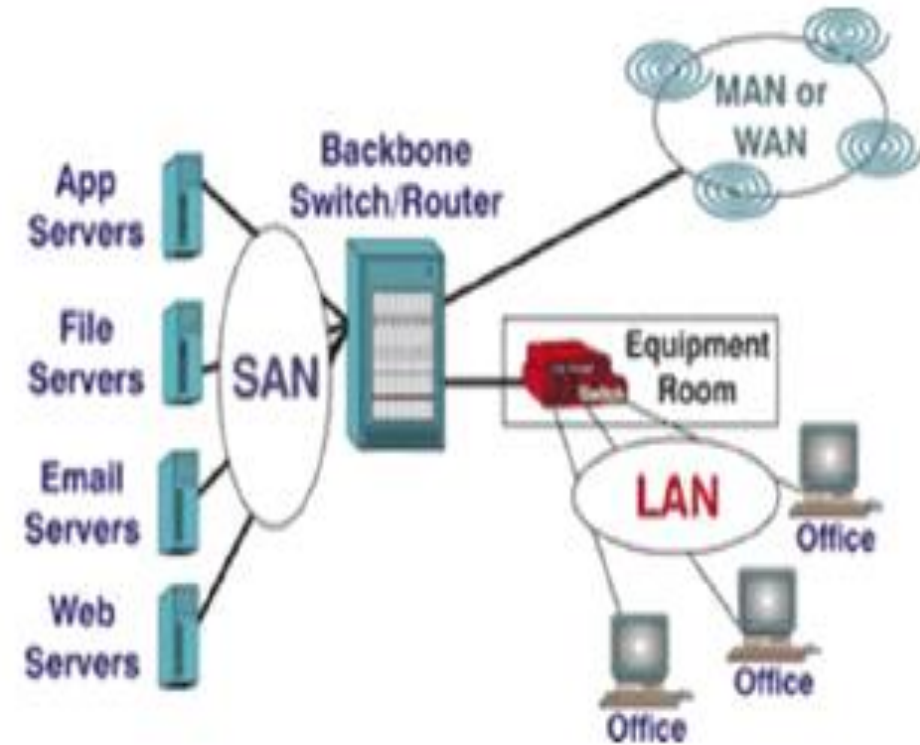
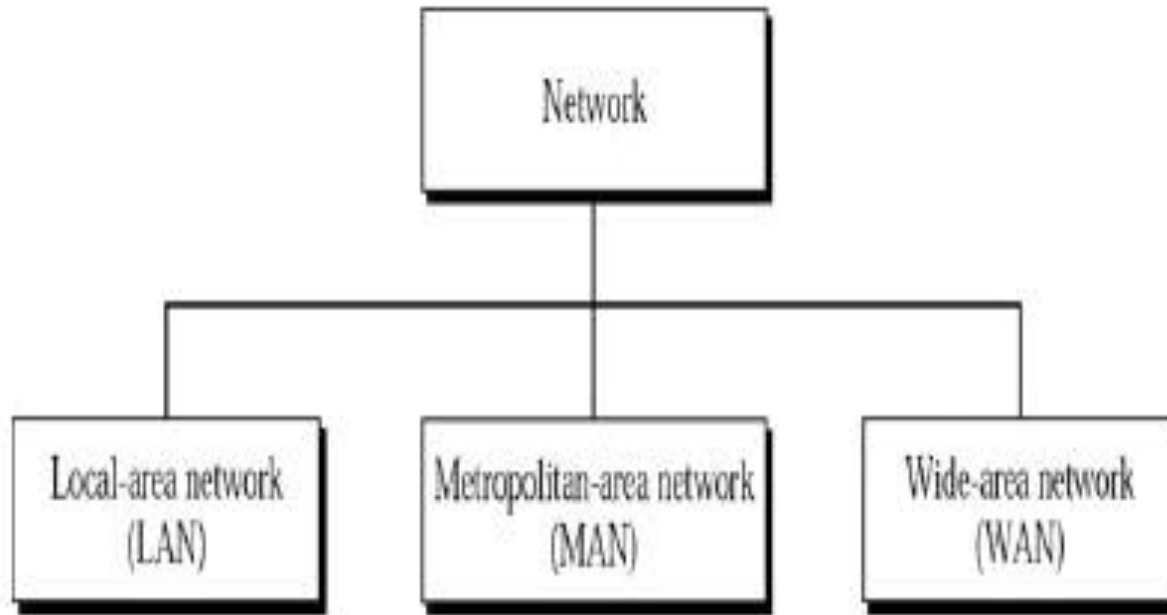
- **Transmitter:** The data generated by the source system is not directly transmitted in the form its generated
- The transmitter transforms and encodes the data in such a form to produce electromagnetic waves or signals
- **Transmission System:** A transmission system can be a single transmission line or a complex network connecting source and destination
- **Receiver:** Receiver accepts the signal from the transmission system and converts it into a form which is easily managed by the destination device
- **Destination:** Destination receives the incoming data from the receiver

Communication model

Characteristic of Communication model

- 1) **Delivery**- The System must deliver the data to the correct Destination.
- 2) **Accuracy**- The System must deliver the data at Accurate way.
- 3) **Timeline** - The System must deliver the data at Exact Time.
- 4) **Jitter** - It refers to the variable in the perfect arrival time

Categories of Networks



Categories of Networks

- The Network allows computers to connect and communicate with different computers via any medium
- LAN MAN and WAN are the three major types of networks designed to operate over the area they cover
- There are some similarities and dissimilarities between them
- One of the major differences is the geographical area they cover
 - LAN covers the smallest area
 - MAN covers an area larger than LAN
 - WAN comprises the largest of all

Categories of Networks

There are other types of Computer Networks also, like :

- PAN (Personal Area Network)
- SAN (Storage Area Network)
- EPN (Enterprise Private Network)
- VPN (Virtual Private Network)

Categories of Networks

Local Area Networks (LAN)

- LAN or Local Area Network connects network devices in such a way that personal computer and workstations can share data, tools and programs.
- The group of computers and devices are connected together by a switch, or stack of switches, using a private addressing scheme as defined by the TCP/IP protocol.
- Routers are found at the boundary of a LAN, connecting them to the larger WAN.
- Data transmits at a very fast rate as the number of computers linked are limited.
- LANs cover smaller geographical area (Size is limited to a few kilometers) and are privately owned.

Categories of Networks

Local Area Networks (LAN)

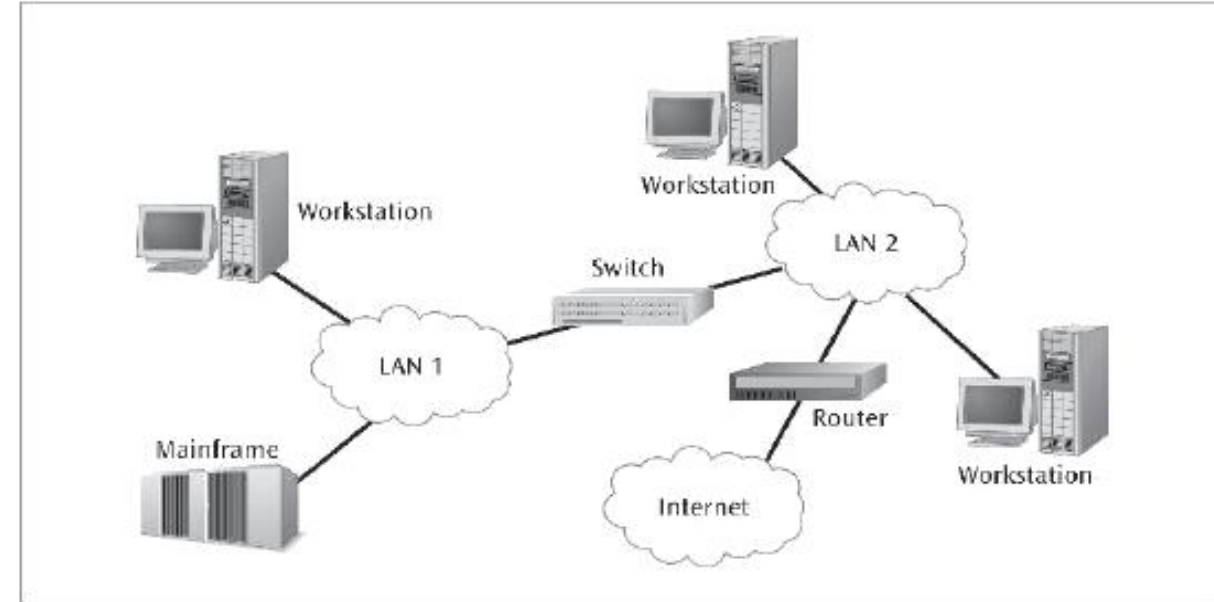
- One can use it for an office building, home, hospital, school, etc.
- LAN is easy to design and maintain. A Communication medium used for LAN has twisted pair cables and coaxial cables. It covers a short distance, and so the error and noise are minimized.
- Early LANs had data rates in the 4 to 16 Mbps range. Today, speeds are normally 100 or 1000 Mbps.
- Advanced LAN has speed in the range of 100 to 400 Gbps.
- The fault tolerance of a LAN is more and there is less congestion in this network.

