Transmission Media

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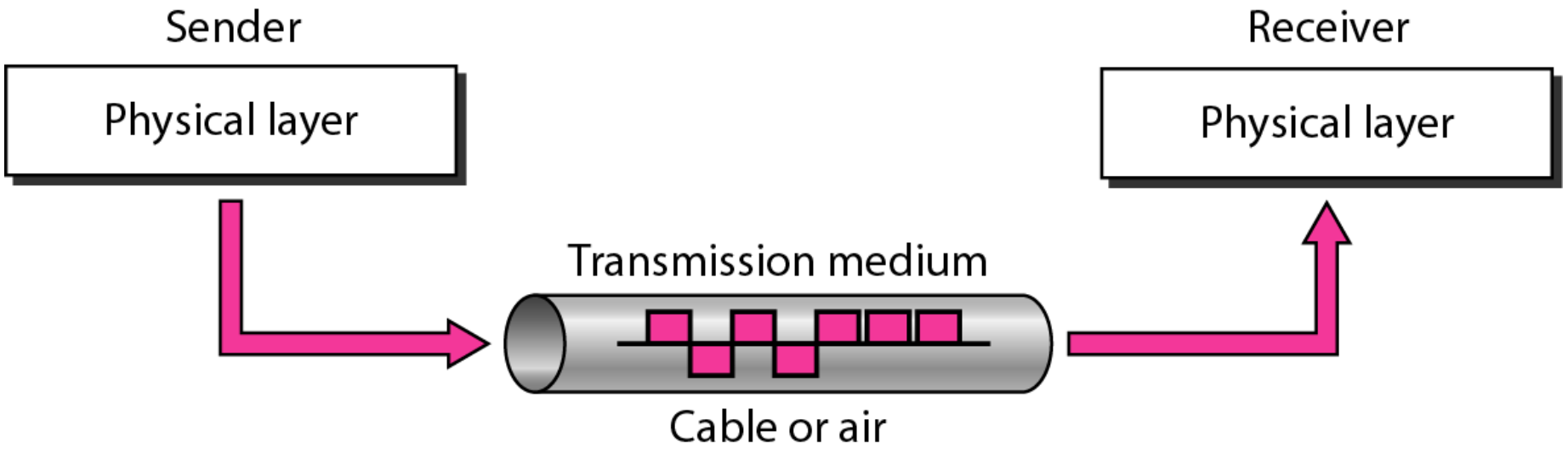
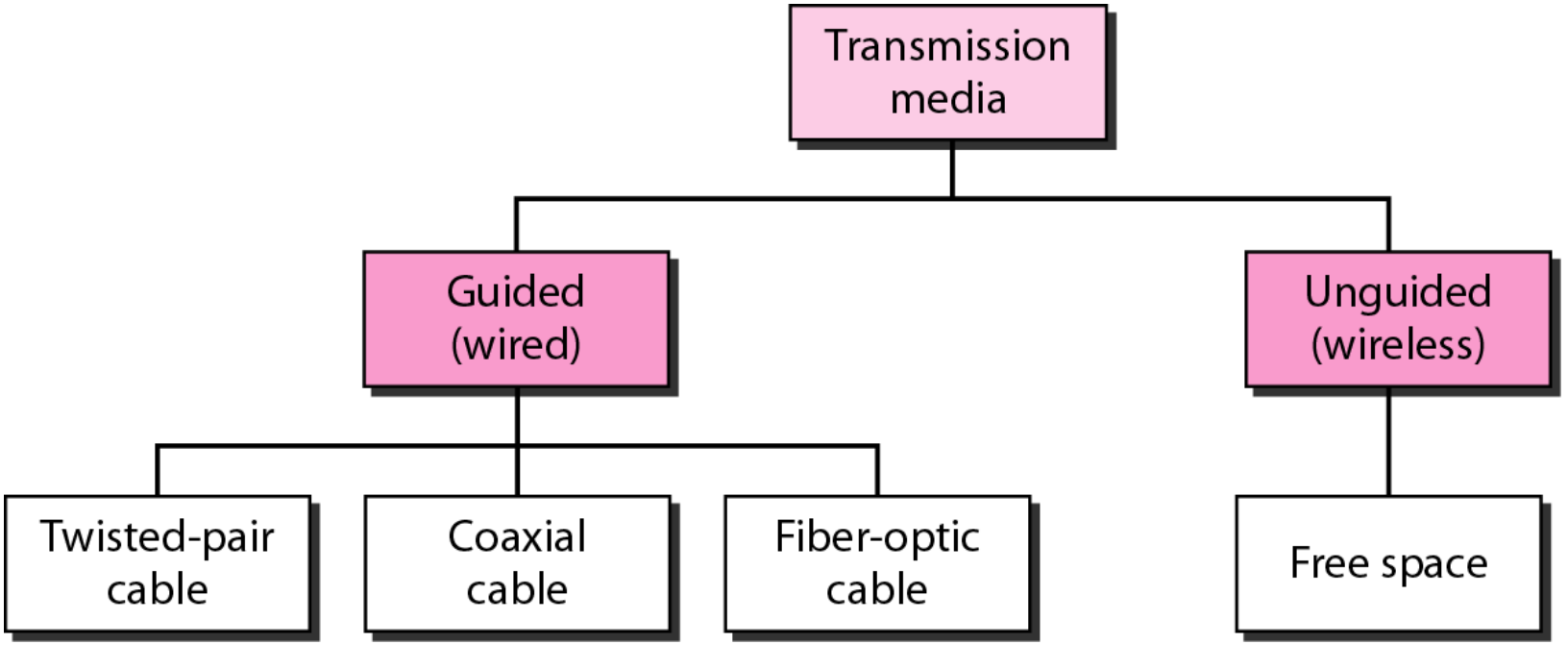
Reading Material for this discussion

