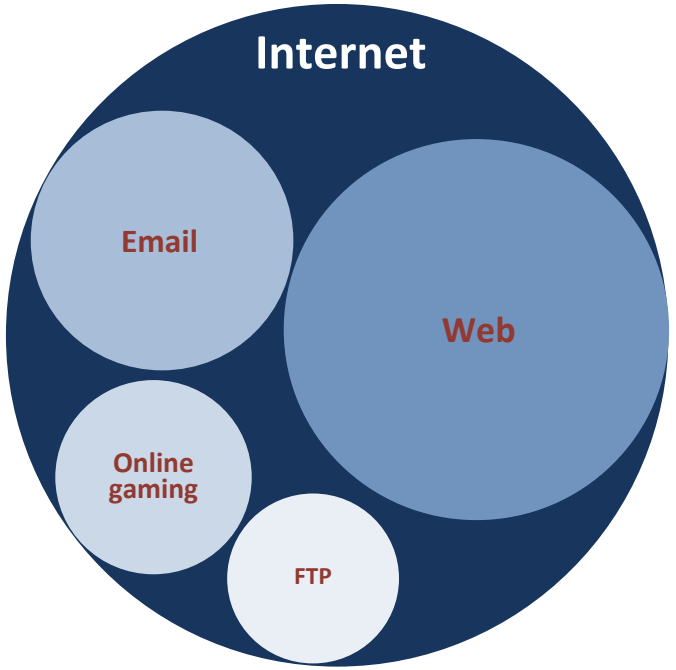
NETWORK

INTERNET = WEB?

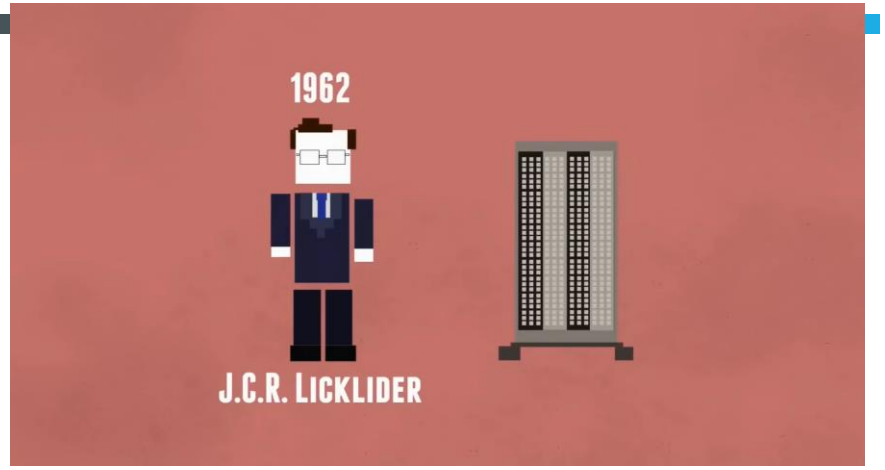
The answer is no

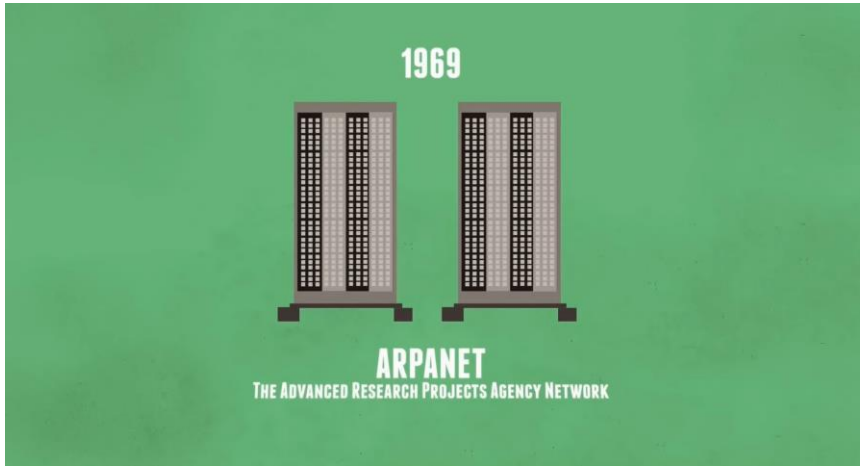
- The World-Wide Web (WWW or simply the Web) is certainly what most people think of when they see the word “internet.”
- But the WWW is only a subset of the Internet.



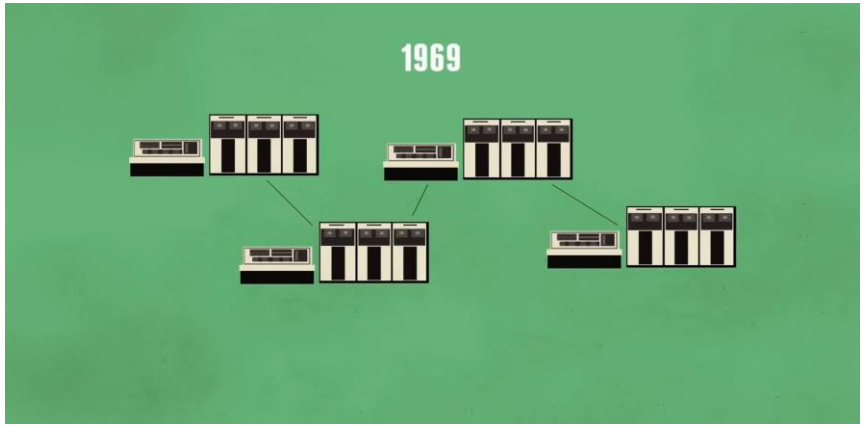
THE INTERNET

+50 YEARS AGO

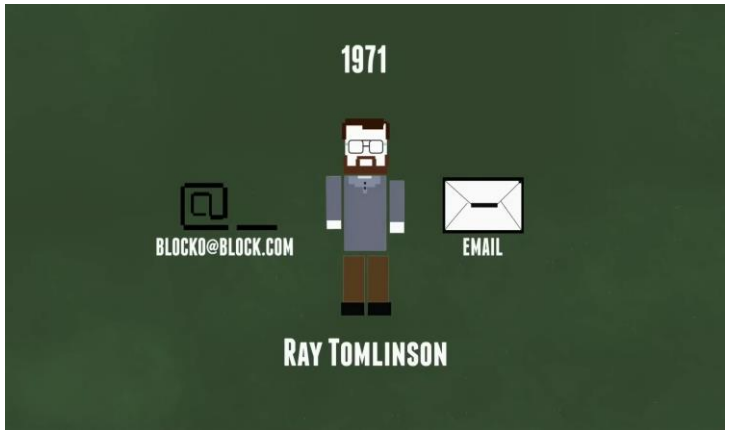

1962
J.C.R. LICKLIDER


1969
ARPANET
THE ADVANCED RESEARCH PROJECTS AGENCY NETWORK


1969
STANDFORD
USCLA
"LOGIN"


1969


1971


1971
BLOCK@BLOCK.COM
EMAIL
RAY TOMLINSON


1971
VINTON CERF


1991
TIM BERNERS-LEE

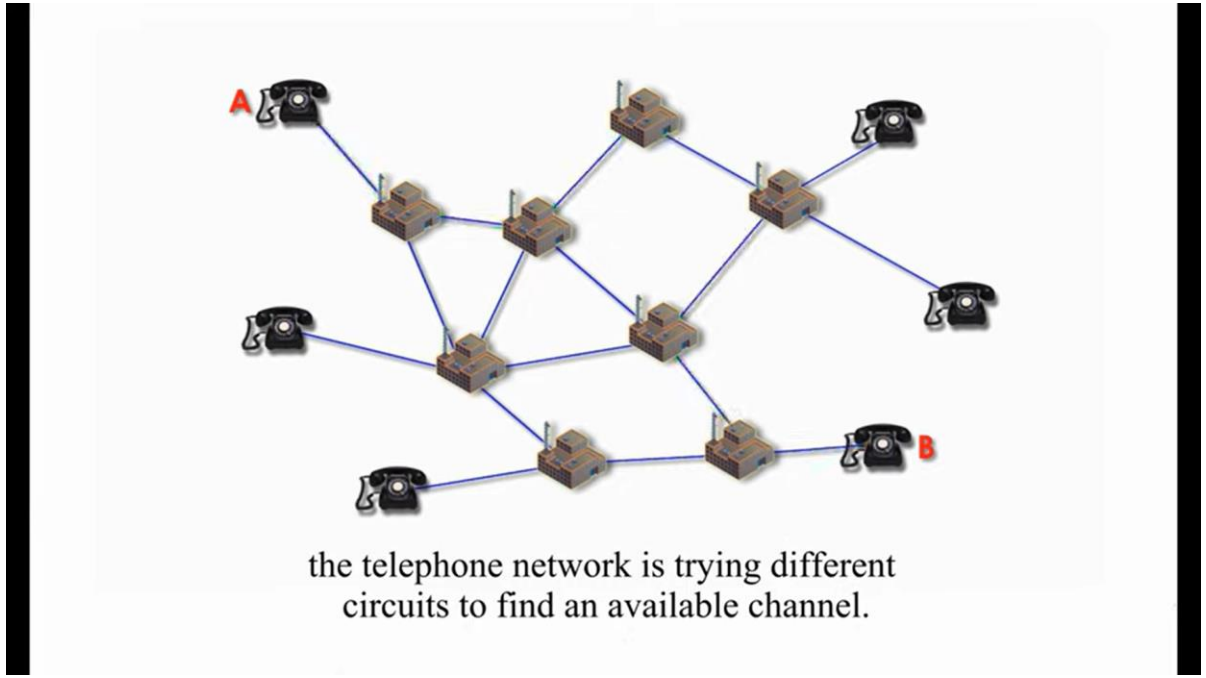
COMMUNICATION DEFINITIONS

WE WILL BEGIN WITH THE TELEPHONE

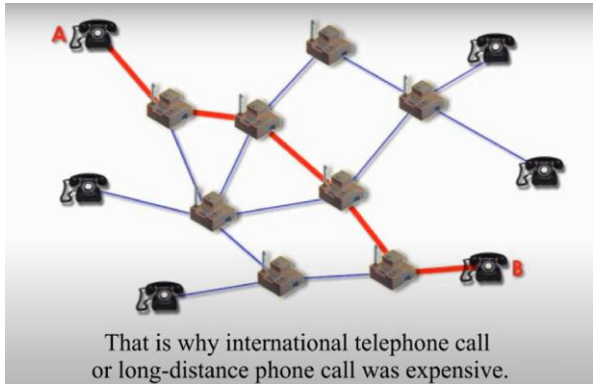
- Telephone networks provide a good starting place to learn about modern digital communications.
- In the telephone networks of old, calls were routed through operators who physically connected caller and receiver by connecting a wire to a switchboard to complete the circuit.

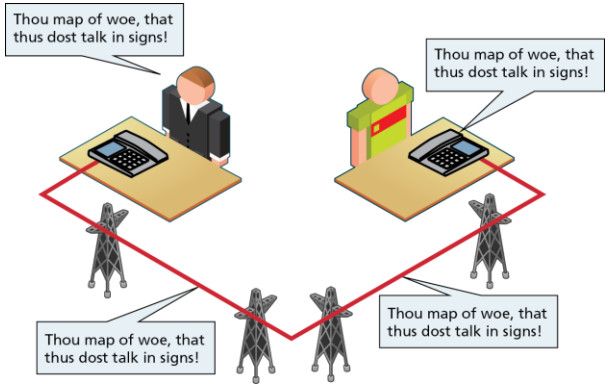
CIRCUIT SWITCHING

- A method used by the old traditional telephone call – carried over the public switched telephone network (PSTN)
- Also referred to as Plain old telephone service (POTS)
- A **circuit switching** establishes an actual physical connection between two people through a series of physical switches.

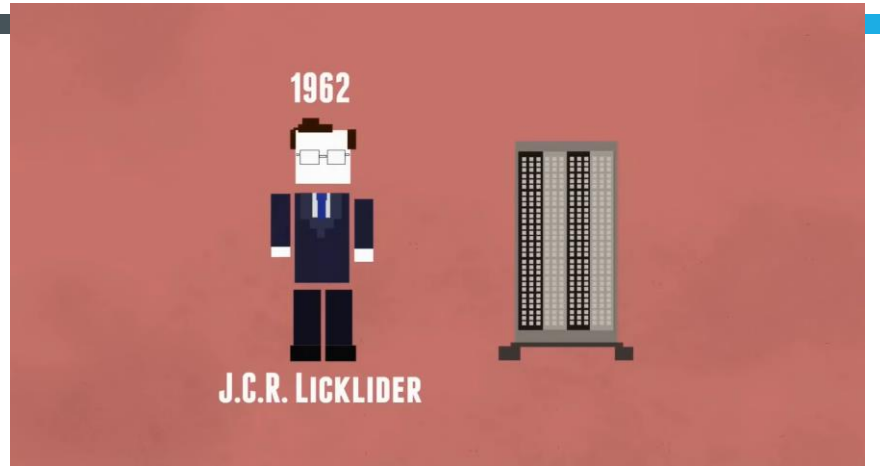


- Circuit Switching Weaknesses
  - You must establish a link and maintain a dedicated circuit for the duration of the call
  - Difficult to have multiple conversations simultaneously
  - Wastes bandwidth since even the silences are transmitted






