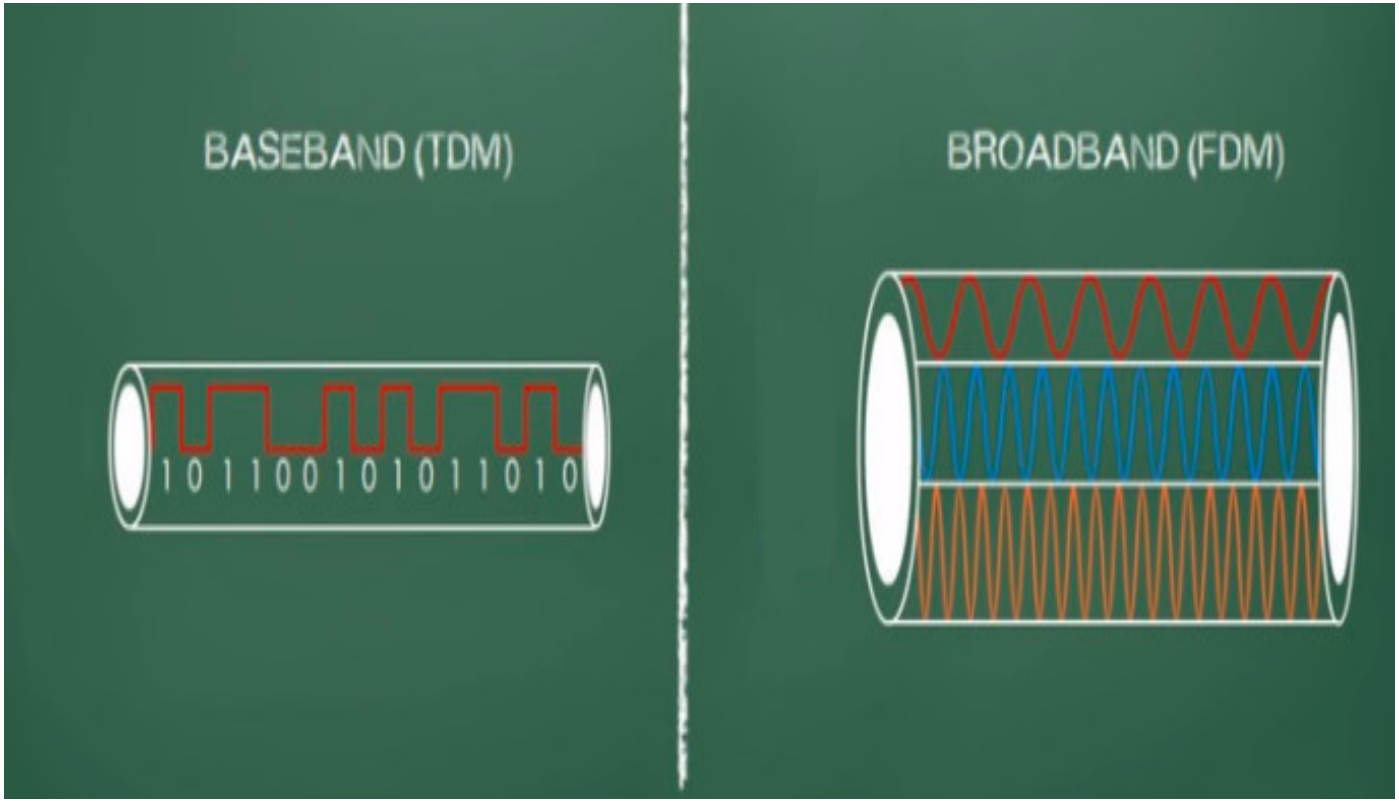
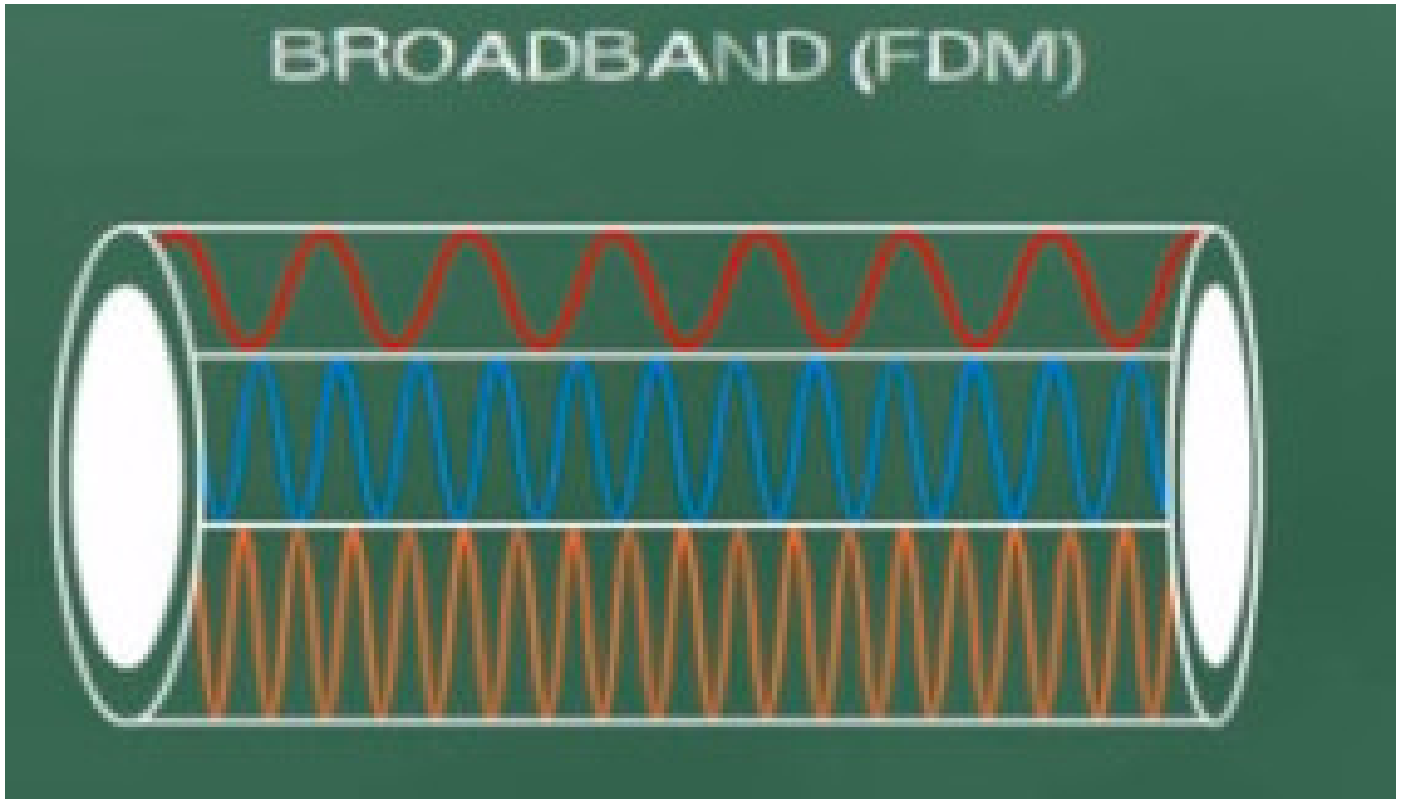
Principles of Data Communications