- DATA COMMUNICATIONS AND NETWORKING, Fourth Edition by Behrouz A. Forouzan, Tata McGraw-Hill
  - Chapter 7, Topic 7.1, Topic 7.2

Transmission medium and physical layer



Classes of transmission media



GUIDED MEDIA

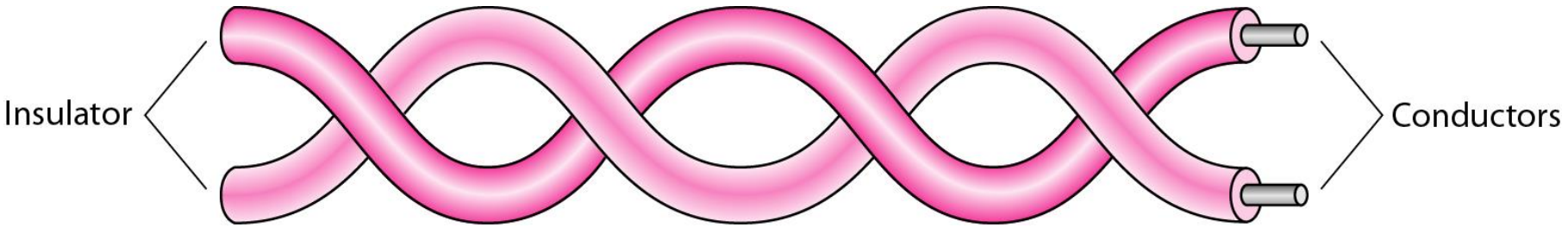
- Provide physical conduit
- Signal directed and contained by physical limits of medium
  - Twisted-Pair Cable – signal as electrical current
  - Coaxial Cable – signal as electrical current
  - Fiber-Optic Cable - signals in the form of light

