

Cybersecurity Fundamentals

Lecture 1: Introduction to Networks Concepts

CYB 670

Cybersecurity Fundamentals

Presented by

Dr. Mohammad Alkhatib



Outline

The module covers the basics of Network Communication

System including:

- Transmission Media,
- Topology and Types of Networks,
- TCP/IP Protocol Stack,
- Wireless Network,
- The Internet.

◆ **A set of communication elements connected by communication links**

⇒ Communication elements

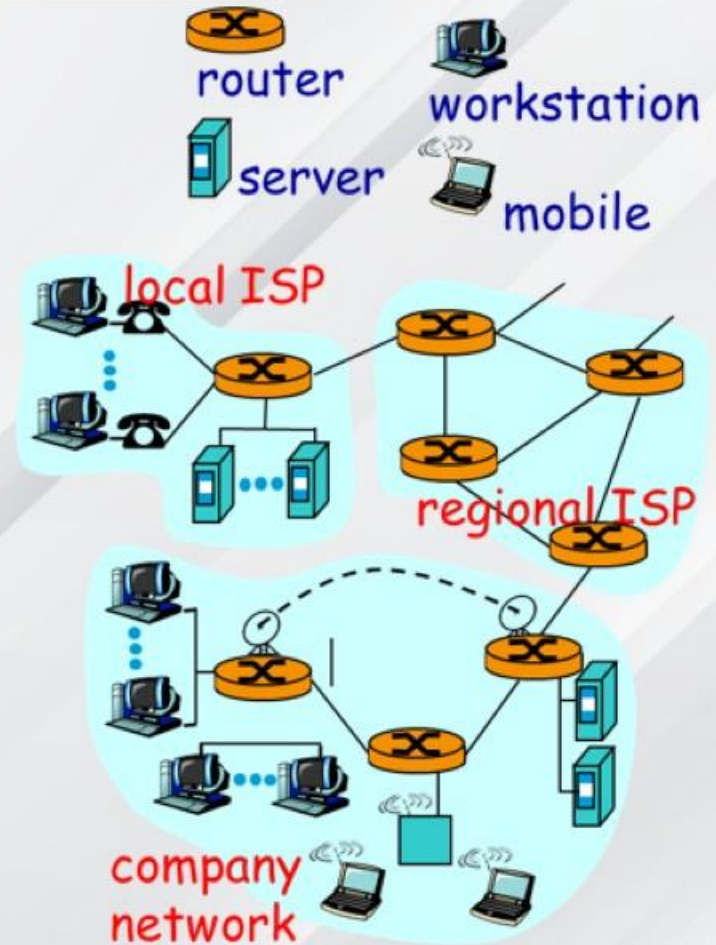
- Computers, printers, mobile phones, ...
- Routers, switches, ...

⇒ Communication links

- optic fiber
- coaxial cable
- twisted pair
- wireless (radio, microwave, satellite)

⇒ Topologies

- Ring, Star, Bus, Tree, Mesh



What is a Computer Network

◆ A software/hardware infrastructure

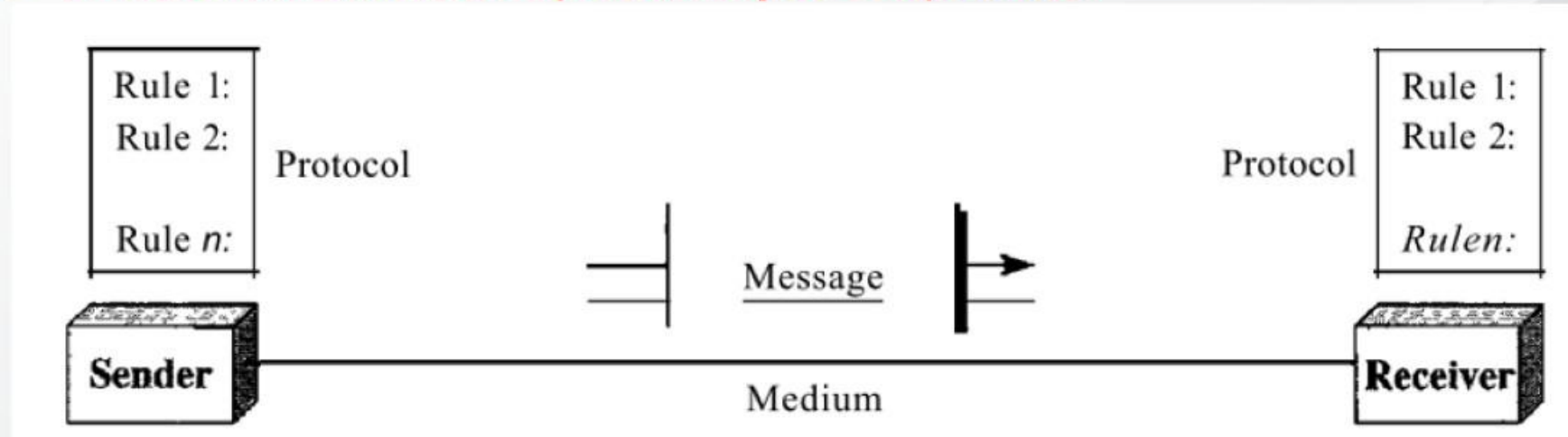
- ⇒ Share resources
 - data, files, computing power, video,...
- ⇒ Information highway
 - communication between geographically dispersed users
- ⇒ Electronic Society
 - Cyberspace
 - Virtual global nation

(Need for Networking)

- Business Applications
- Home Applications
- Mobile Users
- Social Issues

A data communications system components

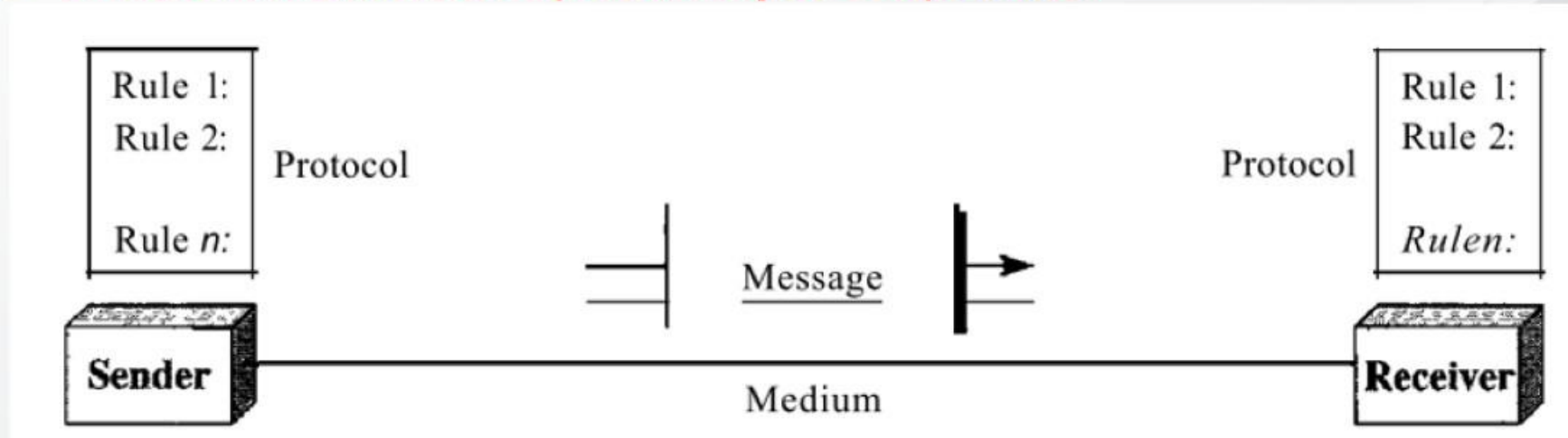
- ▶ *A data communications system has five components:*



1. **Message.** The message is the information (data) to be communicated. Popular forms of information include text, numbers, pictures, audio, and video.
2. **Sender.** The sender is the device that sends the data message. It can be a computer, workstation, telephone handset, video camera, and so on.

A data communications system components

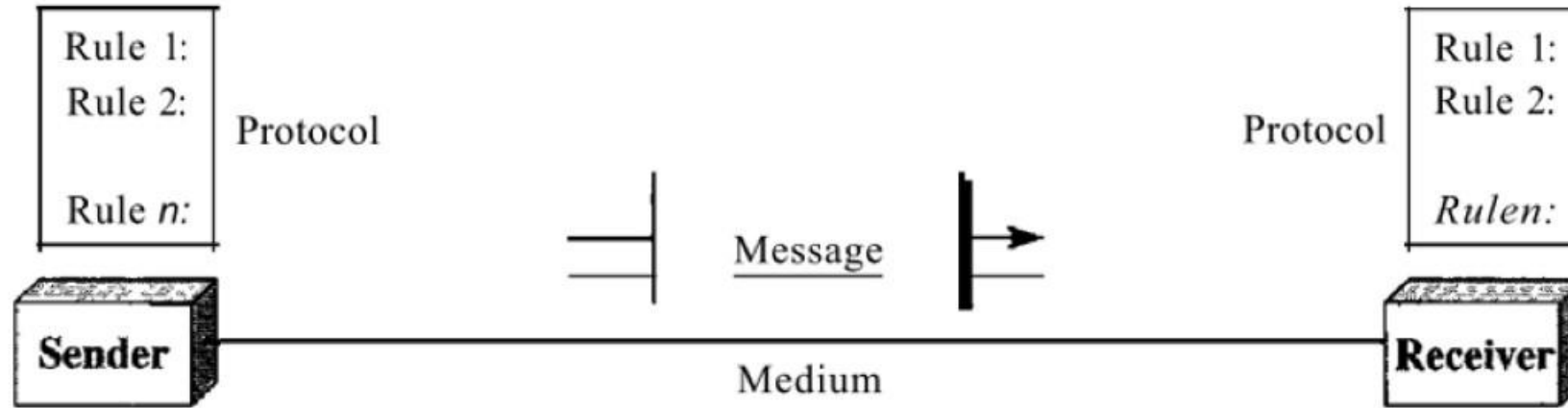
- ▶ *A data communications system has five components:*



3. **Receiver.** The receiver is the device that receives the message. It can be a computer, workstation, telephone handset, television, and so on.
4. **Transmission medium.** The transmission medium is the physical path by which a message travels from sender to receiver. Some examples of transmission media include twisted-pair wire, coaxial cable, fiber-optic cable, and radio waves.

