



NETWORK AND TELECOMMUNICATION





ACADEMIC BACKGROUNDS:

- 1987-1993 Georgia University of Technology (Former USSR) **Specialize: Radio Transmitting Device of Satellite Telecommunication Systems** (Master of Science).
- 1997-1998 Advanced course at the Saint-Petersburg State University of Technology in computer simulation of ground stations Modem for Sputnic communication (Russia).

PREVIOUS EMPLOYMENT:

- 2002-2018 The World Bank Cambodia (IT Analyst, Client Services).
- 1999 -2001 Worked as Systems Engineer at VIRTU International Limited.
- 1995 -1997 Worked as assistant manager in operation and technical department at CAMINTEL.
- 1993 – 1995 Worked as engineer in Operations and Technical Department in HUB-station (ex-UNTAC Networks) at Ministry of Post and Telecommunications of Cambodia.

Teaching Experiences:

- 2000 Royal Academy of Cambodia (MSc.IT).
- 2002 Build Bright University (MSc.IT).
- 2019 National Polytechnic Institute of Cambodia (BSc.Telem).
- 2020 Norton University (BSc.IT)
- 2023 Cambodia Academy of Digital Technology (BSc.Telem).

Network Topologies

- Network topology is the arrangement of the various elements (links, nodes, etc) of a computer network.
- Network topology define the layout, virtual shape or structure of network not only physical but also logical.
- There are two types of Network Topologies
 - Physical Topology
 - Logical Topology

Physical Topology

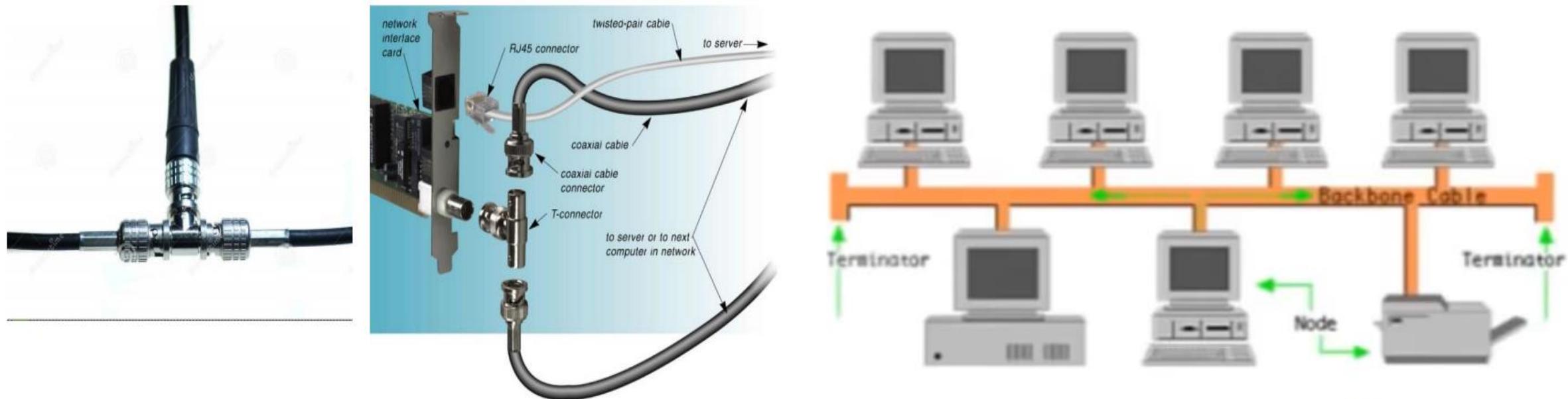
- Physical topology is the physical layout of nodes, workstations and cables in the network.
- It is the arrangement of the various elements(or components) of a network, include device location and cable installation.
- **Types of physical topology:-**
 - BUS Topology
 - STAR Topology
 - RING Topology
 - MESH Topology
 - TREE Topology

Logical Topology

Logical topology means how information is passed b/w two nodes in a network.

This topology is bound to the network protocols and define how data is moved through out the network.

BUS Topology



- In **BUS topology**, All the nodes (computers, servers, printers, etc) are connected to the single cable.
- This cable is known as **BUS** and acts as backbone of the network, which joins every computer and peripheral in the network.
- Both ends of the shared channel have **line terminator**. The data is sent in only one direction and as soon as it reaches the extreme end, the terminator removes the data from the line.



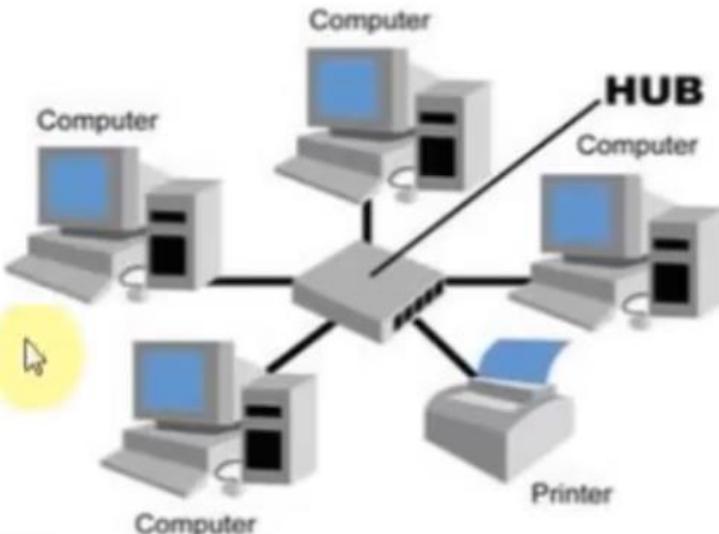
Advantage of BUS Topology

- BUS network are useful in small networks like:- set up in a small office.
- Required less cable length compared to other topologies.
- Easy to connect a computer
- Easy to understand
- BUS topology cost very less

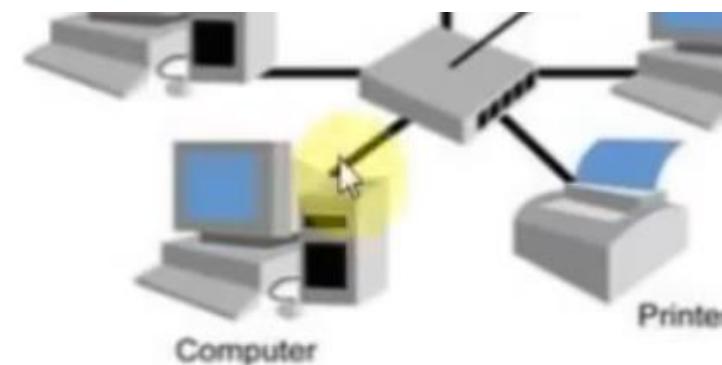
Disadvantage of BUS Topology

- Entire network shuts down, if there is any break in the main cable.
- Cables has a limited length
- It is slow when more devices are added into the network
- It is slower than ring topology

STAR Topology



- In STAR Topology, Every node is connected to central node, which is called hub or switch.
- The Central Node(Hub or Switch) is the server and other nodes are the clients.
- In this topology, Data from the source node is first delivered to the hub and is then transferred to the destination nodes.
- It is easy to add or removes nodes in this topology.
- STAR topology gives better performance because data does not pass through every node unlike BUS topology.
- So if a particular workstation (or a node) gets an error then the entire network is not affected. But if the central workstation (hub/switch) goes down, then the entire network collapses



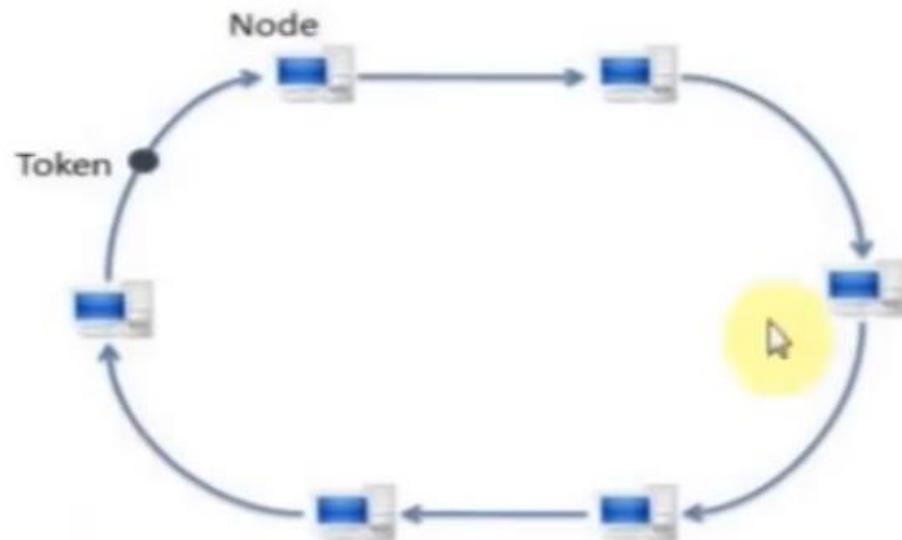
Advantage of STAR Topology

- Easy to install and modify.
- Hub can be upgraded easily.
- Easy to troubleshoot
- New Nodes can be added easily without affecting the other nodes.
- If any of the local computers fails, the remaining portion of the network is unaffected.

Disadvantage of STAR Topology

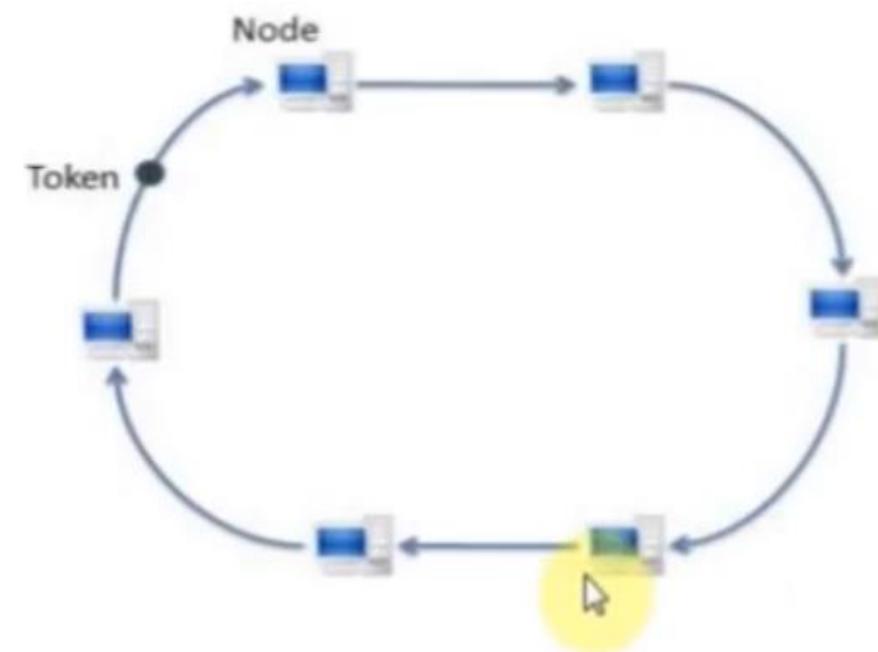
- Whole network depends on central device so if the central device is failed than the whole network is stopped.

RING Topology



- In RING Topology, All the computers(nodes) are connected in a **closed loop**.
- This topology works on the **token based system** and token travels in the loop.
- If token is free, then the node can capture the token and attach the data and destination address to the token, and then leaves the token.
- When token reaches at the destination node, the data is removed by the destination node and token is free to carry the next data.