Categories of Networks

Local Area Networks (LAN)

Advantages of LAN:

- Share resources efficiently
- Support heterogeneous hardware/software
- Access to other LANs and WANs
- High transfer rates with low error rates



Categories of Networks

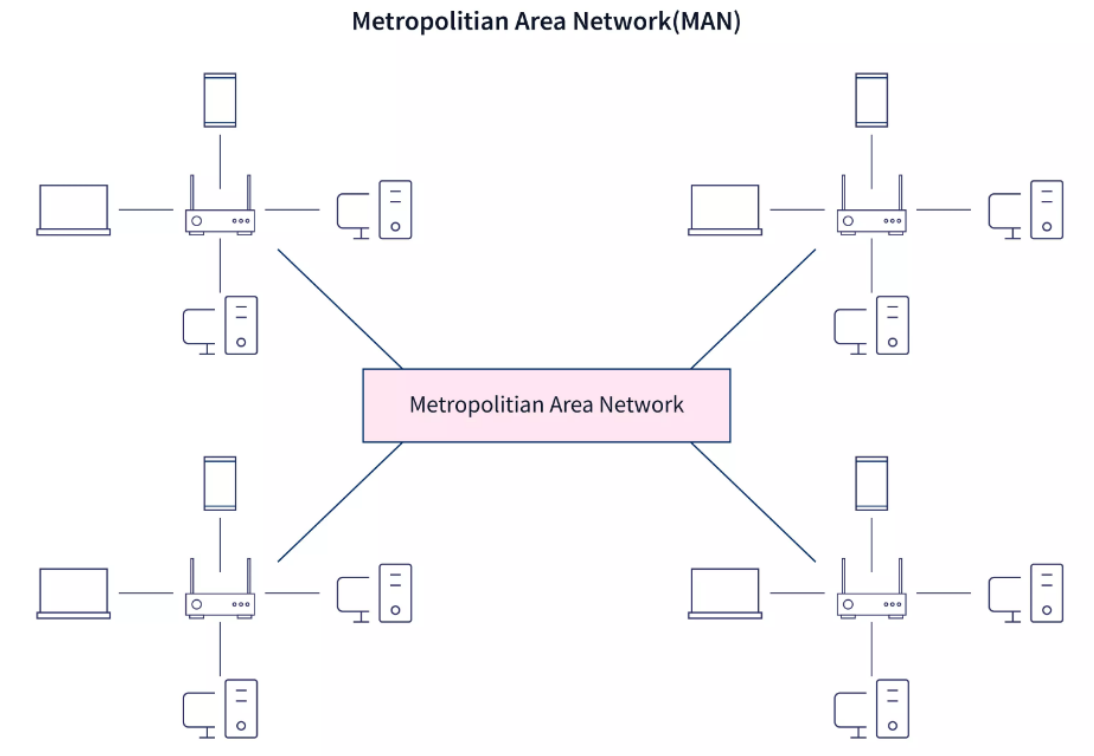
Metropolitan Area Networks (MAN)

- MAN or Metropolitan area Network covers a larger area than that of a LAN and smaller area as compared to WAN.
- It connects two or more computers that are apart but resides in the same or different cities .
- It covers a large geographical area and may serve as an ISP (Internet Service Provider).
- MAN is designed for customers who need a high speed connectivity Speeds of MAN ranges in terms of Mbps.
- It's hard to design and maintain a Metropolitan Area Network.
- The fault tolerance of a MAN is less and also there is more congestion in the network .

Categories of Networks

Metropolitan Area Networks (MAN)

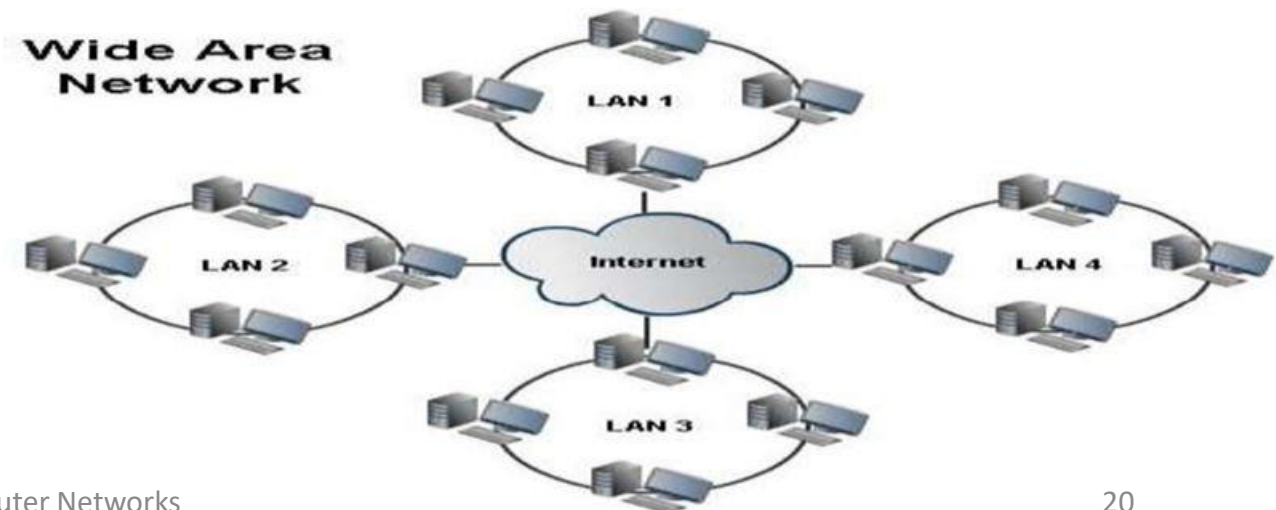
- It is costly and may or may not be owned by a single organization
- Devices used for transmission of data through MAN are Modem and Wire/Cable
- Examples of a MAN are the part of the telephone company network that can provide a high speed DSL line to the customer or the cable TV network in a city



Categories of Networks

Wide Area Networks (WAN)

- WAN or Wide Area Network is a computer network that extends over a large geographical area, although it might be confined within the bounds of a state or country .
- A WAN could be a connection of LAN connecting to other LAN's via telephone lines and radio waves and may be limited to an enterprise (a corporation or an organization) or accessible to the public.
- The technology is high speed and relatively expensive.
- There are two types of WAN:
 - Switched WAN
 - Point to Point WAN