A data communications system components

- ▶ *A data communications system has five components:*



5. **Protocol.** A protocol is a set of rules that govern data communications. It represents an agreement between the communicating devices. Without a protocol, two devices may be connected but not communicating, just as a person speaking French cannot be understood by a person who speaks only Japanese.

All computer communication involves encoding data in a form of energy, and sending the energy across a transmission medium (i.e., the network links).

Guided and Unguided Media

Links can be categorized by the type of path used:

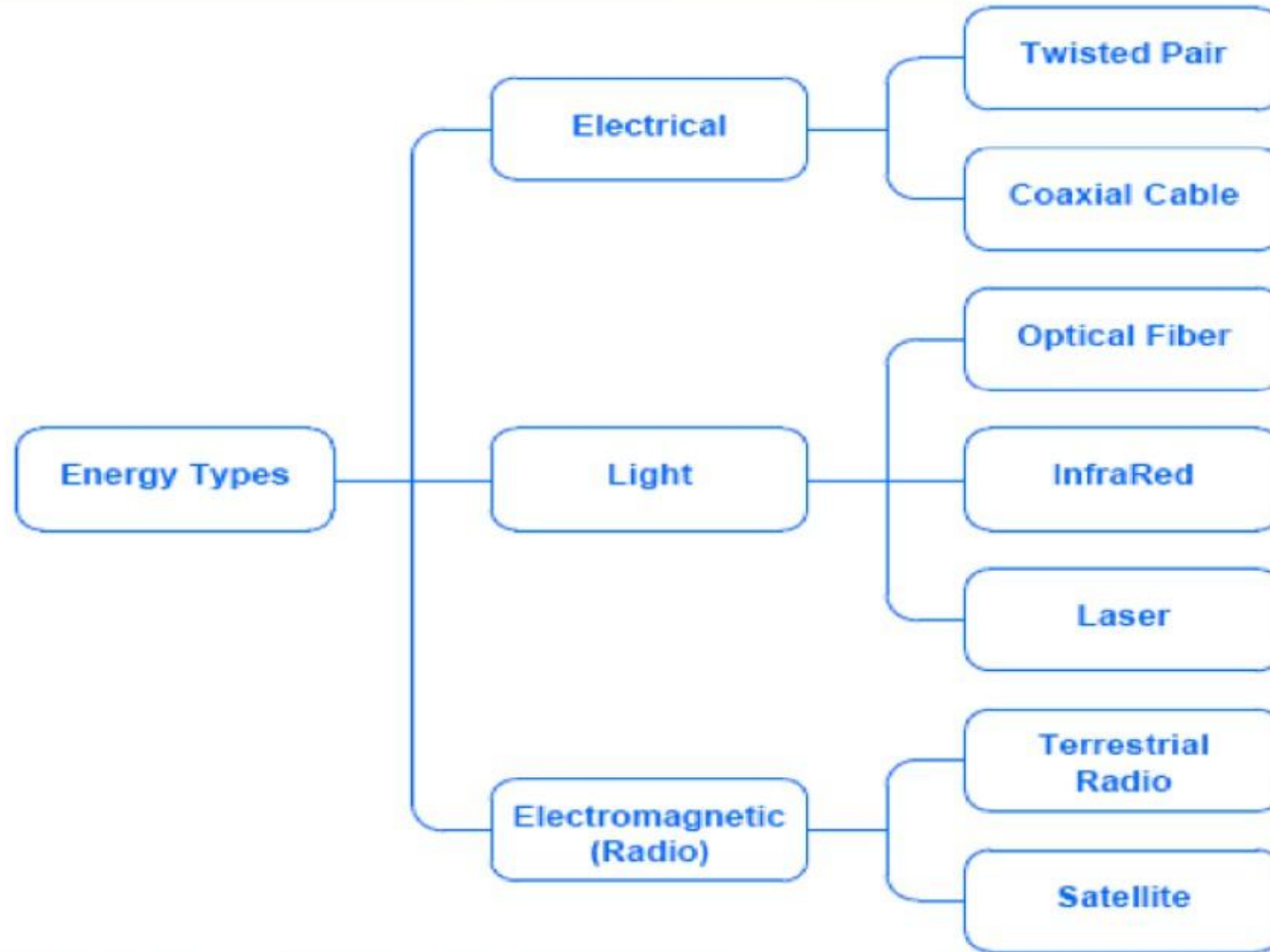
- ***Guided Media:*** communication follows an exact path (such as a wire)
- ***Unguided Media:*** communication follows no specific path (such as a radio transmission)

Forms of Energy

Links can be categorized by the type of energy used for transmission:

- ***Electrical Energy*** is used on wires
- ***Radio Frequency Transmission*** is used for wireless
- ***Light*** is used for optical fibers and lasers

Taxonomy by Forms of Energy



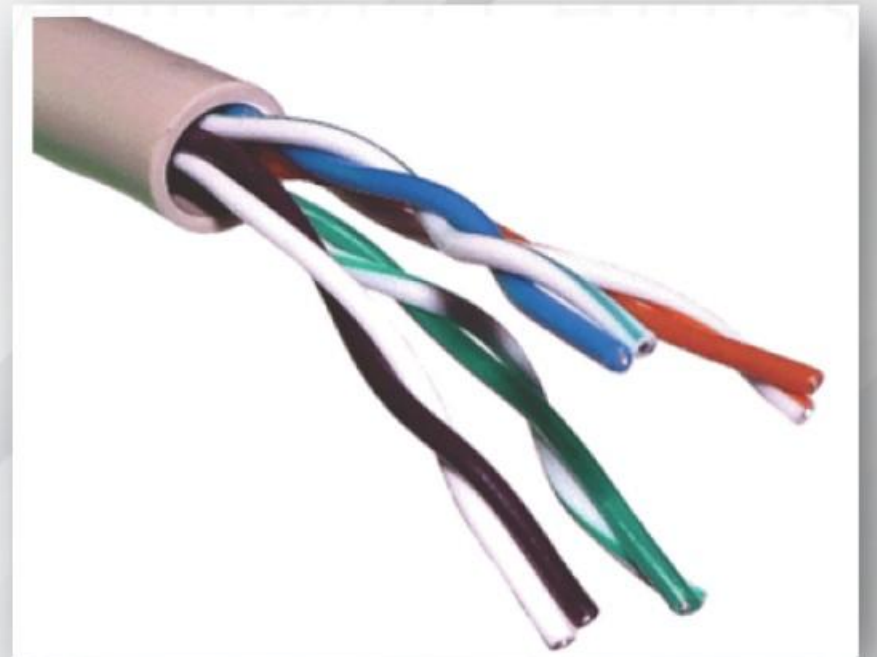
Three important facts about wiring:

1. Noise (also called random electromagnetic radiation) permeates the environment.
 - Even communication systems generate minor amounts of electrical noise as a side-effect of normal operation.
2. Noise can interfere with signals used for communication
 - When it hits metal, electromagnetic radiation produces a small signal
3. Because it absorbs radiation, metal acts as a shield preventing noise from reaching the wiring
 - Thus, placing enough metal between a source of noise and a communication medium can prevent noise from interfering

Example 1: Twisted pair lines

A pair of wires are twisted together (signal wire and ground reference wire).

Multiple twisted pairs can be enclosed within the same cable.



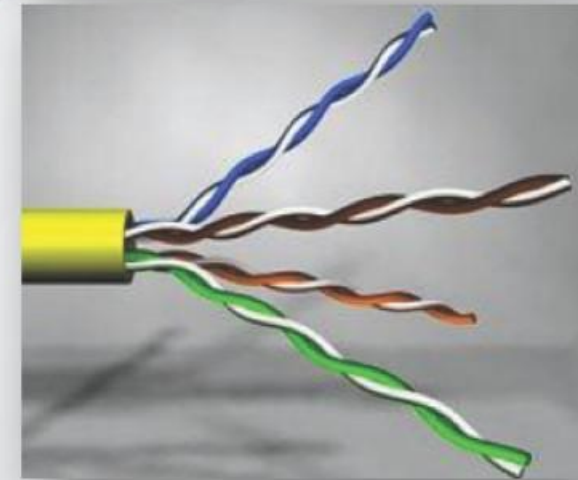
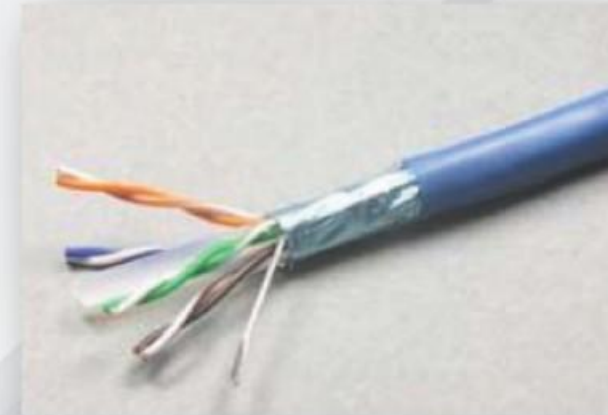
Multiple Twisted Pair Cable

Example 1: Twisted pair lines

Shielded twisted pairs (STP) are also used to reduce the effects of interference.