Credit: Seattle Municipal Archives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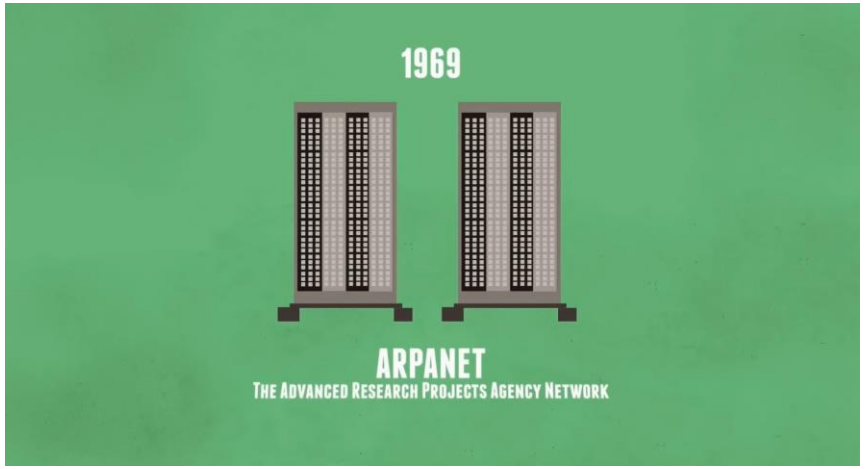
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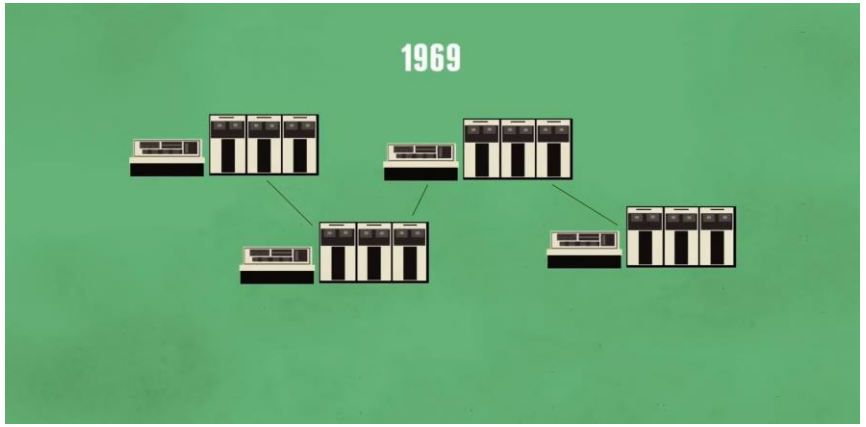
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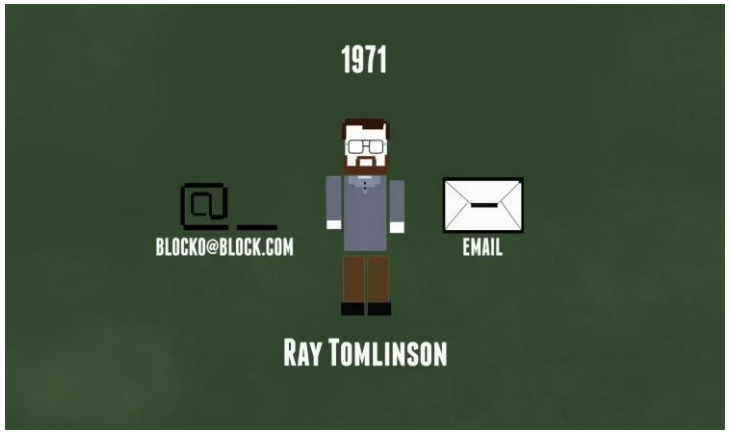
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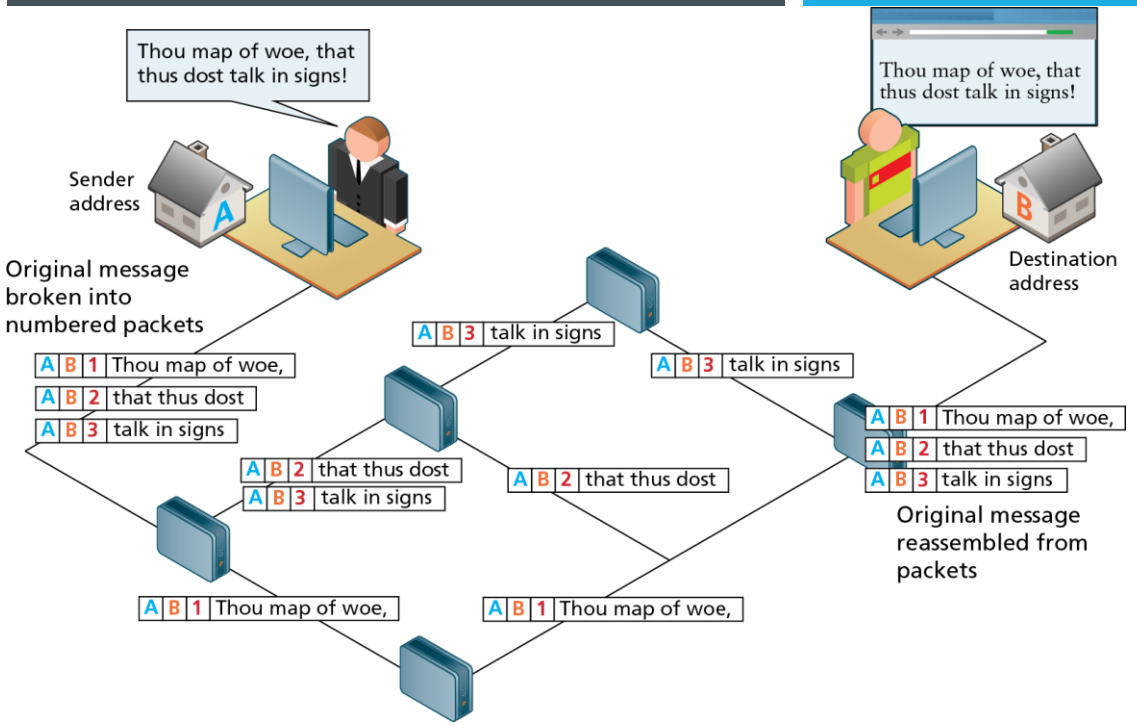
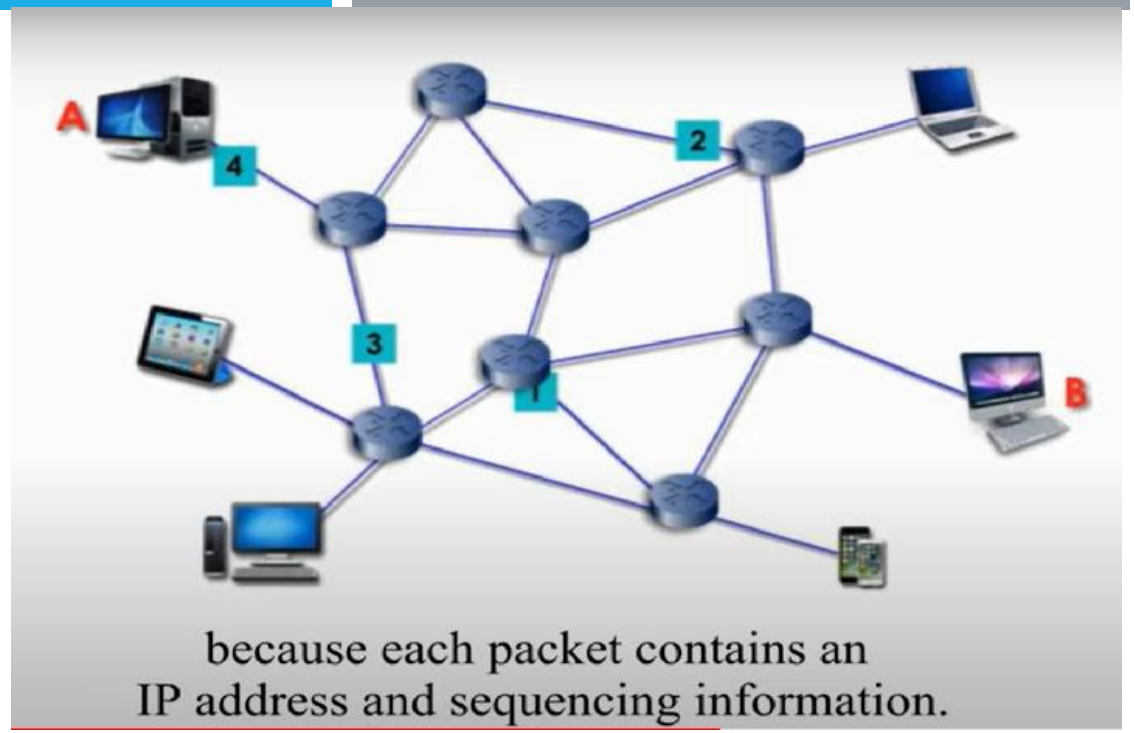
1971
VINTON CERF


1991
TIM BERNERS-LEE

ARPANET The beginnings of the Internet

- **The internet's first transmission was sent 52+ years ago today.** ARPANET was an experimental system that pioneered the then-radical idea of networking different kinds of computers together.
- The project was sponsored by the US Defense Department's Advanced Research Projects Agency (then known as ARPA but since renamed as DARPA).
- The idea was different computers send messages along the same set of wires instead of each getting one.
- The research network ARPANET was created. In the 1960s
  - ARPANET did not use circuit switching
  - It used **packet switching**



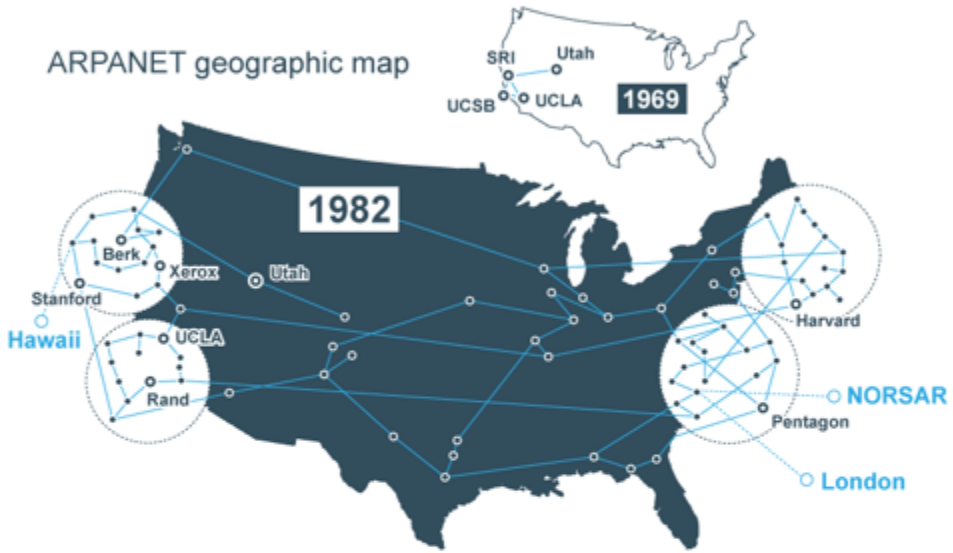


PACKET SWITCHING

Packet switching breaks data into several parts that are packaged in specially formatted units called packets. These are typically routed from the source to the destination using network switches and routers. Then the data is reassembled at the destination.

Each packet contains address information that identifies the sending computer and intended recipient. Using these addresses, network switches and routers determine how best to transfer the packet between hops on the path to its destination.

HOW DID ARPANET WORK?



- ARPANET initially connected four independent network nodes situated at University of California, Los Angeles (UCLA), Stanford Research Institute (SRI), the University of California-Santa Barbara (UCSB) and the University of Utah.
- The first node of the ARPANET was established when networking hardware was installed to UCLA and connected to a host computer on September 2, 1969, but its birthdate is taken from when the first transmission was made, October 29, 1969.
- The team of engineers at UCLA was led by Professor Leonard Kleinrock and featured young graduate student Vint Cerf.
- Cerf later teamed with fellow engineer Bob Kahn to create the TCP (Transmission Control Protocol)/IP protocol suite.

Two characters – 'L' and 'O' – typed into a computer terminal at UCLA were successfully transmitted to a computer at the Stanford Research Institute, some 352 miles (566 km) away, before the connection was lost. Scientists had intended to type in "LOG" through an "Interface Message Processor", but UCLA undergraduate Charley Kline only got as far as sending two characters before the system crashed. The exercise was repeated successfully a few hours later.

1991

1992

ERWISE

1993

MOSAIC

1994

NETSCAPE NAVIGATOR

90% OF WEB USAGE

EARLY 90s

DIAL-UP

Network Devices

- Host
- IP Address
- Network
- Repeater
- Hub
- Bridge
- Switch
- Router

- **Hosts** are any device which **sends** or **receive** traffic
  - **Clients** and **Servers**

www.site.com

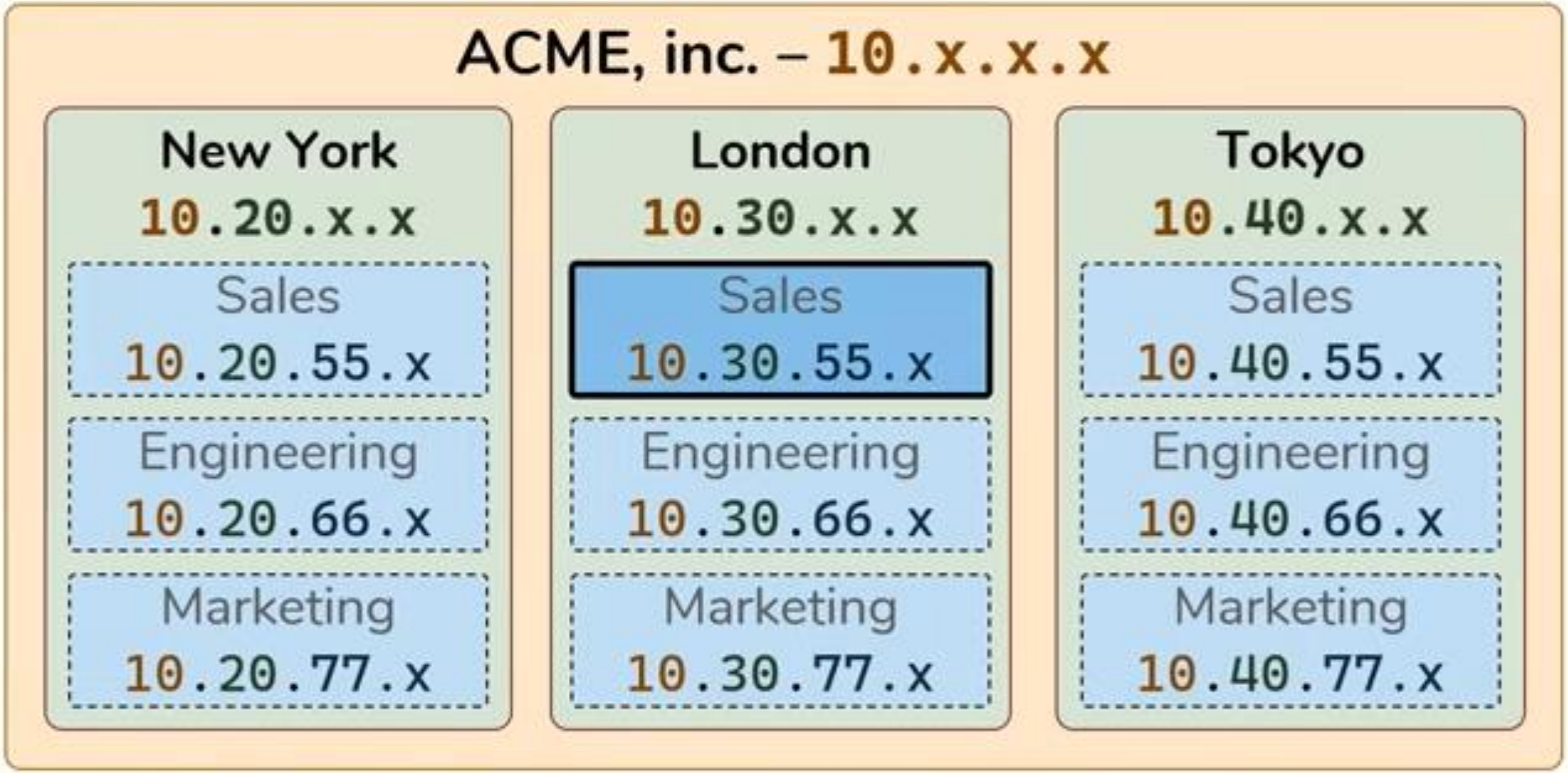
- Client initiate requests, Servers respond
  - Relative to specific communication

- Servers are simply computers with software installed which responds to specific requests

Network Devices

- Host
- IP Address
- Network
- Repeater
- Hub
- Bridge
- Switch
- Router

- An **IP Address** is the identity of each host
  - IP addresses are 32 bits, represented as 4 octets of 0-255
  - Hierarchically assigned