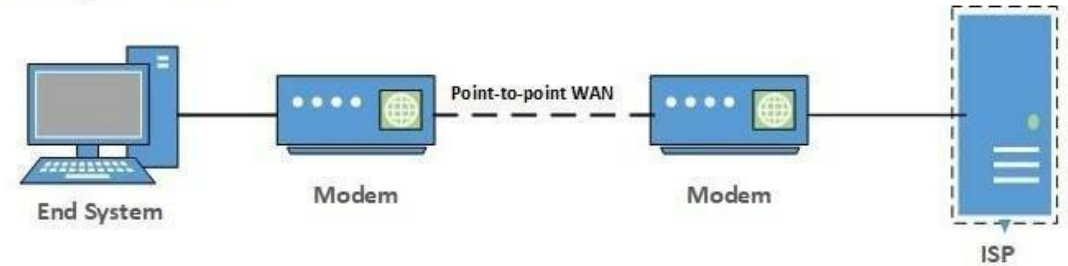


Categories of Networks

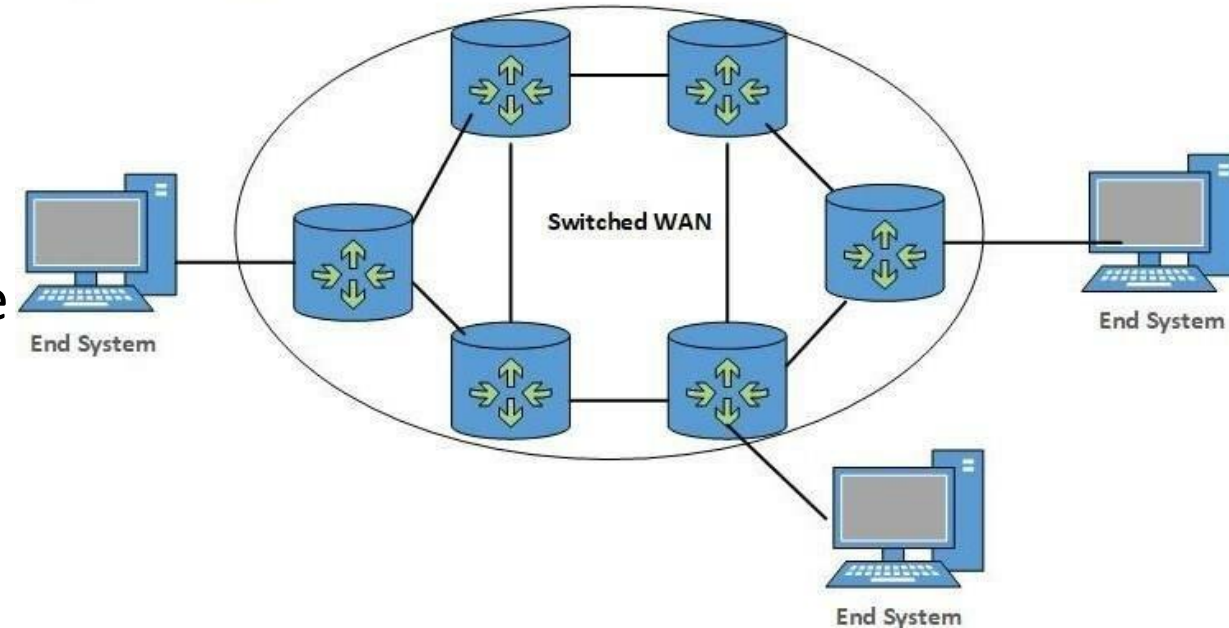
Wide Area Networks (WAN)

- **Switched WAN:** network is used to connect multiple end nodes through a common WAN network, example is Asynchronous Transfer Mode (ATM) network
- **Point to Point WAN:** is one which consists of a two end nodes connected by a leased line, example is a dial-up line that connects a home computer to the Internet

Point-to-point WAN



Switched WAN



Categories of Networks

Wide Area Networks (WAN)

- WAN is difficult to design and maintain.
- Similar to a MAN, the fault tolerance of a WAN is less and there is more congestion in the network.
- A Communication medium used for WAN is Public Switched Telephone Network (PSTN) or Satellite Link.
- Due to long distance transmission, the noise and error tend to be more in WAN.
- WAN's data rate is slow about a 10th LAN's speed, since it involves increased distance and increased number of servers and terminals etc.
- Speeds of WAN ranges from few kilobits per second (Kbps) to megabits per second (Mbps).
- Devices used for transmission of data through WAN are: Optic wires, Microwaves and Satellites.

Categories of Networks

Differentiate Between LAN, MAN and WAN

Differences between LAN, WAN and MAN

LAN	MAN	WAN
LAN stands for Local Area Network.	MAN stands for Metropolitan Area Network.	WAN stands for Wide area network.
LAN's ownership is private.	MAN's ownership can be private or public.	While WAN also might not be owned by one organization.
The transmission speed of LAN is high.	While the transmission speed of MAN is average.	Whereas the transmission speed of WAN is low.
The propagation delay is short in LAN.	There is moderate propagation delay in MAN.	Whereas there is long propagation delay.
There is less congestion in LAN.	While there is more congestion in MAN.	Whereas there is more congestion than MAN in WAN.
LAN's design and maintenance is easy.	While MAN's design and maintenance is difficult than LAN.	Whereas WAN's design and maintenance is also difficult than LAN as well MAN.
There is more fault tolerance in LAN.	While there is less fault tolerance.	In WAN, there is also less fault tolerance.

Organization of Internet

- **Core (Backbone) Network:**
 - The highest level of the Internet consists of high-capacity, high-speed networks called backbones.
 - Backbone providers (Tier 1 ISPs) form the core of the Internet, directly interconnecting with one another.
- **Regional Networks (Tier 2 ISPs):**
 - These connect to the backbone and provide service to smaller networks.
 - They often act as intermediaries between the backbone and access networks.
- **Access Networks (Tier 3 ISPs):**
 - Local ISPs provide direct access to homes, offices, and individuals

Internet

- The network formed by a co-operative interconnection of large number of computer networks.
- The Internet is a global network connecting millions of computers. More than 100 countries are linked into exchanges of data, news and opinions.
- It is also called as network of networks
- It is a network of networks that use the standard Internet protocol suite (TCP/IP).
- The Internet carries an extensive range of information resources and services, such as the inter-linked hypertext documents of the World Wide Web (WWW).
- Graphical representation of the Internet

Internet

Key milestones in evolution of Internet

- Late 1960's: US Department of Defense (DOD) funded a research agency ARPA to do research on Networking. Only few computers were connected.
- ARPA: Advance Research Project Agency.
- 1970: ARPANET was useful for defence proposes. It was having its first step towards transmission control protocol.
- 1971: Universities were added to the network. telnet and FTP were available
- 1972: First Electronic mail was sent
- 1973: ARPANET connected to England and Norway

Internet

Key milestones in evolution of Internet

- 1974: TCP was recognized as a standard and used for communicating across a system of network
- 1982: US DOD started building a defense data network based on ARPANET technology.
- 1983: ARPANET splits into ARPANET and MILNET. MILNET has some extra security requirements
- 1986: National Science Foundation (NSF) implements NFSNET
- 1991: ARCHIE and GOPHER FTP search engines were released
- 1993: World Wide Web (www) was used

Internet

Some facts

- 1994: Hotmail starts web-based email
- 1994: The World Wide Web Consortium (W3C) was founded
- 1995: Java source code was released
- 1998: Google was founded

Internet

Who Owns the Internet?

- No one actually owns the Internet, and no single person or organization controls the Internet in its entirety.
- The Internet is more of a concept than an actual tangible entity, and it relies on a physical infrastructure that connects networks to other networks.
- Every person who makes a connection owns a slice of internet.

Internet

Is Web and Internet the Same?

- The Internet is not synonymous with World Wide Web.
- Internet is a massive network of networks, a networking infrastructure.
- It connects millions of computers together globally, forming a network in which any computer can communicate with any other computer as long as they are both connected to the Internet.
- The **World Wide Web**, or simply **Web**, is a system of interlinked hypertext documents accessed via internet.
- It is an information-sharing model that is built on top of the Internet(act as the backbone).

Internet

World Wide Web	Internet
The World Wide Web , or simply Web , is a system of interlinked hypertext documents accessed via internet.	The Internet is a global network of computers that is accessed by the World wide web.
The world wide web is a service.	The Internet is an infrastructure.
The world wide web is software-oriented.	The Internet is hardware-oriented.
The world wide web uses HTTP.	The Internet uses IP Addresses.