- Cat-5 is suitable for 10 - 100 Mbps for short distances (< 100m)

In telephone networks, unshielded twisted pairs (UTP) are extensively used with sophisticated driver and receiver circuits yielding higher bps over longer distances



Why is Twisted Pair “twisted”?

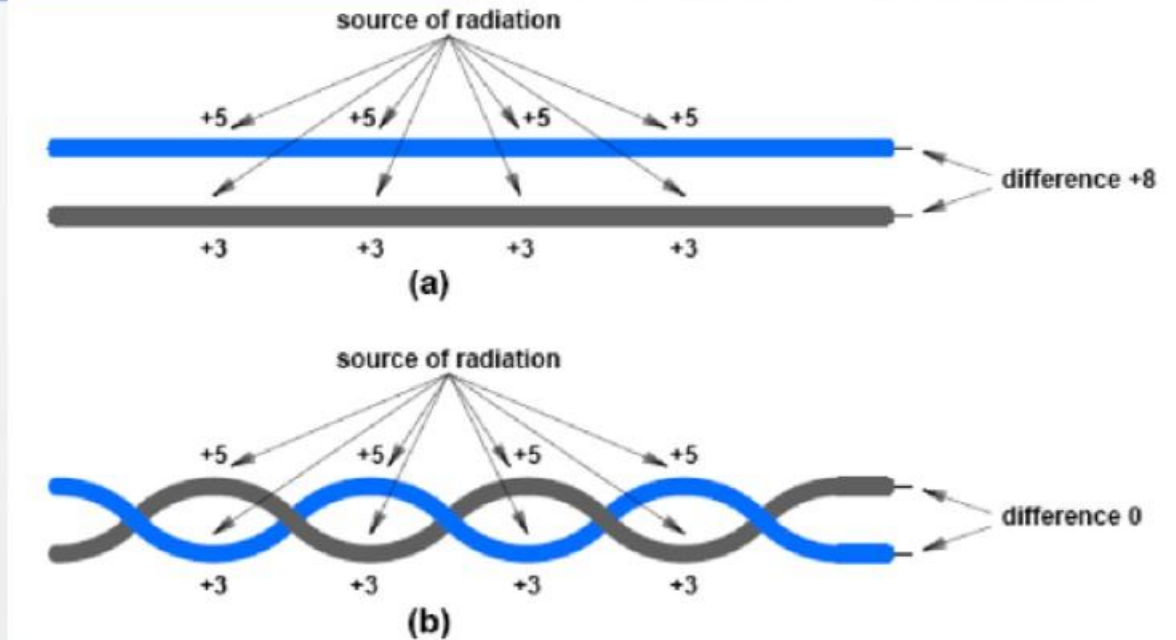
When two wires run in parallel:

- there is a high probability that one of them is closer to the source of electromagnetic radiation than the other
- one wire tends to act as a shield that absorbs some of the electromagnetic radiation
- thus, the second wire receives less energy.

Example: In the figure, a total of 32 units of radiation strikes in each case.

In (a): the top wire absorbs 20 units, and the bottom wire absorbs 12, producing a difference of 8

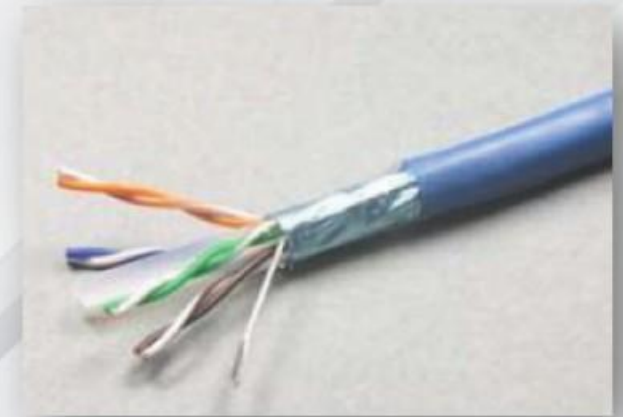
In (b): each of the two wires is on top one-half of the time, which means that each wire absorbs the same amount of radiation



Types of Twisted Pair

One variation is known as **shielded twisted pair (STP)**

- The cable has a thinner, more flexible metal shield surrounding one or more twisted pairs of wires.
- In most versions of STP cable, the shield consists of metal foil, similar to the aluminum foil used in a kitchen.



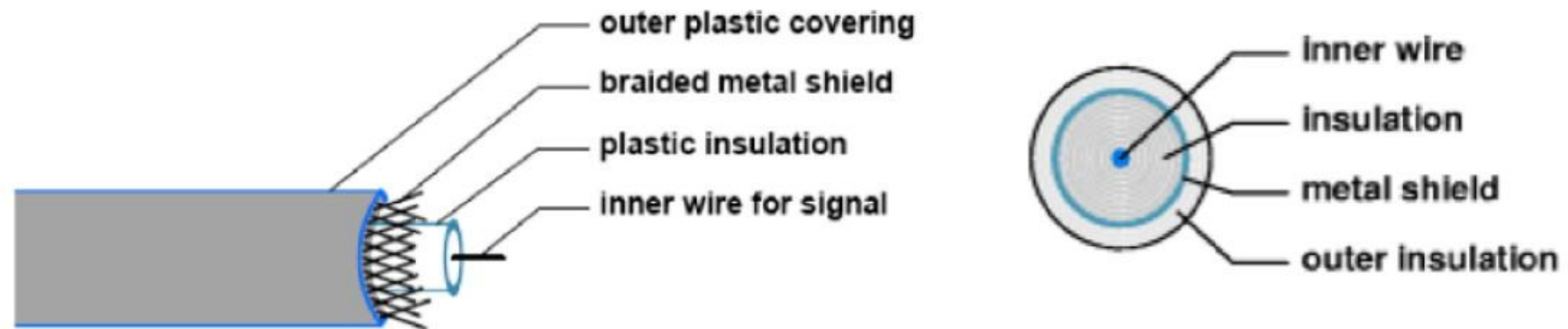
Category	Description	Data Rate (in Mbps)
CAT 1	Unshielded twisted pair used for telephones	< 0.1
CAT 2	Unshielded twisted pair used for T1 data	2
CAT 3	Improved CAT2 used for computer networks	10
CAT 4	Improved CAT3 used for Token Ring networks	20
CAT 5	Unshielded twisted pair used for networks	100
CAT 5E	Extended CAT5 for more noise immunity	125
CAT 6	Unshielded twisted pair tested for 200 Mbps	200
CAT 7	Shielded twisted pair with a foil shield around the entire cable plus a shield around each twisted pair	600

Example 2: Coaxial cable

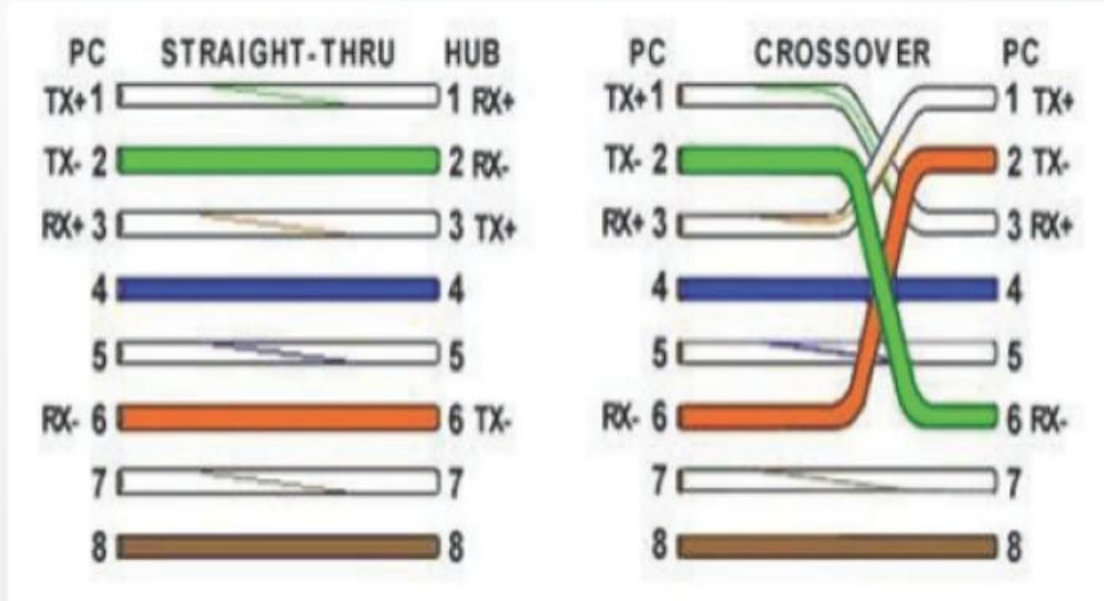
- The shield in a coaxial cable forms a flexible cylinder around the inner wire that provides a barrier to electromagnetic radiation from any direction
- The barrier also prevents signals on the inner wire from radiating electromagnetic energy

ThinNet: Supports 10-100 Mbps over ~200 meters

ThickNet: Supports 10-100 Mbps over ~500 meters



➤ Connection Types for UTP & STP Cable



Straight cable used between different devices such as PC and Switches

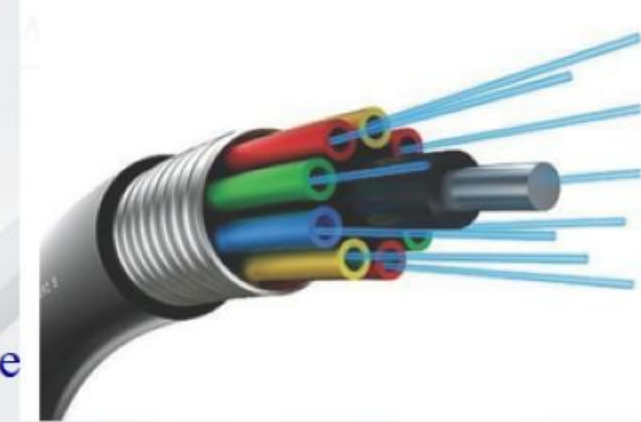
Crossover Cable used between same types of devices such as Switch with Switch



RJ-45 Connector

Optical fiber:

- carries the transmitted information as a fluctuating beam of light
- is immune to electromagnetic interference and crosstalk
- is good for security, because it is difficult to tap an optical fiber cable
- supports transmission rates of hundreds of megabits per second over several kilometers.