Unshielded Twisted-pair (UTP) cable

Wire1 = signal

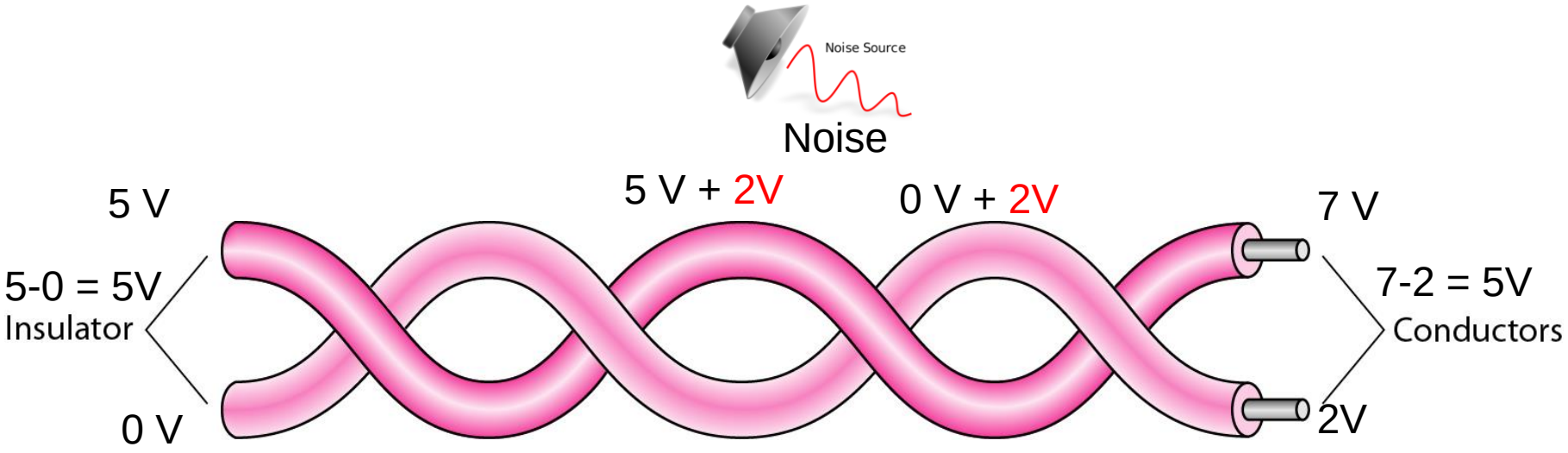
Wire2 = ground reference

Data at receiver = Signal Wire1- Signal Wire2

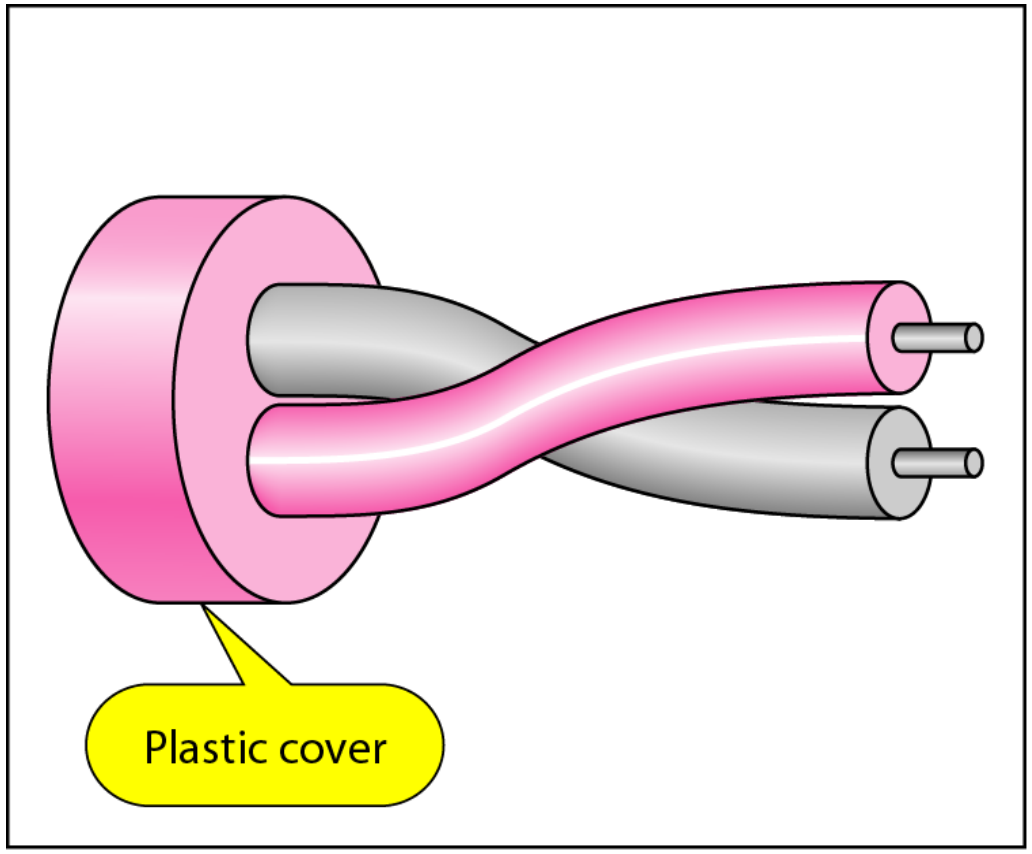


Why Twisted?

- In one twist, one wire is closer to the noise source and the other is farther;
- In the next twist, the reverse is true.