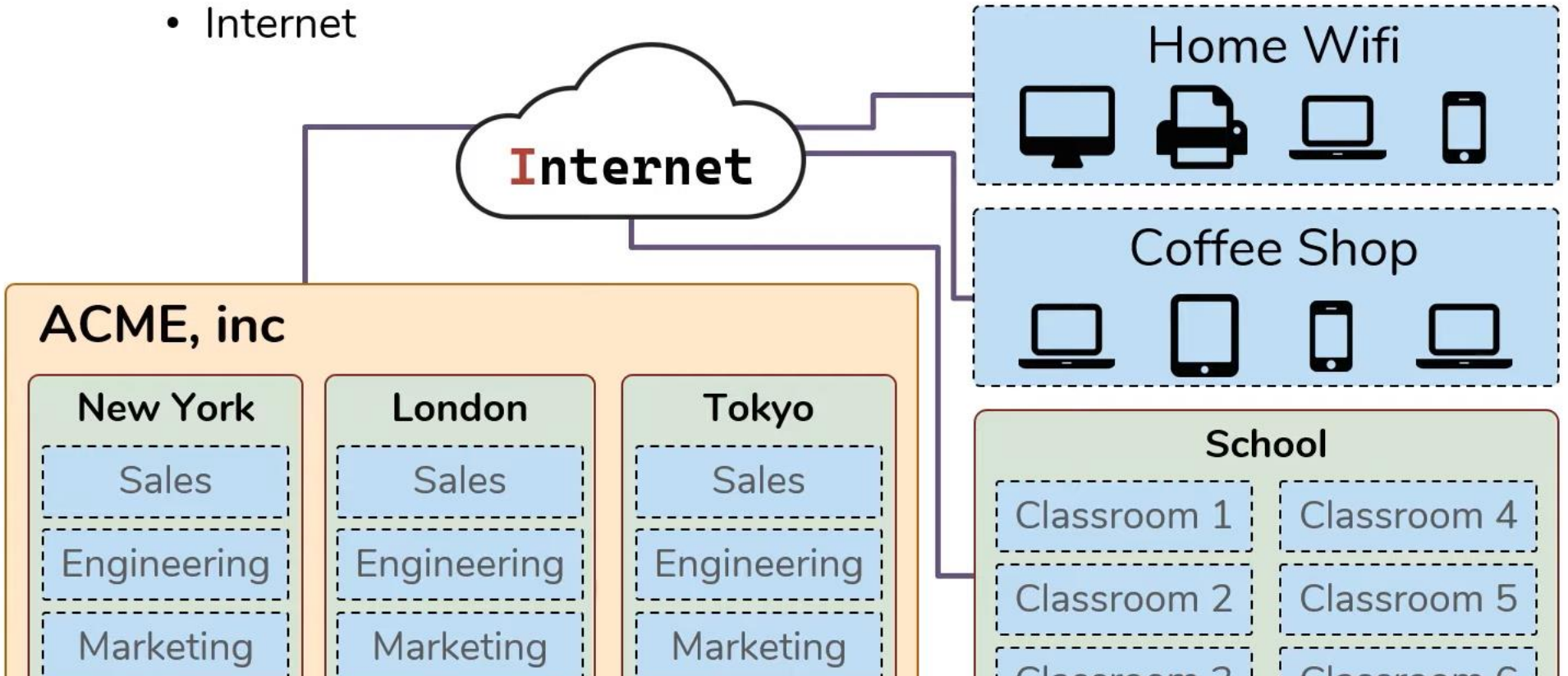


10.30.55.127 – Host at ACME, in London, in Sales

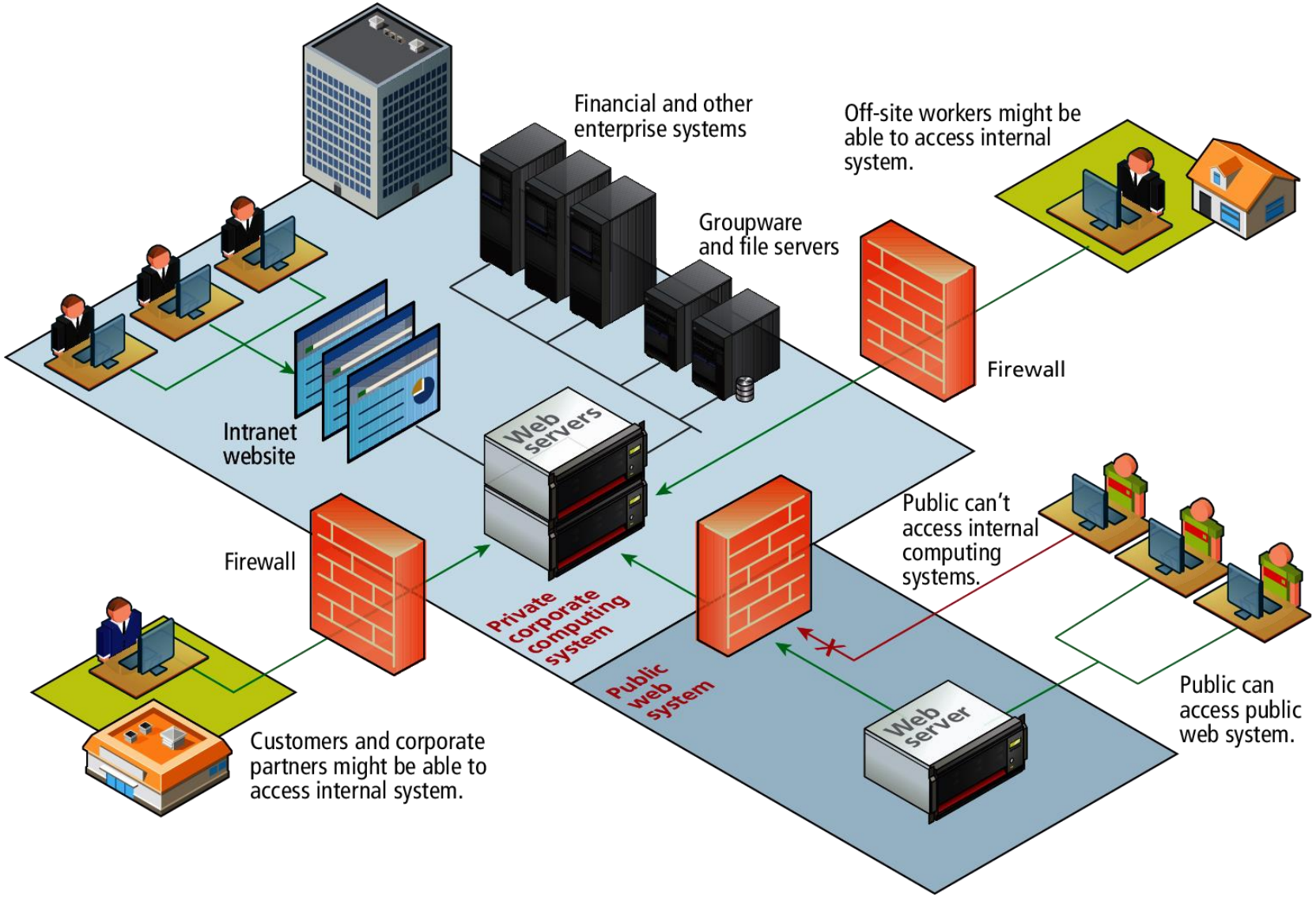
Network Devices

- Host
- IP Address
- **Network**
- Repeater
- Hub
- Bridge
- Switch
- Router

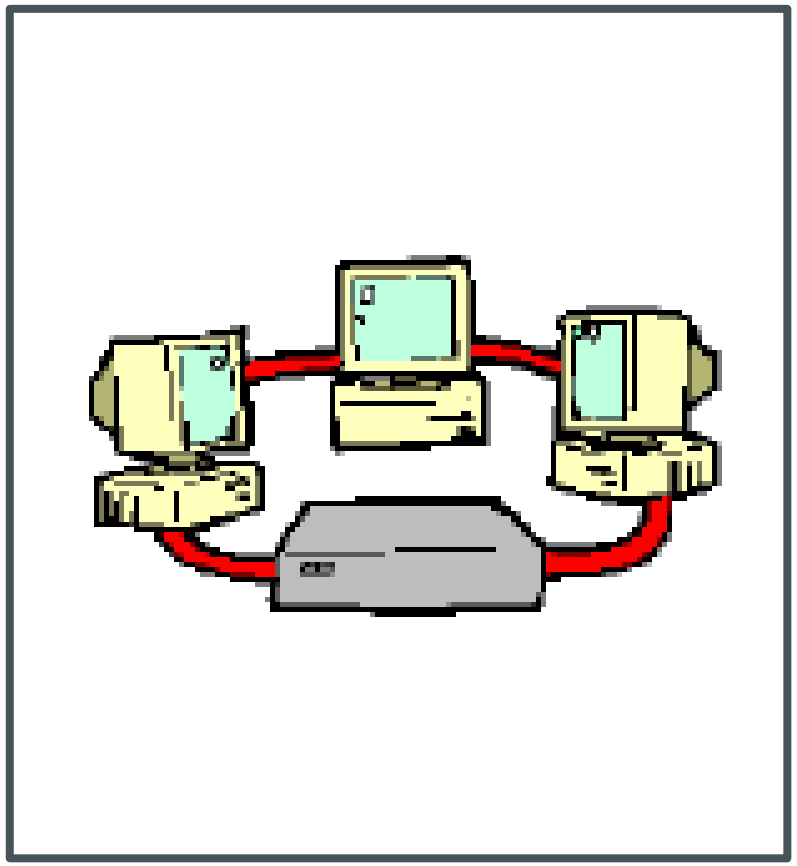
- A **Network** is what transports traffic between Hosts
  - Logical grouping of hosts which require similar connectivity
  - Networks can contain other networks
    - Sometimes called **Sub-Networks** or **Subnets**
  - Networks connect to other networks
    - Internet



INTRANET VERSUS INTERNET



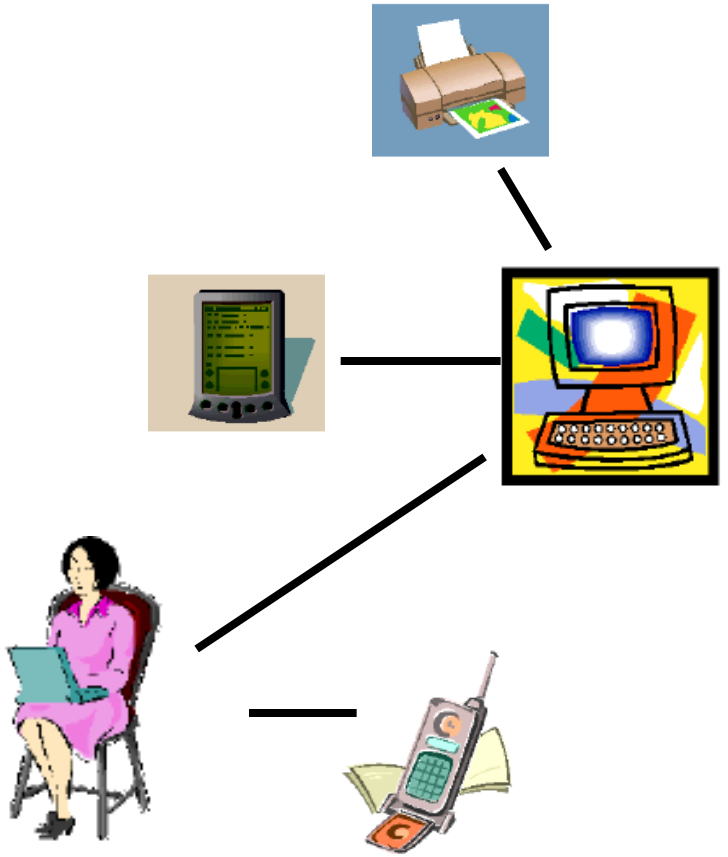
COMPUTER NETWORKS CLASSIFICATION

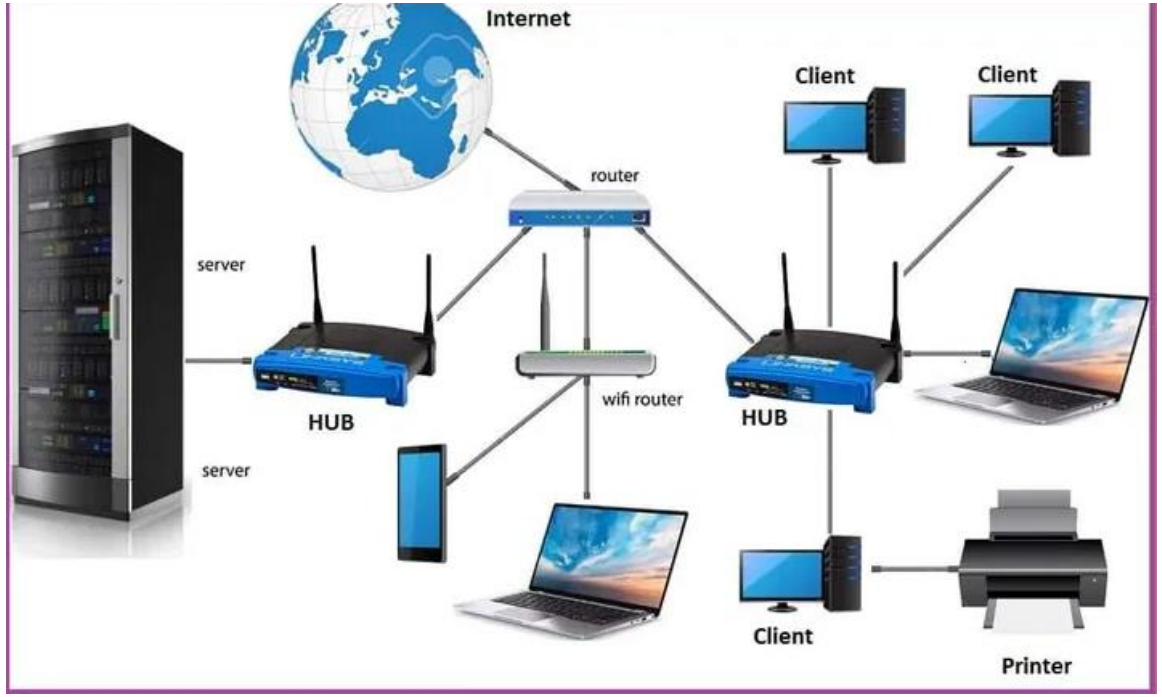


- Personal area network (PAN)
- Local area network (LAN)
- Campus area network (CAN)
- Metropolitan area network (MAN)
- Wide area network (WAN)

Personal Area Network (PAN)

- *A PAN is a network that is used for communicating among computers and computer devices (including telephones) in close proximity of around a few meters within a room*
- It can be used for communicating between the devices themselves, or for connecting to a larger network such as the internet
- PAN's can be wired or wireless
  - PAN's can be wired with a computer bus such as a universal serial bus: *USB* (a serial bus standard for connecting devices to a computer-many devices can be connected concurrently)
  - A wireless personal area network (WPAN) can be made using the network technologies such as Bluetooth, IrDa, UWB, Z-Wave, ZigBee, Body Area Network.





LOCAL AREA NETWORK (LAN)

LAN stands for **Local Area Network**. It is a network which is limited to a small geographical area such as home, office or school. It is useful for sharing resources such as files and printers. This type of networks has a high data transferring rate and lower congestion as it covers a small area.

- LAN's enable the sharing of resources such as files or hardware devices that may be needed by multiple users
- Is limited in size, typically spanning a few hundred meters, and no more than a mile
- Is very fast, with speeds from 10 Mbps to 10 Gbps
- Requires very little wiring, typically a single cable connecting to each device
- Has lower cost compared to MAN's or WAN's

Mbps VS MBps : WHAT'S THE DIFFERENCE?

Mbps: Megabits per second measure the rate at which information is uploaded or downloaded based on your internet connection speed.

MBps: Megabytes per second is a measurement of file size or a data amount.

You want to download a short SD video and the file size is 10MB. Your Internet connection gives you download speeds up to 16 Mbps.

Divide by 8 to get an MBps of 2. Now divide the file size (10 MB) by your MBps (2) to get the amount of time it will take to download the file. 10/2= 5. It will take approximately 5 seconds to download your 10 MB file with an Internet connection of 16 Mbps.

Bit (b)

Byte (B)

Speed	Data
1024 Bit = 1 Kilo Bit (Kb)	1024 Byte = 1 Kilo Byte (KB)
1024 Kb = 1 Mega Bit (Mb)	1024 KB = 1 Mega Byte (MB)
1024 Mb = 1 Giga Bit (Gb)	1024 MB = 1 Giga Byte (GB)
1024 Gb = 1 Tera Bit (Tb)	1024 GB = 1 Tera Byte (TB)

Example:

Q: How long will it take for a 128KB file to go across at 1Mbps?