RING Topology

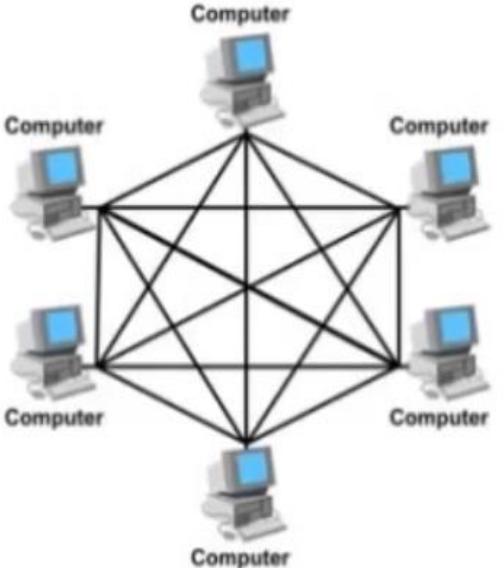


Advantage of RING Topology

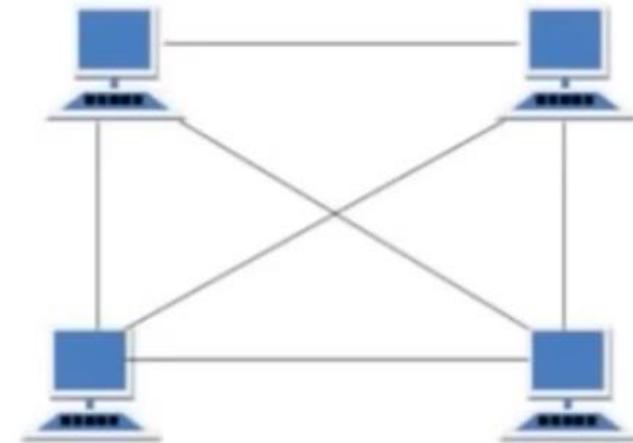
- Additional components do not affect the performance of network.

Disadvantage of STAR Topology

- The main drawback of ring topology is that if one node fails, then the complete network will go down.



MESH Topology



- In MESH Topology, each of node are interconnected with one another.
- Every node sends its own signals and also relay data from other nodes.
- MESH topology network can be formed by using the formula:

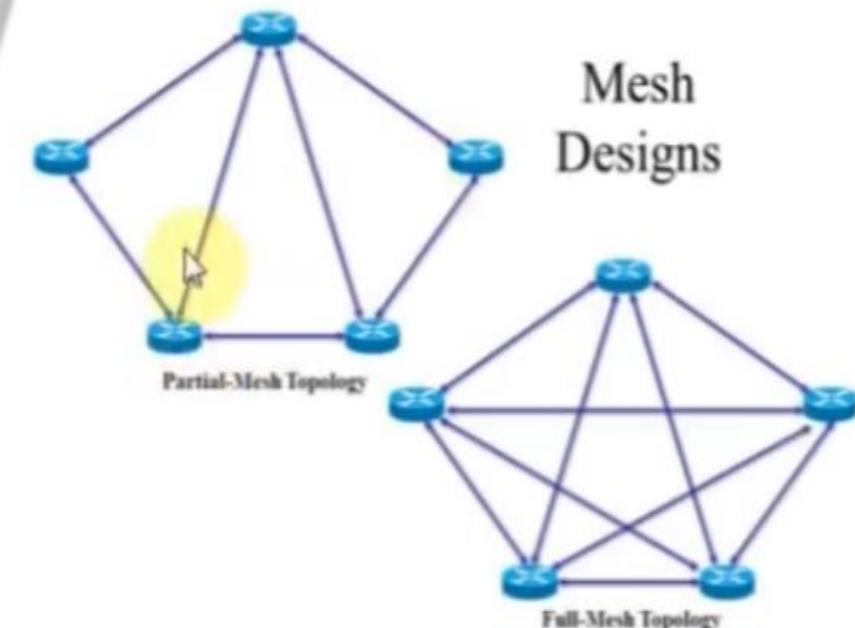
$$\text{Number of Cables} = (n(n-1))/2$$

If, 4 pc, then $(4(4-1))/2 = (4 \times 2)/2 = 6$ cables

MESH Topology

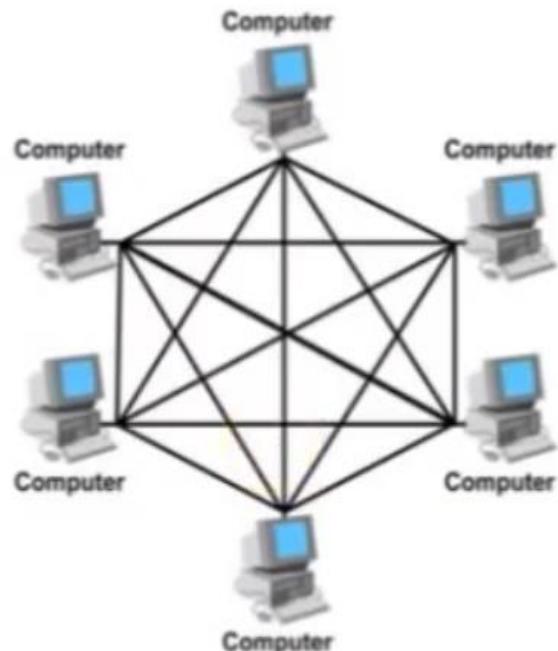
- There are two types of MESH Topology

- Full MESH Topology
 - Partial MESH Topology



- In Full MESH Topology, each node is connected to every other node in the network.
- In Partial MESH Topology, some nodes are not connected to every node.

MESH Topology

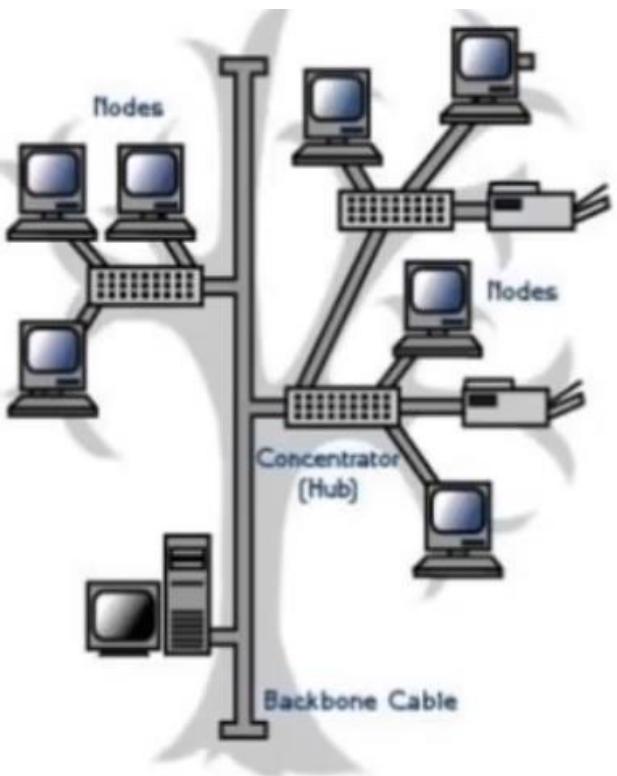


Advantage of MESH Topology

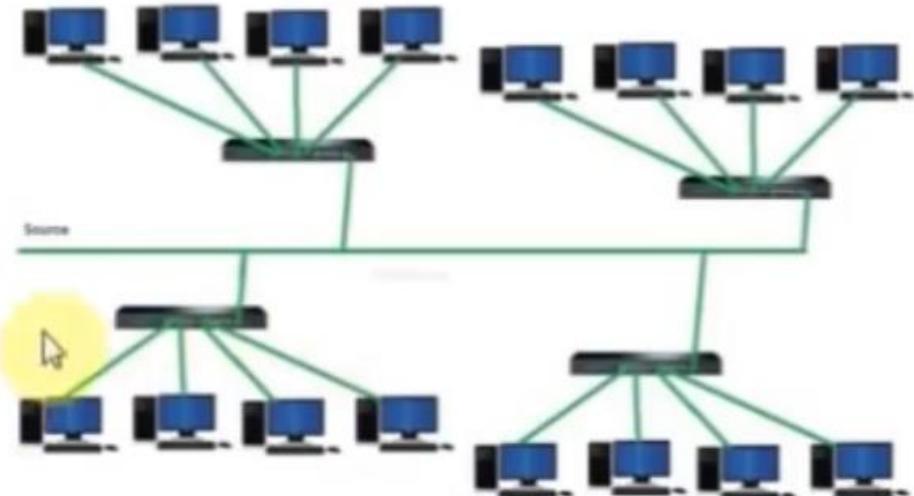
- If one of the device(node) fails, then there is always an alternative present.
- Expansion and Modification can be done without disrupting other nodes.
- Communication is very fast b/w two nodes.

Disadvantage of MESH Topology

- It is quite expensive because a higher length of cable is required.
- Installation and maintenance is very difficult.

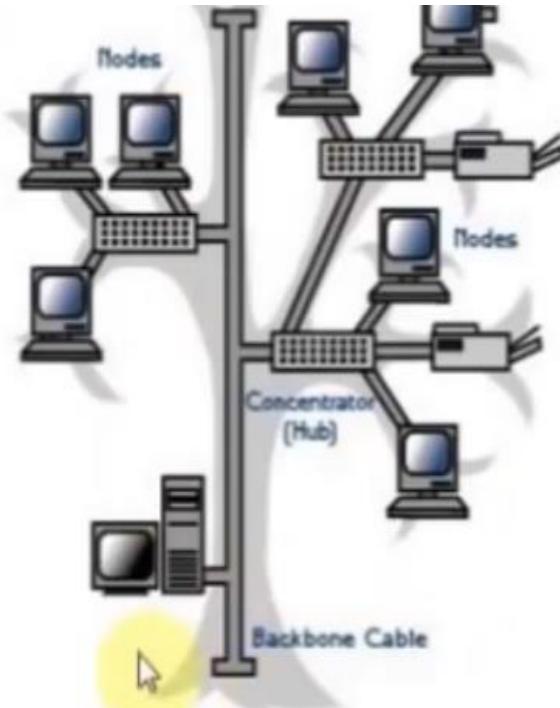


Tree Topology



- Tree topology is the combination of BUS and STAR topology.
- A tree topology is also known as a star bus topology.
- The whole network is divided into segments, which can be easily managed and maintained.

Tree Topology



Advantage of Tree Topology

- Expansion of nodes is possible and easy.
- Other hierarchical networks are not affected if one of them gets damaged.
- Easier maintenance and fault finding.

Disadvantage of Tree Topology

- If the backbone line breaks, than the entire segment goes down.
- Huge cabling is needed.
- A lot of maintenance is needed.
- If the network becomes extremely large it becomes difficult to manage.

Types of Networks

Personal Area Network (PAN)

Local Area Network (LAN)