Reference Book: Data Communications and Networking by Behrouz A. Forouzan


BASEBAND (TDM)
1 0 1 1 0 0 1 0 1 0 1 1 0 1 0
BROADBAND (FDM)

- Baseband- Digital sgl transmitted as such (Digital txion)
- Broadband- Digital to Analog and then transmitted (Analog txion)

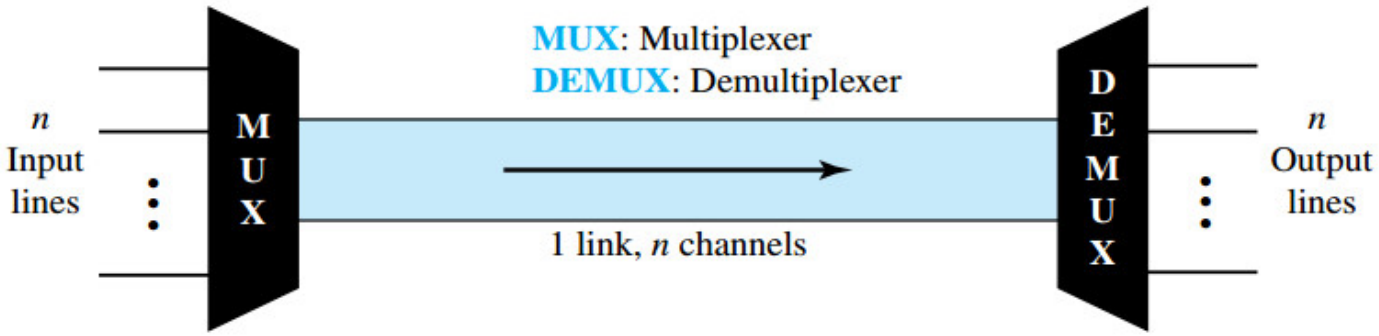


- Broadband signals can share one medium
- Eg) Multiple Lane Highway; Two or Three Vehicles can share the highway side by side at the same time

MULTIPLEXING

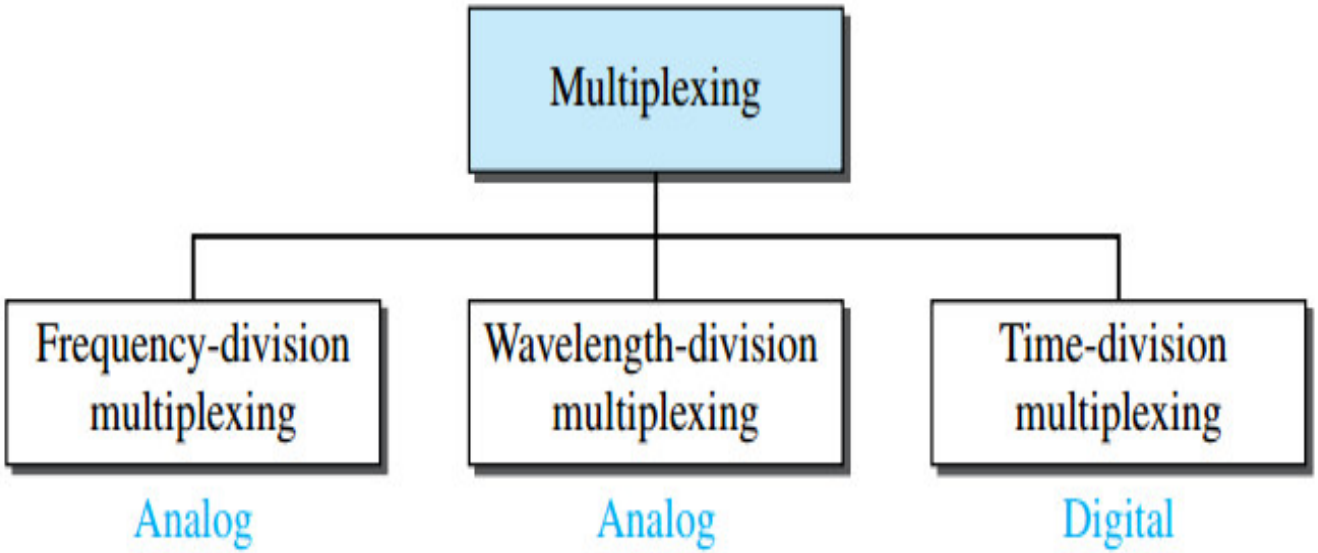
- Whenever the bandwidth of a medium linking two devices is greater than the bandwidth needs of the devices, the link can be shared.
- Multiplexing is the set of techniques that allow the simultaneous transmission of multiple signals across a single data link.
- As data and telecommunications use increases, so does traffic.
- We can accommodate this increase by continuing to add individual links each time a new channel is needed; or we can install higher-bandwidth links and use each to carry multiple signals.
- If the bandwidth of a link is greater than the bandwidth needs of the devices connected to it, the bandwidth is wasted.
- An efficient system maximizes the utilization of all resources; bandwidth is one of the most precious resources we have in data communications.