LAN

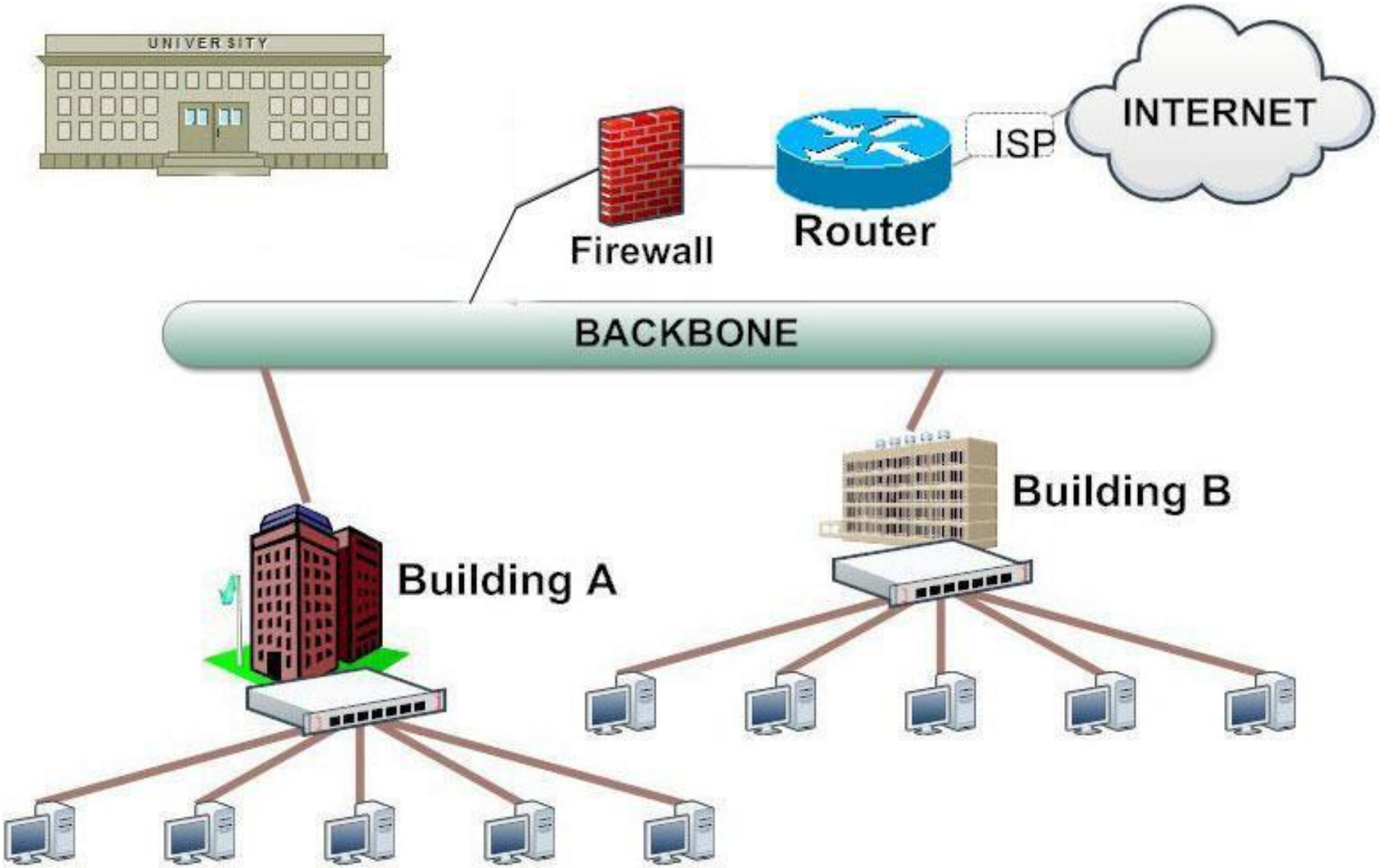
- LAN provides multiple advantages for the users. It allows sharing of information, databases, resources and other networking related services. It also improves communication between individuals as well as the departments in an organization. However, there should be skilled employees to set up the network and to maintain it. Furthermore, a fault in a server might affect the other devices in the network.
- WLAN – Wireless LAN

LAN

- LAN's can either be made wired or wireless. Twisted pair, coax or fiber optic cable can be used in wired LAN's
- Nodes in a LAN are linked together with a certain *topology*. A *node* is defined to be any device connected to the network. This could be a computer, a printer etc.
- A Switch or *Hub* is a networking device that connects multiple segments of the network together
- A *Network Interface Card* (NIC) is the circuit board that is used to connect computers to the network. In most cases, this is an *Ethernet* card plugged in a computer's motherboard
- The *Network Operating System* (NOS) is the software that enables users to share files and hardware and communicate with other computers. Examples of NOS include: Windows XP, Windows NT, Sun Solaris, Linux, etc..
- Resource sharing in a LAN is accomplished with different *access methods*. These include:
  - Token based access
  - CSMA/CD

CAMPUS AREA NETWORK (CAN)

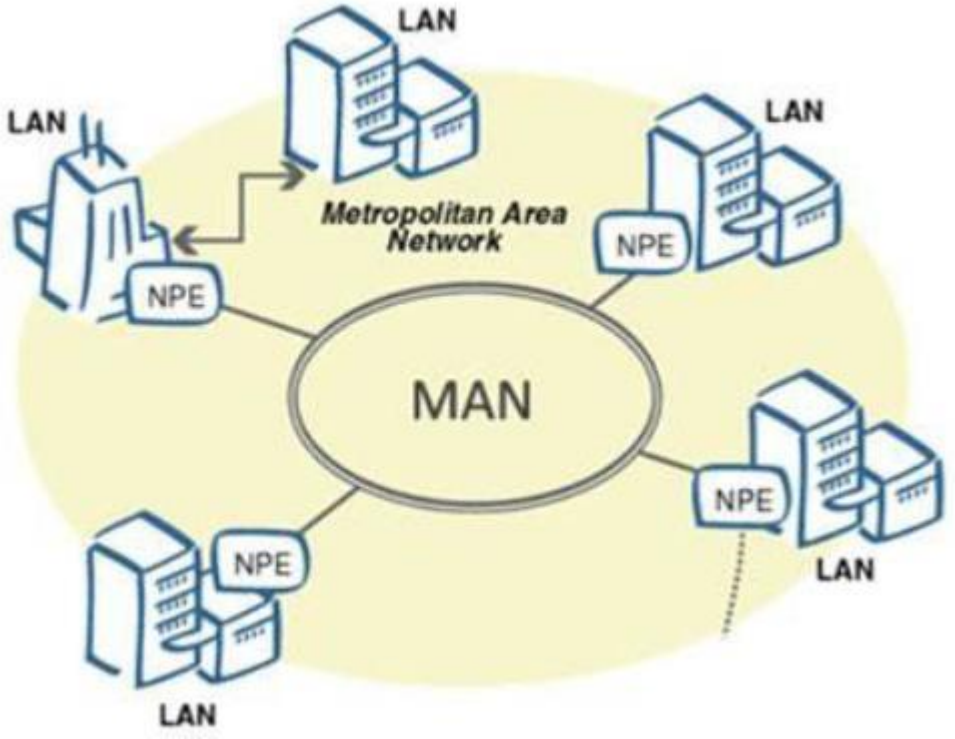
- A campus area network (CAN) is a computer network that spans a limited geographic area. CANs interconnect multiple local area networks (LAN) within an educational or corporate campus. Most CANs connect to the public Internet.
- CANs are smaller than metropolitan area networks (MAN) and wide area networks (WAN), which stretch over large geographic areas. Typically, the organization that owns the campus also owns and operates all the networking equipment and infrastructure for the CAN. In contrast, MANs and WANs may combine infrastructure operated by several different providers.
- At colleges, universities, and other educational institutions, CANs provide Internet access for students and faculty. CANs also enable connected users to quickly share files and data within the network: since data does not have to leave the CAN, users experience far less latency than they would when sending and receiving data within a MAN or WAN.


UNIVERSITY
INTERNET
ISP
Firewall
Router
BACKBONE
Building B
Building A

METROPOLITAN AREA NETWORK (MAN)

MAN stands for **Metropolitan Area Network**. It covers a geographical area larger than LAN but smaller than WAN. It refers to a network in a city or a small town. These networks can cover an area within 100km. It can also be considered as a collection of LANs.

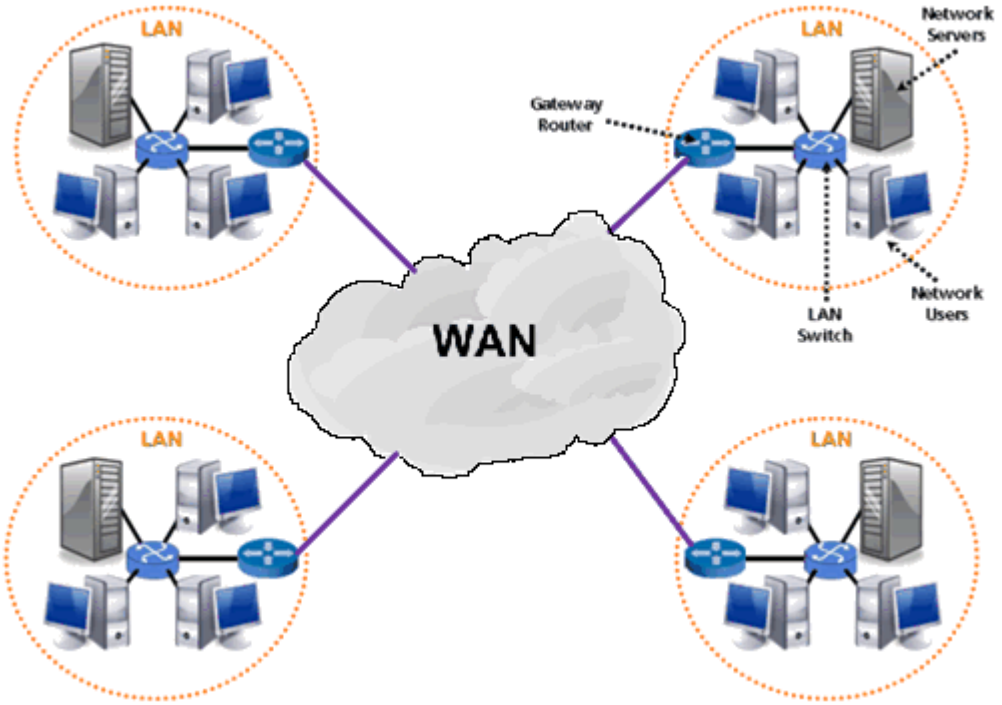
MAN can work as a good backbone for a large network to access WAN. Moreover, MAN uses a distributed queue duel bus. It allows transferring data to both directions simultaneously. Nevertheless, implementing MAN is costly as it requires more equipment. Furthermore, it can be difficult to protect the network from hackers.



WIDE AREA NETWORK (WAN)

WAN stands for **Wide Area Network**. It covers a large geographical area such as a state or a country. Therefore, it is the network which covers more than 100 km. It is an interconnection of small networks consisting of LANs, CANs and MANs. WAN helps to share data, voice, images and videos over a long distance. It improves communication between businesses organizations located in different continents.

As WAN is a large network, it can face numerous security threats. The network has a tendency to be affected by malicious software such as viruses, worms, etc. Therefore, it is important to take measures to prevent outsiders from entering the network. Furthermore, setting up the WAN can be difficult and complex. Additionally, there should be skilful employees with technical knowledge to maintain the network.



NETWORK TOPOLOGIES

NETWORK TOPOLOGY

- The term *network topology* refers to the shape of how the computers and other network components are connected to each other. There are several different types of network topologies, each with advantages and disadvantages.

✦ **Node:** A *node* is a device that is connected to the network. For our purposes here, a node is the same as a computer. Network topology deals with how the nodes of a network are connected to each other.

✦ **Packet:** A *packet* is a message that is sent over the network from one node to another node. The packet includes the address of the node that sent the packet, the address of the node the packet is being sent to, and data

Physical Topology :

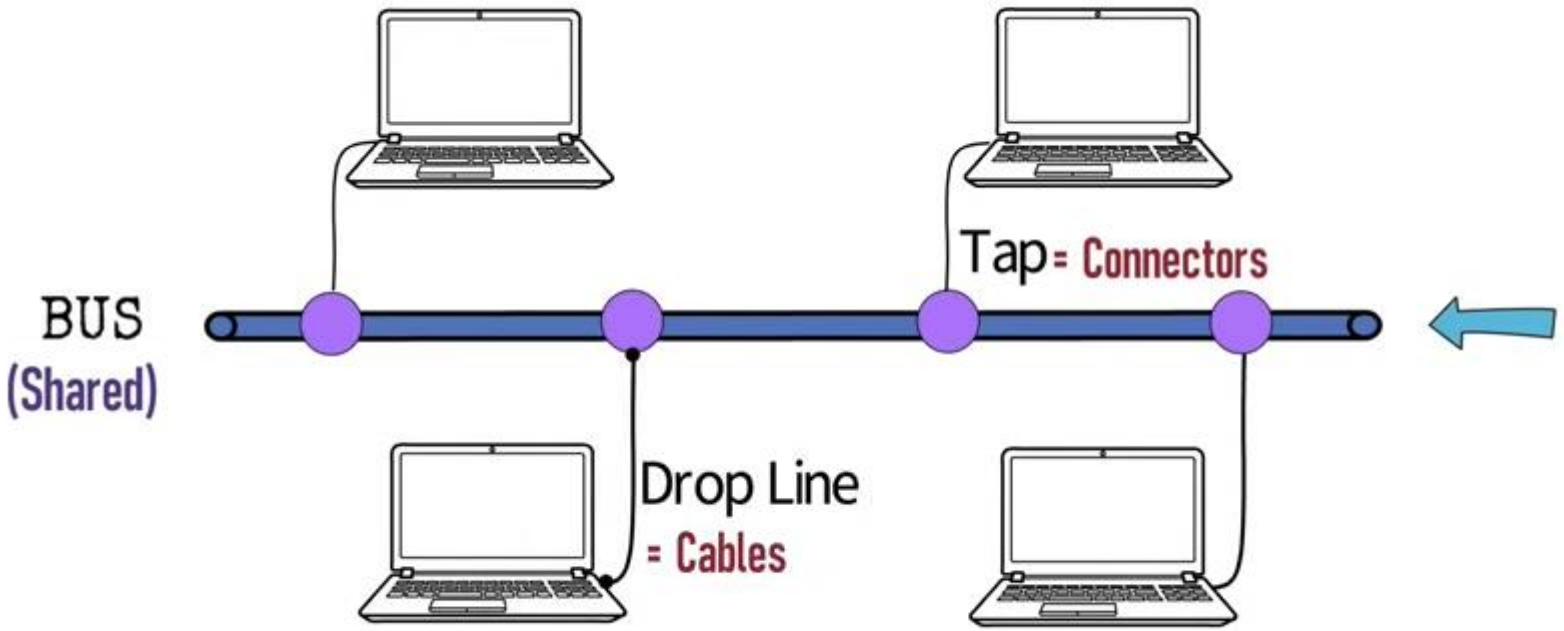
Physical topology indicates arrangement of different elements of a network. It reflects physical layout of devices and cables to a form a connected network. It is concerned with essentials of network ignoring minute details like transfer of data and device type. The pattern of arrangement of nodes (computers) and network cables depends on ease of installation and setup of the network. It affects cost and bandwidth capacity based on solution of devices. It takes into account placement of nodes and distance between them.