Organization of Internet

Internet Service Providers (ISPs)

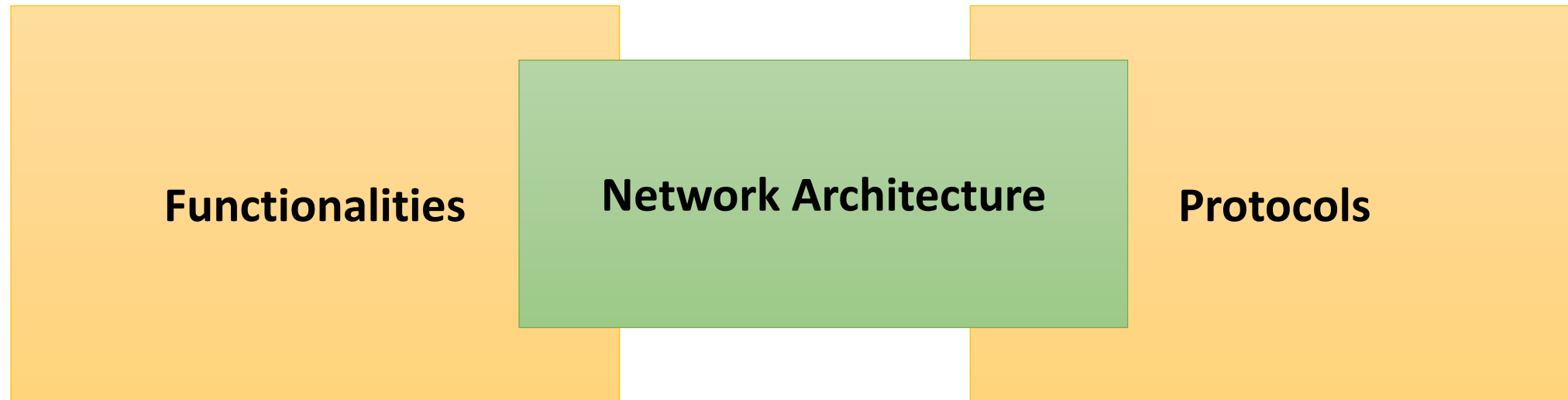
An organization that maintain one or more gateway computers and provides internet access facility to other user by allowing them to connect their computer to its own gateway computer(s) by using a modem.

Example: BSNL, Airtel, Reliance jio, etc.

ISPs categorized into multiple layers:

- Tier 1 ISPs: Large international companies providing backbone connectivity.
- Tier 2 ISPs: Regional ISPs connected to Tier 1 providers.
- Tier 3 ISPs: Local ISPs connected to Tier 2 providers, serving end users.