Dividing a link into channels



- In a multiplexed system, n lines share the bandwidth of one link. The lines on the left direct their transmission streams to a multiplexer (MUX), which combines them into a single stream (many-to-one).
- At the receiving end, that stream is fed into a demultiplexer (DEMUX), which separates the stream back into its component transmissions (one-to-many) and directs them to their corresponding lines.
- In the figure, the word link refers to the physical path. The word channel refers to the portion of a link that carries a transmission between a given pair of lines. One link can have many (n) channels.

Categories of multiplexing

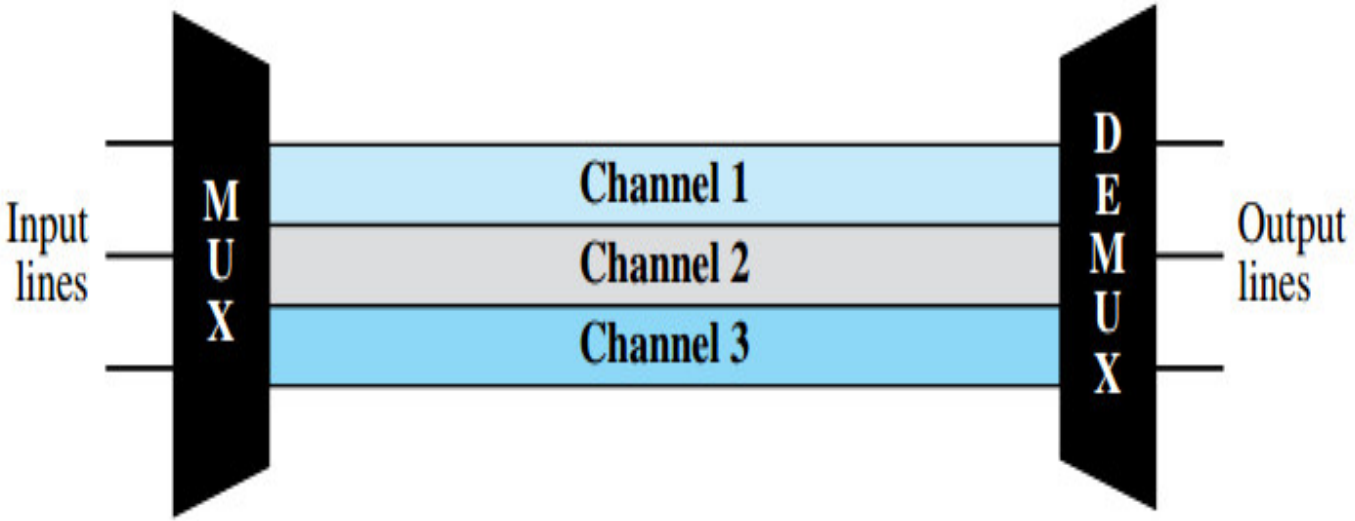


- There are three basic multiplexing techniques:
  - Frequency-division multiplexing (FDM)
  - Wavelength-division multiplexing (WDM)
  - Time-division multiplexing (TDM)
- The first two are techniques designed for analog signals, the third, for digital signals.