Components:

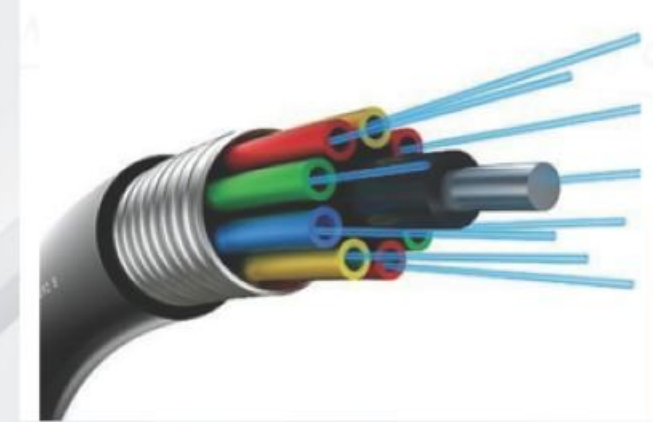
- Single glass fiber for each signal
- Optical transmitter (light-emitting diode (LED) or injection diode (ILD)) converts from electrical signals to a light signal
- Optical Receiver (photodiode or photo transistor) converts from light signals to electrical

➤ *Fiber Optic Advantages*

- ▶ greater capacity (bandwidth of up to 2 Gbps)
- ▶ smaller size and lighter weight
- ▶ lower attenuation
- ▶ immunity to environmental interference
- ▶ highly secure due to tap difficulty and lack of signal radiation

➤ *Fiber Optic Disadvantages*

- ▶ expensive over short distance
- ▶ requires highly skilled installers
- ▶ adding additional nodes is difficult



Comparing Copper Wiring and Fiber

Optical Fiber

- Immune to electrical noise
- Less signal attenuation
- Higher bandwidth

+ Harder to tap into fiber

Copper

- Lower overall cost
- Less expertise/equipment needed
- Less easily broken

Why we need a topology?

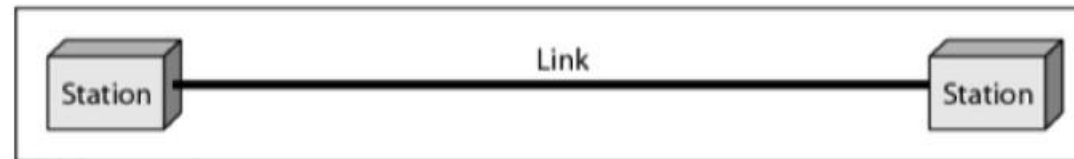
Choosing one topology over another can impact :

- ▶ type of equipment the network needs
- ▶ capabilities of the equipment
- ▶ network's growth
- ▶ way a network is managed

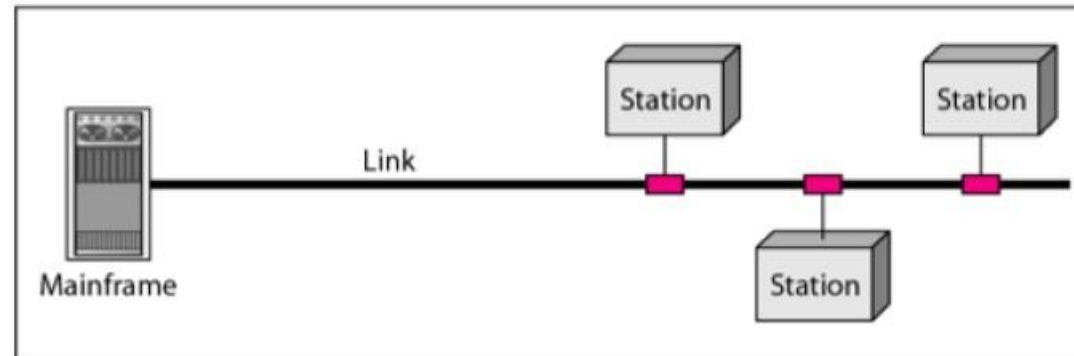
- *The topology* of a network defines how the nodes of a network are connected.
- A network is defined by a *physical topology* and a *logical topology*.
- *Physical topology* defines how the nodes of the network are physically connected .
- *Logical topology* dedicated connections between certain selected source-destination pairs using the underlying physical topology.
- In order to have an efficient system, the logical topology should be chosen such that either the average hop distance or the packet delay or the maximum flow on any link must be minimal.
- Another important issue to select the logical topology is the simplicity of the routing.

Categorizing Networks

- Based on link configuration:
 - Point-to-point (two devices)
 - Point-to-multipoint (shared among N devices)
 - Easier to allow multiple devices to communicate with each other
 - Harder to control the “sharing” of the medium

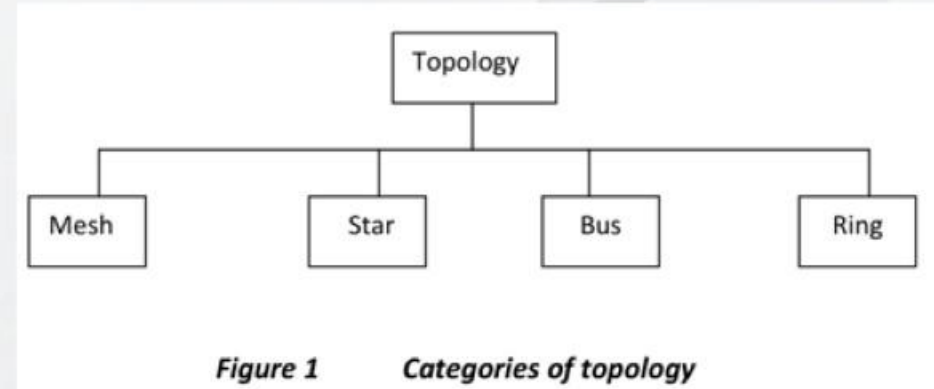


a. Point-to-point



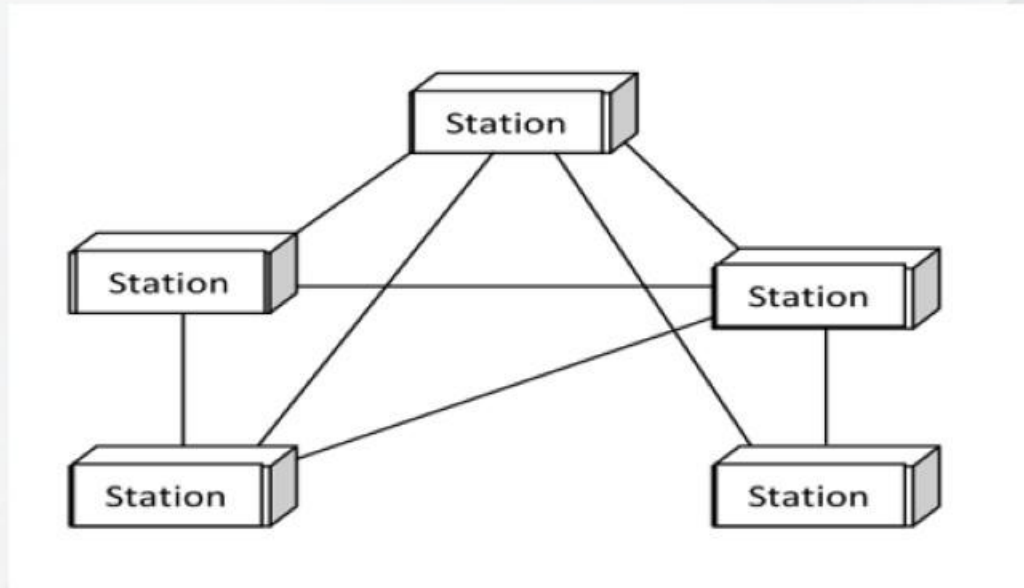
b. Multipoint

- ▶ The topology of a network is the geometric representation of the relationship of all the links and linking devices (usually called nodes) to one another.
- ▶ Physical topology: physical layout of nodes on a network
- ▶ Four fundamental shapes:
 - 1 The Bus Network
 - 2 Hub/Tree Network
 - 3 Star Network
 - 4 Ring Network
- ▶ May create hybrid topologies
- ▶ Topology integral to type of network, cabling infrastructure, and transmission media used



❖ *Mesh*

- ▶ Every device has a dedicated point to point link to every other device.
- ▶ The term dedicated means that the link carries traffic only between the two devices it connects.



