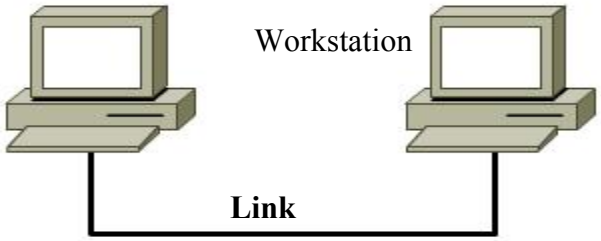
TOPIC 2: BASIC CONCEPTS

Line Configuration – defines the attachment of communication devices to a link

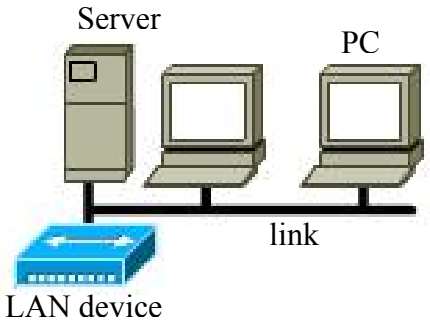
Link – a physical communication pathway that transfers data from one device to another.

Types:

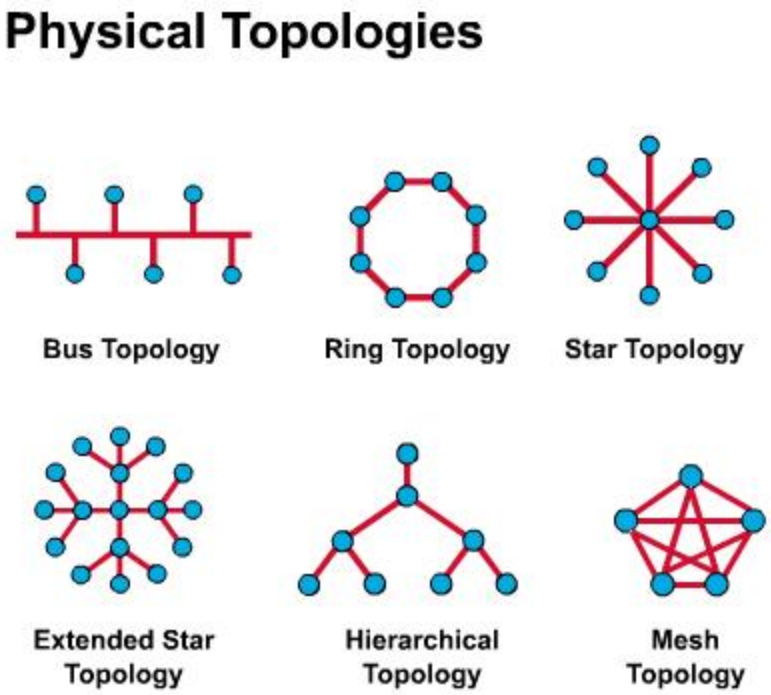
1. **point-to-point** – a line configuration where two and only two devices are connected by a dedicated link.



2. **multipoint** – a line configuration in which more than two specific devices share a single link



Topology – defines the structure of the network. There are two parts to the topology definition: the physical topology, which is the actual layout of the wire (media), and the logical topology, which defines how the media is accessed by the hosts.



1. **Mesh** – a topology where every device has a dedicated point-to-point link to every other device. A fully connected mesh network has [n(n-1)]/2 physical channels to link n devices. To accommodate such number of links, every device on the network must have n –1 input/output (I/O) ports.

   Advantages:
   - the use of dedicated links guarantees that each connection can carry its own load
   - robust
   - evidence of privacy and security
   - ease in fault identification and fault isolation

   Disadvantages:
   - difficulty in installation and reconfiguration
   - sheer bulk of wiring can be greater than the available space
   - hardware requirements to connect each link is relatively expensive

2. **Star** – Each device has a dedicated point-to-point link only to a central controller, generally called a **hub**.

   Advantages:

   - less expensive as compared to mesh topology
   - ease in installation and configuration
   - robustness

   Disadvantage: more cabling is required in a star than in some other topologies (except mesh)

3. **Extended star -** An extended star topology uses the star topology to be created. It links individual stars together by linking the hubs/switches. This extends the length and size of the network.

   - *Advantages:*
   - takes all the advantages of the star topology
   - more devices may be attached; hence, network size is increased
   - allows the network to isolate and prioritize communications from different computers.

   Disadvantage: a break in the cable connecting two hubs will isolate the network beyond the break.

4. **Bus** – a multipoint configuration where a long cable acts as a backbone to link all the devices in the network.

   drop line – a connection running between the device and the main cable.

   tap - a connector that either splices the main cable or punctures the sheathing of a cable to create a contact with the metallic core.

   Advantage: ease of installation since less cabling is required.