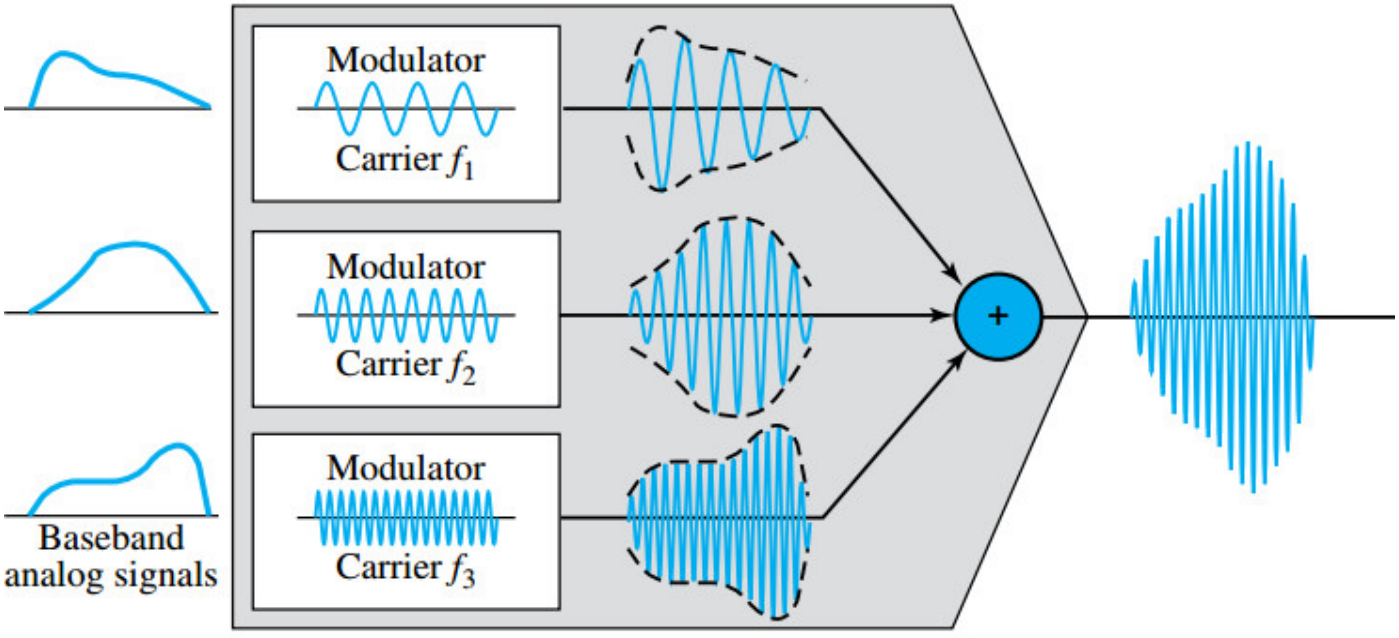
Frequency-Division Multiplexing

- Frequency-division multiplexing (FDM) is an analog technique that can be applied when the bandwidth of a link (in hertz) is greater than the combined bandwidths of the signals to be transmitted.
- In FDM, signals generated by each sending device modulate different carrier frequencies.
- These modulated signals are then combined into a single composite signal that can be transported by the link.
- Carrier frequencies are separated by sufficient bandwidth to accommodate the modulated signal.
- These bandwidth ranges are the channels through which the various signals travel.
- Channels can be separated by strips of unused bandwidth-guard bands -to prevent signals from overlapping.

Frequency-division multiplexing



FDM process


Modulator
Carrier f_1
Modulator
Carrier f_2
Modulator
Carrier f_3
+
Baseband
analog signals

- Five channels, each with a 100-kHz bandwidth, are to be multiplexed together. What is the minimum bandwidth of the link if there is a need for a guard band of 10 kHz between the channels to prevent interference?

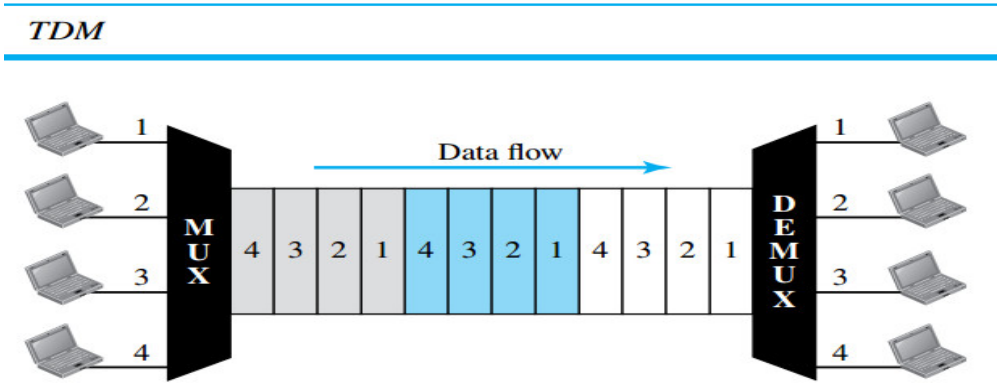
Frequency-Division Multiplexing

- We consider FDM to be an analog multiplexing technique; however, this does not mean that FDM cannot be used to combine sources sending digital signals.
- A digital signal can be converted to an analog signal before FDM is used to multiplex them.

Wavelength-Division Multiplexing

- Wavelength-division multiplexing (WDM) is designed to use the high-data-rate capability of fiber-optic cable.
- The optical fiber data rate is higher than the data rate of metallic transmission cable, but using a fiber-optic cable for a single line wastes the available bandwidth.
- Multiplexing allows us to combine several lines into one.
- WDM is conceptually the same as FDM, except that the multiplexing and demultiplexing involve optical signals transmitted through fiber-optic channels.
- The idea is the same: We are combining different signals of different frequencies. The difference is that the frequencies are very high.