Advantages & Disadvantages of Mesh Topology

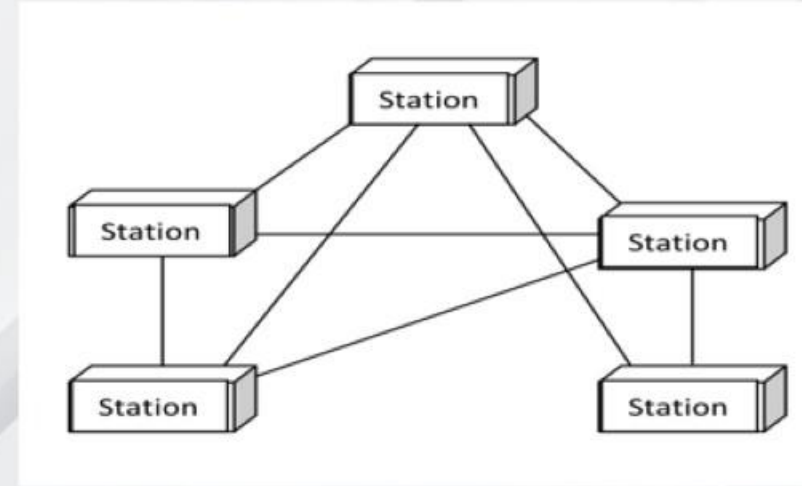
□ Advantages

1. Use of dedicated links guarantees that each connection can carry its own data load.
2. A mesh topology is robust.
3. The advantage of privacy or security
4. Point to point links make fault identification and fault isolation easy

This enables the network manager to discover the exact location of the fault and helps in finding its cause and solution.

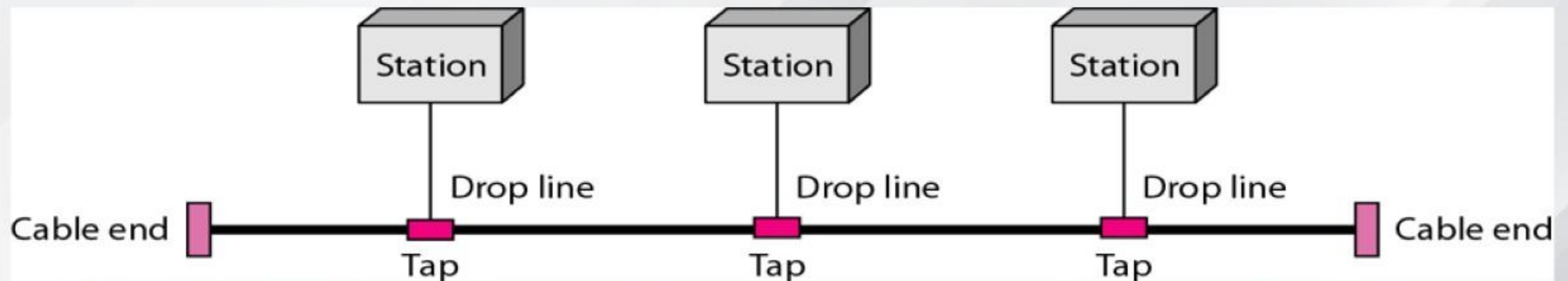
□ Disadvantages

The amount of cabling and that of I/O ports required: - installation and reconnection are difficult, - the wiring can be greater than the available Space, - the hardware required to connect each link



Bus Topology

- ▶ Single cable connects all network nodes without intervening connectivity devices
- ▶ Devices share responsibility for getting data from one point to another
- ▶ **Terminators** stop signals after reaching end of wire
 - ▶ Prevent signal bounce
- ▶ Inexpensive, not very scalable
- ▶ Difficult to troubleshoot, not fault-tolerant

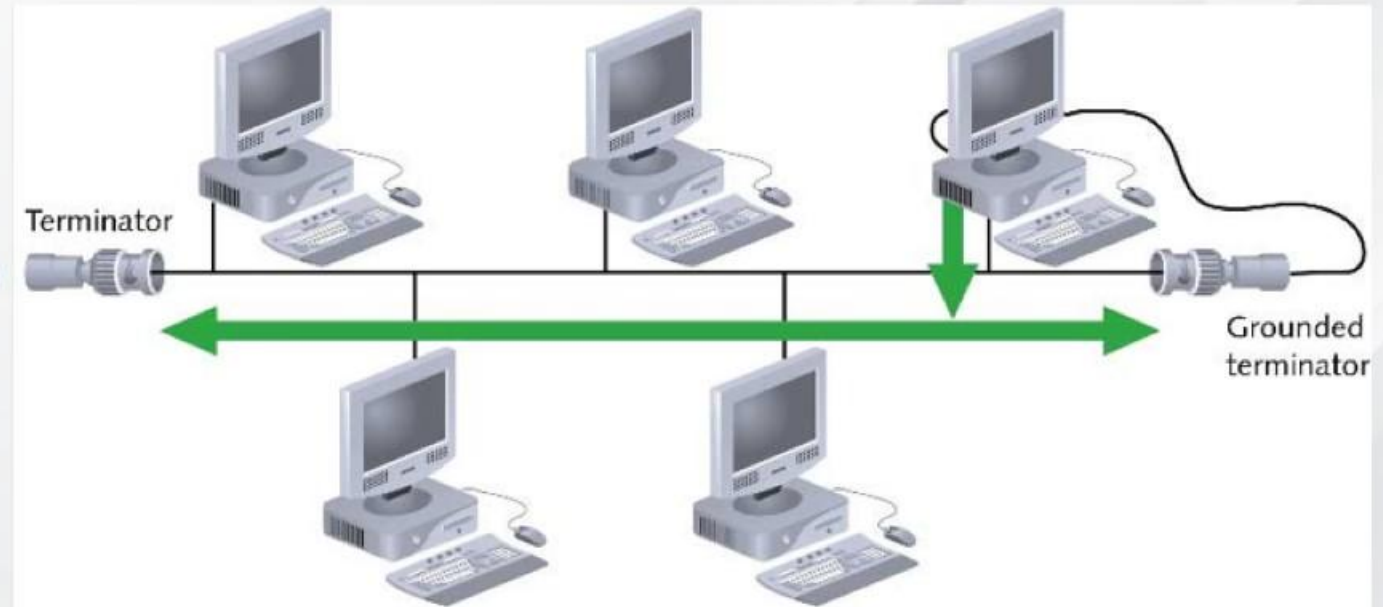


Advantages

- ▶ Works well for small networks
- ▶ Relatively inexpensive to implement
- ▶ Easy to add to it

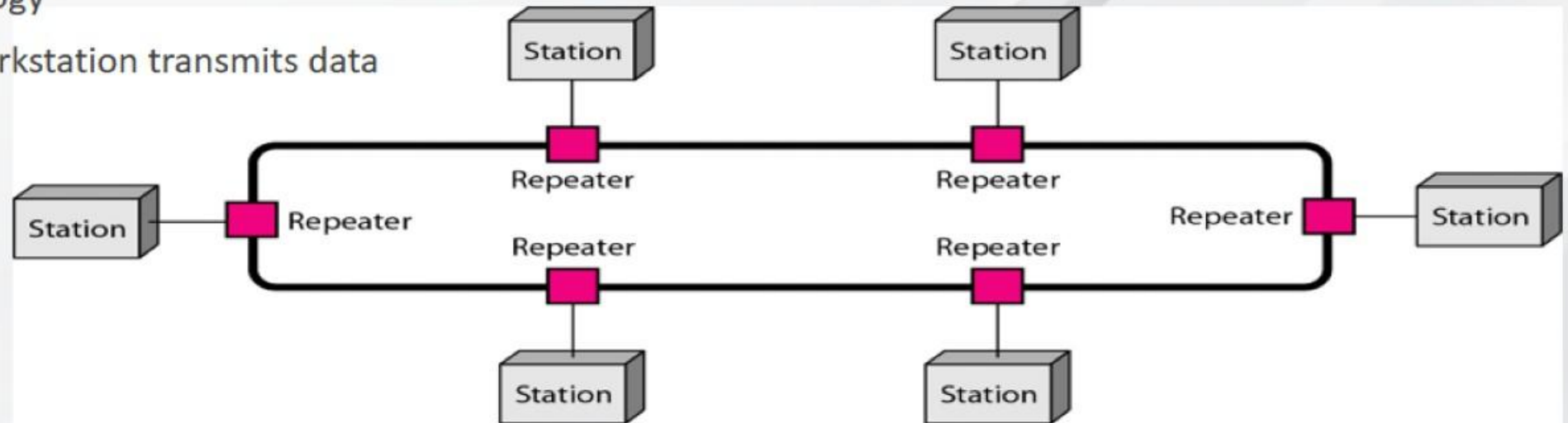
Disadvantages

- ▶ Management costs can be high
- ▶ Potential for congestion with network traffic



Ring Topology

- ▶ Each node is connected to the two nearest nodes so the entire network forms a circle
- ▶ One method for passing data on ring networks is **token passing**
- ▶ Active topology
 - ▶ Each workstation transmits data



- The unidirectional traffic can be a disadvantage.
- In a simple ring, a break in the ring (such as a disabled station) can disable the entire network. This weakness can be solved by using a dual ring or a switch capable of closing off the break.