   Disadvantages:

   - difficulty in reconfiguration and fault isolation
   - network won't transmit correctly if even one node on the network is malfunctioning
   - cable breaks may cause problems for the bus topology

5. **Ring** – a topology where each device has a dedicated point-to-point line configuration only with the two devices on either side of it. Each device in the ring incorporates a repeater.

   Advantages:
   - relatively easy to install and reconfigure
   - simplified fault isolation

   Disadvantage: a break in the ring (like a disabled station) can disable the entire network.

6. **Hierarchical** - created similar to an extended star but instead of linking the hubs/switches together, the system is linked to a computer that controls the traffic on the topology.

7. **Hybrid** – combination of topologies acting as subnetworks linked together in a larger topology.

Transmission Mode – defines the direction of information flow between two linked devices

1. **Simplex** – communication is unidirectional; only one of the two stations on a link can transmit; the other can only receive.
2. **Half-duplex** – each station can both transmit and receive, but not at the same time. When one item is sending, the other device can only receive, and vice versa.
3. **Full-duplex** – both stations can transmit and receive simultaneously.

Categories of Networks

Into which category a network falls is determined by its size, its ownership, the distance it covers and its physical architecture.

1. **Local Area Network (LAN)** – LANs are designed to:
   - Operate within a limited geographic area
   - Allow many users to access high bandwidth media
   - Control the network privately under the local administration
   - Provide full-time connectivity to local services
   - Connect physically adjacent devices

2. **Metropolitan Area Network (MAN)** - Network that spans a metropolitan area or designed to extend over a city. A MAN may be wholly owned or operated by a private company.
3. **Wide Area Network (WAN)** – WANs are designed to:
    - Operate over a large geographic area
    - Allow access over serial interfaces operating at lower speeds
    - Provide full-time and part-time connectivity
    - Connect devices separated over wide, even global areas.

internet – a contraction of the word internetwork, which is a connection of two or more networks.

Note: The term *internet* should not be confused with the term *Internet*

3 Roles for Computers in a LAN

1. **Clients**, which us but do not provide network resources
2. **Peers**, which both use and provide network resources
3. **Servers,** which provide network resources

Based on the roles of the computers attached to them, networks are divided into three parts:

- **Server-based** – contains clients and the servers that support them
- **Peer** – has no servers and uses the network to share resources among independent peers
- **Hybrid network** – a client-server network that also has peer-sharing resources.

SIGNALS

Basic Concepts

- ✓ Information can be in the form of data, voice, picture and so on.
- ✓ Generally, the information usable to the person or application is not in a form that can be transmitted over a network.
- ✓ Instead, an encoder is normally used to create a stream of 0s and 1s and tells the receiving device to reconstruct the information.
- ✓ Even the 0s and 1s cannot be sent across the network links. For transmission to be possible, information must be transformed into electromagnetic signals.
- ✓ Data can be analog or digital.
- ✓ Signals can be analog or digital (like the information they represent). Analog signals can have any value in a range; digital signals can only have a limited number of values.

Forms of signals

Periodic signal – signal that completes a pattern within a measurable time frame and repeats over identical subsequent periods

Period – amount of time required to complete one cycle.

Aperiodic signal – a signal having no repetitive pattern

It has been proved that any aperiodic signal can be decomposed into an infinite number of periodic signals.

Analog Signals

Sine wave – most fundamental form of a periodic signal. A sine wave can be fully described by three fundamental characteristics:

Amplitude – generally refers to the height of the signal. Its unit depends on the type of the signal.

Period – time needed to complete one cycle. Frequency refers to the number of periods in one second. Frequency and period are inverses of each other.

Phase – describes the position of the waveform relative to time zero (amount of shift forward or backward)

Ex: A sine wave is offset 1/6 of a cycle with respect to time zero backwards. What is its phase?

Time-domain plot – shows changes in signal amplitude with respect to time.
Frequency-domain plot – shows the relationship between amplitude and frequency

Note: A low-frequency signal in the frequency domain corresponds to a signal with a long period in the time domain and vice versa. A signal that changes rapidly in the time domain corresponds to high frequencies in the frequency domain.

Composite Signals

The *Fourier series* allows us to decompose a composite periodic signal into a possibly infinite series of sine waves, each having a different frequency and phase.

The *Fourier transform* allows us to decompose a composite aperiodic signal into an infinite series of simple sine waves, each having a different frequency and phase.

Frequency spectrum of a signal – the combination of all sine waves that make up the signal. The width of the frequency spectrum is the bandwidth of the signal.

Examples:

1. If a periodic signal is decomposed into five sine waves with frequencies 200, 400, 600, 800 and 1000 Hz, what is he bandwidth? Draw the spectrum, assuming all components have maximum amplitude of 10 volts.
2. A signal has a bandwidth of 30 Hz. The highest frequency is 70 Hz. What is the lowest frequency? Draw the spectrum if the signal contains all integral frequencies of the same amplitude.