Logical Topology :

Logical Topology reflects arrangement of devices and their communication. It is the transmission of data over physical topology. It is independent of physical topology, irrespective of arrangements of nodes. It is concerned with intricate details of network like type of devices (switches, routers) chosen and their quality, which affect rate and speed of data packets delivery. The logical topology ensures optimal flow control that can be regulated within network. The data can either flow in a linear pattern called Logical bus or in form of a circle Logical ring.

SIMPLE PHYSICAL TOPOLOGIES

- Physical topology: physical layout of nodes on a network
- Fundamental shapes:
  - Bus
  - Ring
  - Star
  - Mesh
  - Hybrid
- Topology integral to type of network, cabling infrastructure, and transmission media used



BUS

BUS

- The key to understanding how a bus topology works is to think of the entire network as a single cable, with each node “tapping” into the cable so that it can listen in on the packets being sent over that cable. If you’re old enough to remember party lines, you get the idea.
- In a bus topology, every node on the network can see every packet that’s sent on the cable. Each node looks at each packet to determine whether the packet is intended for it. If so, the node claims the packet. If not, the node ignores the packet. This way, each computer can respond to data sent to it and ignore data sent to other computers on the network.
- If the cable in a bus network breaks, the network is effectively divided into two networks. Nodes on either side of the break can continue to communicate with each other, but data can’t span the gap between the networks, so nodes on opposite sides of the break can’t communicate with each other.

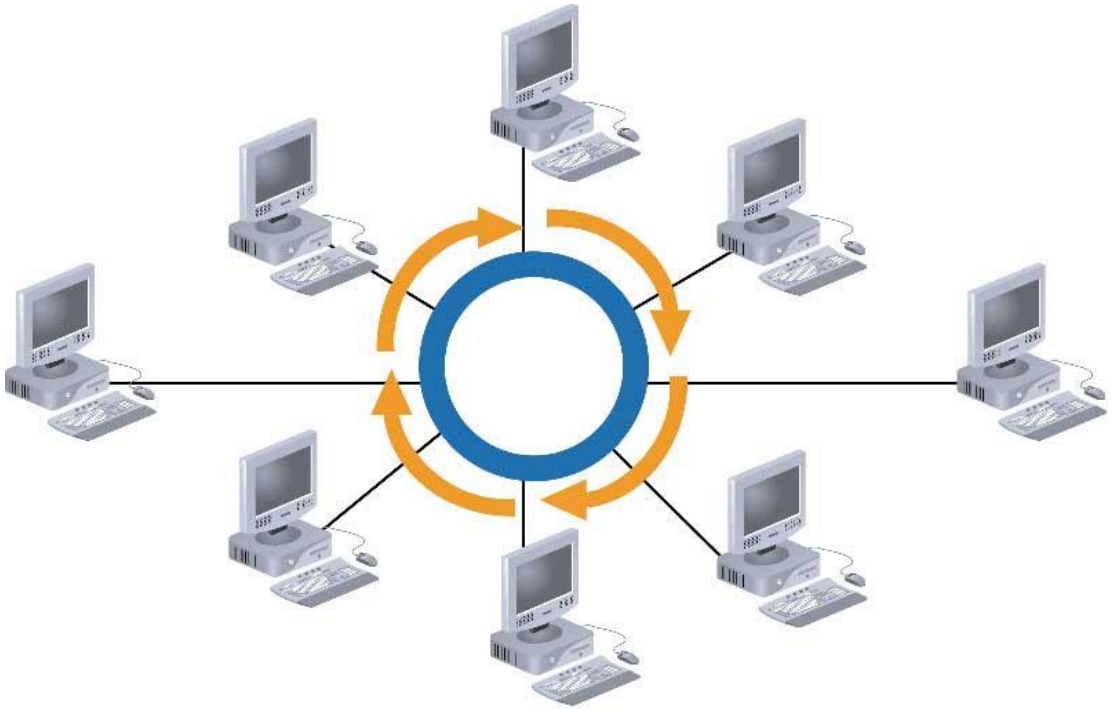
ADVANTAGES & DISADVANTAGES OF BUS TOPOLOGY

Advantages

- Works well for small networks
- Only one wire relatively inexpensive to implement
- Suited for temporary network

Disadvantages

- Not fault tolerant
- Limited cable length
- Potential for congestion with network traffic and security

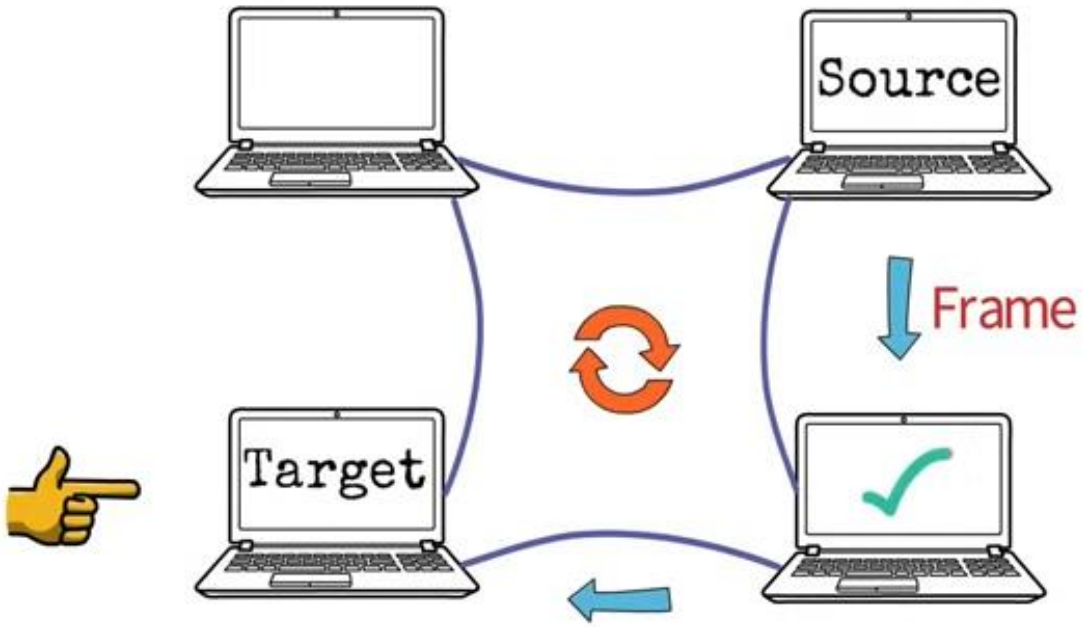


RING

RING

- In a ring topology, is a bus topology in a closed loop.Packets are sent around the circle from computer to computer. Each computer looks at each packet to decide whether the packet was intended for it. If not, the packet is passed on to the next computer in the ring.
- It’s a peer to peer LAN topology and it is unidirectional.
- Sending and receiving data takes place using a TOKEN.
- Years ago, ring topologies were common in LANs, as two popular networking technologies used rings: ARCNET and Token RinARCNET is still used for certain applications such as factory automation, but is rarely used in business networks. Token Ring is a popular network technology for IBM midrange computers. Although plenty of Token Ring networks are still in existence, not many new networks use Token Ring any more.

Ring Topology



ADVANTAGES & DISADVANTAGES OF RING TOPOLOGY

Advantages

- Easier to manage; easier to locate a defective node or cable problem
- Well-suited for transmitting signals over long distances on a LAN
- Handles high-volume network traffic
- Enables reliable communication

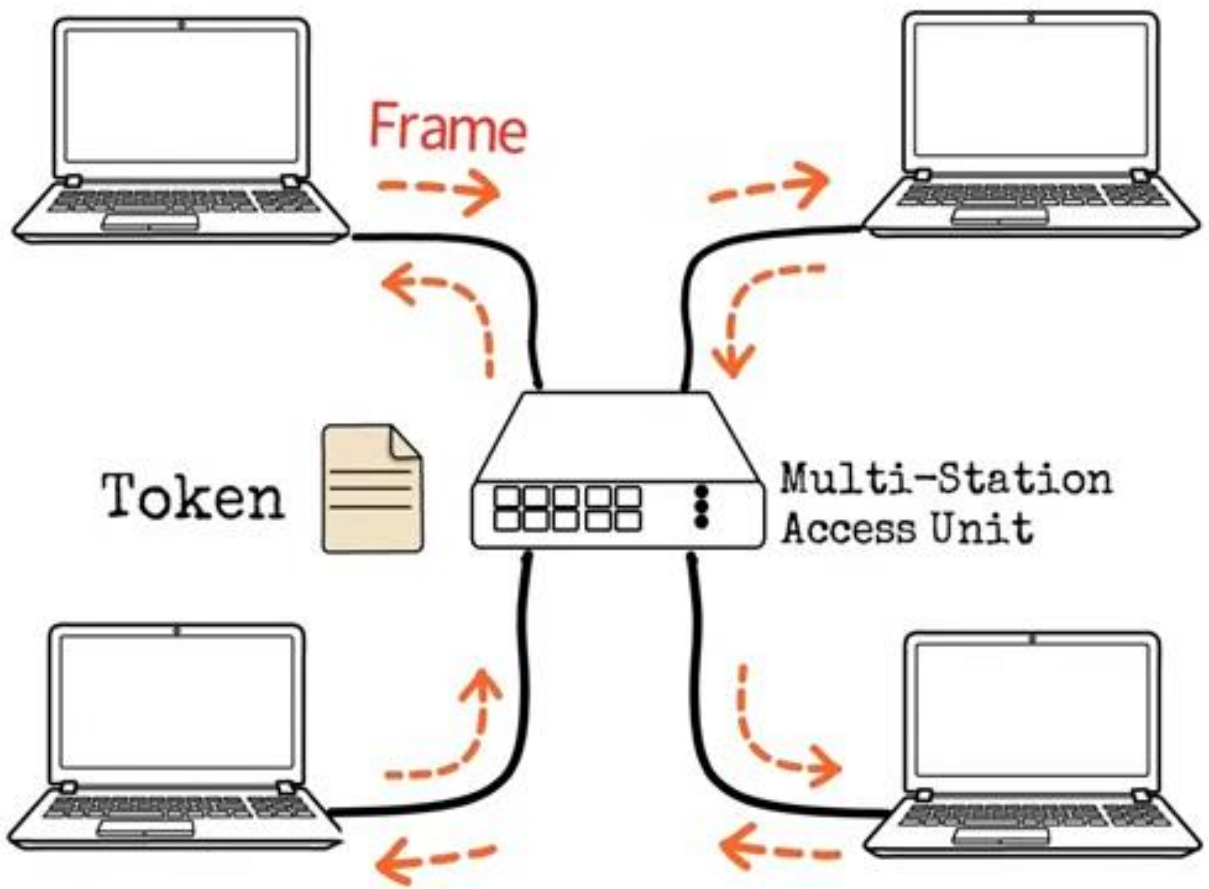
Disadvantages

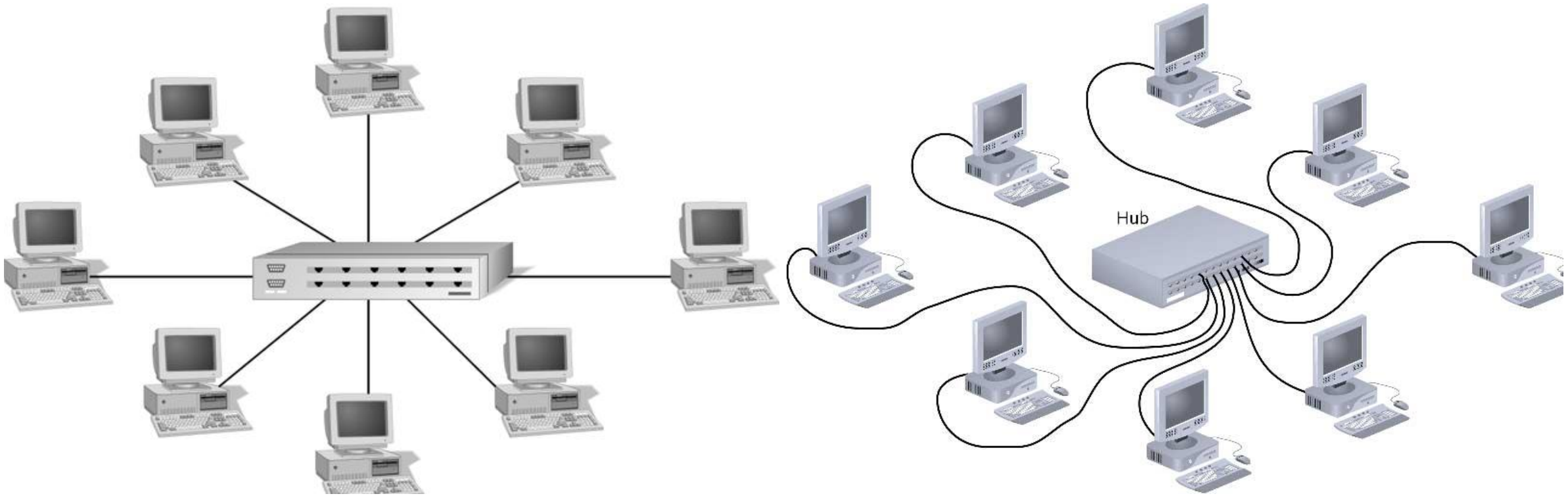
- Expensive
- Requires more cable and network equipment at the start
- Not used as widely as bus topology
  - Fewer equipment options
  - Fewer options for expansion to high-speed communication

Physical Star

Token Ring

Logical Ring

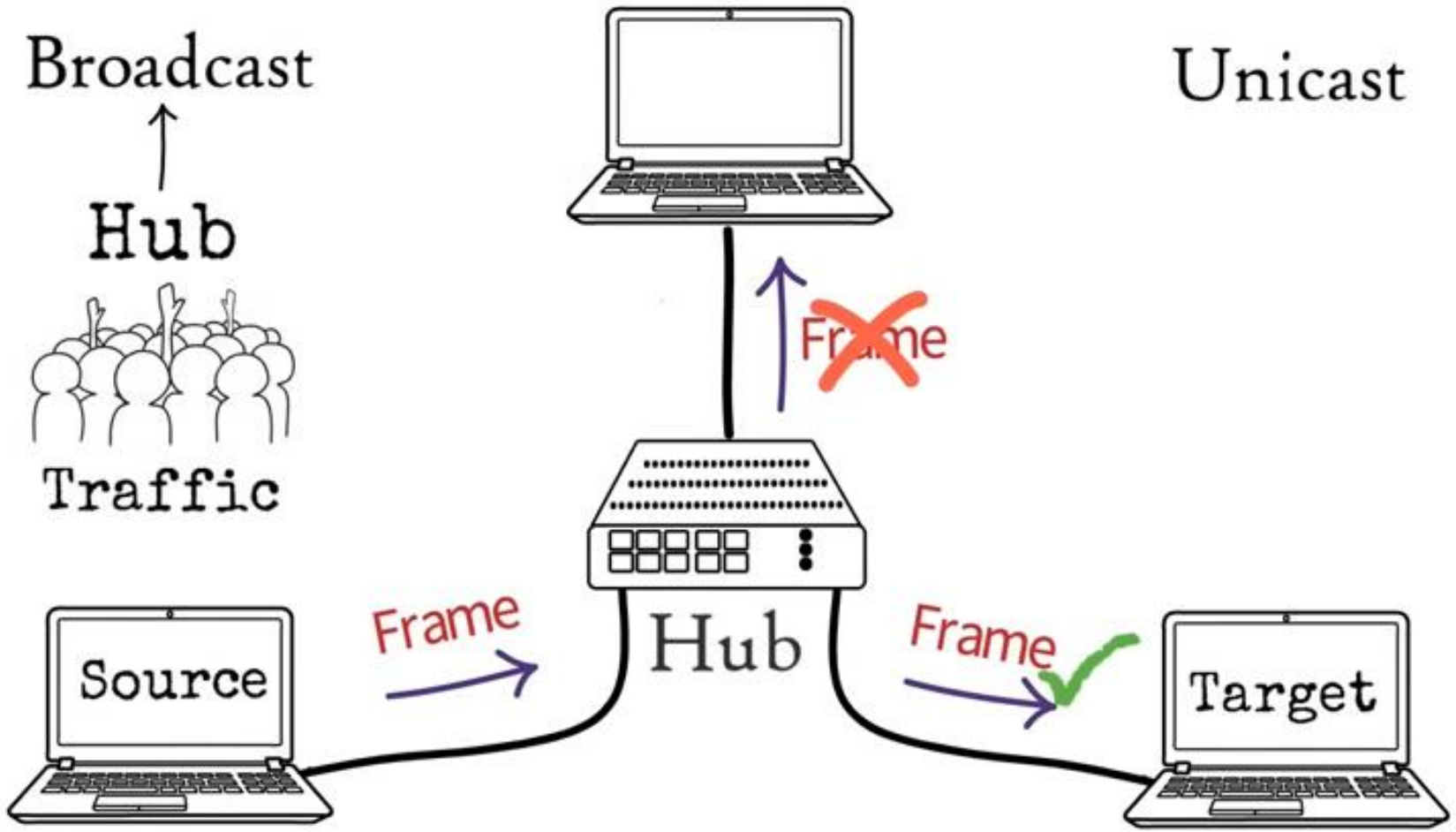




STAR

STAR

- In a star topology, each network node is connected to a central device called a *hub* or a *switch* is a cable in a star network breaks, only the node connected to that cable is isolated from the network. The other nodes can continue to operate without interruption — unless, of course, the node that's isolated because of the break happens to be the file server.
  You should be aware of the somewhat technical distinction between a hub and a switch. Simply put, a *hub* doesn't know anything about the computers that are connected to each of its ports.
- So when a computer connected to the hub sends a packet to a computer that's connected to another port, the hub sends a duplicate copy of the packet to all its ports.