Advantages and Disadvantages of Ring Topology

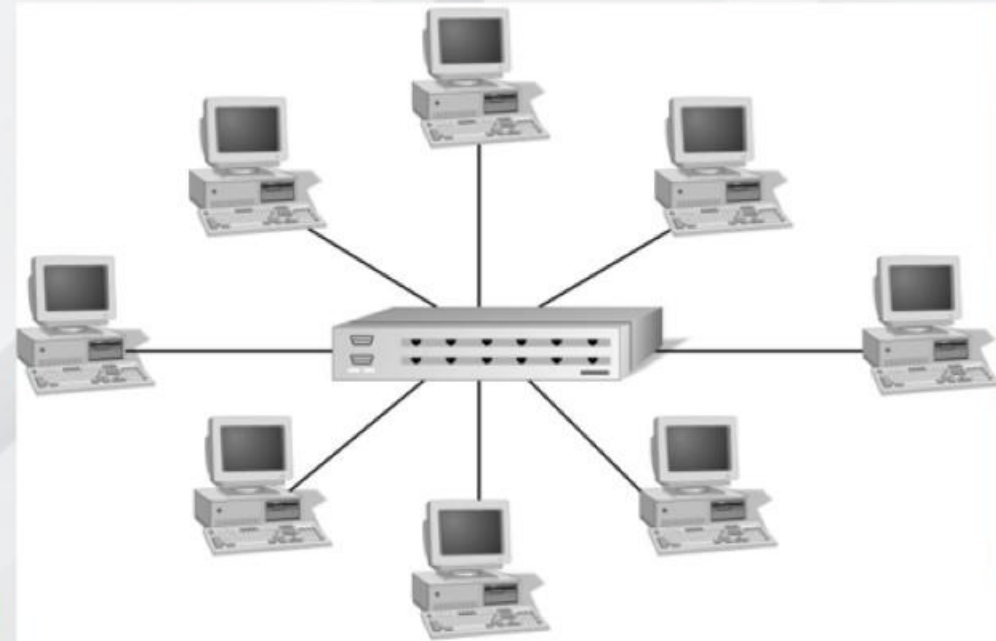
Advantage

- S** ▶ 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

- ▶ **Every node on the network is connected through a central device**
- ▶ Any single cable connects only two devices
 - ▶ Cabling problems affect two nodes at most
- ▶ Requires more cabling than ring or bus networks
 - ▶ More fault-tolerant
- ▶ Easily moved, isolated, or interconnected with other networks
 - ▶ Scalable
- ▶ Supports max of 1024 addressable nodes on logical network



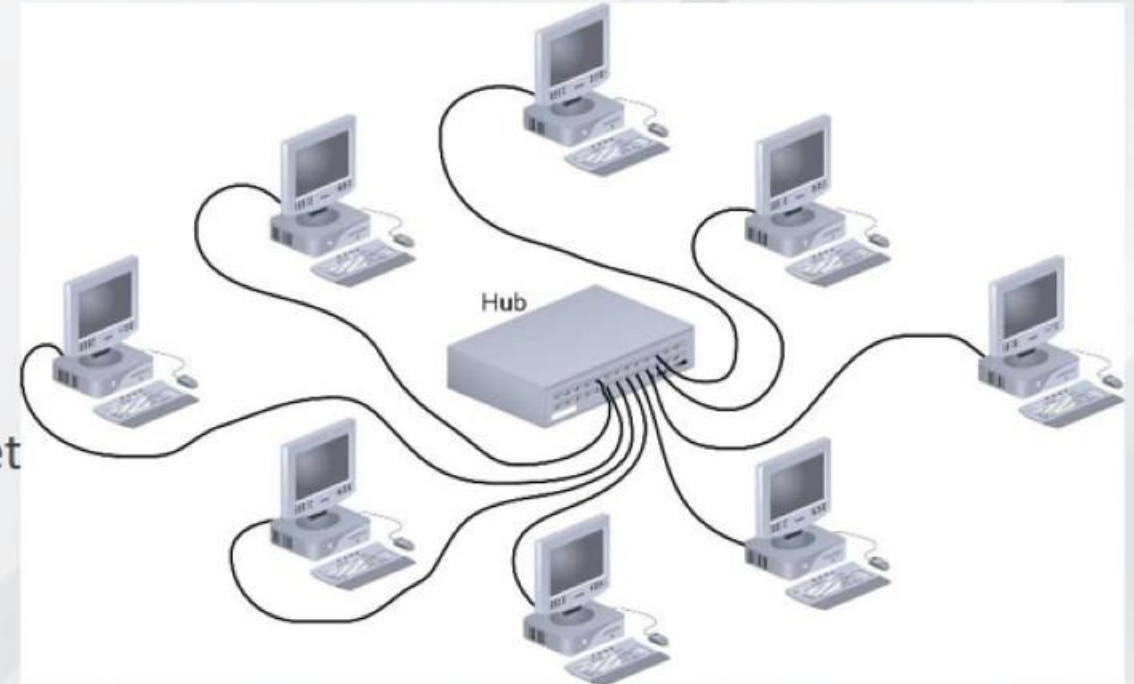
Advantages & Disadvantages of Star Topology

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

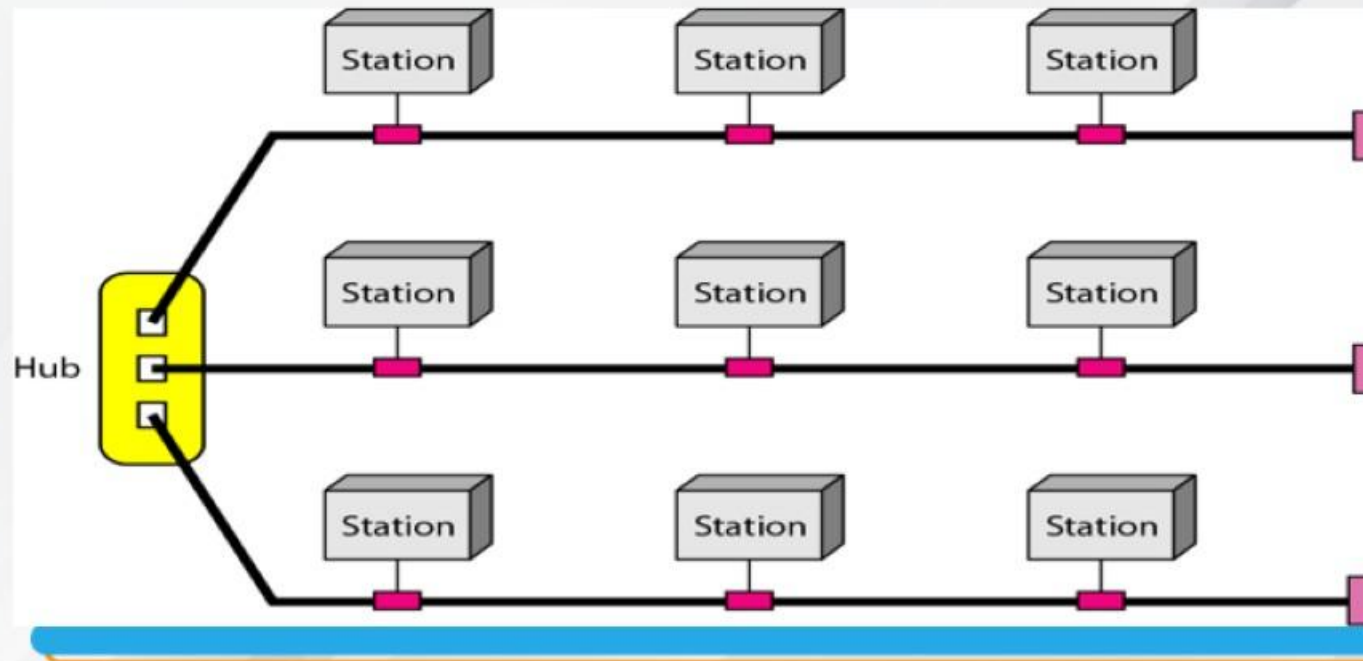
- ▶ Hub is a single point of failure
- ▶ Requires more cable than the bus



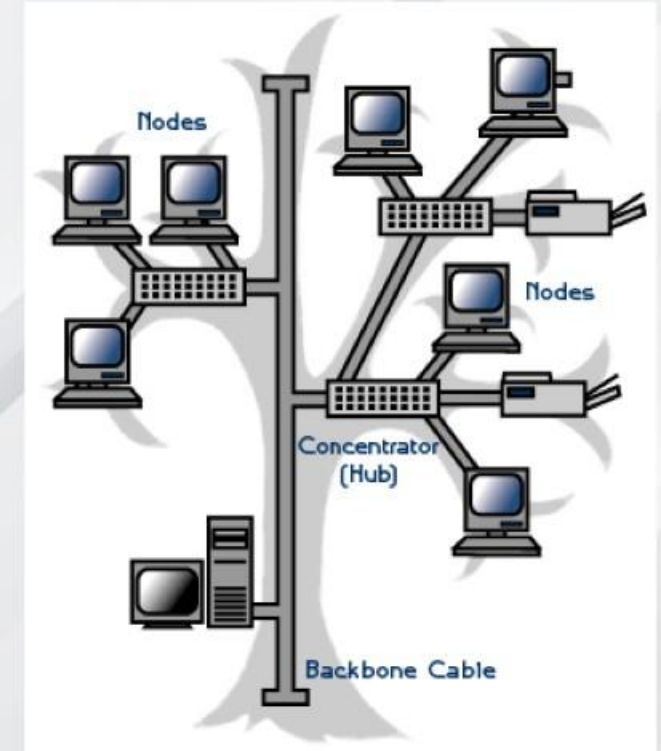
❖ *Hybrid Topology*

A network can be hybrid. For example, we can have a main star topology with each branch connecting several stations in a bus topology