Networks Structure and Architecture



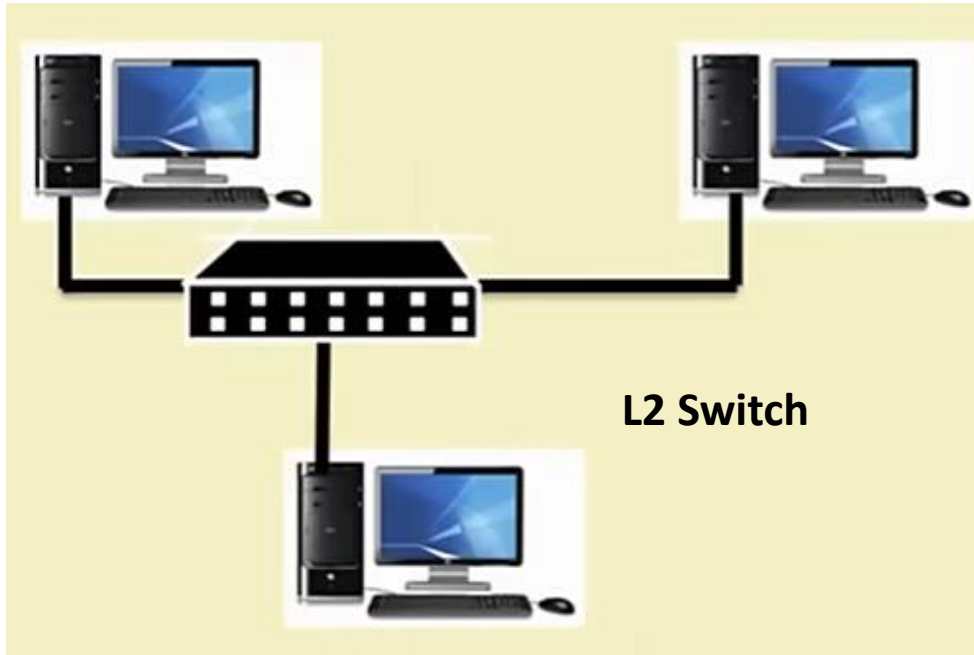
Network Architecture



Requirement: Converting digital data to analog data and vice versa

Physical

Network Architecture

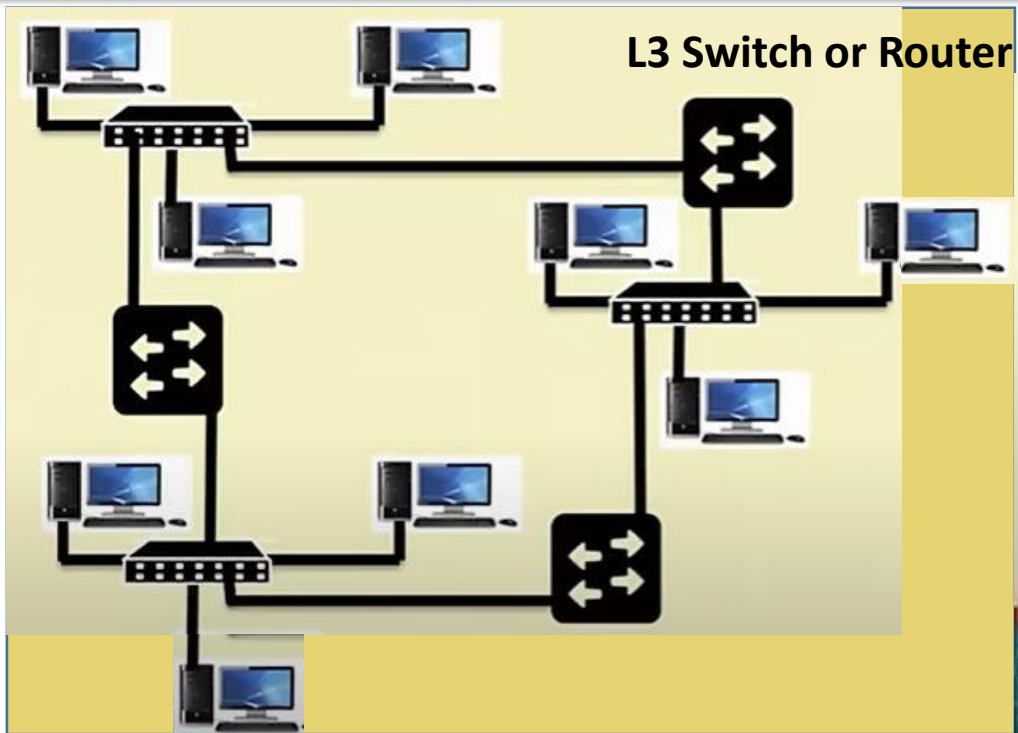


Requirement: Ensure proper scheduling in media access

Data Link

Physical

Network Architecture



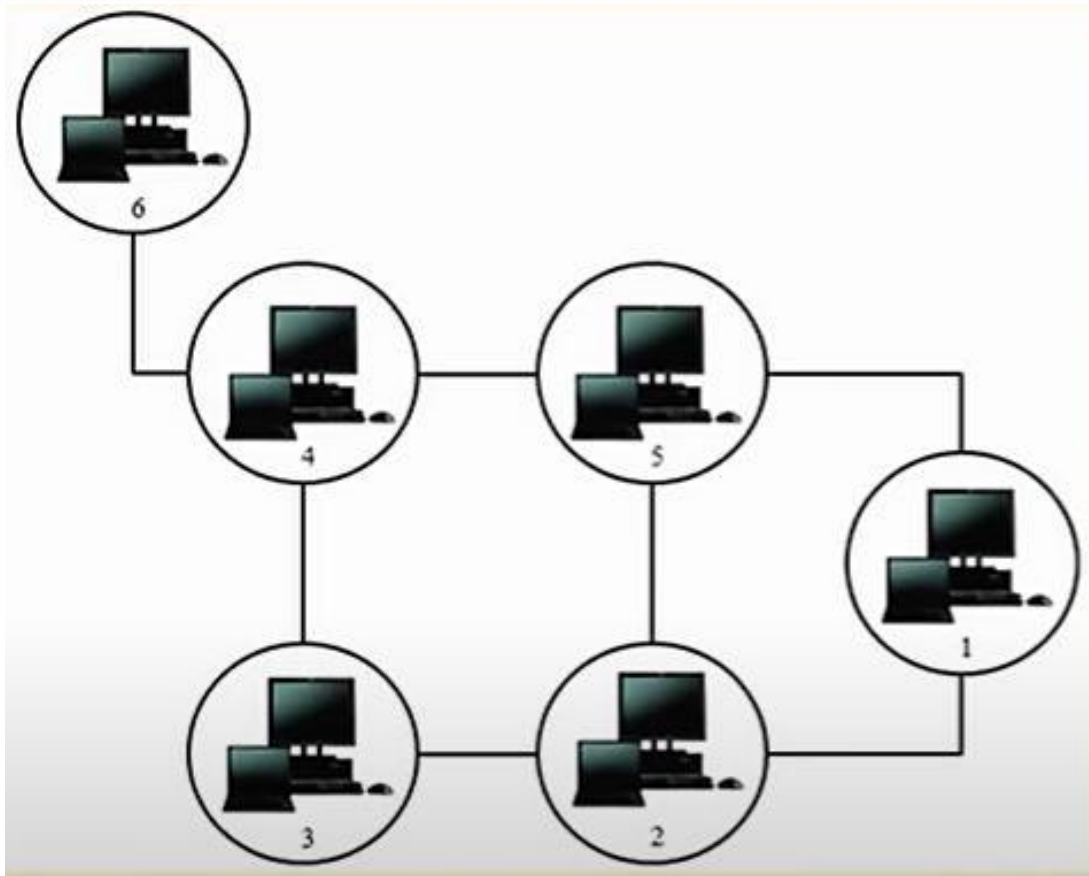
Requirement: Find out suitable path to transfer data

Network

Data Link

Physical

Network Architecture



Transport

Network

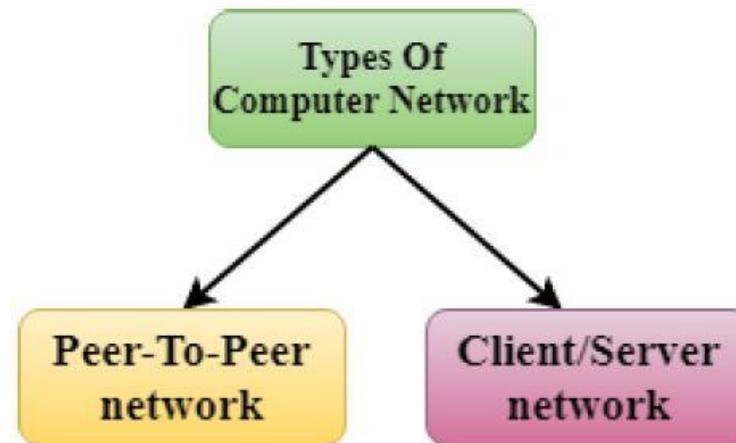
Data Link

Physical

Requirement: End to end traffic control in the network

Network Architecture

- Computer Network Architecture is defined as the physical and logical design of the software, hardware, protocols, and media of the transmission of data
- Simply we can say that how computers are organized and how tasks are allocated to the computer
- The two types of network architectures are used



Network Architecture

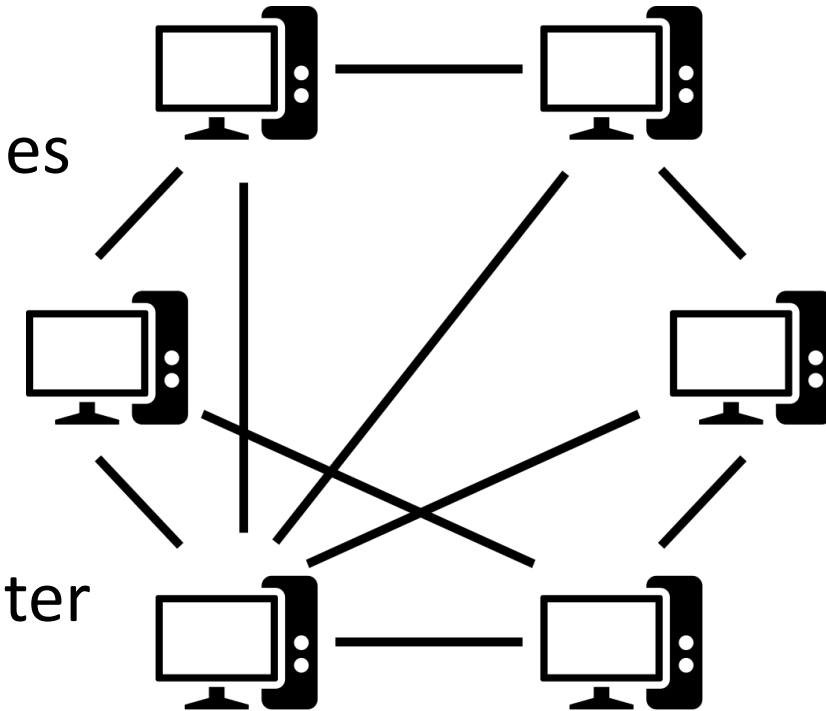
Peer To Peer network

- Network in which all the computers are linked together with equal privilege and responsibilities for processing the data.
- Peer To Peer network is useful for small environments, usually up to 10 computers.
- Peer To Peer network has no dedicated server.
- Special permissions are assigned to each computer for sharing the resources, but this can lead to a problem if the computer with the resource is down.

Network Architecture

Peer To Peer network

- A network in which all the computers are linked together with **equal privileges** and responsibilities for processing the data.
- Peer-to-peer networks are useful for **small environments**, usually up to 10 computers.
- Peer To Peer network has **no dedicated server**.
- Special permissions are assigned to each computer for sharing the resources,
- if the computer with the resource is down, this can lead to a problem



Network Architecture

Advantages Of Peer To Peer Network

- It is less costly as it does not contain any dedicated server.
- If one computer stops working but, other computers will not stop working.
- It is easy to set up and maintain as each computer manages itself.

Disadvantages Of Peer To Peer Network

- In the case of Peer To Peer network, it does not contain the centralized system . Therefore, it cannot back up the data as the data is different in different locations.
- It has a security issue as the device is managed itself.

Network Architecture

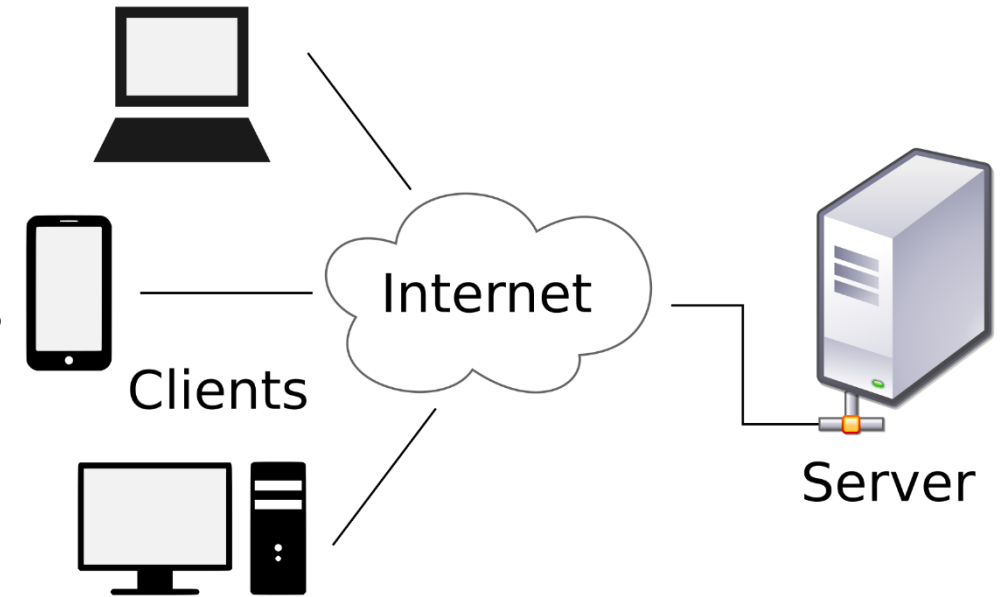
Client-Server Network

- Client-Server network is a network model designed for the end users called clients, to access resources such as songs, video, etc. from a central computer known as a Server.
- The central controller is known as a server while all other computers in the network are called clients
- A server performs all the major operations such as security and network management.
- A server is responsible for managing all the resources such as files, directories, printer, etc.