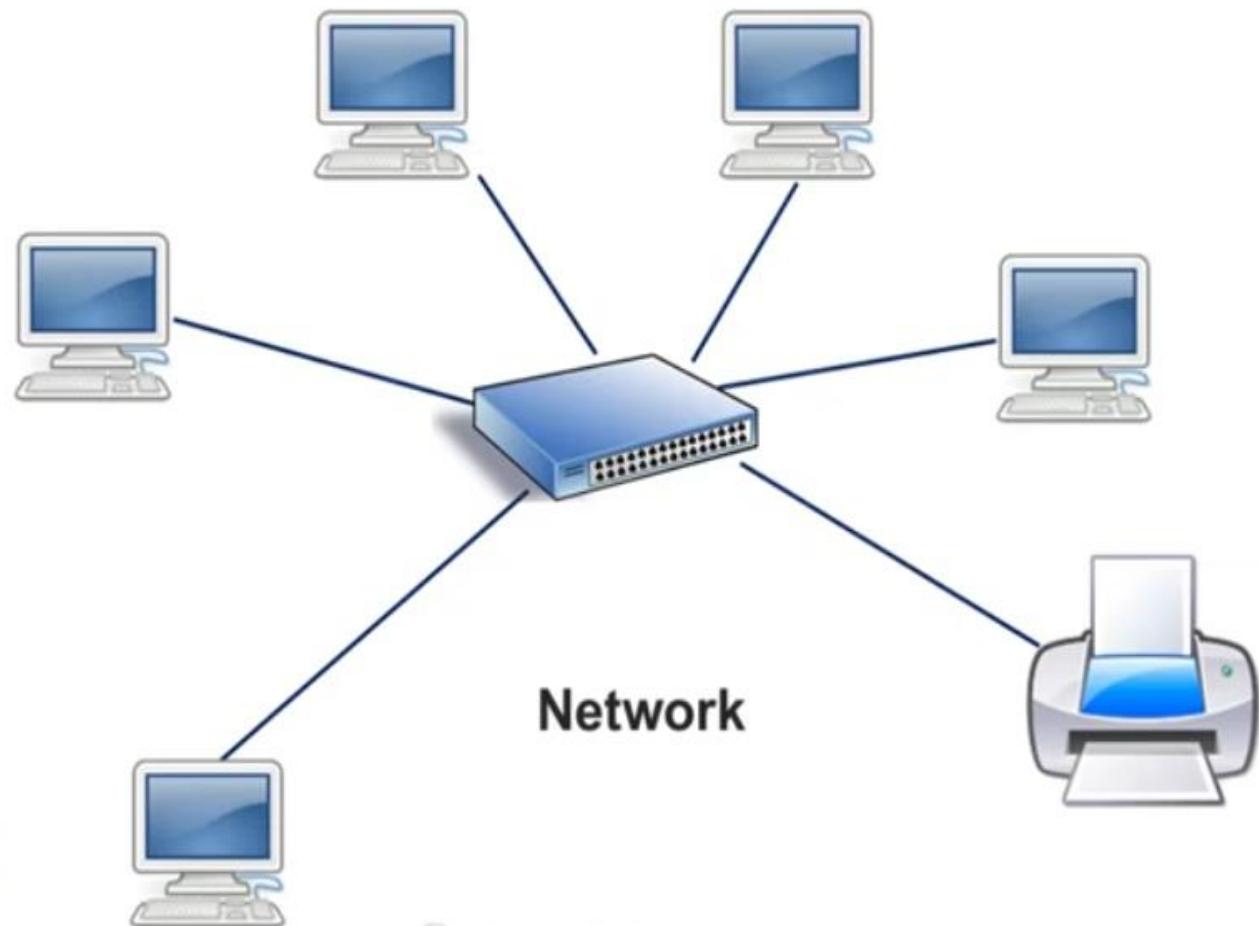
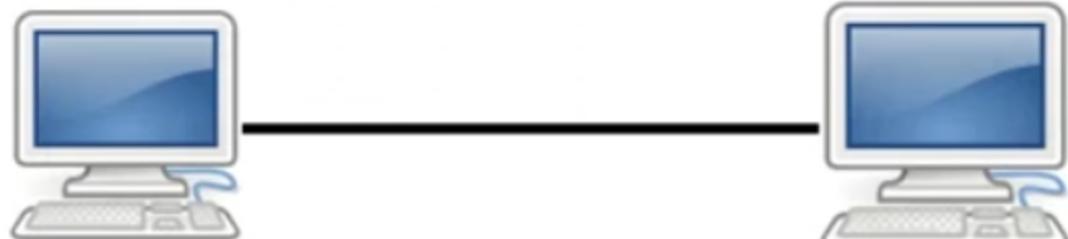
Metropolitan Area Network (MAN)

Wide Area Network (WAN)

What is a Network?

A network is just a communication between two or more computer devices.

when two or more devices are connected to each other for the purpose of communication is called a **network**.



Personal Area Network (PAN)

- PAN means a personal area network is the **smallest network** which is very personal to a user.
- This network used in the personal space of a person that's why this network name is a personal area network.
- This network normally ranges within **around 10 meters**.
- PAN network may include **Bluetooth enable devices or infrared enable devices**.
- All the Bluetooth devices like keyboard, mouse, Bluetooth-enabled headphones, speakers, etc all are the network which is used in the personal area.
- Infrared enable devices like TV remote, cordless keyboard/mouse, infrared touch screen are also a part of the personal area network.



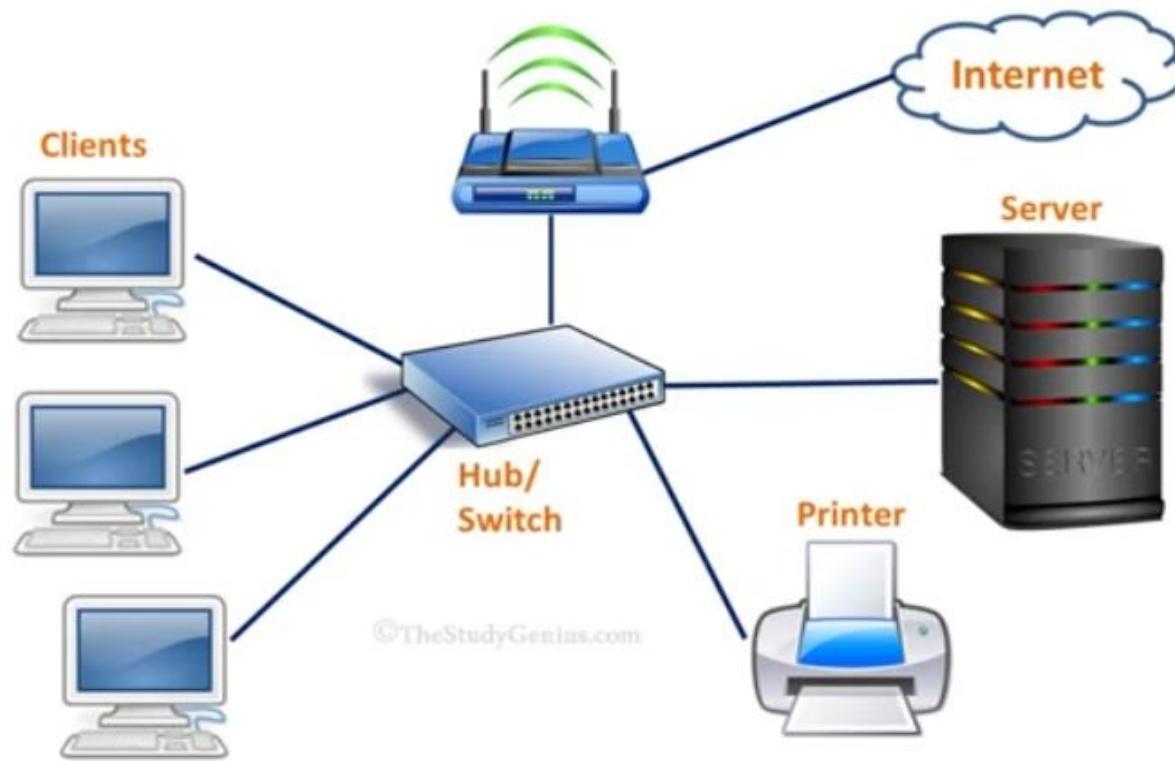
Local Area Network (LAN)

- **Local area network** is a network, which is used in **local areas** means it is a small network that covers small areas like an office, school, college, building, etc.
- In this network, we can connect computers, printers, servers, and other network devices.
- LAN network is a **privately owned network** that means **anyone can create this network easily**, we just need some cables like Ethernet cables or central devices like hub or switch.
- It is most **secured network** because there is no outside connection with the local area network, so the data which is shared on LAN network is safe and can't be accessed outside.
- LAN are small size networks so they are considerably faster, data transfer speed over a LAN network can reach up to 1000 Mbps.
- Using Ethernet cables, data transfer speed can reach up to 10 Mbps and by using FDDI or Gigabit Ethernet, data transfer speed can reach up to 1 Gbps.

Uses of Local Area Network

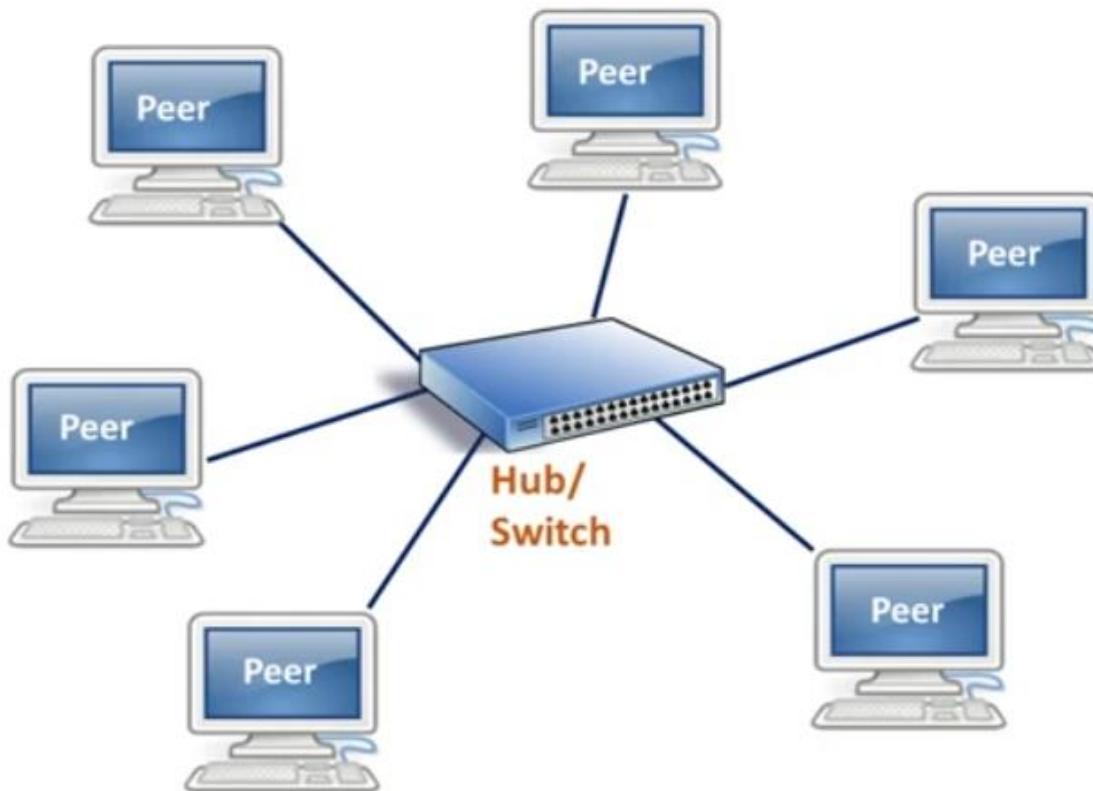
- LAN networks are mostly used in **businesses** where all business data is stored in servers.
- This network can be used in **factories**.
- This network can be used in **Schools and Colleges** where all the students, teachers, staff all the data stored in servers.
- This network can also be used in **our homes** where all the computers, mobiles, printers are connected to the switch/router, and these devices can exchange data.

Client/Server LANs vs



- Client/Server LANs network is **mostly used in business organizations** where central servers are used and all the business data stored in a server.
- All the clients' computers are connected to the central server where they can access data from the server.

Peer-to-peer LANs



- Peer-to-peer LAN networks are **mostly used in homes** where all computers are connected to each other and can exchange data with each other without a server.
- If your mobiles, computers, tablets, smart TV and printer all are connected to your home Wi-Fi connection, then you are using a peer to peer LAN network.

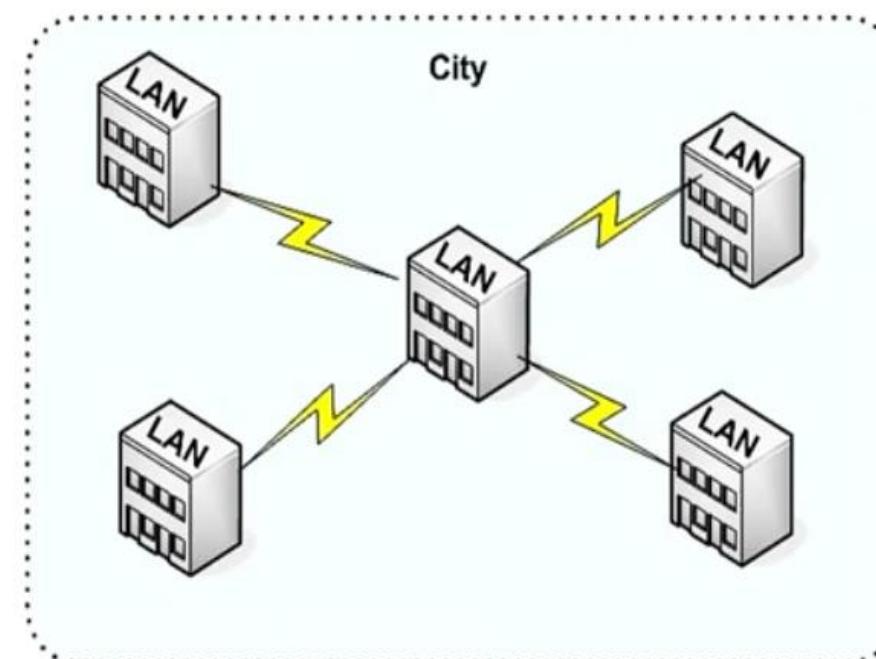
- the "peers" are computer systems which are connected to each other.
- Files can be shared directly between systems on the network without the need of a central server.
- In other words, each computer on a P2P network becomes a file server as well as a client.
- Once connected to the network, P2P software allows you to search for files on other people's computers.
- Software for peer-to-peer network is included with most modern desktop operating systems such as Windows and Mac OS.
- Peer-to-peer networks are more common in small offices or within a single department of a larger organization.