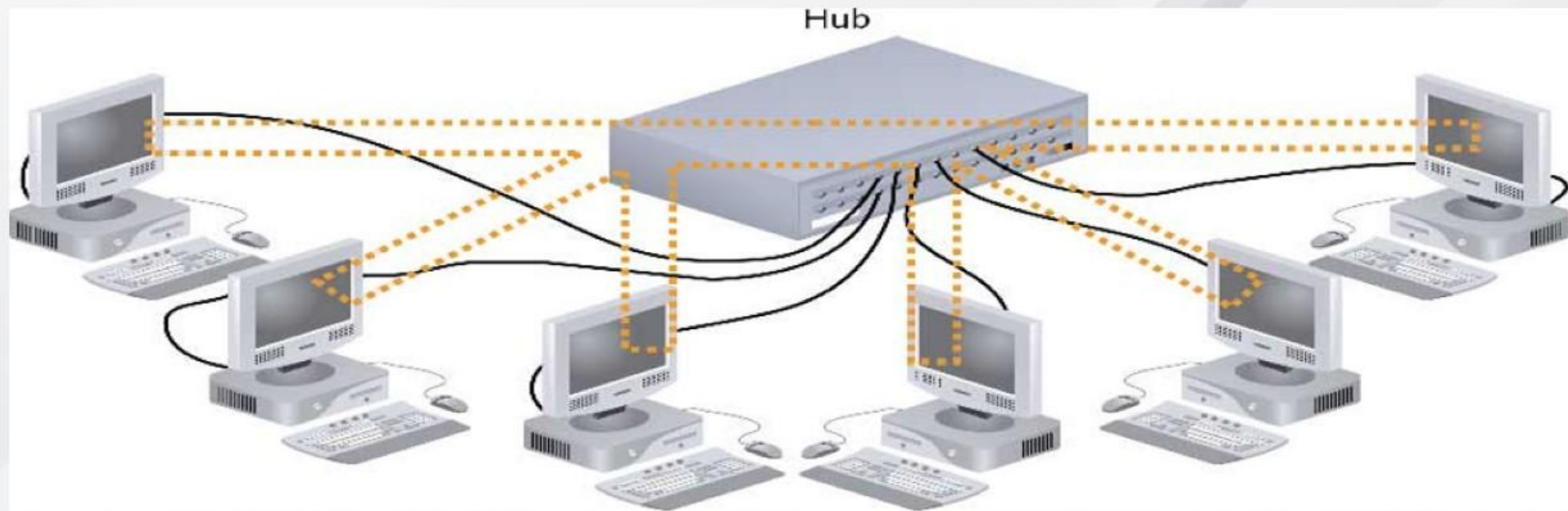
- Combination of two or more network topology



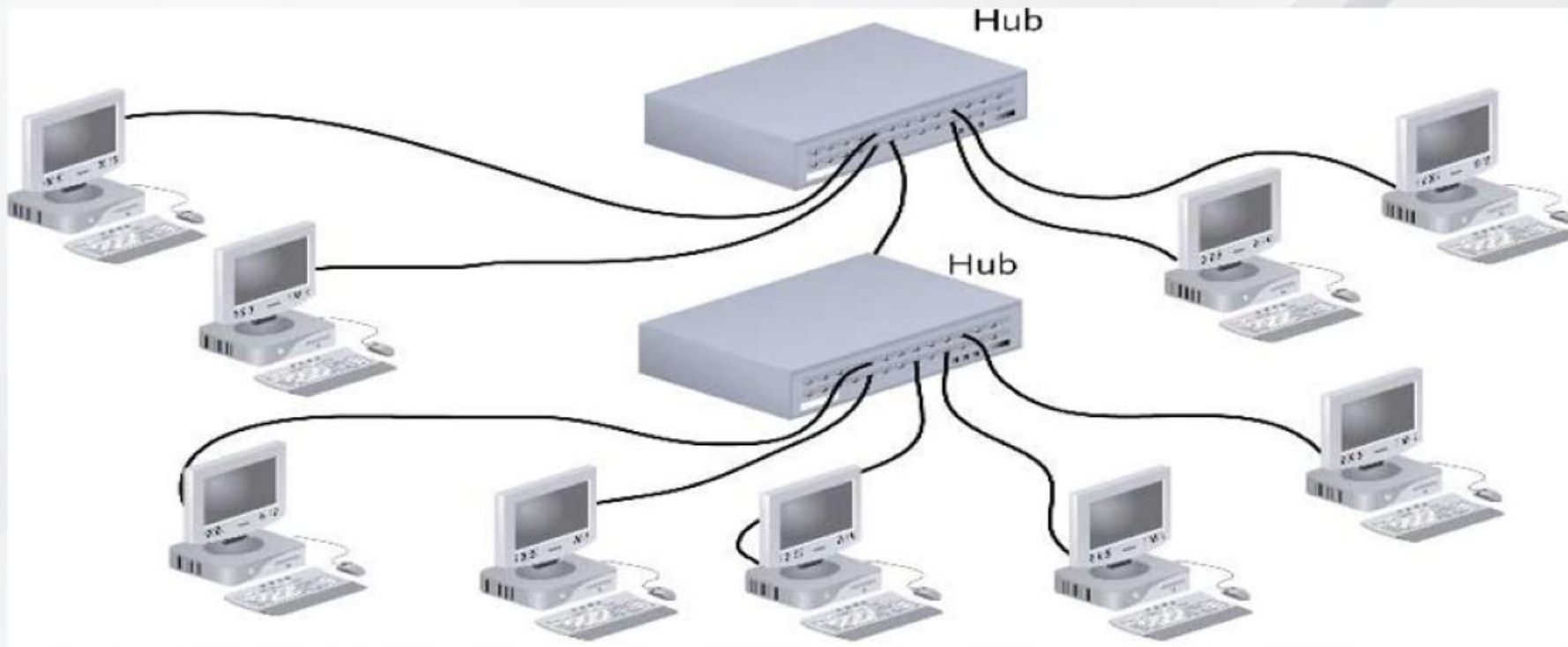
- One example of **Hybrid Topology** is **Tree topology**
- *Tree topology* is a combination of Bus and Star topology.
- It consists of groups of star-configured workstations connected to a linear bus backbone cable.
- If the backbone line breaks, the entire segment goes down
- An example of this network could be cable TV technology



- *Star-Wired Ring*



- ***Star-Wired Bus***



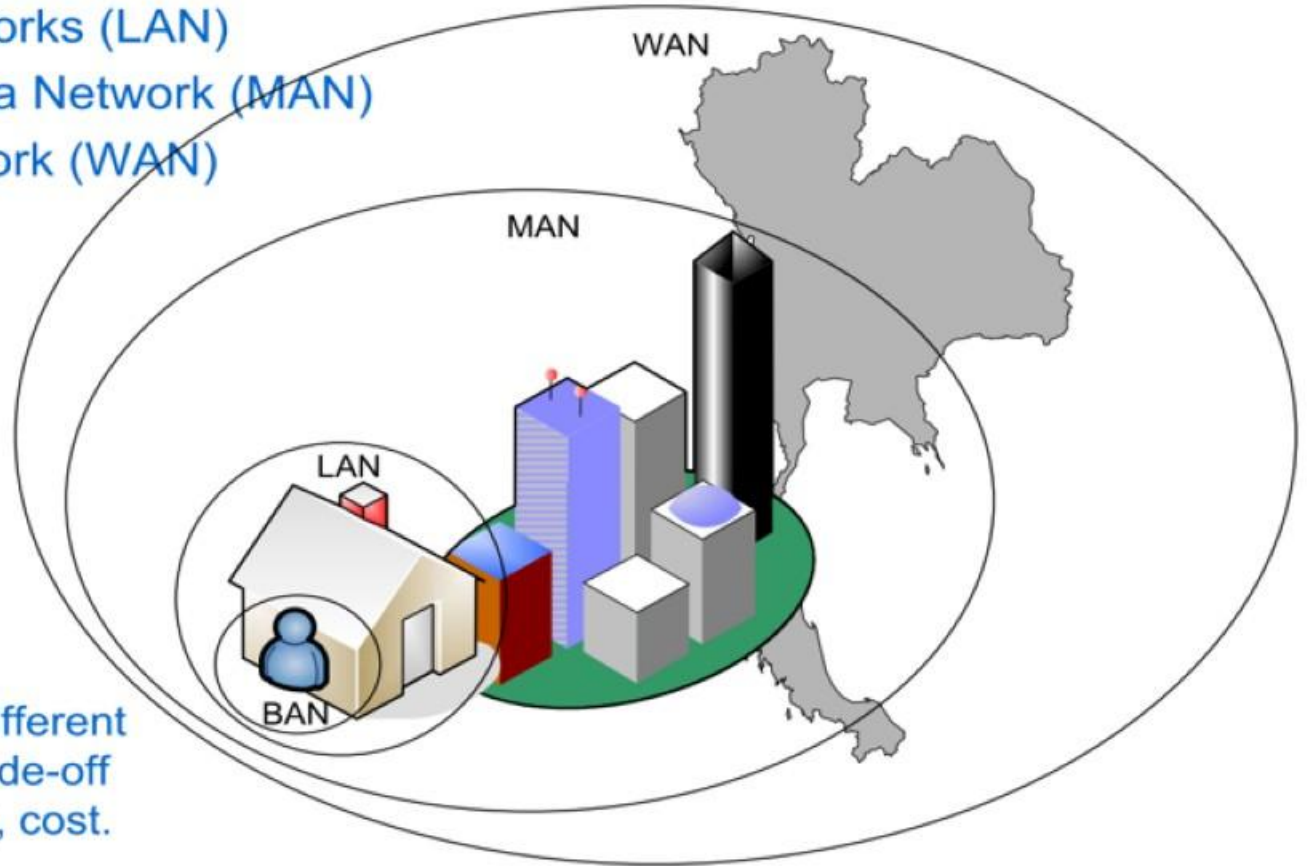
- ▶ **Logical topology:** how data is transmitted between nodes
 - ▶ May not match physical topology
- ▶ **Bus logical topology:** signals travel from one network device to all other devices on network
 - ▶ Required by bus, star, star-wired physical topologies
- ▶ **Ring logical topology:** signals follow circular path between sender and receiver
 - ▶ Required by ring, star-wired ring topologies

Type of Networks

- Based on geographical coverage:
 - Body Area Networks (BAN)
 - Local Area Networks (LAN)
 - Metropolitan Area Network (MAN)
 - Wide Area Network (WAN)

Users of networks have different requirements.