Time-Division Multiplexing

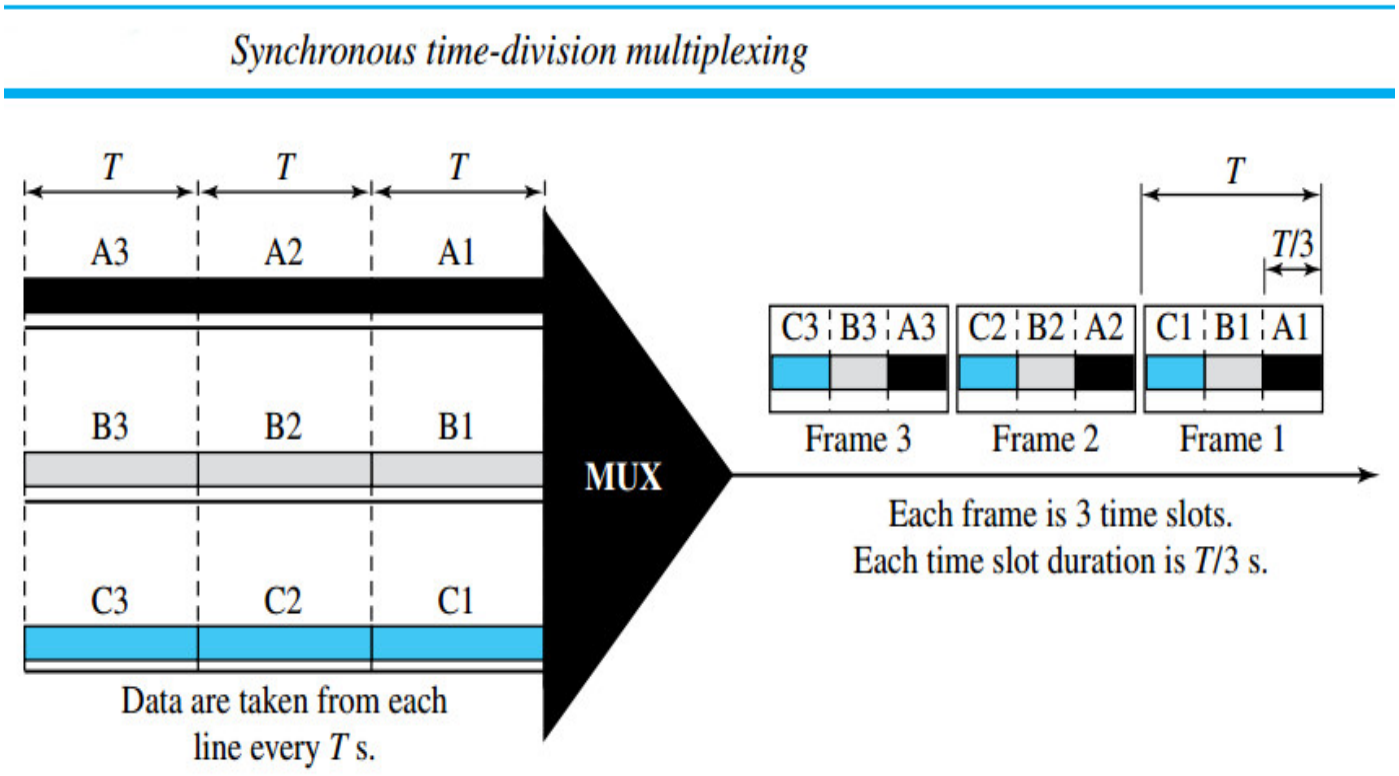


- Time-division multiplexing (TDM) is a digital process that allows several connections to share the high bandwidth of a link.
- Instead of sharing a portion of the bandwidth as in FDM, time is shared.
- Each connection occupies a portion of time in the link.
- Two Types: Synchronous TDM, Statistical TDM

Synchronous TDM

- In synchronous TDM, each input connection has an allotment in the output even if it is not sending data.

Synchronous TDM



- In synchronous TDM, the data flow of each input connection is divided into units, where each input occupies one input time slot.
- A unit can be 1 bit, one character, or one block of data.
- Each input unit becomes one output unit and occupies one output time slot.

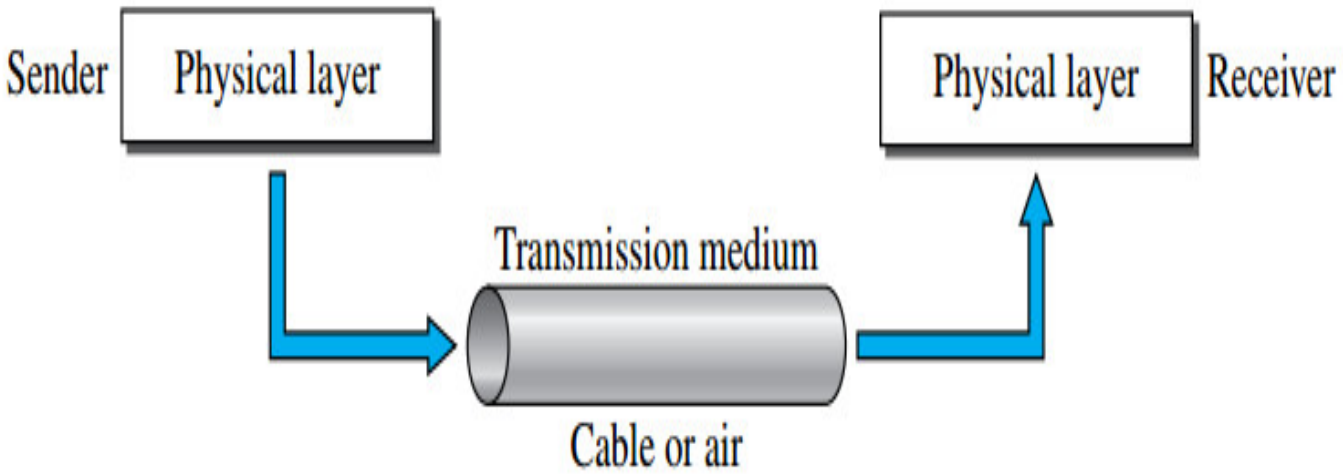
- However, the duration of an output time slot is n times shorter than the duration of an input time slot.
- If an input time slot is T s, the output time slot is T/n s, where n is the number of connections.
- In other words, a unit in the output connection has a shorter duration; it travels faster.
- Figure shows an example of synchronous TDM where n is 3.

Statistical time-division multiplexing

- In synchronous TDM, each input has a reserved slot in the output frame. This can be inefficient if some input lines have no data to send.
- In statistical time-division multiplexing, slots are dynamically allocated to improve bandwidth efficiency. Only when an input line has a slots worth of data to send is it given a slot in the output frame.