- Peer to peer networking is common on small local area networks (LANs), particularly home networks. Both wired and wireless home networks can be configured as peer to peer environments. Computers in a peer to peer network run the same networking protocols and software. Peer networks are also often situated physically near to each other, typically in homes, small businesses or schools.
- Nearly all Operating Systems come with the ability to act as some kind of a server to share resources. You can setup different computers to allow others to use its peripherals such as printers or CDROM drives, and other computers to allow others to read or write to its hard disk allowing sharing of files, while other computers may allow access to its Internet connection. When you allow workstation computers to become servers and share things in this manner, it is called a Peer-to-peer network.

Metropolitan Area Network (MAN)

- MAN means a **metropolitan area network** is a network, which is bigger than the local area network.
- MAN network is used in larger areas than LANs.
- In other words, When two or more two LANs network connected for the purpose of communication then it becomes MAN network.
- It is bigger than the LAN network but also smaller than the WAN network.

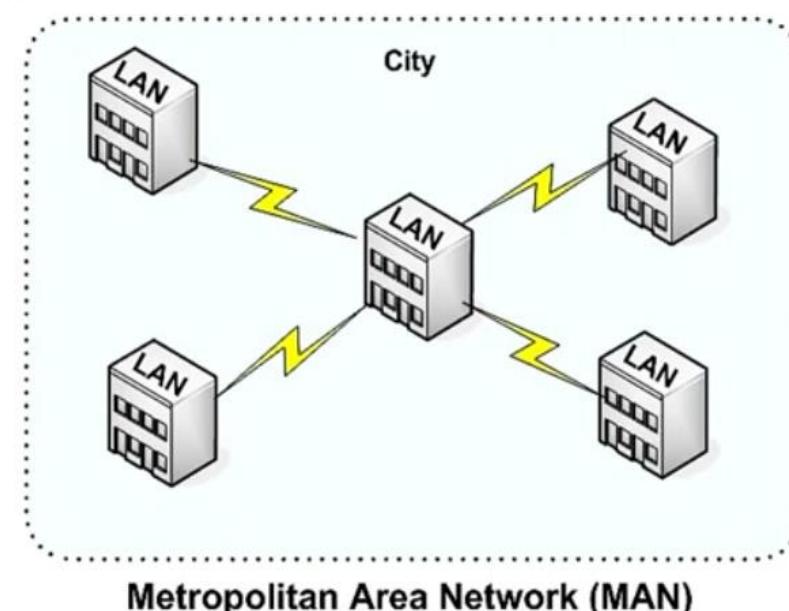
For Example: a business company has many branches in different locations and every branch uses a LAN network. So the company connects all these LAN networks through a telephone line so now this network becomes a Metropolitan Area Network.



Metropolitan Area Network (MAN)

Uses of MAN network

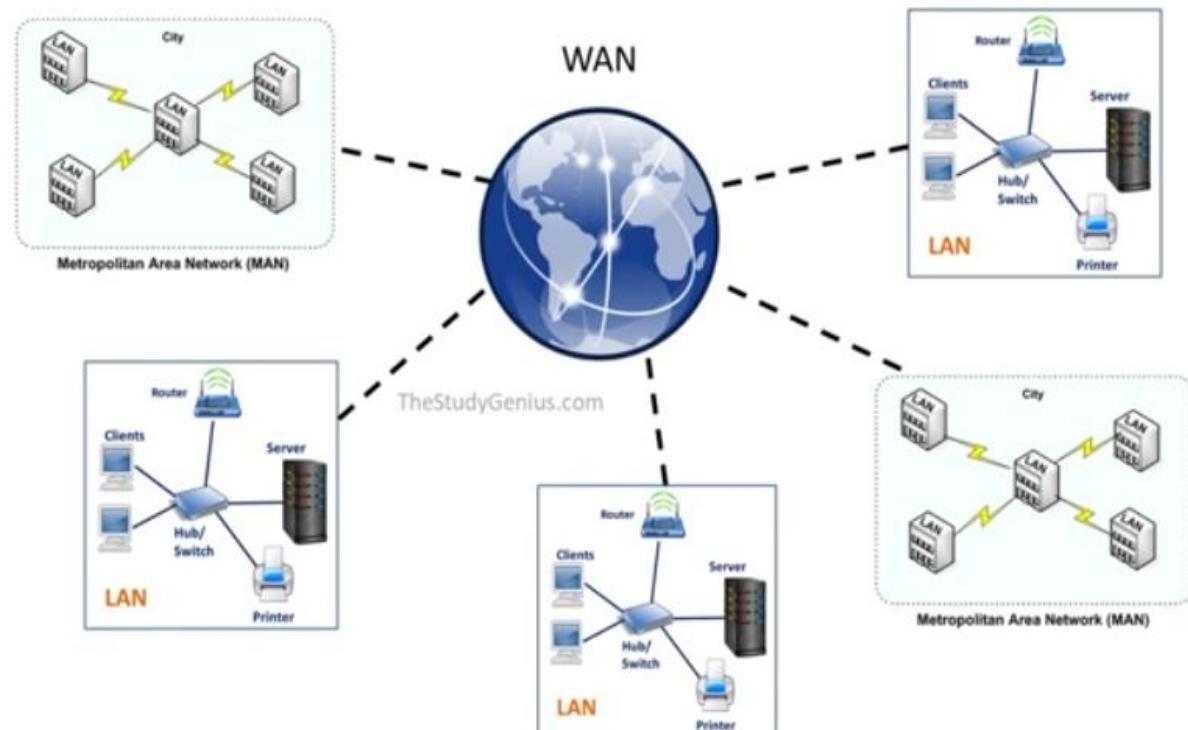
- MAN networks are widely used in **cable television networks**, available in the whole city
- This network can be used in **private industries**.
- This network can be used in **universities or colleges**.
- This network can be used in **military areas** for communication.
- This network also can be used in **railways or airlines**



Wide Area Network (WAN)

- WAN means a **wide area network** is a wide network that means this network is used in **large geographical areas** like in the **whole country or continent** and uses common carriers like – satellite systems, telephone lines, etc.
- In other words, when many LANs and MAN's networks are connected to each other for the purpose of communication then it's become WAN network because now the area of the network is too wide so it is called a wide area network.
- This network generally covers larger distance areas (like states, countries, continents).

Actually, you are watching this video on the internet which is the largest WAN network in the world, where thousands of LAN and MAN networks are connected to each other.





Network Interface Card (NIC)