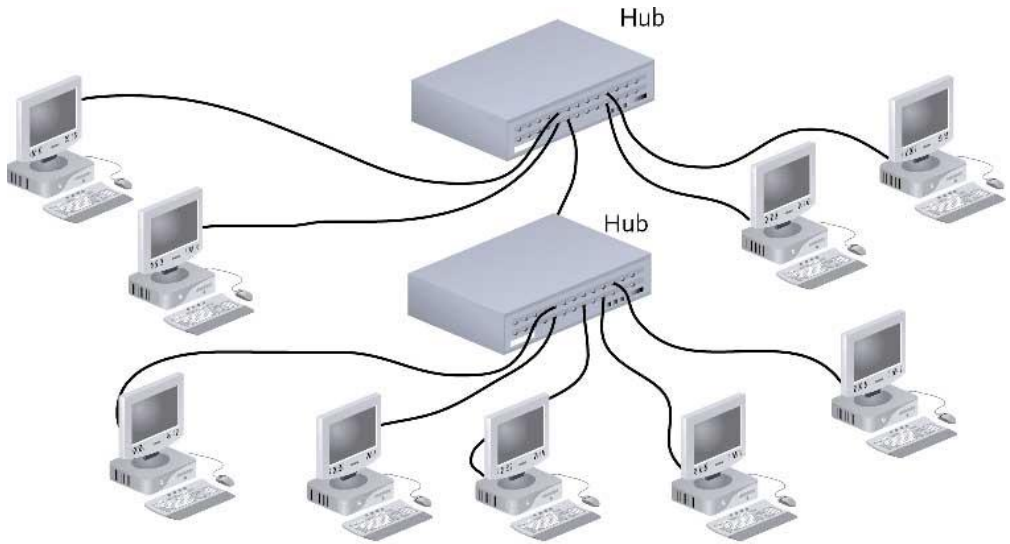

Broadcast
Hub
Traffic
Unicast
Frame
Source
Frame
Hub
Frame
Target

- In contrast, a switch knows which computer is connected to each of its ports. As a result, when a switch receives a packet intended for a particular computer, it sends the packet only to the port that the recipient is connected to.
- Strictly speaking, only networks that use switches have a true star topology. If the network uses a hub, the network topology has the physical appearance of a star, but is actually a bus. That's because when a hub is used, each computer on the network sees all the packets sent over the network, just like in a bus topology.
- In a true star topology, as when a switch is used, each computer sees only those packets that were sent specifically to it, as well as broadcast packets that were specifically sent to all computers on the network.

EXPANDING STARS

- A simple bus or star topology is suitable only for small networks, with a dozen or so computers, but small networks inevitably become large networks as more computers are added. For larger networks, it's common to create more complicated topologies that combine stars and buses.
- For example, a bus can be used to connect several stars. In this case, two or more hubs or switches are connected to each other using a bus. Each of these hubs or switches is then the center of a star that connects two or more computers to the network. This type of arrangement is commonly used in buildings that have two or more distinct workgroups. The bus that connects the switches is sometimes called a backbone.

STAR-WIRED BUS



Another way to expand a star topology is to use a technique called *daisychaining*. When you use daisy-chaining, a hub or switch is connected to another hub or switch as if it were one of the nodes on the star. Then, this second hub or switch serves as the center of a second star.

ADVANTAGES & DISADVANTAGES OF STAR TOPOLOGY

Advantages

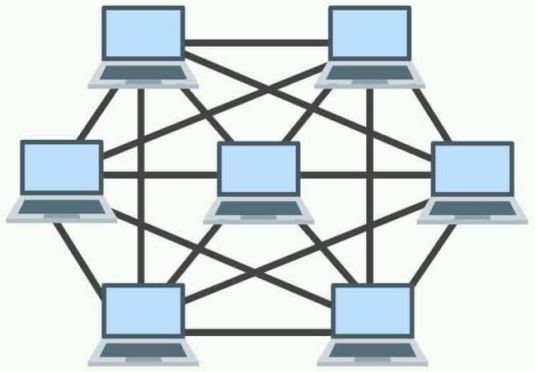
- Good option for modern networks
- Low startup costs
- Easy to manage
- Offers opportunities for expansion
- Most popular topology in use; wide variety of equipment available

Disadvantages

- Hub is a single point of failure
- Requires more cable than the bus

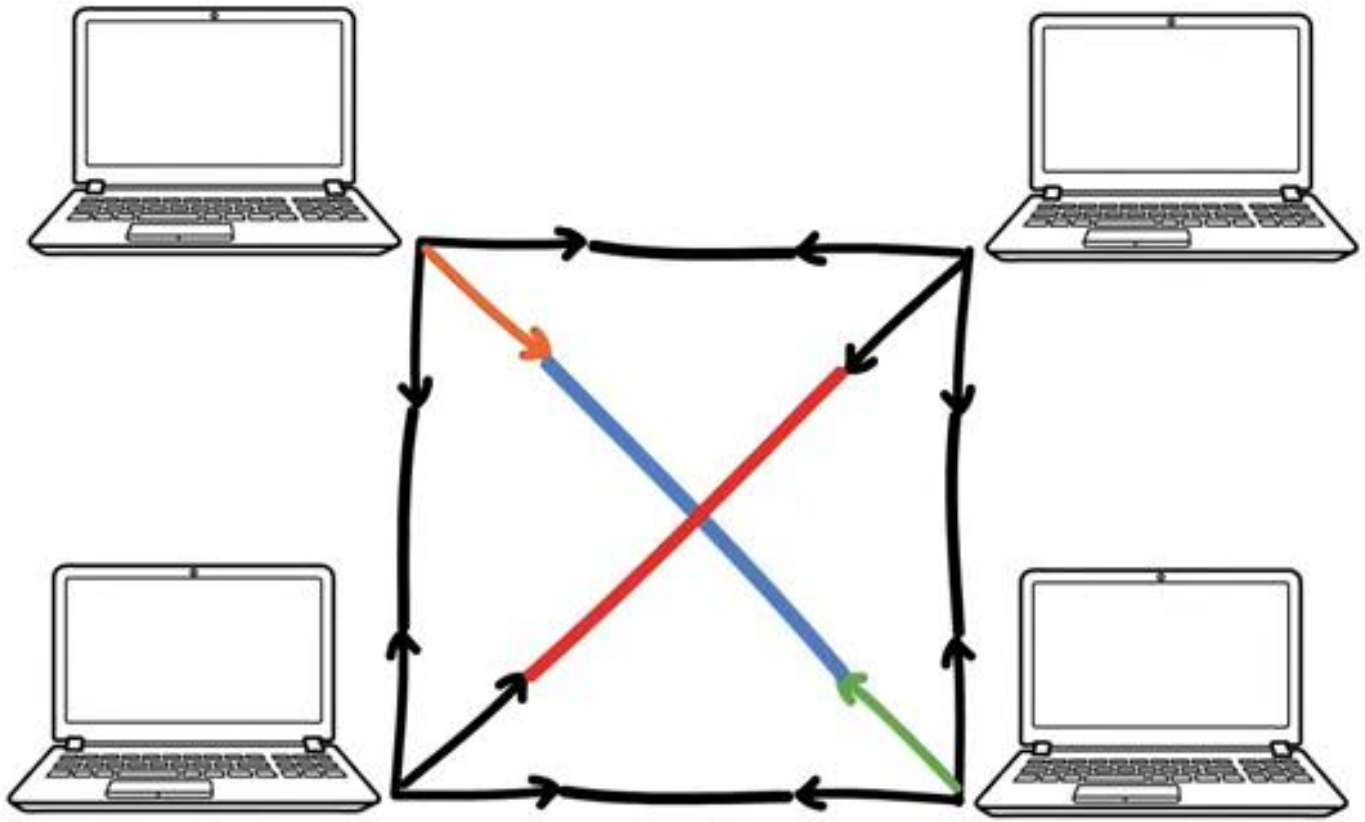
MESH TOPOLOGY

- *A mesh,* has multiple connections between each of the nodes on the network advantage of a mesh topology is that if one cable breaks, the network can use an alternative route to deliver its packets.
- Mesh networks are not very practical in a LAN setting. For example, to network eight computers in a mesh topology, each computer would have to have seven network interface cards, and 28 cables would be each computer to the seven other computers in the network required to connect



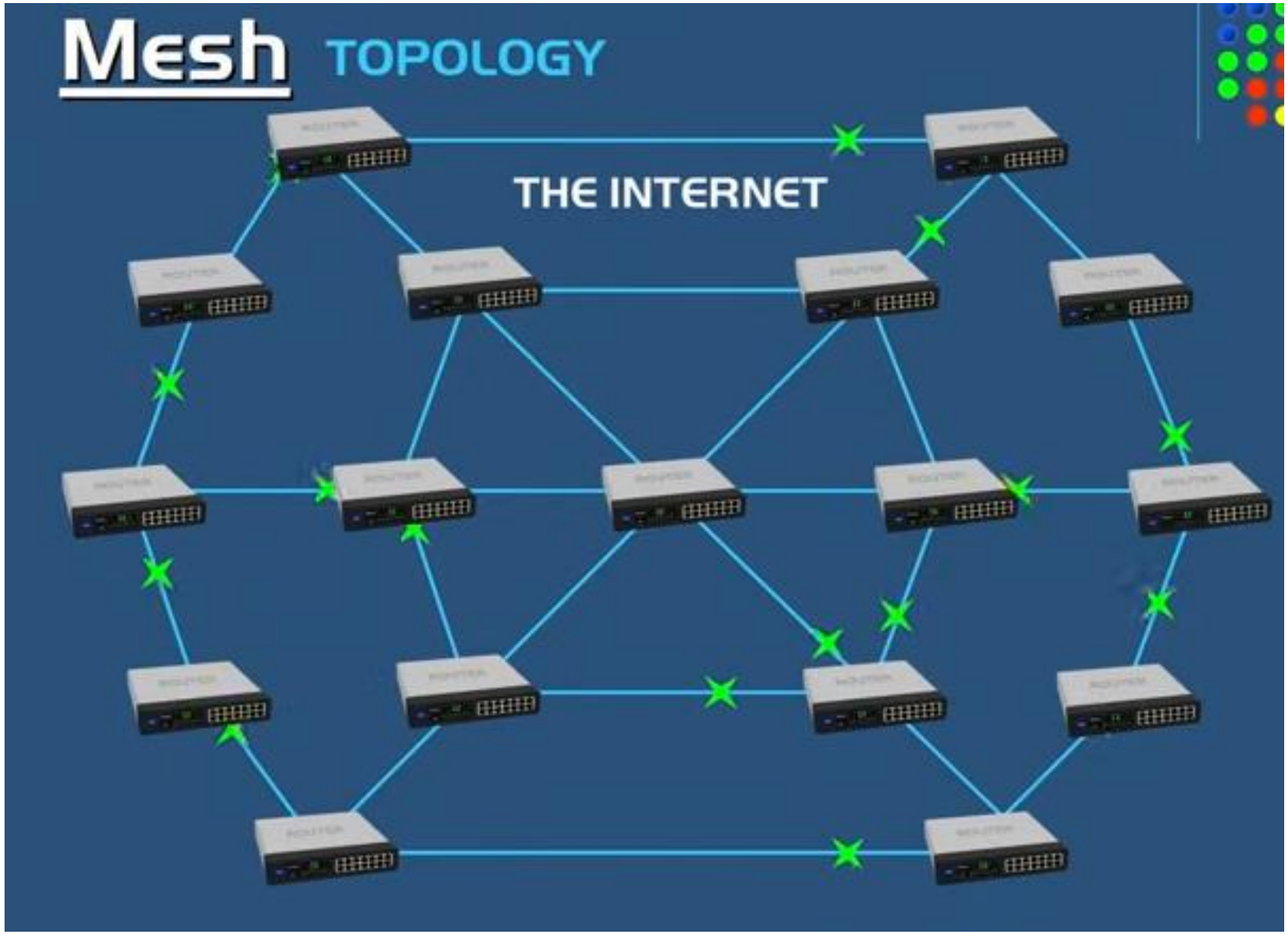
Full Mesh Topology

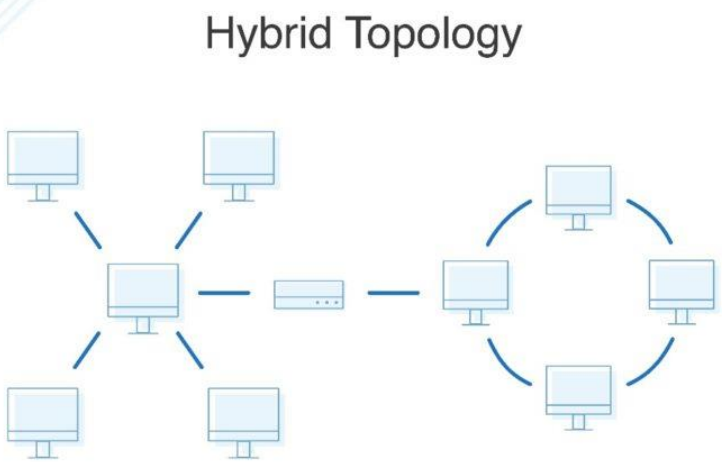
- However, mesh networks are common for metropolitan or wide area networks.
- These networks use devices called routers to route packets from network to network. For reliability and performance reasons, routers are usually arranged
- in a way that provides multiple paths between any two nodes on the network in a mesh-like arrangement.