- Thus both wires are equally affected by noise
- Receiver, which calculates the difference between the two, receives no noise



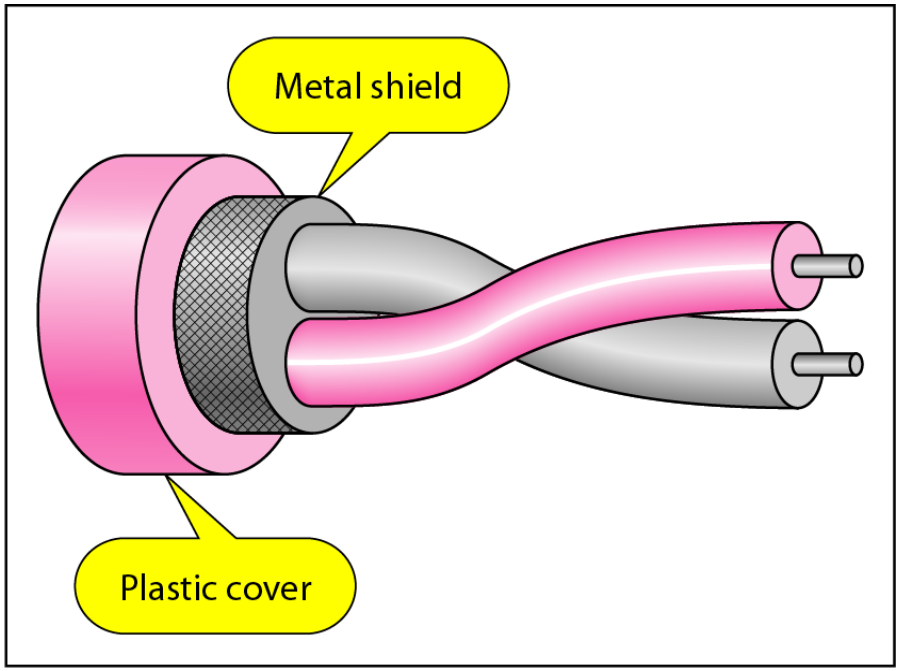
UTP cables



a. UTP

Shielded Twisted-pair (UTP) cable

- By IBM
- Metal foil or braided mesh covering
- Metal prevents the penetration of noise
- It is bulkier and more expensive