USB NIC

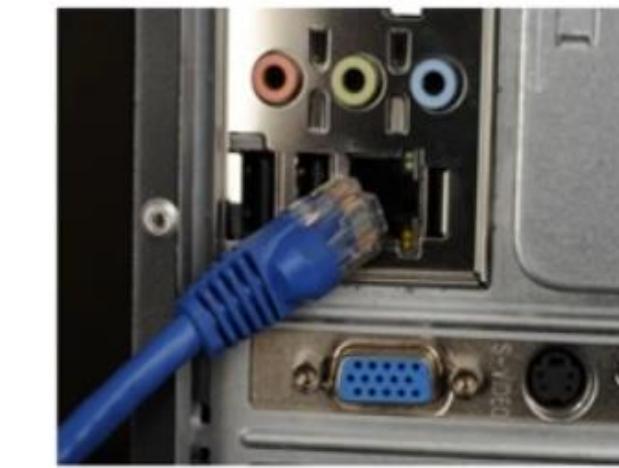


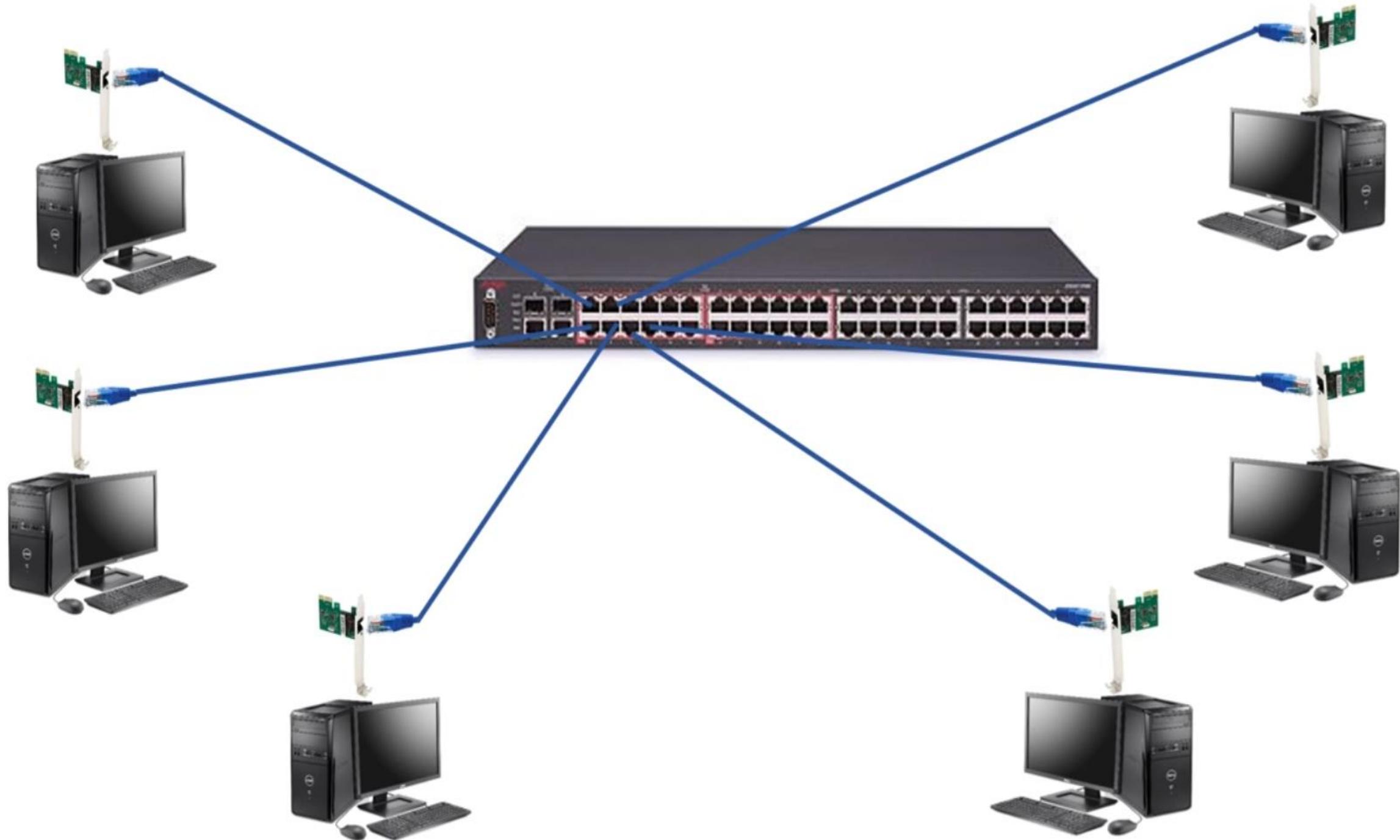
Wired NIC



Wireless NIC





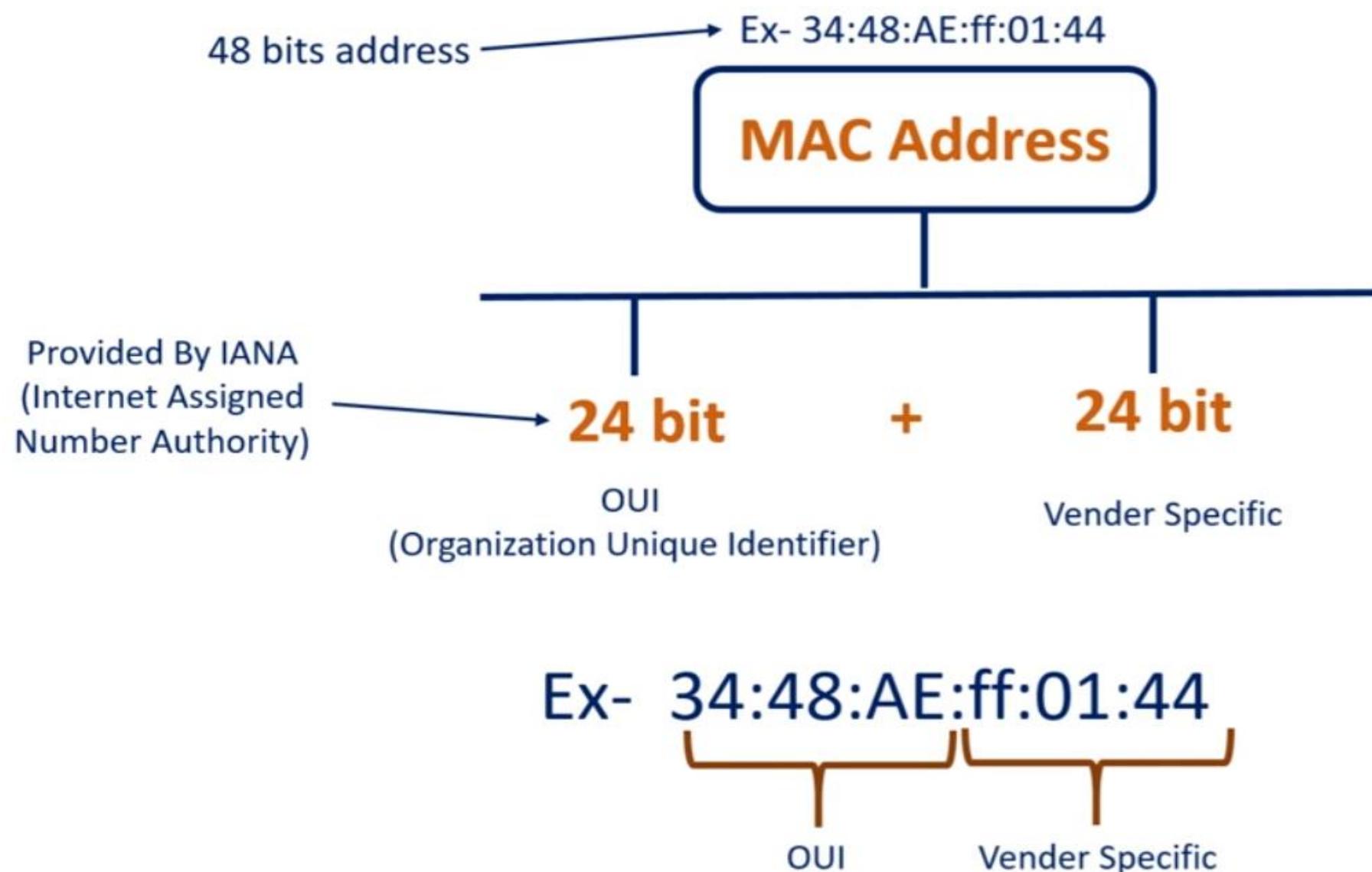


Network Interface Card (NIC)



- NIC is the most necessary hardware component for a network connection, install in computers, servers, printers, or any other devices that allow a device to connect with other devices on a network.
- It is a **circuit board** installed in a computer that provides a dedicated network connection to the computer.
- It is also called network interface controller, network adapter or LAN adapter.
- Any device which wants to connect to the network must contain a NIC card, even switch and routers also consist network interface card (NIC) in order to connect to the networks.
- NIC installed in one computer is used to communicate with other NICs which installs to another computer.
- Every NIC has a **48-bit unique serial number** called a **MAC address** which is stored in ROM carried on the card. Every computer must have **at least one NIC** if it wants to connect to the internet.
- Every NIC comes with a **speed rating** such as 11 Mbps, 100 Mbps, etc. that suggests the performance of the NIC.

How NIC Works



How NIC Works



How NIC Works?

- It is a physical card or chip, which contains MAC addresses, helps to identify the device on the network.
- NIC works on the **physical layer and the data-link layer**. It acts as a middleman between your computer and the data network. It is responsible to exchange the computer's data with a network. Any incoming data that comes from the network medium is received by the NIC.



How NIC transmits the data?

- For outgoing data, first the network protocol transfers a packet to the buffer, present on the NIC card.
- Then the source and destination MAC address are attached as the frame header and calculate the CRC.
- CRC (Cyclic Redundancy Code) is a numerical value, is a powerful type of checksum, which has the purpose of detecting errors.
- Lastly, NIC transmits frames onto the medium as bit signals.



How NIC received the data?

- Bit signals travel along with the medium and are received by the NIC, then the received bits are formatted into a frame.
- First, the CRC (a type of checksum) is calculated and compared to the CRC in the frame trailer.
- If they don't match that means the frame is damaged or changed and the frame is discarded.
- If the CRC is okay, then the destination MAC address is checked.
- Once the MAC address is checked and verified, the frame header and trailer are removed and the packet comes out from the frame, which is sent to the network protocol for further processing.

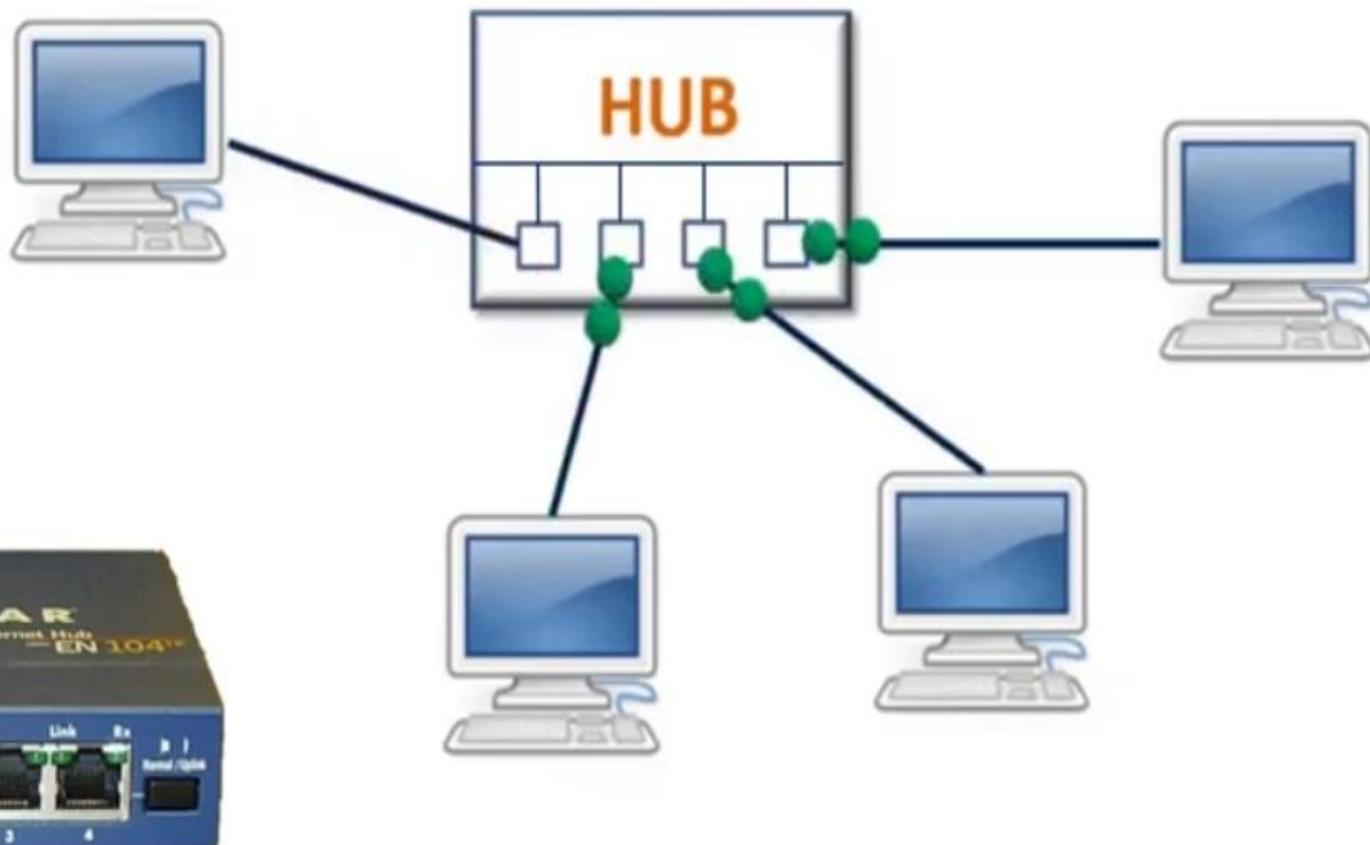


HUB, Switch & Router

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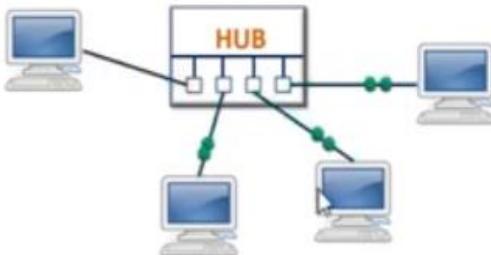
HUB Device



- LAN Device
- Always Broadcast
- Layer 1 Device
- Unintelligent Device
- Half Duplex
- single collision domain
- Does not maintain any kind of table

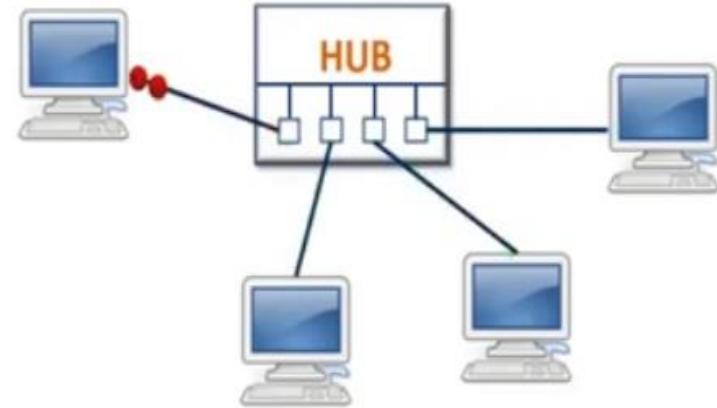
- A hub is a **networking device** that is used to connect multiple devices or segments on a local network.
- A hub is a **physical layer (layer-1)** device that simply broadcast all incoming data to all other output ports. means if a **hub** has eight ports, then any input data that arrives on port 1 will be transmitted on ports 2 through 8.
- It is **not an intelligent device** because it does not have any memory to store device information. If a computer wants to send information to another computer, the hub **broadcasts information** to all the other computers, connected to the hub, that's why it is not an intelligent device.

- Hub works like an electric wire, it receives data signals from one device in his one port and forwards to all the other ports, except the source port.
- It does not have any capability to identify any frames to know where it should forward because **it does not maintain any kind of table** like switch. So there is a **lot of traffic on the network** and network performance is also very poor, only one device transmits information at a particular time.
- It works on **star topology** physically because all the devices are connected to the central node, but logically it acts as a **bus topology**.



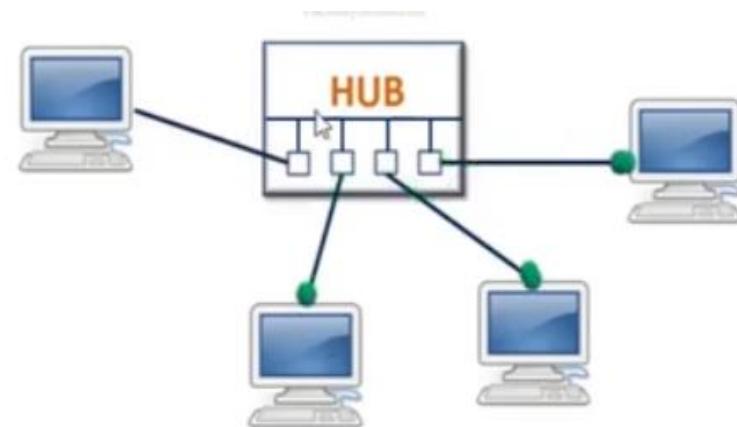
Basic Features of Hub Network

- **Always Broadcast:** Hub always broadcasts the data, means whatever computer will connect with the hub, it will broadcast data to all those computers.
- **Half-duplex Communication:** Hub can communicate only in the half-duplex method. Only one computer can transmit data at a particular time, if other computers want to transmit data, then it has to wait.
- Other computers can not send data at the same time. If another computer sends data at the same time, the message will collide from both computers.
- **Single Collision Domain:** Hub works on a single collision domain means Two PC's cannot send data at the same time if they send data at the same time, the packets collide each other and the packet destroys.
- **Use only local network:** Hub network is used only in the local network means you can use this network in your home or in a small department, etc. This hub network cannot be used in larger networks.
- **Cannot store MAC:** It is not an intelligent device. It cannot store the MAC address of computers. It does not maintain any kind of table.