n(devices) = n = 10 Total I/O ports = (n-1) = 9

Simplex Links = n(n-1) Duplex Links = n(n-1)/2 = 45


Mesh
TOPOLOGY
THE INTERNET



HYBRID TOPOLOGY

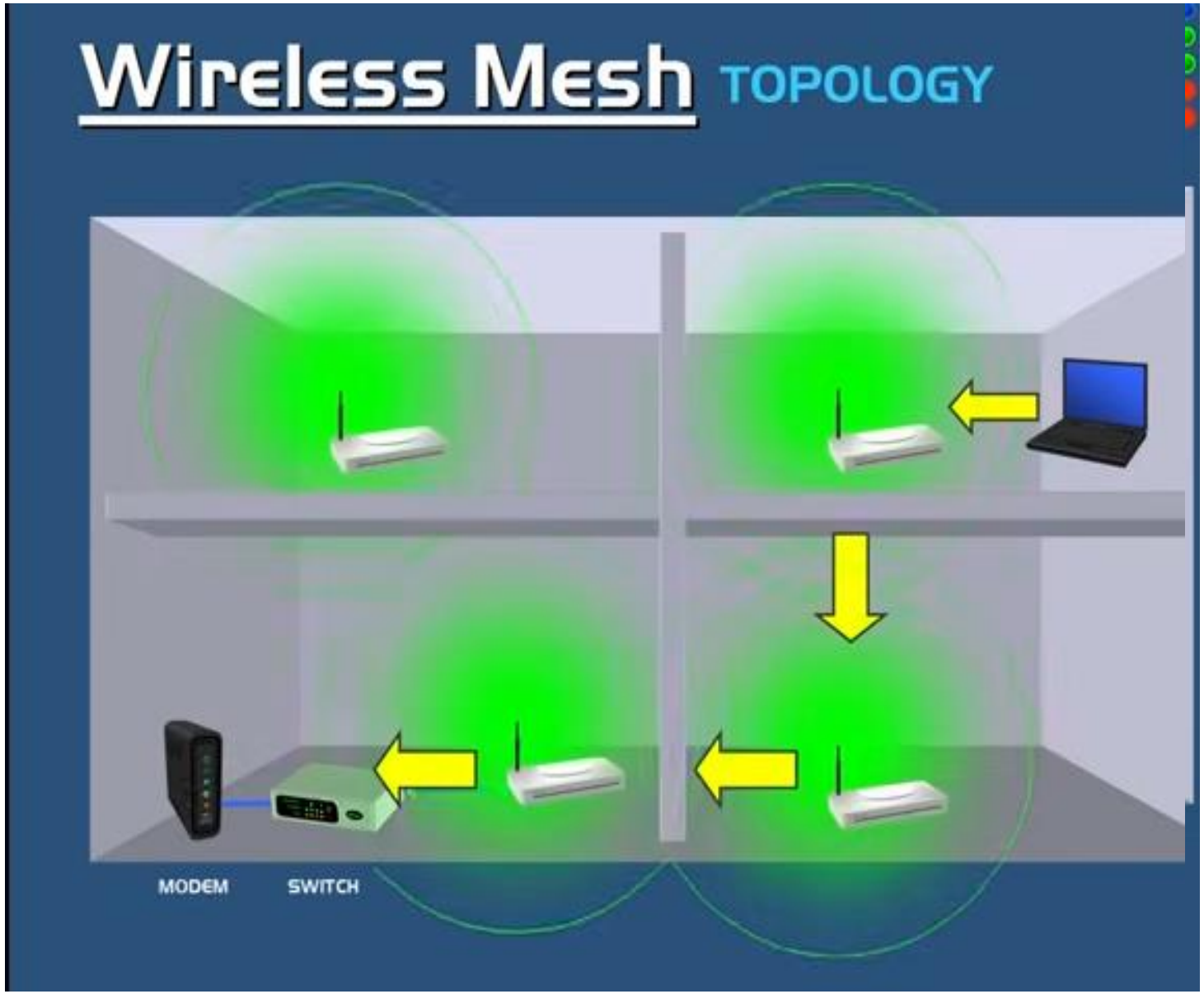
- Hybrid topologies combine two or more different topology structures—the tree topology is a good example, integrating the bus and star layouts. Hybrid structures are most commonly found in larger companies where individual departments have personalized network topologies adapted to suit their needs and network usage.

Advantages of Hybrid Topology

- The main advantage of hybrid structures is the degree of flexibility they provide, as there are few limitations on the network structure itself that a hybrid setup can’t accommodate.

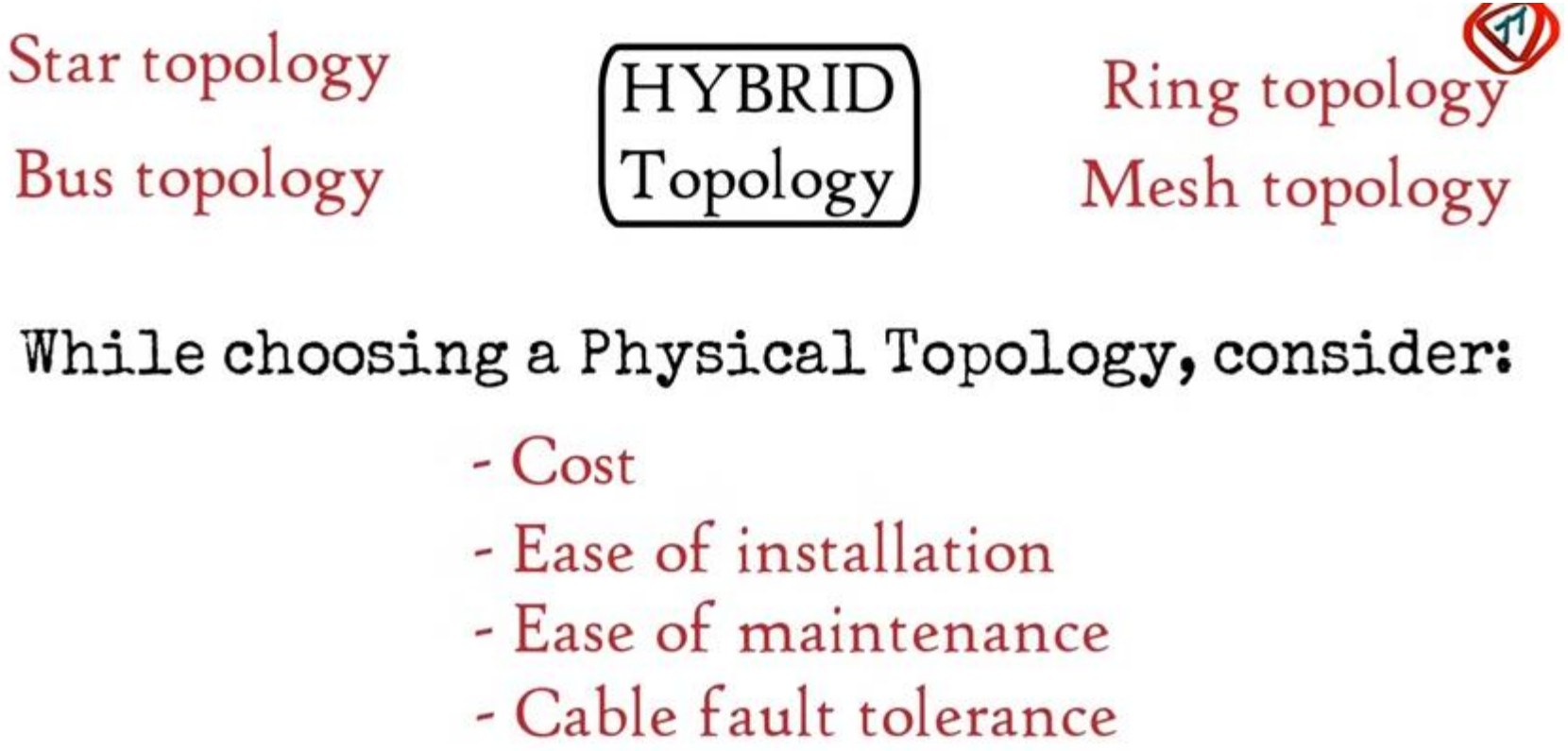
Disadvantages of Hybrid Topology

- However, each type of network topology comes with its own disadvantages, and as a network grows in complexity, so too does the experience and know-how required on the part of the admins to keep everything functioning optimally. There’s also the monetary cost to consider when creating a hybrid network topology.


Wireless Mesh TOPOLOGY
MODEM
SWITCH

WHICH TOPOLOGY IS BEST FOR YOUR NETWORK?

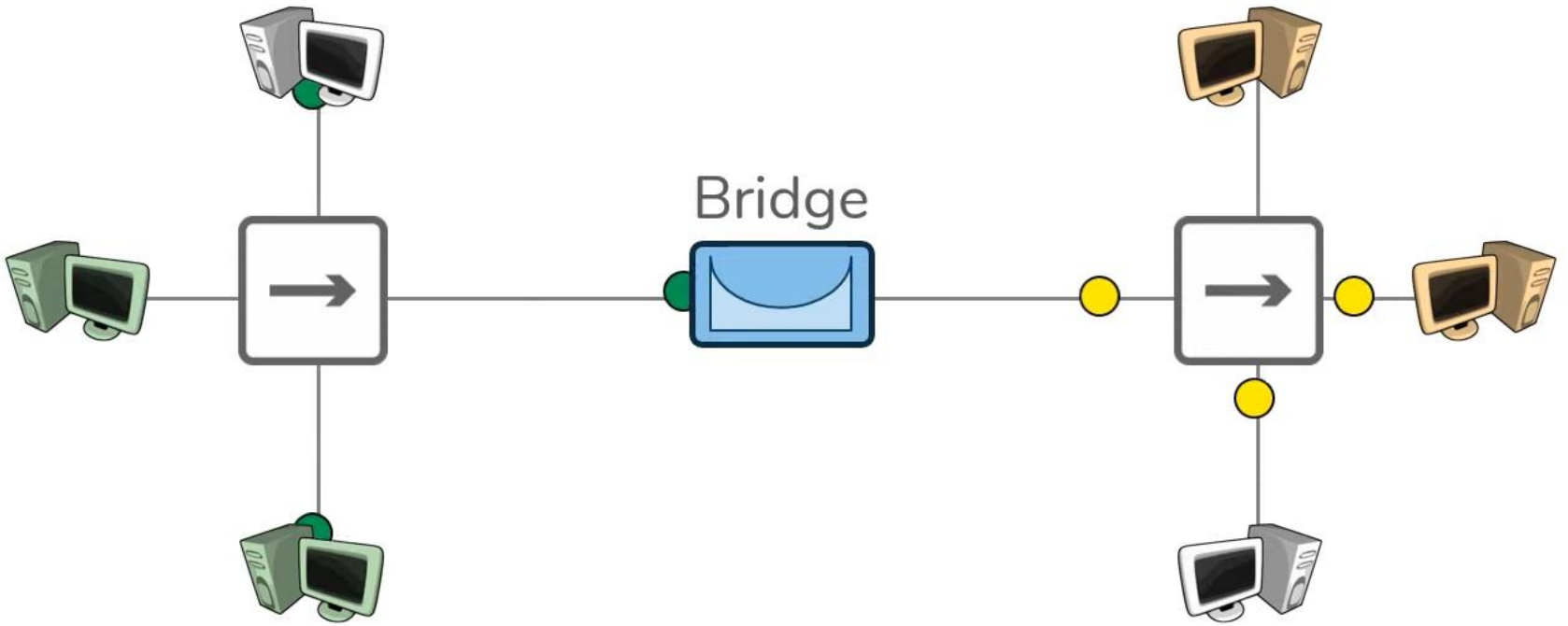
- No network topology is perfect, or even inherently better than the others, so determining the right structure for your business will depend on the needs and size of your network. Here are the key elements to consider:



Network Devices

- Host
- IP Address
- Network
- Repeater
- Hub
- **Bridge**
- Switch
- Router

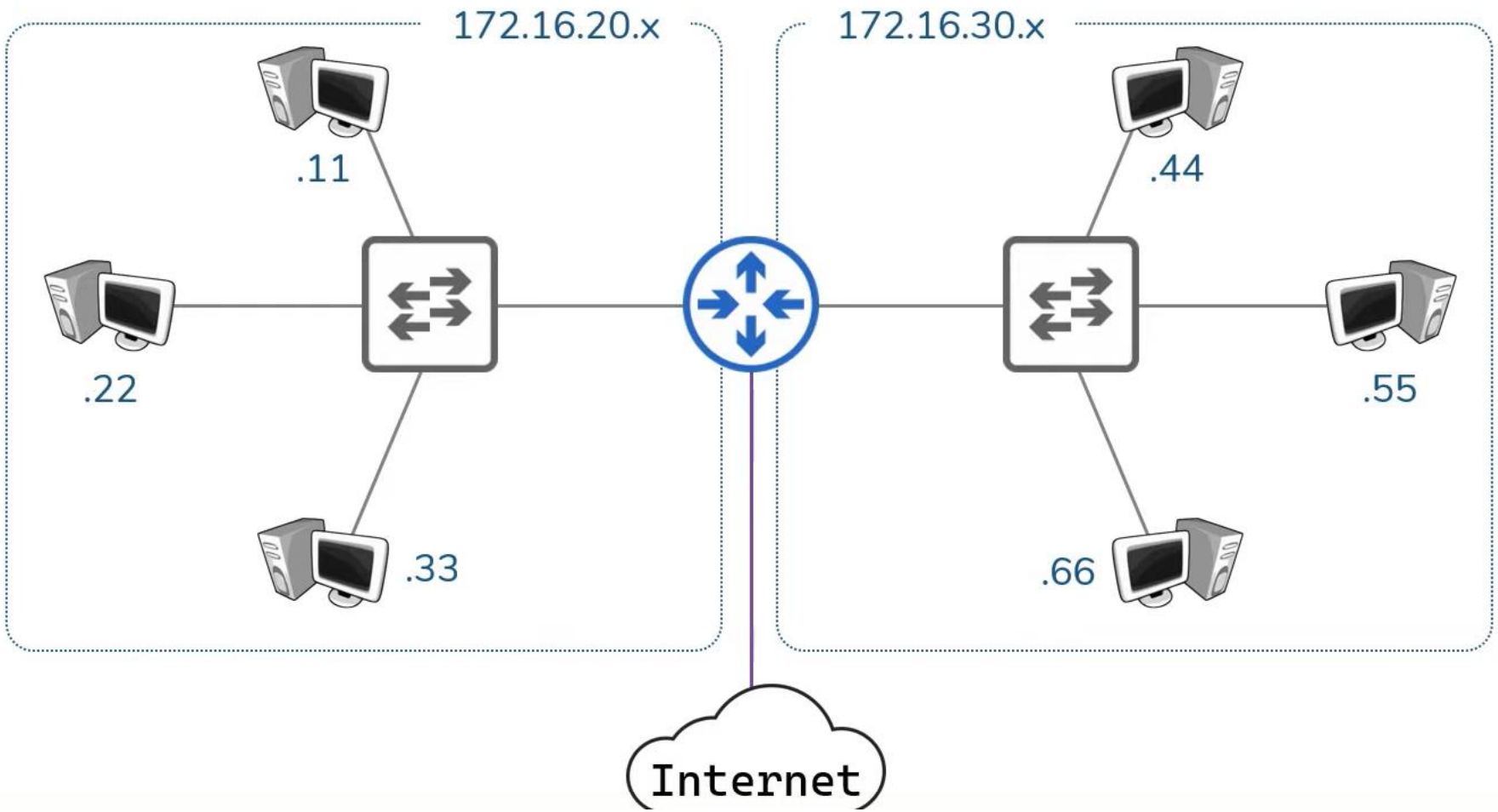
- **Bridges** sit between Hub-connected hosts
  - Bridges only have two ports
  - Bridges learn which hosts are on each side