Network Architecture

Client Server Network

- All the clients communicate with each other through a server.
- For example, if client1 wants to send some data to client 2, then it first sends the request to the server for the permission. The server sends the response to the client 1 to initiate its communication with the client 2.



Network Architecture

Advantages Of Client-Server Network

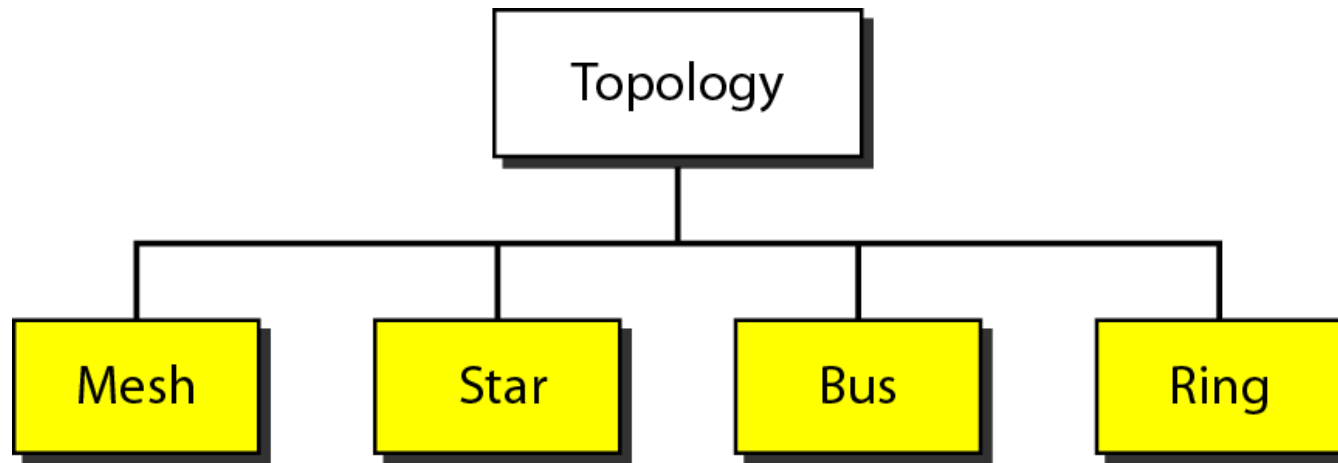
- A Client-Server network contains a centralized system, therefore we can back up the data easily
- It has a dedicated server that improves the overall performance
- Security is better in Client-Server network as a single server administers the shared resources
- It also increases the speed of the sharing of resources

Disadvantages Of Client-Server Network:

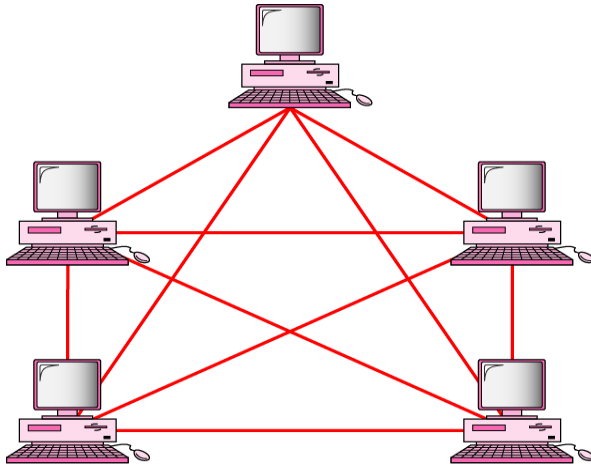
- Client-Server network is expensive as it requires a server with large memory.
- A server has a Network Operating System(NOS) to provide the resources to the clients, but the cost of NOS is very high.

Network Topology

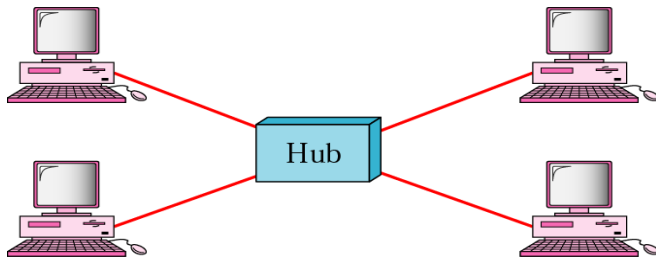
The topology of a network is the geometric representation of the relationship of all the links and linking devices (nodes) to one another.



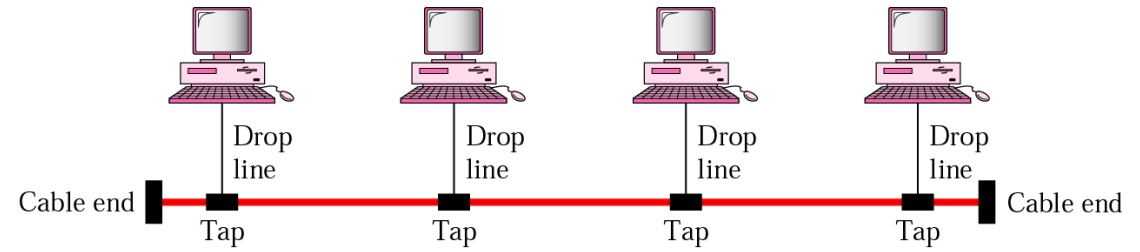
Network Topology



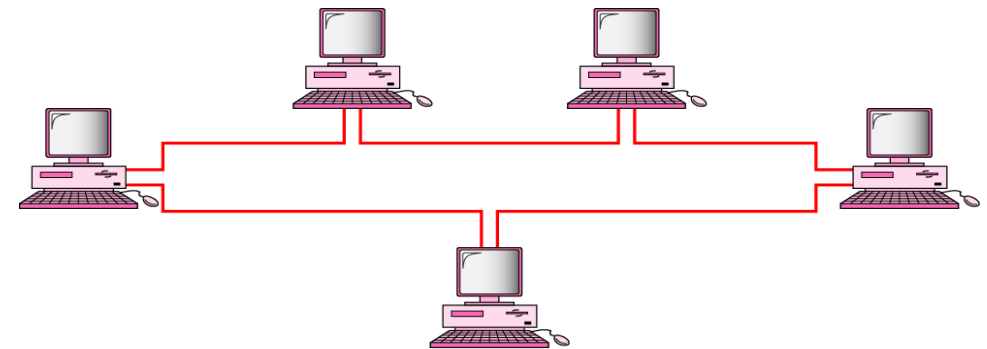
mesh



star



bus

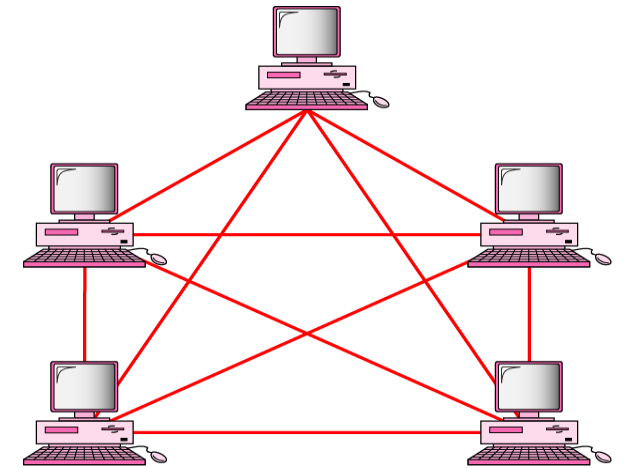


ring

Network Topology

Mesh Topology

- Every link is dedicated point-to-point link
- The term dedicated means that the link carries traffic only between the two devices it connects
- To link n devices fully connected mesh has:
 $n(n-1)/2$ physical channels (Full-Duplex)
- Every Device on the network must have
 $n-1$ ports