Types of Hub

- **Active hub** needs electricity (AC power) because, it regenerates signals, makes it powerful again, and then sends it forward so it can communicate for long-distance. It acts as a repeater and also known as “multi-port repeater”. It can extend communication distance over a network.
- **Passive hub** is simply used to create a network, where it simply receives packets and broadcast it over the network. It does not amplify signals. It simply receives signals and forwards it.



Disadvantages of Hub Network

- There is **no security** in a hub network because **message broadcast** to all devices so anyone can access the message.
- It works on **half-duplex mode** means only one device can communicate at a time.
- It works on a **single collision domain** if two or more devices try to send data at the same time, the packet collides with each other.
- There is **no data retransmission** means if the message destroys during transmission for any reason, it will not transmit again.
- It cannot store the **MAC address** because it does not maintain any kind of table.

A **hub** is a networking device that is used to **connect multiple devices or segments** on a local network.

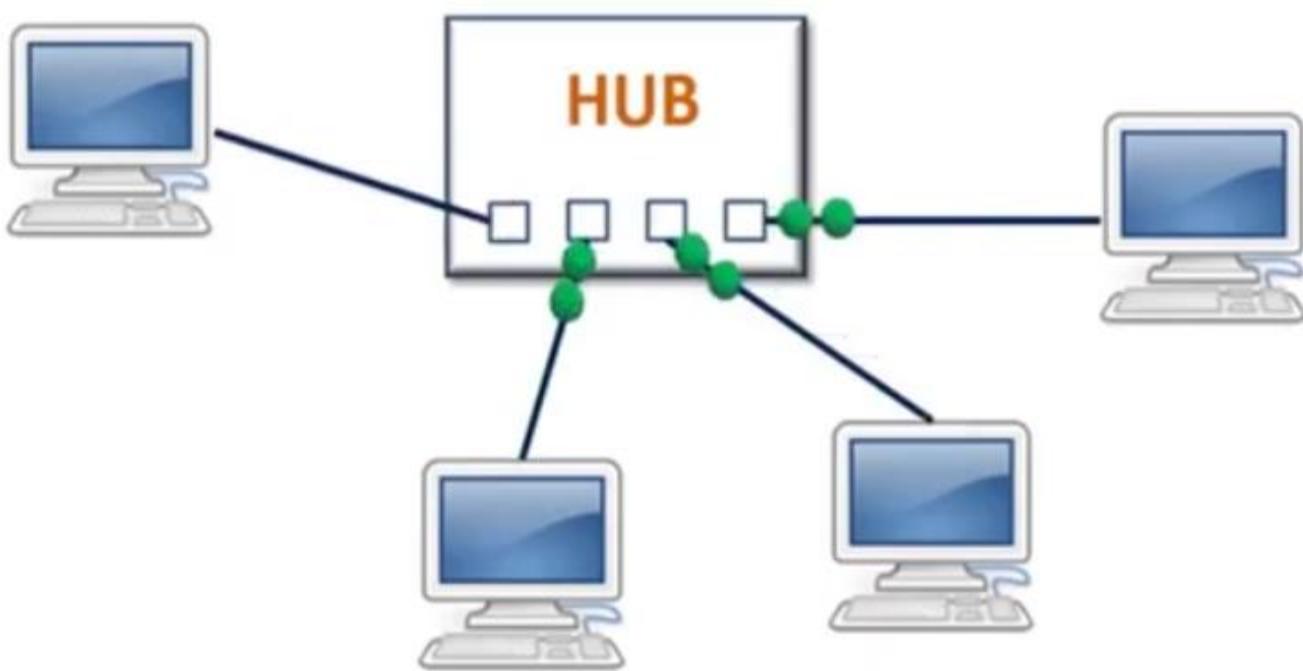
It is a **physical layer (layer-1)** device that simply **broadcasts** all incoming data to all other output ports.

If a hub has eight ports, then any input data that arrives on port 1 will be transmitted on all ports 2 to 8.

It is **not an intelligent device**.

How Hub Works

It works on **star topology** physically but logically it acts as a **bus topology**.



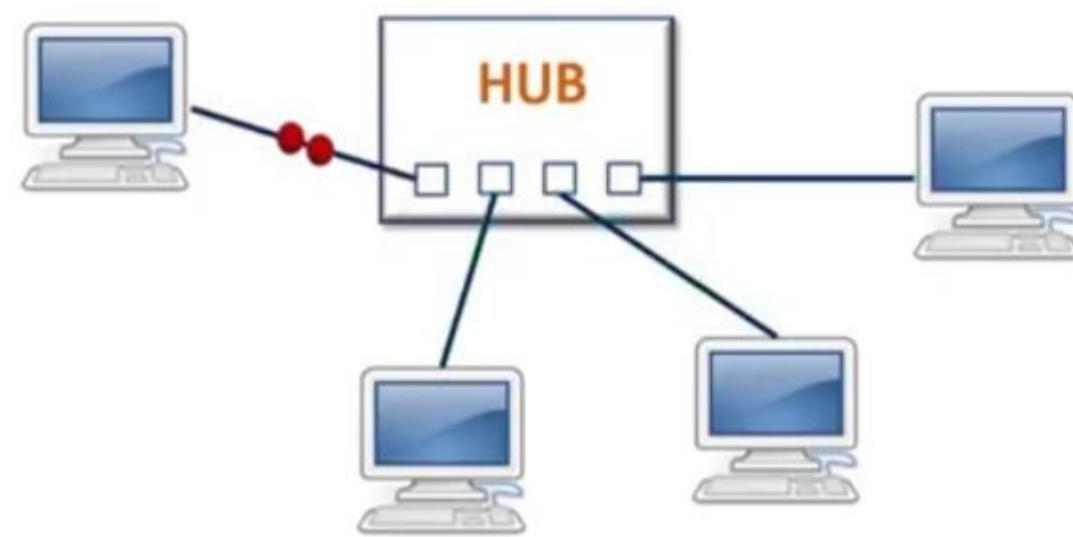
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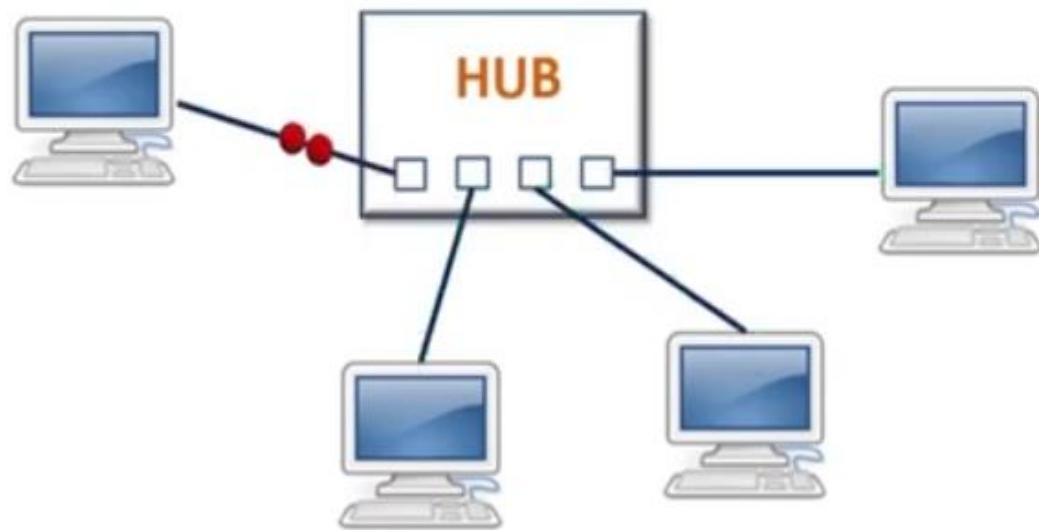
Basic Features of Hub Network

- **Hub Device** can only be used in **local network**.
- Hub always **broadcasts** the data
- Works on **Half-duplex Mode**
- Works on **Single Collision Domain**



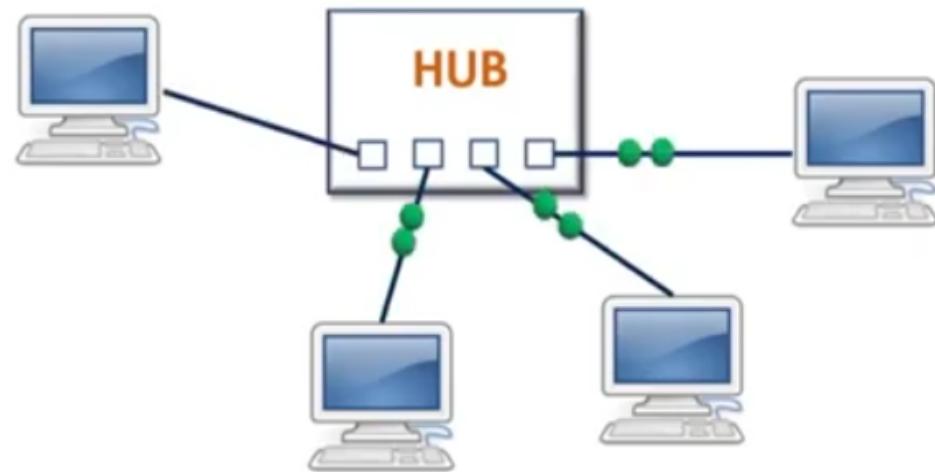
Benefits of Hub Network

- We can easily **create a small network** using a hub device.
- It can boost the signal which helps to extend the network.
- It is cheaper than other networking devices.
- It supports different types of network devices.



Drawbacks of Hub Network

- There is **no security** in a hub network because messages are broadcast to all devices so anyone can access the message.
- It **works on half-duplex mode** means only one device can communicate at a time.
- It **works on a single collision domain** if two or more devices try to send data at the same time, the packet collides with each other.
- There is **no data retransmission** means if the message destroys during transmission for any reason, it will not transmit again.
- It **cannot store the MAC address** because it does not maintain any kind of table.



Types of Hub in networking

Active Hub

Active Hub acts as a **repeater** and is also known as a “**multi-port repeater**”. It can extend communication distance over a network.