Transmission media have different physical characteristics. Trade-off between data rate, distance, cost.

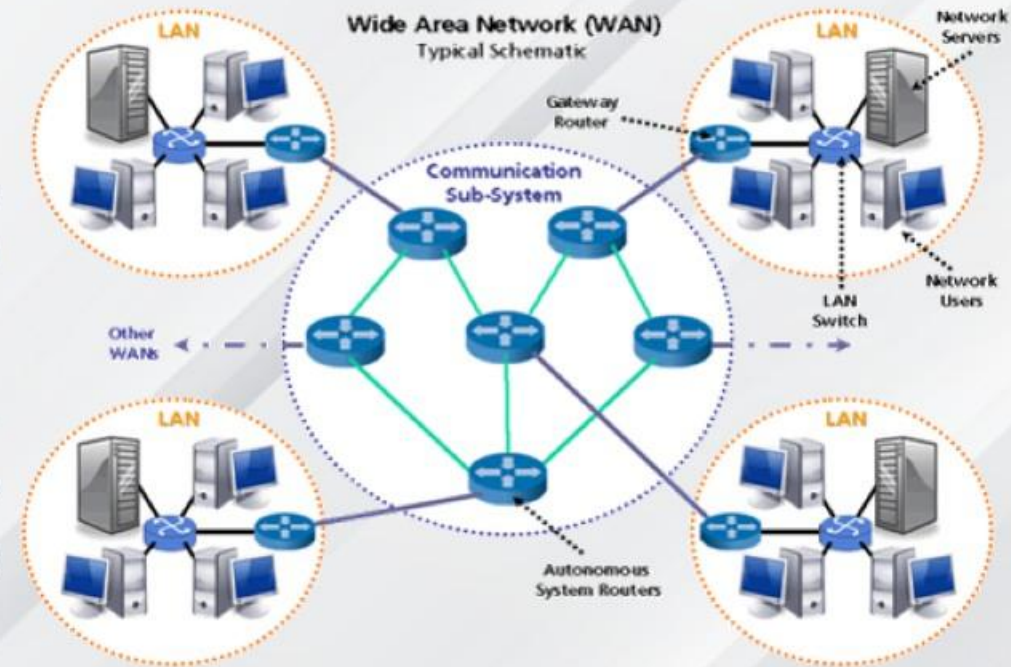


Categories of Networks / Network Technologies

- ▶ Today There are two primary categories: local area networks (LANs) and wide area networks (WANs).
- ▶ The category into which a network falls is determined by its size.
- ▶ A LAN normally covers an area less than 2 miles; a WAN can be worldwide.
- ▶ Networks of a size in between are normally referred to as metropolitan area networks (MANs) and span tens of miles.

Wide Area Network (WAN)

- ▶ WAN provides long distance transmission of data, image, audio, video information over large geographic area that may comprise a country, a continent or even the whole world.
- ▶ **Switched WAN:** complex as the backbones that connect the Internet.
 - The switched WAN connects the end systems which usually comprise a router (internet – working connecting devices) that connects together LAN or WAN.
- ▶ **Point to Point WAN:** simple as a dial-up line that a home computer to the Internet.



The point to point WAN is normally a line leased from a telephone or cable T.V provider that connects a home computer or a small LAN to an Internet service provider (ISP).

❖ *Interconnection of Networks: Internetwork*

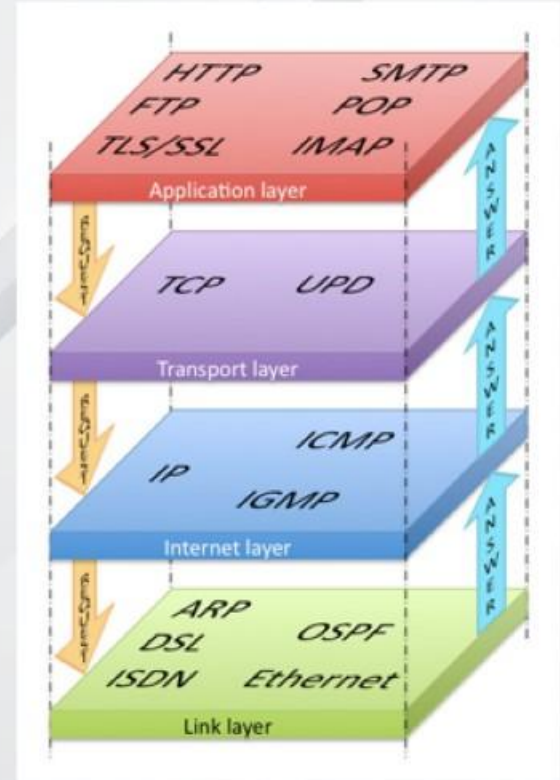
- Today, it is very rare to see a LAN, a MAN or a WAN in isolation; they are connected to one another.
- When two or more networks are connected, they become an internetwork or internet.



Internet: A network of networks, joining many government, university and private computers together and providing an infrastructure for the use of E-mail, bulletin boards, file archives, hypertext documents, databases and other computational resources.

Internet: The largest network of networks in the world.

- The **TCP/IP Stack**, or the internet protocol suite, is a set of communication protocols used by the Internet or similar networks.
- The TCP/IP stack comprises a series of Protocols (HTTP, FTP, SMTP, ISDN, IGMP, ARP).
- The TCP/IP Stack works just like the **OSI model** by establishing a set of rules and standards for communication in and between the different layers. These rules ensure that different products can communicate with each other because they are developed around the same guidelines.



► *What is a wireless network?*

- A technology that enables two or more entities to communicate without network cabling



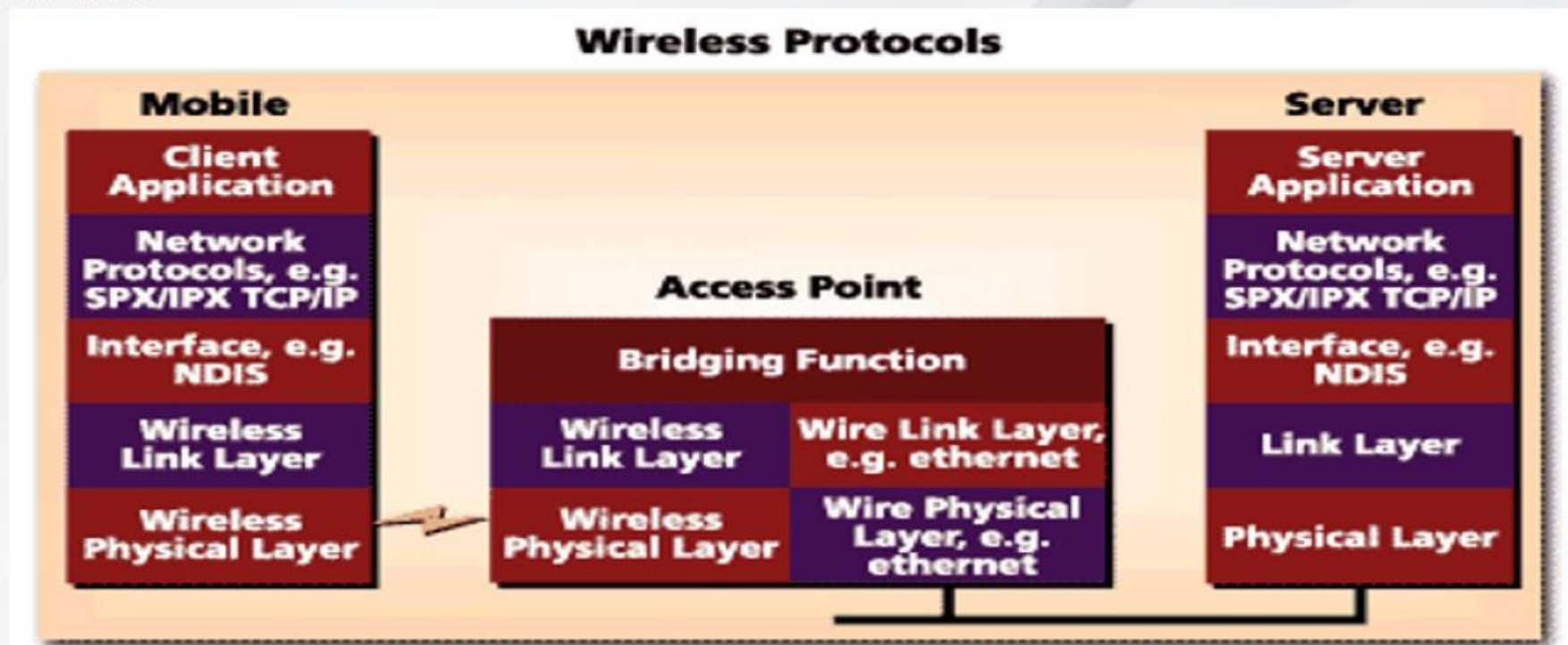
Complete Wireless Networks

- ▶ The physical size of the network is determined by the maximum reliable propagation range of the radio signals
- ▶ Referred to as **ad hoc** networks
- ▶ Are self-organizing networks without any centralized control
- ▶ Suited for temporary situations such as meetings and conferences.



Integration With Existing Networks

- ▶ Wireless Access Points (APs) - a small device that bridges wireless traffic to your network.
- ▶ Most access points bridge wireless LANs into **Ethernet networks**, but Token-Ring options are available as well.



Self Assignment Question:

- 1- What is the Backbone Networks: Serial Backbone and Daisy chain?
- 2- OSI model.

The END 😊



Thank You