Digital Signals

Most digital signals are aperiodic, thus, frequency or period is not appropriate.
bit interval – time required to send one single bit
bit rate – number of bits sent in one second

Examples:

1. A digital signal has a bit rate of 4000 bps. What is the duration of each bit (bit interval)?
2. A digital signal has a bit interval of 50 microseconds. What is the bit rate?

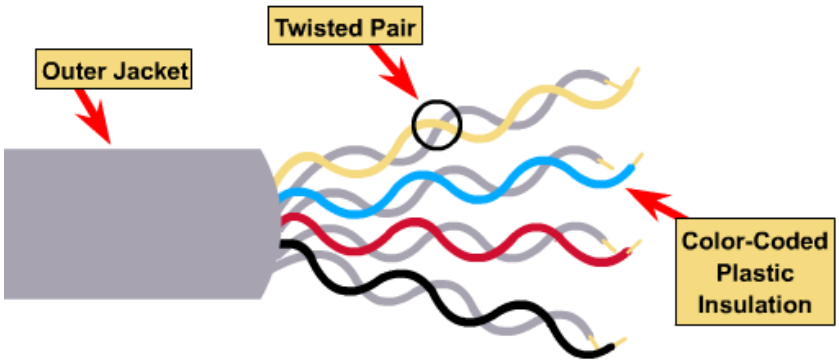
A digital signal can be decomposed into a infinite number of simple sine waves called **harmonics,** each with a different amplitude, phase and frequency and phase. The significant spectrum of a digital signal is the portion of the signal's spectrum that can adequately reproduce the original signal.

Transmission Media

Signals travel from transmitter to receiver via a path. This path, called the **medium** can be guided or unguided.

A. Guided Media- contained within physical boundaries

1. Twisted Pair Cable
    a) Unshielded twisted-pair (UTP) – consists of two conductors each surrounded with its own colored plastic insulation for identification.



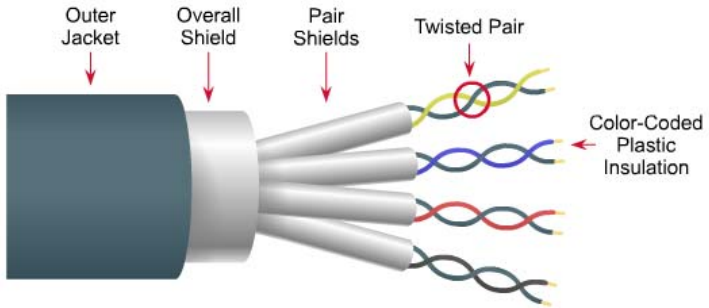
This type of cable relies solely on the cancellation effect, produced by the twisted wire pairs, to limit signal degradation caused by EMI and RFI. To further reduce **crosstalk** between the pairs in UTP cable, the number of twists in the wire pairs varies.

The EIA has developed standards to grade UTP cables by quality. Categories are determined by cable quality, with 1 as the lowest and 5 as the highest. Each EIA category is suitable for certain uses and not for others:

- **Category 1 (CAT 1).** The basic twisted pair cabling used in telephone systems. This level of quality is fine for voice but inadequate for all but low-speed data communication.
- **Category 2 (CAT 2).**The next higher grade, suitable for voice and for data transmission up to 4 Mbps.
- **Category 3 (CAT 3).** Required to have at least three twists per foot and can be used for data transmission up to 10 Mbps. It is now the standard cable for most telephone systems.
- **Category 4 (CAT 4)**. Must have at least 3 twists per foot as well as other conditions to bring the possible transmission rate to 16 Mbps.
- **Category 5 (CAT 5)**. Used for data transmission up to 100 Mbps.

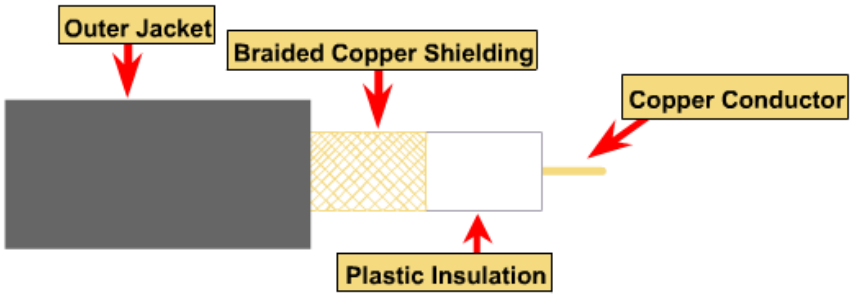
Connectors. UTP is most commonly connected to network devices via type of snap-in plug like that used with telephone jacks. Connectors are either male (plug) or female (receptacle). The most frequently used UTP connector is the RJ-45.

b. Shielded twisted-pair cable (STP) – has a metal foil or braided-mesh covering that encases each pair of insulated conductors. The metal casing prevents the penetration of electromagnetic noise and also eliminates a phenomenon called crosstalk, which is the undesired effect of one circuit (or channel) on another circuit (or channel).