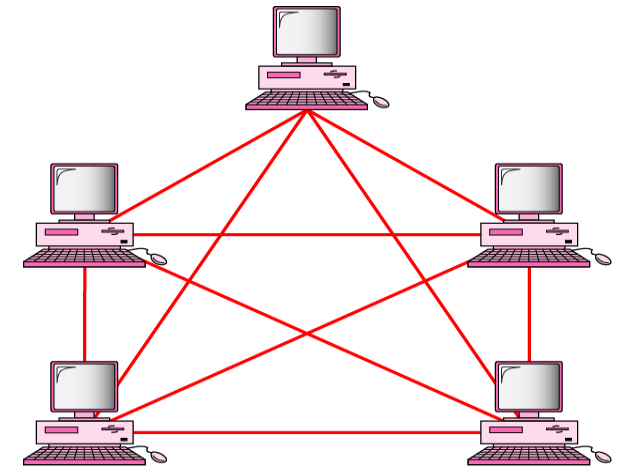
Mesh

Network Topology

Mesh Topology

Example

- **8** devices in mesh has links: $n(n-1) / 2$
- number of links = $8(8-1)/2 = \mathbf{28}$
- number of ports per device = $n - 1 = 8 - 1 = \mathbf{7}$



Mesh

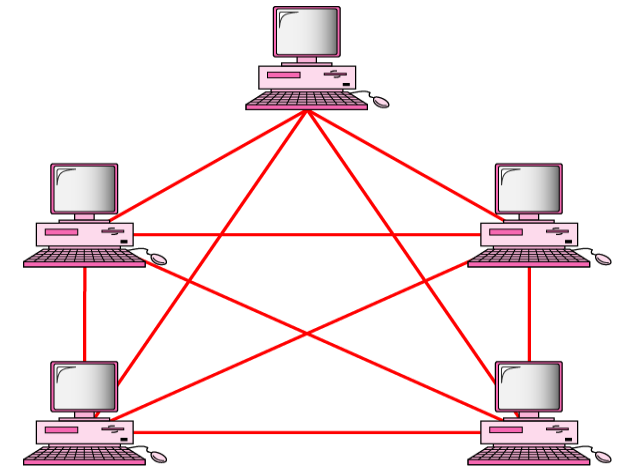
Note: Mesh topology is implemented in a limited fashion; e.g., as backbone of hybrid network

Network Topology

Mesh Topology

Advantages

- Each connection carry its own data load (no traffic problems)
- A mesh topology is robust
- Privacy or security
- Fault identification and fault isolation



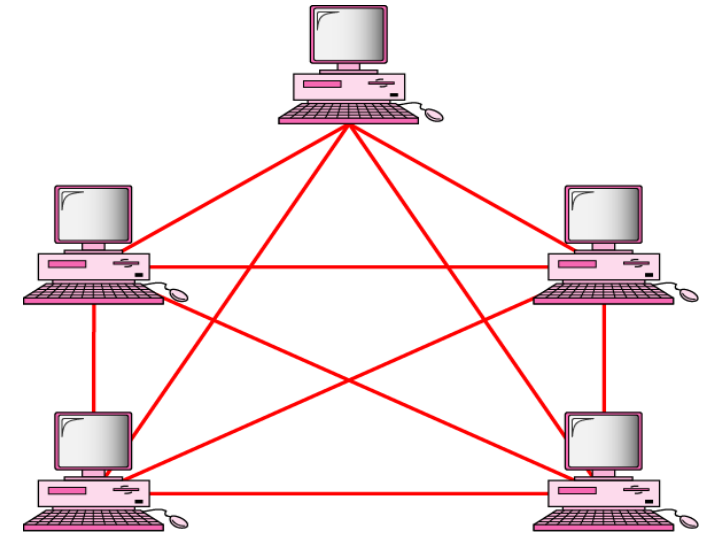
Mesh

Network Topology

Mesh Topology

Disadvantages

- Big amount of cabling
- Big number of I/O ports
- Installation and reconnection are difficult
- Sheer bulk of the wiring can be greater than the available space
- Hardware connect to each I/O could be expensive

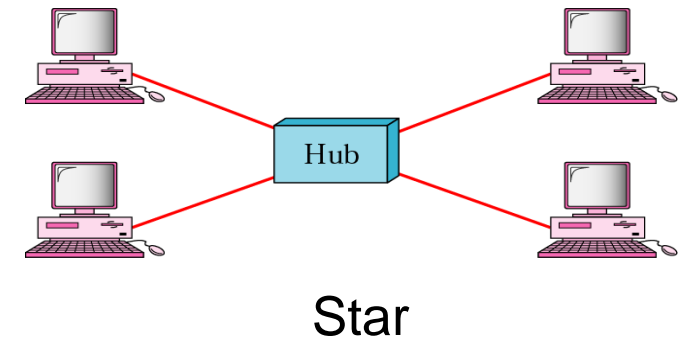


Mesh

Network Topology

Star Topology

- Dedicated point-to-point to a central controller (Hub)
- No direct traffic between devices
- The control acts as an exchange

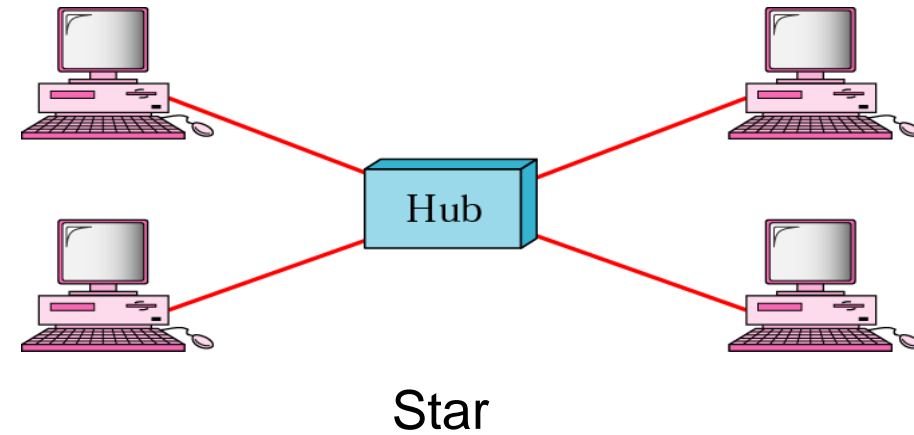


Network Topology

Star Topology

Advantages

- Less expensive than mesh
(1 Link + 1 port per device)
- Easy to install and reconfigure
- Less cabling
- Additions, moves, and deletions required one connection
- **Robustness** : one fail does not affect others
- Easy fault identification and fault isolation

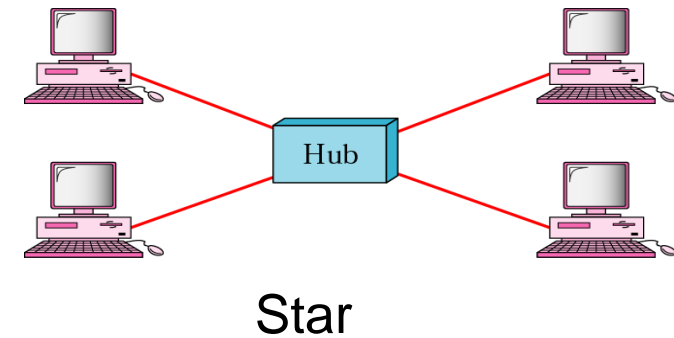


Network Topology

Star Topology

Disadvantages

- Dependency of the whole topology on one single point (hub)
- More cabling than other topologies (ring or bus)