Network Devices

- Host
- IP Address
- Network
- Repeater
- Hub
- Bridge
- Switch
- **Router**

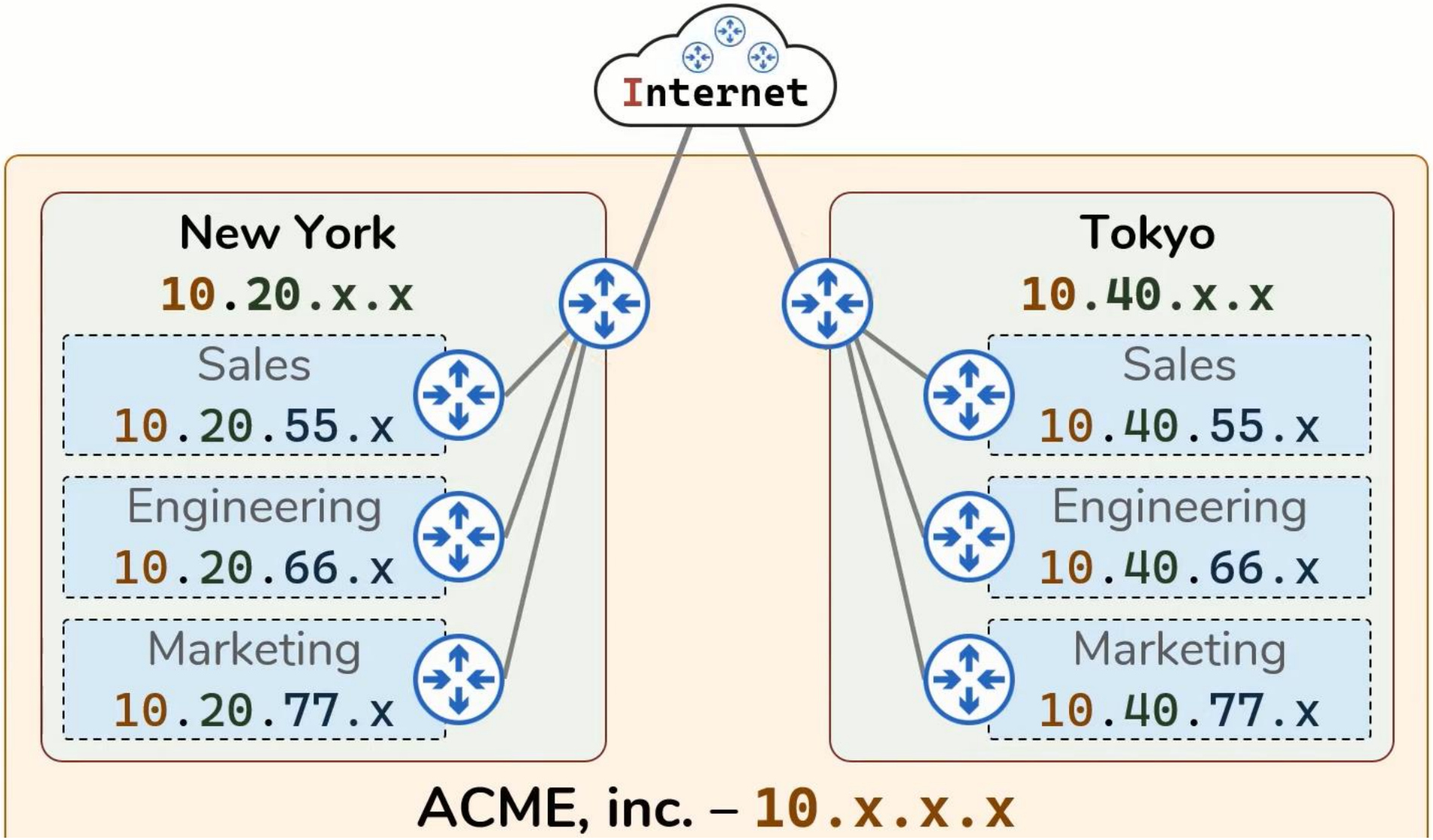
- **Routers** facilitate communication **between** networks
  - **Network**: Grouping of hosts which require similar connectivity
  - Provides a traffic control point (security, filtering, redirecting)
    - Traditionally, Switches could not perform such filtering



Network Devices

- Host
- IP Address
- Network
- Repeater
- Hub
- Bridge
- Switch
- **Router**

- **Routers** facilitate communication **between** networks
  - Create the Hierarchy in Networks and the entire Internet



Network Devices

- Host
- IP Address
- Network
- Repeater
- Hub
- Bridge
- **Switch**
- **Router**

- **Routers** facilitate communication **between** networks
- **Switches** facilitate communication **within** a network

- **Routing** is the process of **moving data between networks**
  - A Router is a device whose primary purpose is Routing

- **Switching** is the process of **moving data within networks**
  - A Switch is a device who's primary purpose is Switching

- There are many other Network Devices:
  - Access Points
  - Firewalls
  - Load Balancers
  - Virtual Switches
  - Layer 3 Switches
  - IDS / IPS
  - Proxies
  - Virtual Routers

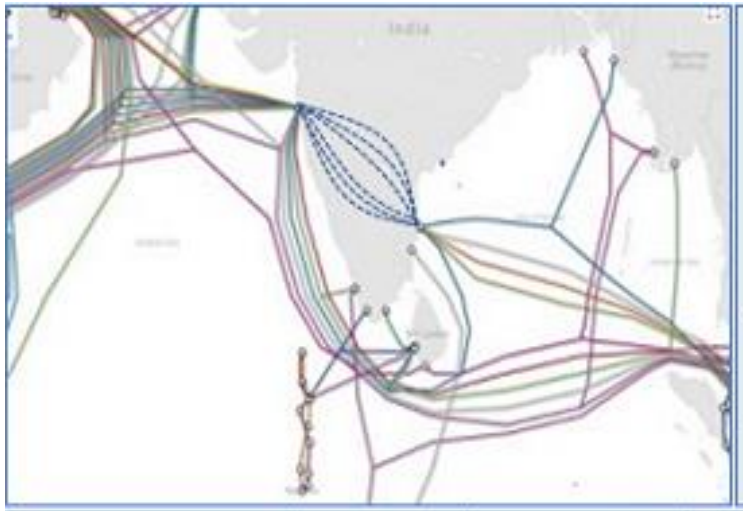
- All of them perform Routing and/or Switching

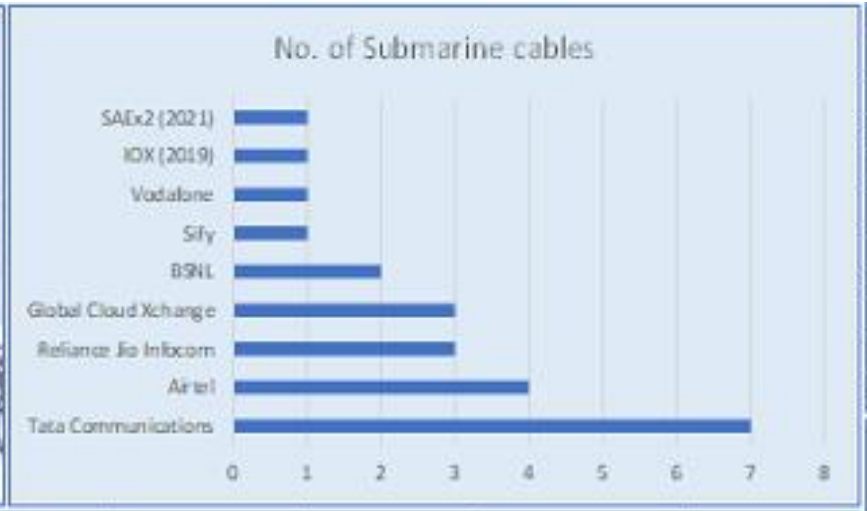
HOW THE INTERNET TRAVELS ACROSS THE OCEANS?

HOW THE INTERNET TRAVELS ACROSS THE OCEANS?

- As per the existing telecom licensing regime in India, the Telecom Regulatory Authority of India (TRAI) establishes the orders, regulations and directions on telecommunications sector, while the Department of Telecommunications (DoT) issues licenses.

- The company laying submarine cables in Indian Territorial Waters must hold a valid International Long Distance (ILD) license issued by the Department of Telecommunications (DoT). International Long-Distance Operators (ILDOs) licensees are allowed to set up Cable Landing Station (CLS) for landing of submarine cables, governed by the regulations/orders as may be made by the TRAI from time to time.





Mumbai	Chennai	Trivendrum	Tuticorine	Puduchery
IMEWE	TIC	WARF	BLCS	IOX
TGN-EA/SEACOM	i2i CN	SAFE		
SMW4	SMW4			
BBG	BBG			
EIG				
SMW3				
FLAG Europe-Asia				
AAE-1				
FALCON				
GBIC/MENA				

Tata Communications	Airtel	Global Cloud Exchange	Reliance Jio	BSNL	Vodafone	Sify	IOX
IMEWE	IMEWE	FLAG EA	BBG	BLCS	BBG	GBIC/MENA**	IOX (2019)
SMW4	SMW4	FALCON	AAE-1	CACS (2019)			
SMW3	EIG	WARF	i2i CN*				
FLAG	i2i CN						
TGN-EA/Seacom	GBIC/MENA						
SAFE							
TIC							

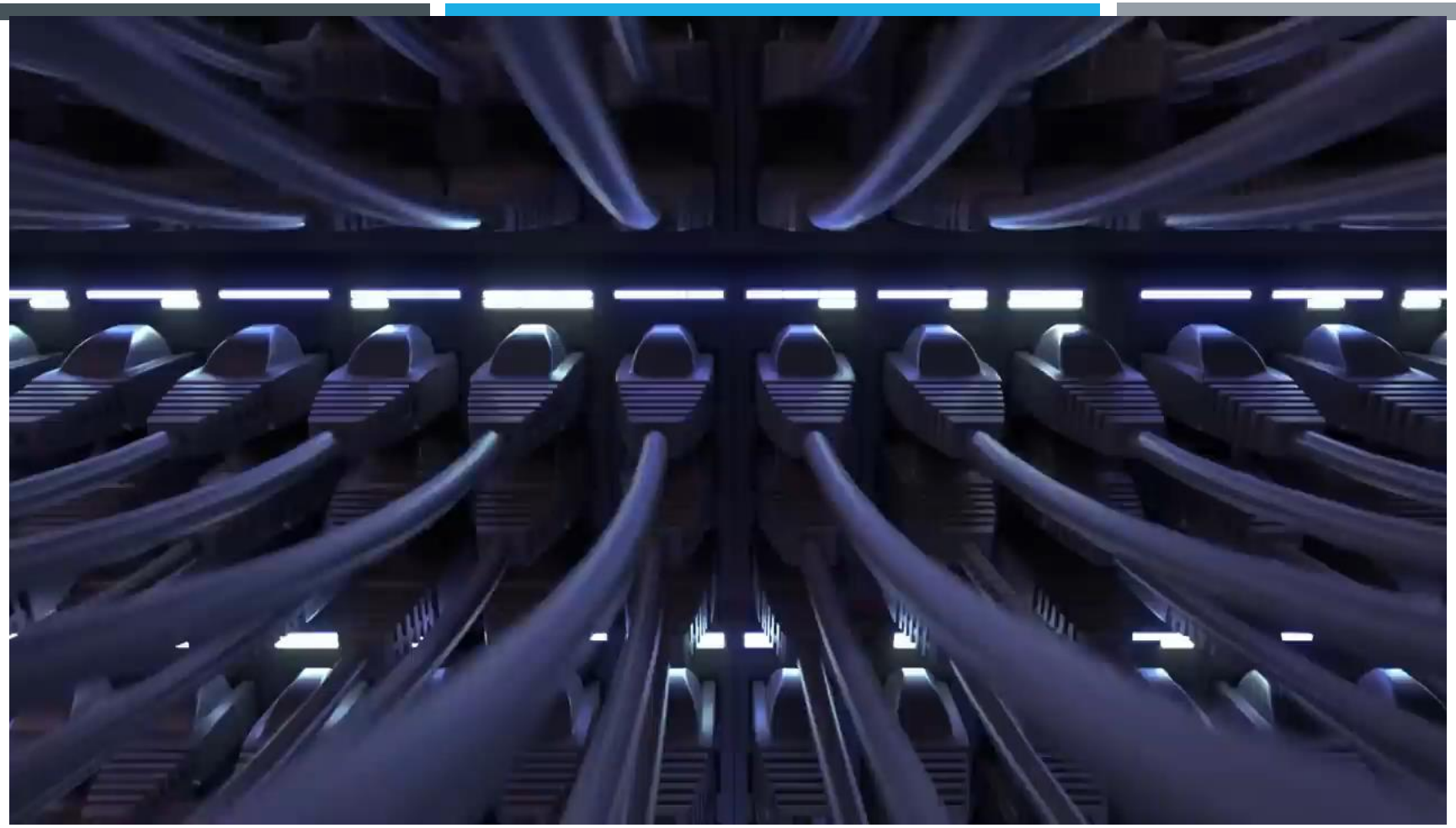
** Only Fiber Pair, ** Only CLS*

Distribution of Cable Landing Stations and providers that own them	Mumbai	Chennai	Cochin	Trivandrum	Tuticorine	Puduchery	Digha	Visakhapatnam
Tata Communications	3	1	1					
Airtel	1	2						
Reliance Jio	1	1						1
Global Cloud Xchange	1			1				
Vodafone	1							
Sify	1							
BSNL					1		1	
IOX						1		

CLS Operational — CLS Under Construction

Complete list of submarine cables landing in India

S No.	Submarine Cable System	Landing City	Landing Party	RFS	Length (kms)	No. of Fiber Pair	No. of Consortium Members
1	FLAG EA	Mumbai	GCX	1997	28,000	Two-fiber-pair	1
2	SMW3	Mumbai, Cochin	TCL	1999	39,000	Two-fiber-pair	54
3	SAFE	Cochin	TCL	2002	13,500	Two-fiber-pair	29
4	i2i	Chennai	Airtel	2002	3,200	Eight-fiber-pair	1
5	TIC	Chennai	TCL	2004	3,175	Six-fiber-pair	1
6	SMW4	Mumbai, Chennai	TCL, Airtel	2005	20,000	Two-fiber-pair	16
7	BLCS	Tuticorin	BSNL	2006	325	Two-fiber-pair	2
8	FALCON	Mumbai	GCX	2006	10,300	Six-fiber-pair	1
9	WARF	Cochin	GCX	2007	680	Two-fiber-pair	3
10	IMEWE	Mumbai	TCL, Airtel	2010	12,091	Three-fiber-pair	9
11	TGN-EA/SEACOM	Mumbai	TCL	2011	9,280	Two-fiber-pair	1
12	EIG	Mumbai	Airtel	2011	15,000	Four-fiber-pair	16
13	GBIC/MENA	Mumbai	Sify	2012	1,500	Four-fiber-pair	1
14	BBG	Mumbai, Chennai	Jio, Vodafone	2016	8,100	Three-fiber-pair	10
15	AAE-1	Mumbai	Jio	2017	25,000	Five-fiber-pair	19
16	CACN	Chennai	BSNL	2019	2,300	Four-fiber-pair	1
17	IOX	Puduchery	IOX	2019	8,850	Four-fiber-pair	1
18	SAEx2	Chennai	SAEX	2021	13,900	Six-fiber-pair	1
19	Jio New Cable	Mumbai, Chennai	Jio	2022	8,000	Twelve-fiber-pair	2/3/4(!)
20	IIP New Cable	Mumbai, Chennai	IIP	2022	10,000	12/16/32 fiber-pair	3/4 (!)



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