STP affords greater protection from all types of external interference, but is more expensive and difficult to install than UTP.

2. **Coaxial cable** - consists of a hollow outer cylindrical conductor that surrounds a single inner wire made of two conducting elements. One of these elements - located in the center of the cable - is a copper conductor. Surrounding it is a layer of flexible insulation. Over this insulating material is a woven copper braid or metallic foil that acts as the second wire in the circuit, and as a shield for the inner conductor. This second layer, or shield, can help reduce the amount of outside interference. Covering this shield is the cable jacket.



Coaxial cable standards

Different coaxial cable designs are categorized by the radio government (RG) ratings, adapted for a specialized function.

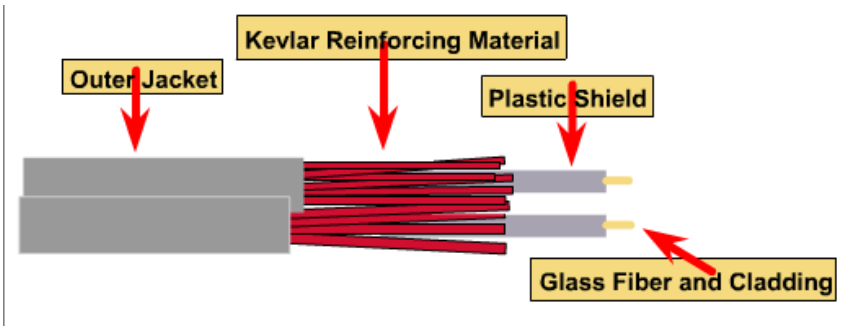
- RG-8. Used in thick Ethernet
- RG-9. Used in thick Ethernet
- RG-11. Used in thick Ethernet
- RG-58. Used in thin Ethernet
- RG-59. Used for TV.

Coaxial Cable Connectors

Bayonet network connector (BNC) – the most popular barrel connector which pushes on and locks in place with a half turn.

T-connector – allows a secondary cable or cables to branch off from a main line.

3. **Optical Fiber** - networking medium capable of conducting modulated light transmissions. Compared to other networking media, it is more expensive; however, it is not susceptible to electromagnetic interference and is capable of higher data rates than any of the other types of networking media.



The light-guiding parts of an optical fiber are called the *core* and the *cladding*. The core is usually very pure glass with a high index of *refraction*.

Propagation Modes

1. **Multimode** – multiple beams of light source move through the core in different paths. How these beams move within the cable depends on the structure of the core
    a. **multimode step-index** propagation – the core density is constant and the light beams changes direction suddenly at the interface between the core and the cladding.

    b. **multimode-graded index** propagation – the core density decreases distance with the center. This causes a curving of the light beams.

2. **Single mode** - uses a step-index fiber and highly focused light source that limits beams to a small range of angles, all close to the horizontal. The single-mode fiber is manufactured with a small diameter with a lower density. The decrease in density results in a critical angle close enough to 90 degrees to make propagation almost horizontal.

Fiber Sizes

Optical fibers are defined by the ratio of the diameter of the core to the diameter of the cladding.

Fiber types

Fiber type	Core (microns)	Cladding (microns)
62.5/125	62.5	125
50/125	50	125
100/140	100	140
8.3/125	8.3	125

Advantages of Optical Fibers

- Noise resistance
- Less signal attenuation
- Higher bandwidth

Disadvantages of Optical fibers

- Cost
- Installation/Maintenance
- Fragility

B. **Unguided Media** (wireless communication) – transport electromagnetic waves without using a physical conductor.

Radio Frequency Allocation: VLF, LF, MF, HF, VHF, UHF, SHF,EHF

Types of propagation of radio waves

- Surface
- Tropospheric
- Ionospheric
- Line-of-sight
- Space

Transmission Impairments

1. **Attenuation** – loss of a signal strength due to the resistance of the medium.
2. **Distortion** – any change in a signal due to noise, attenuation or other influences.
3. **Noise**

Performance of transmission media

1. **Throughput** – measurement of how fast data can pass through a point
2. **Propagation speed** – measures the distance of a signal or a bit can travel through a medium in a second.
3. **Propagation time** – measures the time required for a signal to travel from one point of the transmission medium to the other.

Shannon's Capacity – determines the theoretical highest data rate for a channel

$$\mathbf{C = B \log_2 (1 + S/N)}$$

Ex: Calculate the highest theoretical bit rate of a regular telephone line, if the normal bandwidth is 3000 Hz and the S/N is 35 dB.