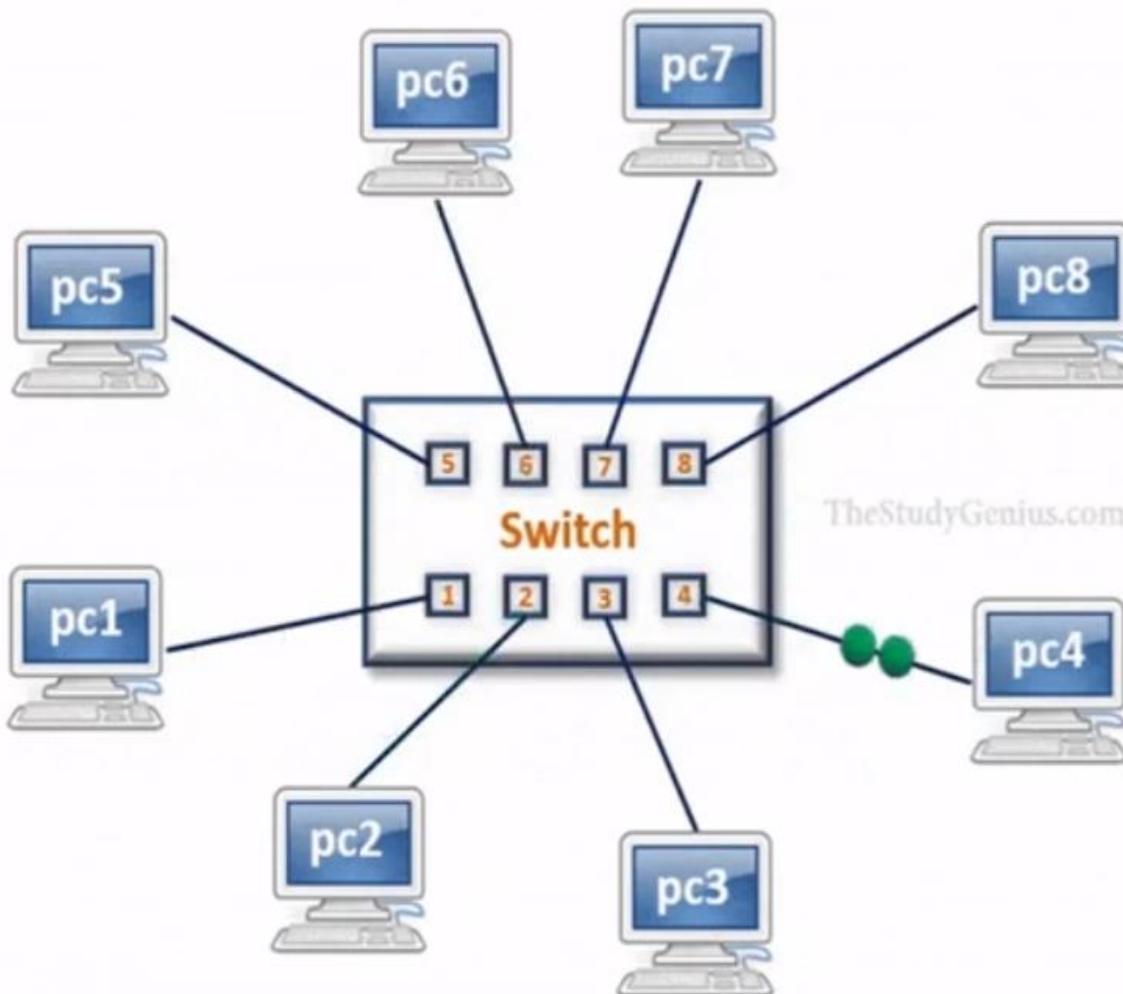
Active hub needs electricity (AC power) because, it regenerates signals, makes it powerful again, and then sends it forward so it can communicate for long-distance.

Passive Hub

Passive hub is simply used to create a network, where it simply receives packets and broadcasts it over the network.



Switch Device

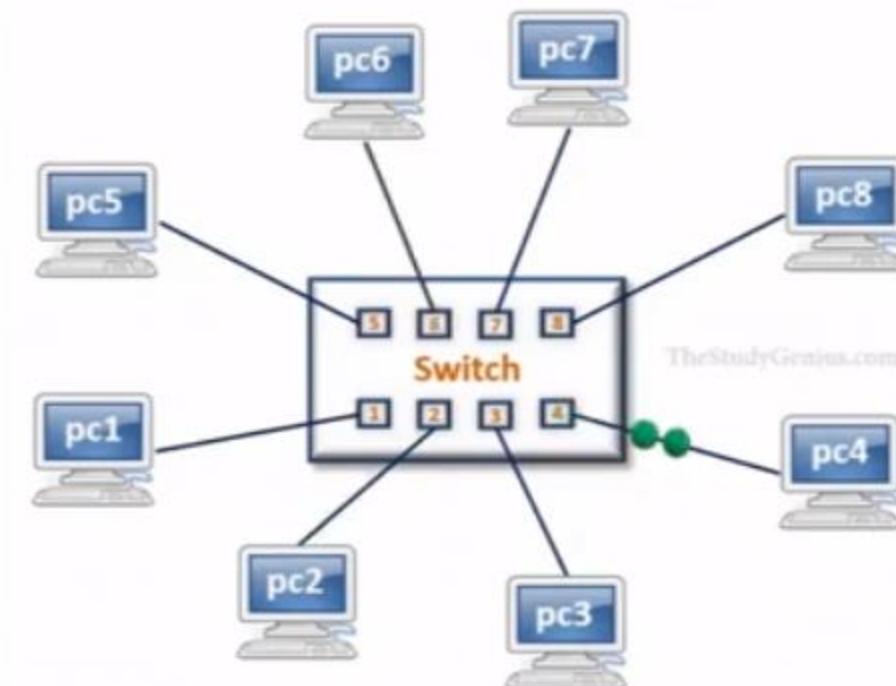


- LAN Device
- Layer 2 Device
- Intelligent Device
- Full Duplex
- Every port has separate collision domain.
- Maintain CAM table
- Store MAC addresses

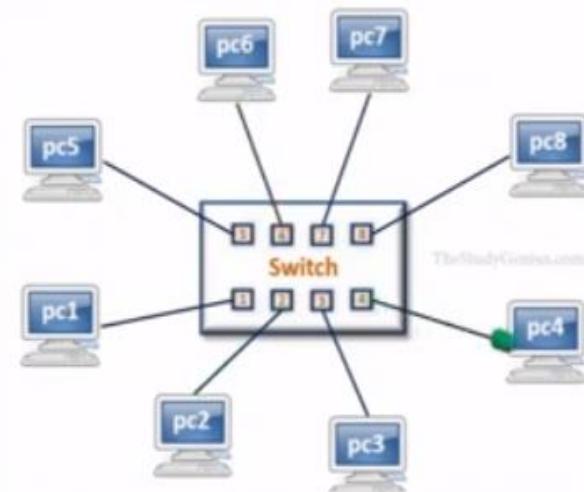
- Switch is a network device that has multiple ports that are used to connect multiple devices and create a network.
- A switch can actually learn the **MAC addresses** (physical address) of the devices, that are connected to it and it stores these MAC addresses in its table.
- It is a **layer-2 (data-link layer) device** because it forward frames based on MAC addresses. It has storage capability, where a table is maintained. That's table helps to identify every device connected to switch on the basis of MAC addresses.
- It is an **intelligent device** because it has a memory where it maintains the table called **CAM table** (**Content Accessible Memory**), and stores the port number and MAC addresses of all devices, which helps to identify every device on a network.

Switching Table/CAM Table

Port No	MAC address
1	AA:25:C1:D2:16:A3
2	BA:26:21:A2:56:73
3	1A:85:A1:12:26:A6
4	5A:6C:C1:A2:46:B7
5	7A:75:31:C2:29:C3
6	23:5A:11:42:A6:31
7	88:29:D1:D2:26:A2
8	C7:55:A1:22:55:A3

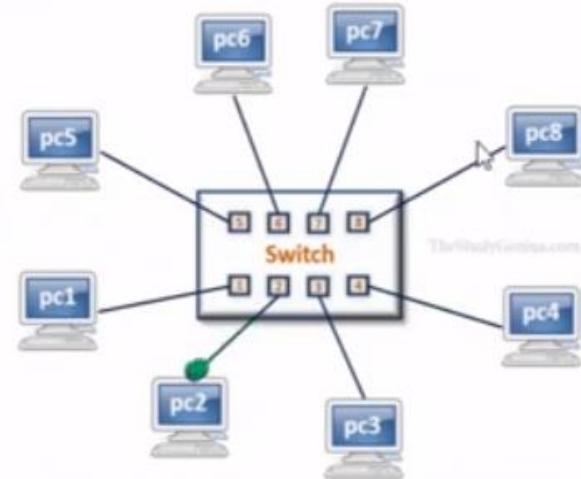


How Switch Work?



- It works on **star topology** because all the devices are connected to the central node. Data from the source device is first arrived at the switch and then transferred to the destination device.
- When first-time devices are connected to the switch, it broadcast the message, where it identifies the port number and MAC address and store it on its table, this information helps to identify the destination device on the network and sends it directly to that device.
- So after the broadcast, the switch knows which device is connected to which port no, so next time it does not need to broadcast the message, it will forward the information with the help of port no and MAC addresses.

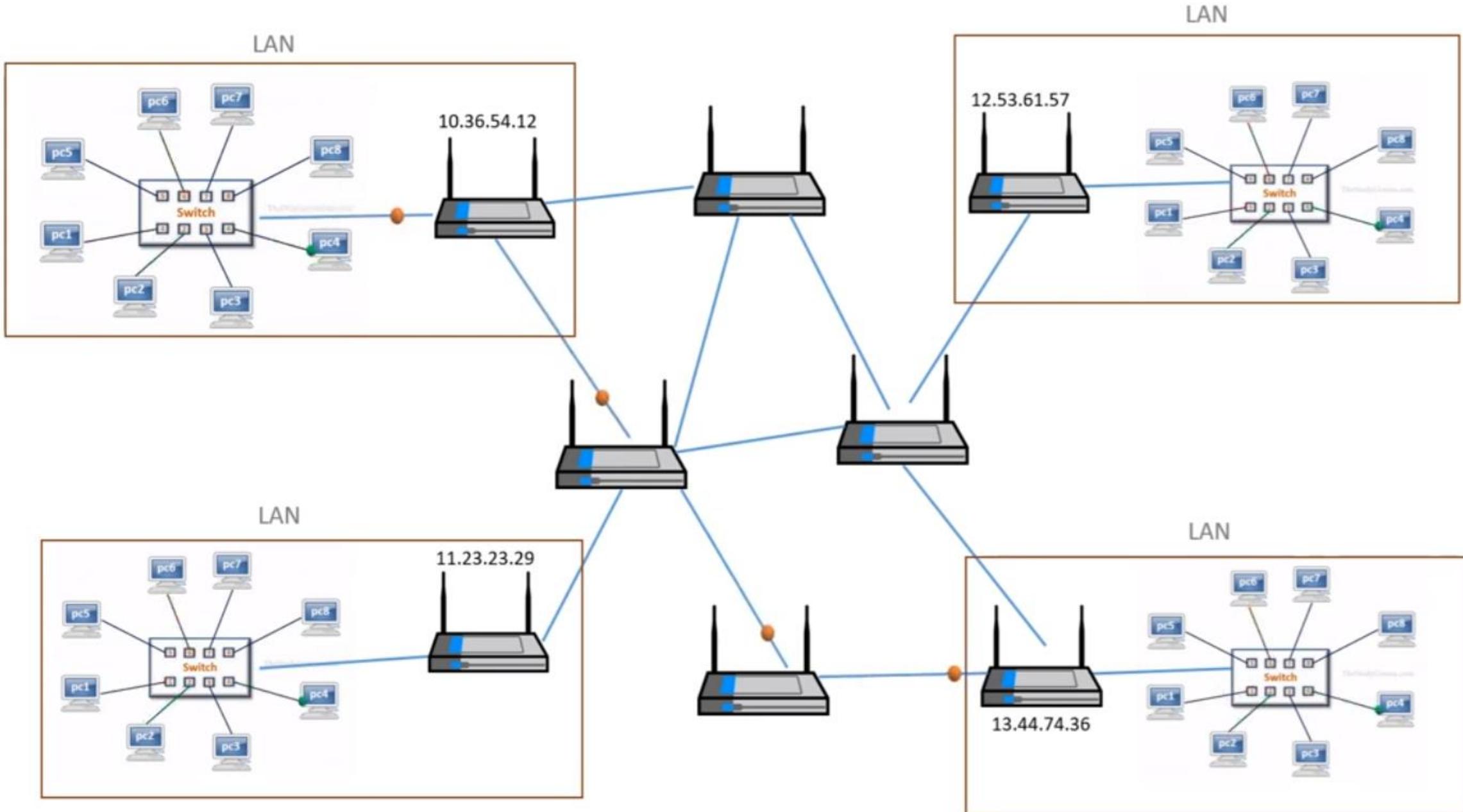
Advantages of Switch



- Multiple computers can connect using the switch and communicate with each other.
- It is an **intelligent device** because it can learn other device's MAC address.
- It **maintains a table**, helps to identify every computer on a network.
- Switch is able to work on **full-duplex mode** means each computer is able to send and receive data at the same time.
- There is no or very less frame collision because every port of the switch has a separate collision domain.
- It increases the performance of the network.

HUB	Switch
It is used to create a network.	It is used to create a network.
It always broadcast the data to every device.	First time it broadcast to identify every device on a network, then unicast the data.
Hub is not an intelligent device.	Switch is an intelligent device.
It works on layer-1 (physical layer) of the OSI model.	It works on layer-2 (data-link layer) of the OSI model.
It does not have any memory to store devices information	It has the capability to store devices information.
It does not maintain any kind of table.	It maintains a table where all device information is stored.
It cannot store MAC address.	It can store all device's MAC addresses and port numbers.
It operates on half-duplex mode.	It operates on full-duplex mode.
It has single collision domain.	Every port has separate collision domain.
Only one device communicate at a time.	Two or more devices can communicate at a time.