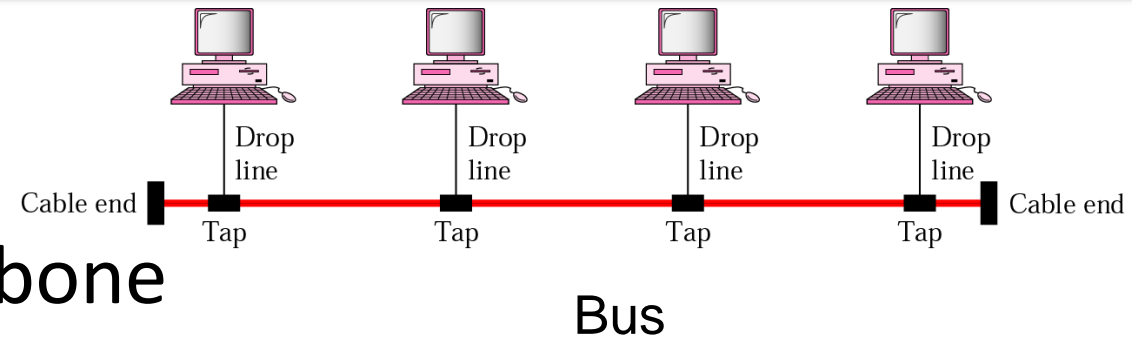


Note: Used in LAN

Network Topology

Bus Topology

- It is multipoint
- One long cable acts as a backbone
- Used in the design of early LANs, and Ethernet LANs
- Nodes connect to cable by drop lines and taps
- Signal travels along the backbone and some of its energy is transformed to heat
- Limit of number of taps and the distance between taps



Network Topology

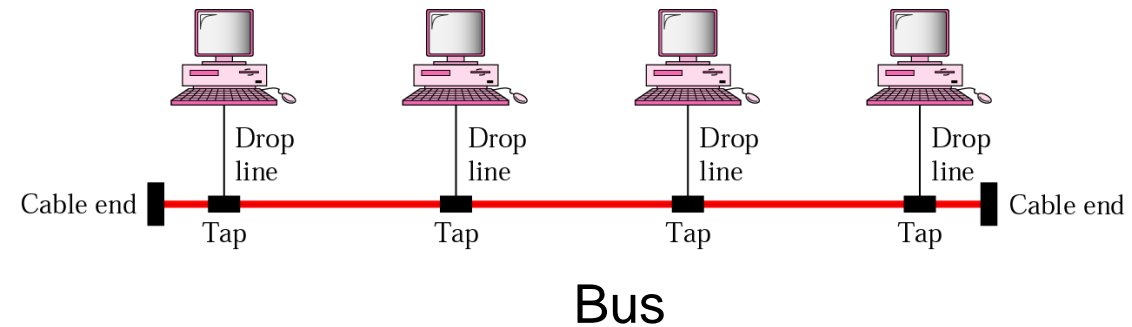
Bus Topology

Advantages

- Ease of installation
- Less cables than mesh, star topologies

Disadvantages

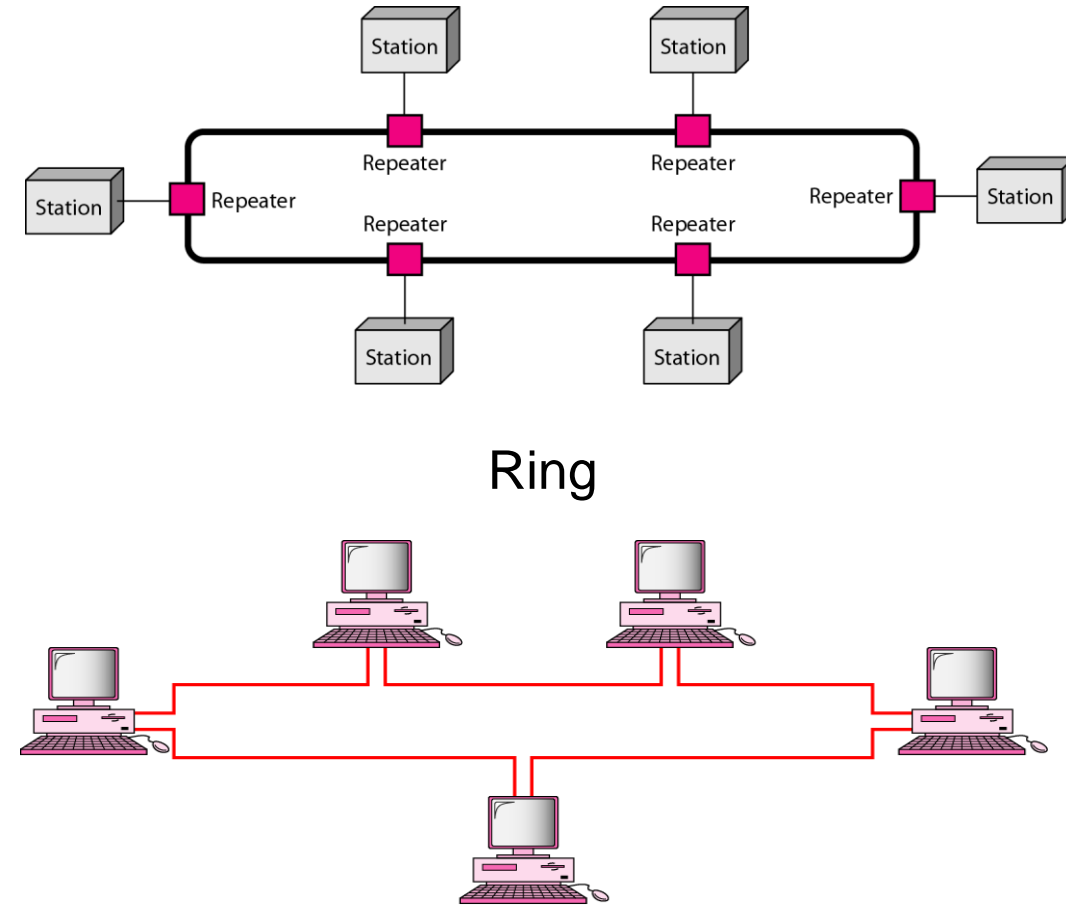
- Difficult reconnection and fault isolation (limit of taps)
- Adding new device requires modification of backbone
- Fault or break stops all transmission
- The damaged area reflects signals back in the direction of the origin, creating noise in both directions



Network Topology

Ring Topology

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



Network Topology

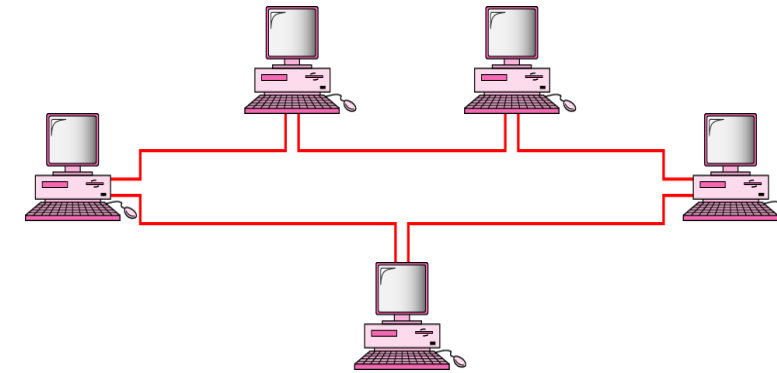
Ring Topology

Advantages

- Easy of install and reconfigure
- Connect to immediate neighbors
- Move two connections for any moving (Add/Delete)
- Easy of fault isolation

Disadvantage

- Unidirectional
- One broken device can disable the entire network. This weakness can be solved by using a dual ring or a switch capable of closing off the break



Ring

Internet Governance Standards

- **IETF (Internet Engineering Task Force)**
- **ICANN (Internet Corporation for Assigned Names and Numbers)**
- **IANA (Internet Assigned Numbers Authority)**
- **W3C (World Wide Web Consortium)**

Thank you!