Transmission Media

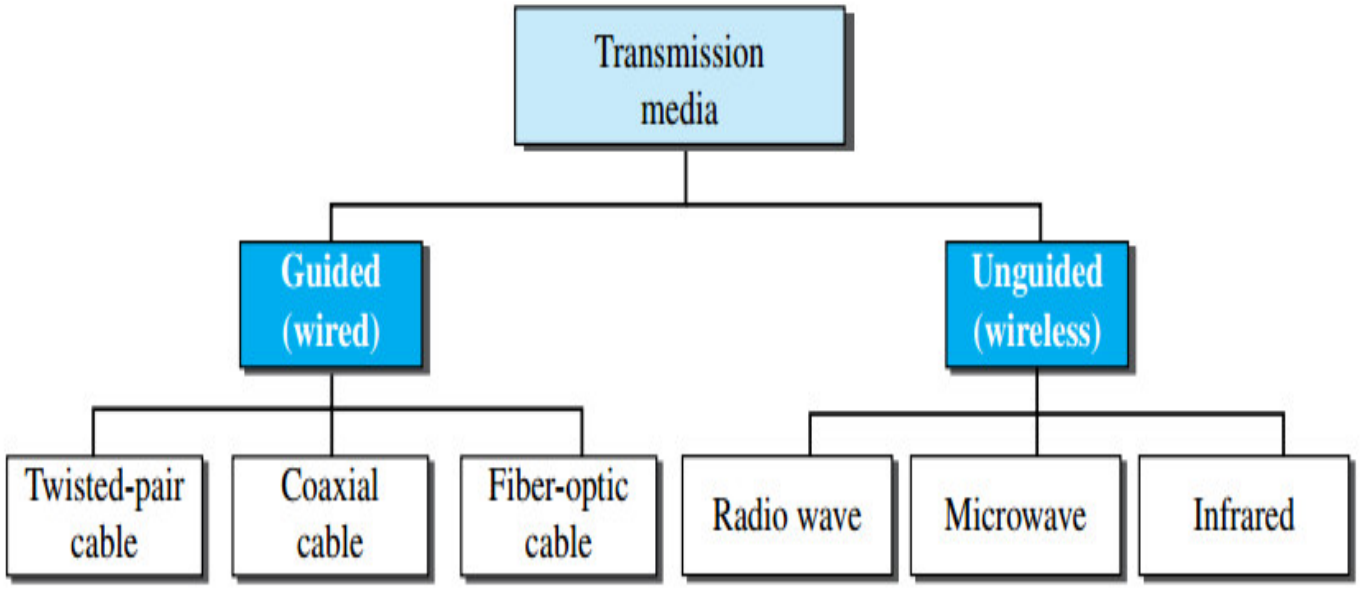
Transmission medium and physical layer



- Transmission media are actually located below the physical layer and are directly controlled by the physical layer.

- A transmission medium can be broadly defined as anything that can carry information from a source to a destination.
- For example, the transmission medium for two people having a dinner conversation is the air.
- For a written message, the transmission medium might be a mail carrier, a truck, or an airplane.

Classes of transmission media

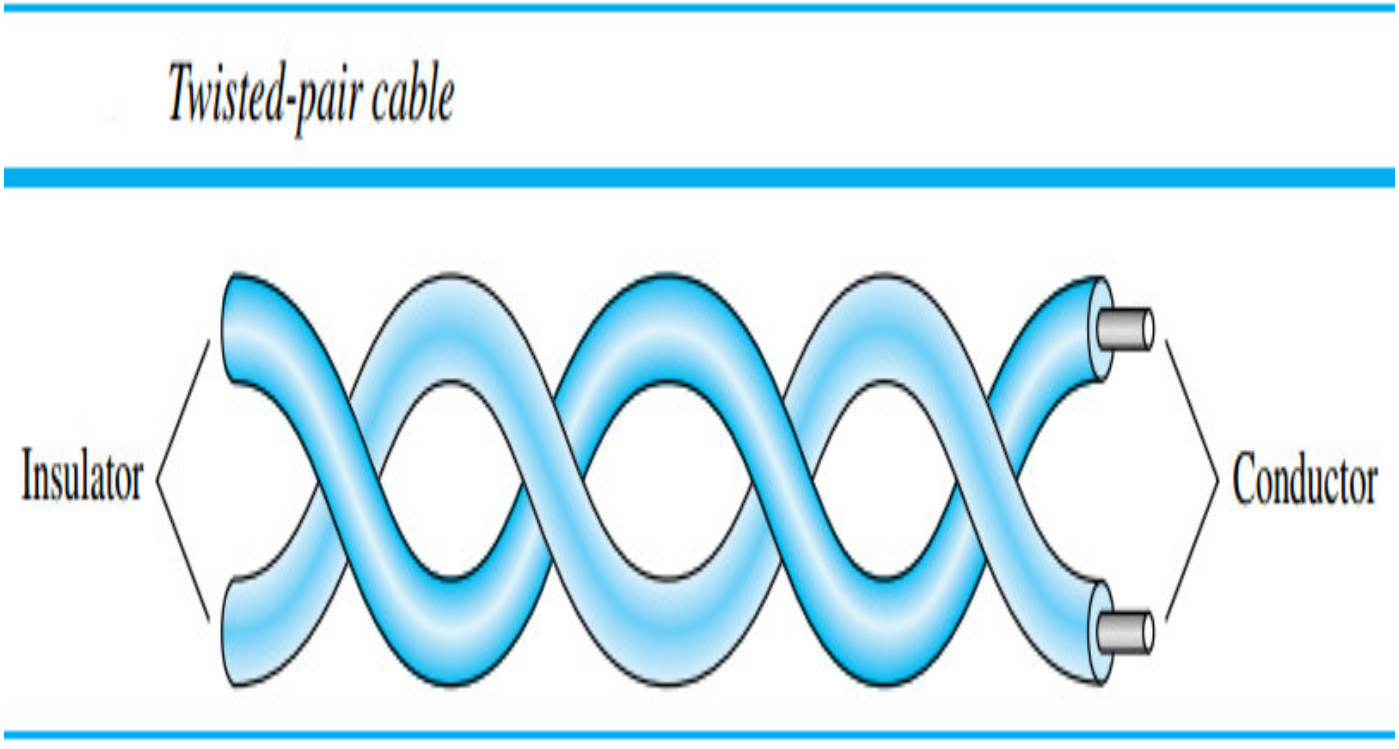


- In telecommunications, transmission media can be divided into two broad categories:
  - Guided: include twisted-pair cable, coaxial cable, and fiber-optic cable.
  - Unguided: free space.