Router Device



- WAN Device
- Connect Two or more Networks
- Layer 3 Device
- Intelligent Device
- Maintain Routing Table
- Store IP addresses in its table

Router Device

- A router is an internetworking device, that receives IP packets from one computer network and forwards it to another computer network.
- It is used to establish connections between two or more different computer networks.
- It can be a physical or virtual networking device, which is designed to receive the data packets from one network, analyze it, and forward it to another computer network.

How Router Works?

- Internet is the group of networks, means many smaller and bigger networks create the internet, and the router is the only device that can connect to these networks with each other. Router is connected to other routers also, and the data packets are forwarded to one router to another router until it reaches its destination node.
- When a computer sends a message, the message breaks into IP packets which contain sender and receiver network information and the router has the capability to read this information, using this information, it calculates the best route for IP packets to travel on the network.
- It is an intelligent device because it maintains a routing table which decides the packet's next route and also helps to find the best route to transmit the IP packets from source to destination.
- A router can be used in LAN and WAN environments. For example, a router can be used in homes and offices for connecting devices, and can also be used to create a connection between different networks.

Basic Features of Router

- It allows connecting two or more LAN networks.
- It allows us to connect to the internet because the internet is a group of networks.
- It **forward packets** to other routers on the network until the packet reaches its destination node.
- It determines, which is the **best route to forward packets** from one network to another.
- It stores destination **IP addresses** in its routing table.
- It comes in 2, 4, or 8 ports.
- It controls the traffic of the internet and also your private local network.

Difference b/w Router and Switch

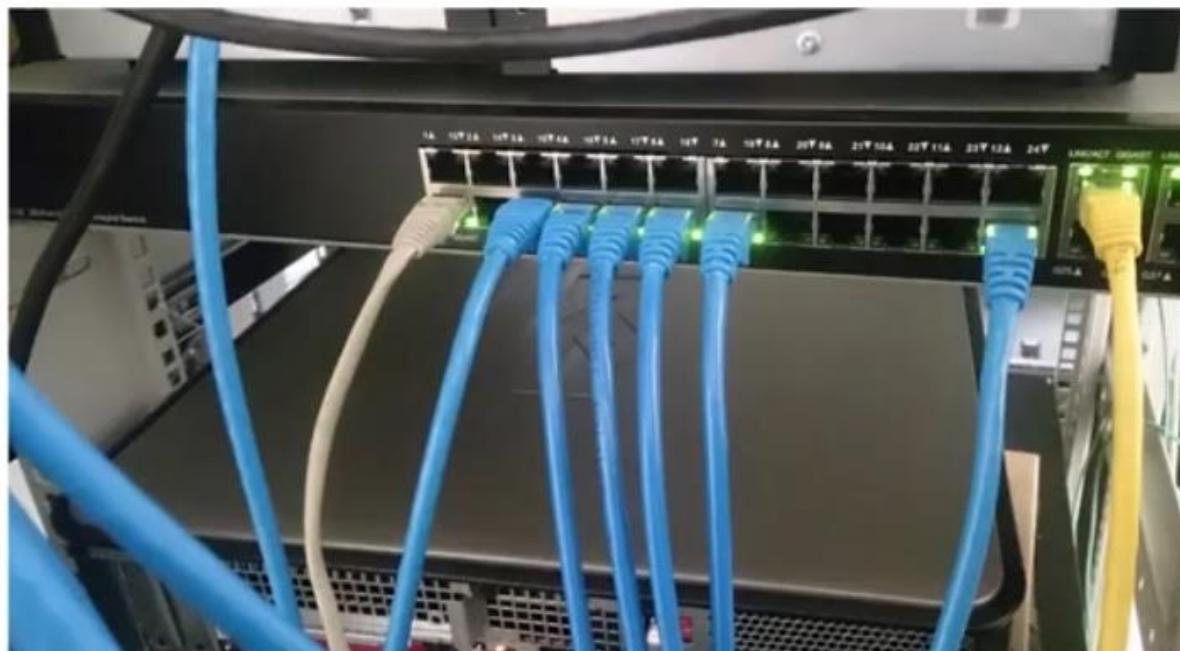
Router	Switch
The main use of router is to connect different networks.	The main use of switch is to create a network.
It uses IP address for sending data.	It uses MAC address for sending data.
It reads packets for sending data.	It reads frames for sending data.
Works on Network layer (layer-3).	Works on Data-link layer (layer-2).
It is an intelligent device.	It is also an intelligent device.
It maintains routing table, where all network information is stored.	It maintains switching table, where all device information is stored.
It stores IP addresses in its table.	It stores MAC addresses in its table.
It can be used in LAN, MAN, and WAN.	It is used only in LAN network.

What is a Switch Device?

Switch is a networking device, mainly used to **create a network**.



It **works on the data-link layer** of the OSI model, and has multiple switching ports, whichever PC connects to its ports, connects that computer to the network.



What is a Switch Device?



Why switch is a layer-2 (Data link layer) device?

Switch is called a **Layer-2 device** because it forward frames based on **MAC addresses**.

Switch is a networking device, mainly used to **create a network**.

It **works on the data-link layer** of the OSI model, and has multiple switching ports, whichever PC connects to its ports, connects that computer to the network.

Switch can actually **learn the physical addresses** of devices that are connected to it, and store these addresses in its table.

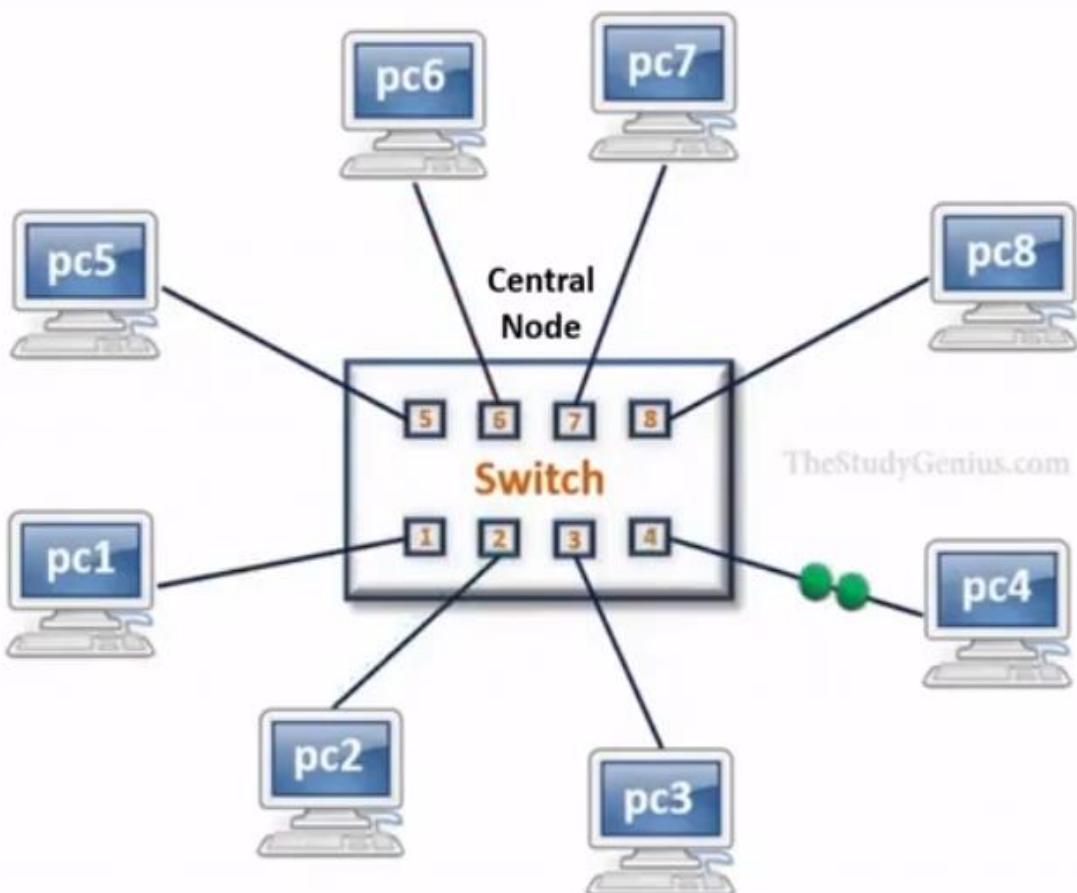
It's an **intelligent device** because it has a memory where is store information of all the connected devices.

In his memory, It's maintains a table called **CAM table**.

CAM table (Content Accessible Memory) stores the port number and MAC addresses of all devices

How Switch Works

It works on **star topology**.

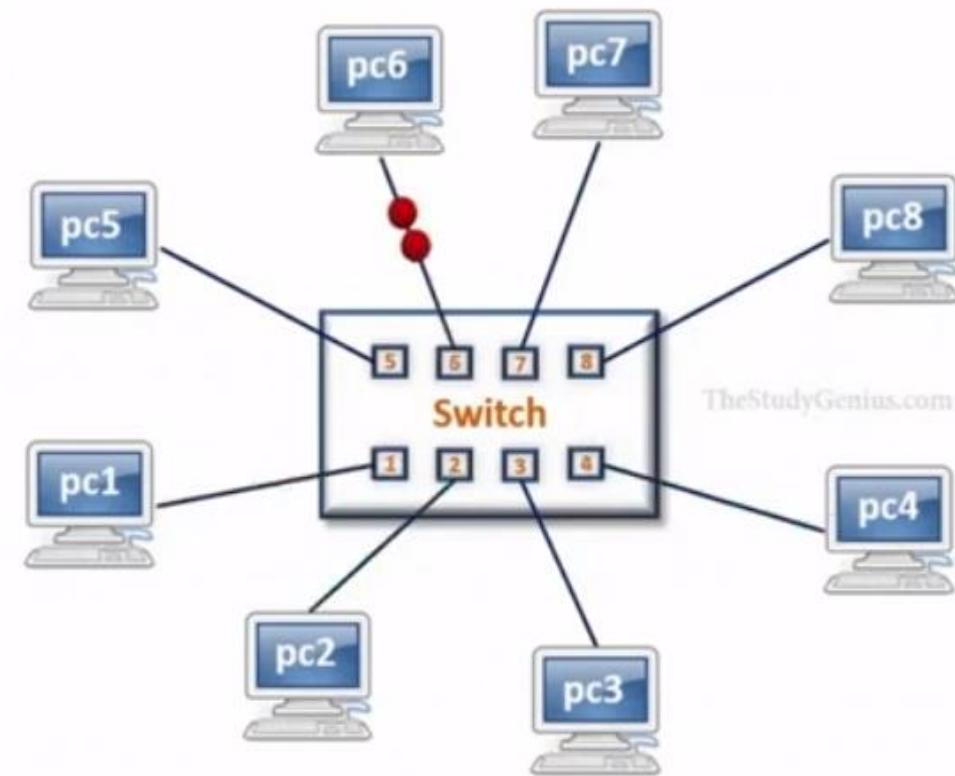


When **first-time devices** are connected to the switch, it **broadcast the message**, where it identifies the port number and MAC address and stores it on its table, this information helps the switch, to identify the destination device on the network.

So after the broadcast, the switch knows which device is connected to which port number, so next time it does not need to broadcast the message, it will forward the information with the help of port number and MAC addresses.

Benefits of Switch Network

- we can **create a network** using the switch device.
- It increases the performance of the network.
- Switch can learn device MAC addresses, and knows which data comes from which computer.
- It maintains a table, helps to identify every computer on a network.
- Switch is able to work on **full-duplex mode**.
- There is no or very less frame collision, because every port of the switch has a separate collision domain.



Difference Between Hub and Switch

HUB	Switch
<ul style="list-style-type: none">It is used to create a network.	<ul style="list-style-type: none">It is used to create a network.
<ul style="list-style-type: none">It always broadcast the data to every device.	<ul style="list-style-type: none">First time it broadcast to identify every device on a network, then unicast the data.
<ul style="list-style-type: none">It works on layer-1 (physical layer) of the OSI model.	<ul style="list-style-type: none">It works on layer-2 (data-link layer) of the OSI model.
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