GUIDED MEDIA

- Guided media, which are those that provide a conduit from one device to another, include twisted-pair cable, coaxial cable, and fiber-optic cable.
- A signal traveling along any of these media is directed and contained by the physical limits of the medium.
- Twisted-pair and coaxial cable use metallic (copper) conductors that accept and transport signals in the form of electric current.
- Optical fiber is a cable that accepts and transports signals in the form of light.

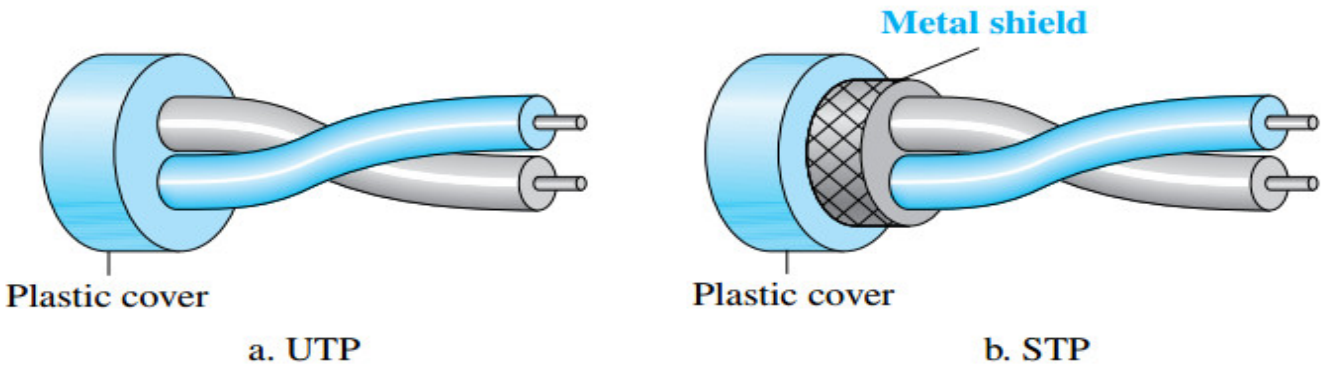
Twisted-Pair Cable



- A twisted pair consists of two conductors (normally copper), each with its own plastic insulation, twisted together

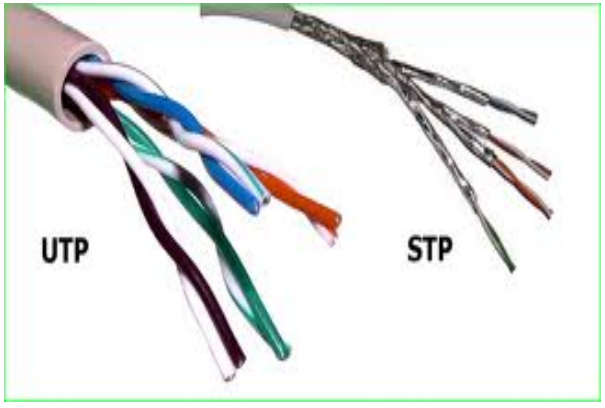
Unshielded Versus Shielded Twisted-Pair Cable

UTP and STP cables



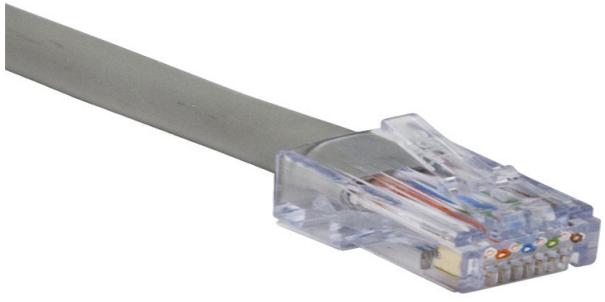
- The most common twisted-pair cable used in communications is referred to as unshielded twisted-pair (UTP).
- IBM has also produced a version of twisted-pair cable for its use, called shielded twisted-pair (STP).
- STP cable has a metal foil or braidedmesh covering that encases each pair of insulated conductors.
- Although metal casing improves the quality of cable by preventing the penetration of noise or crosstalk, it is bulkier and more expensive.

Unshielded Versus Shielded Twisted-Pair Cable



- 10Base-T : 10Mbps, Baseband, Twisted Pair
- 100Base-T
- 1000Base-T

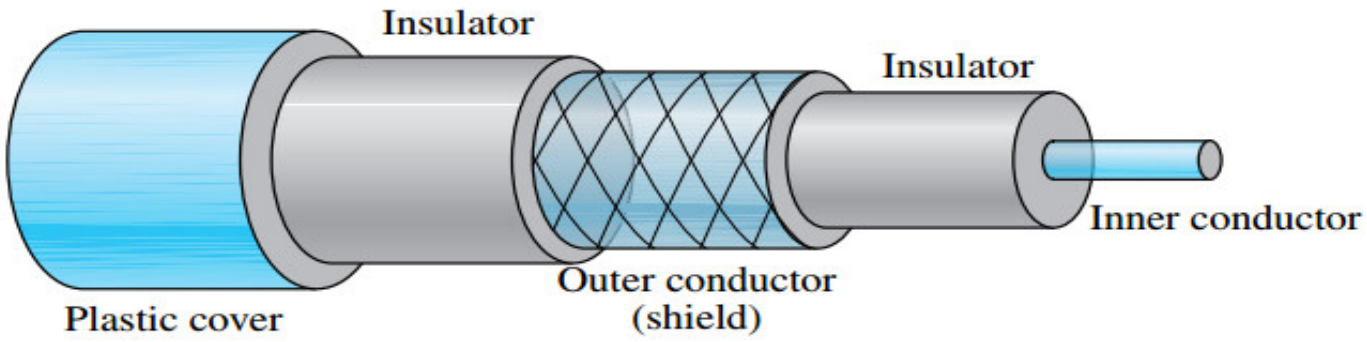
Connectors



- The most common UTP connector is RJ45 (RJ stands for registered jack)

Coaxial Cable

Coaxial cable



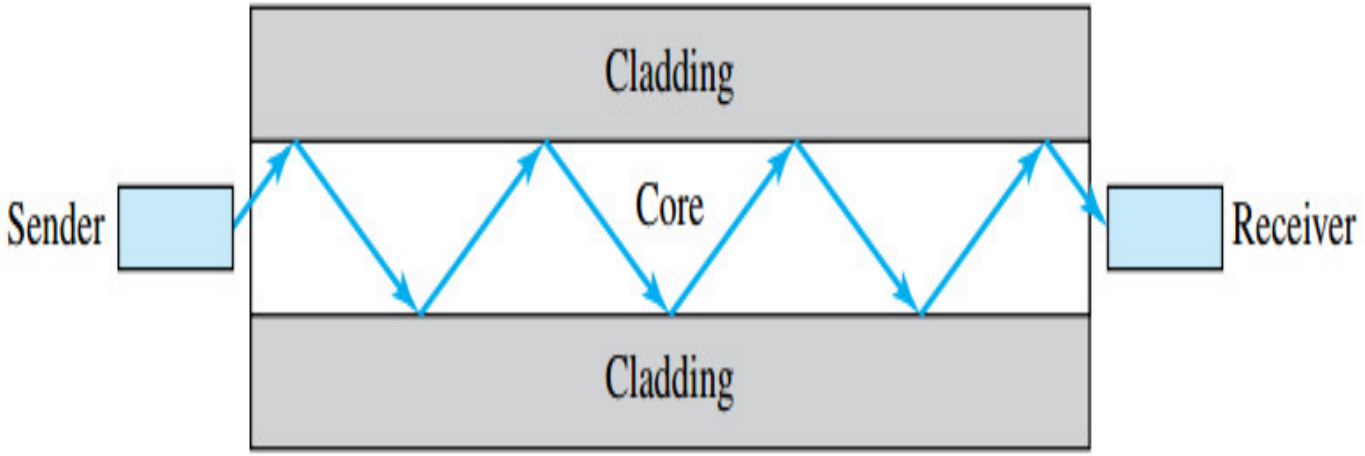
- Coaxial cable (or coax) carries signals of higher frequency ranges than those in twistedpair cable, in part because the two media are constructed quite differently.
- Instead of having two wires, coax has a central core conductor of solid or stranded wire (usually copper) enclosed in an insulating sheath, which is, in turn, encased in an outer conductor of metal foil, braid, or a combination of the two.
- The outer metallic wrapping serves both as a shield against noise and as the second conductor, which completes the circuit.

Coaxial Cable

Fiber-Optic Cable

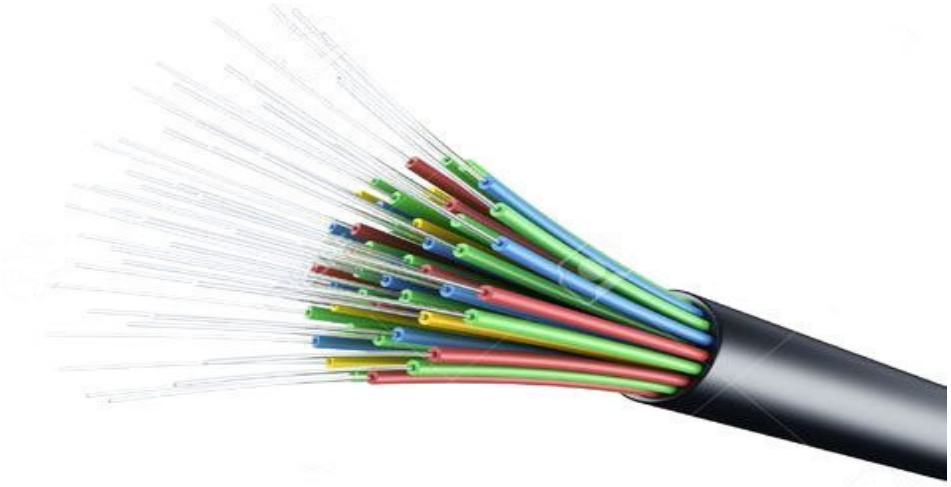
- A fiber-optic cable is made of glass or plastic and transmits signals in the form of light.
- To understand optical fiber, we first need to explore several aspects of the nature of light.
- Light travels in a straight line as long as it is moving through a single uniform substance.
- If a ray of light traveling through one substance suddenly enters another substance (of a different density), the ray changes direction.

Optical fiber



- Optical fibers use reflection to guide light through a channel.
- A glass or plastic core is surrounded by a cladding of less dense glass or plastic.
- The difference in density of the two materials must be such that a beam of light moving through the core is reflected off the cladding instead of being refracted into it.

Fiber-Optic Cable



Summary

- Multiplexing: FDM, WDM, TDM
- Transmission Medium

THANK YOU