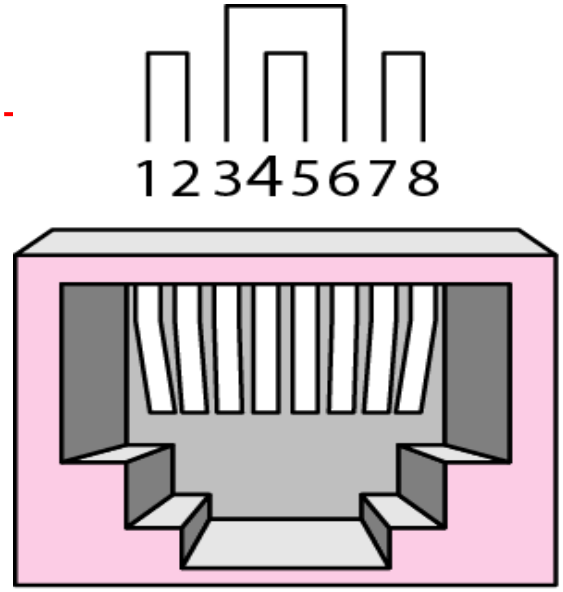


b. STP

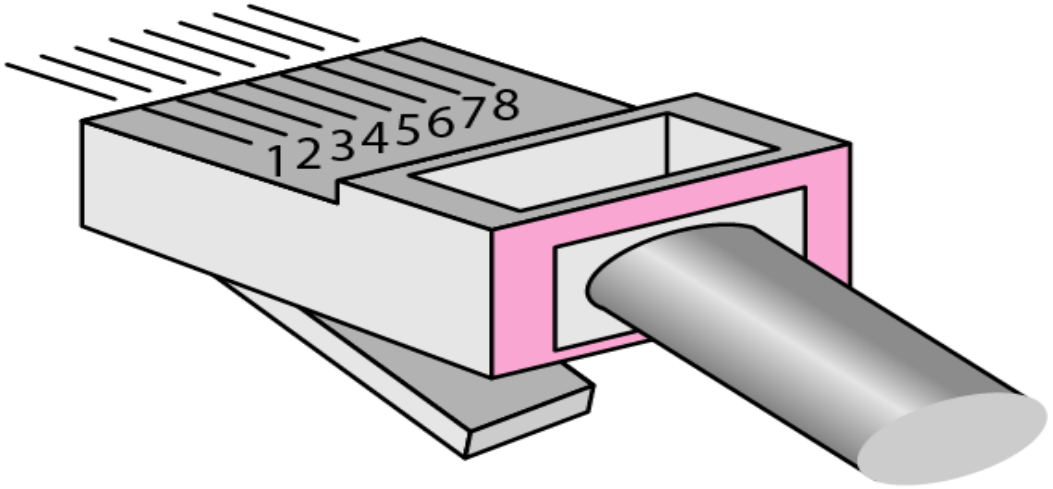
Categories by Electronic Industry Association (EIA)

Category	*Specification*	*Data Rate (Mbps)*	*Use*
1	Unshielded twisted-pair used in telephone	< 0.1	Telephone
2	Unshielded twisted-pair originally used in T-lines	2	T-1 lines
3	Improved CAT 2 used in LANs	10	LANs
4	Improved CAT 3 used in Token Ring networks	20	LANs
5	Cable wire is normally 24 AWG with a jacket and outside sheath	100	LANs
5E	An extension to category 5 that includes extra features to minimize the crosstalk and electromagnetic interference	125	LANs
6	A new category with matched components coming from the same manufacturer. The cable must be tested at a 200-Mbps data rate.	200	LANs
7	Sometimes called SSTP (shielded screen twisted-pair). Each pair is individually wrapped in a helical metallic foil followed by a metallic foil shield in addition to the outside sheath. The shield decreases the effect of crosstalk and increases the data rate.	600	LANs

UTP connector - RJ45 (RJ stands for registered jack)



RJ-45 Female

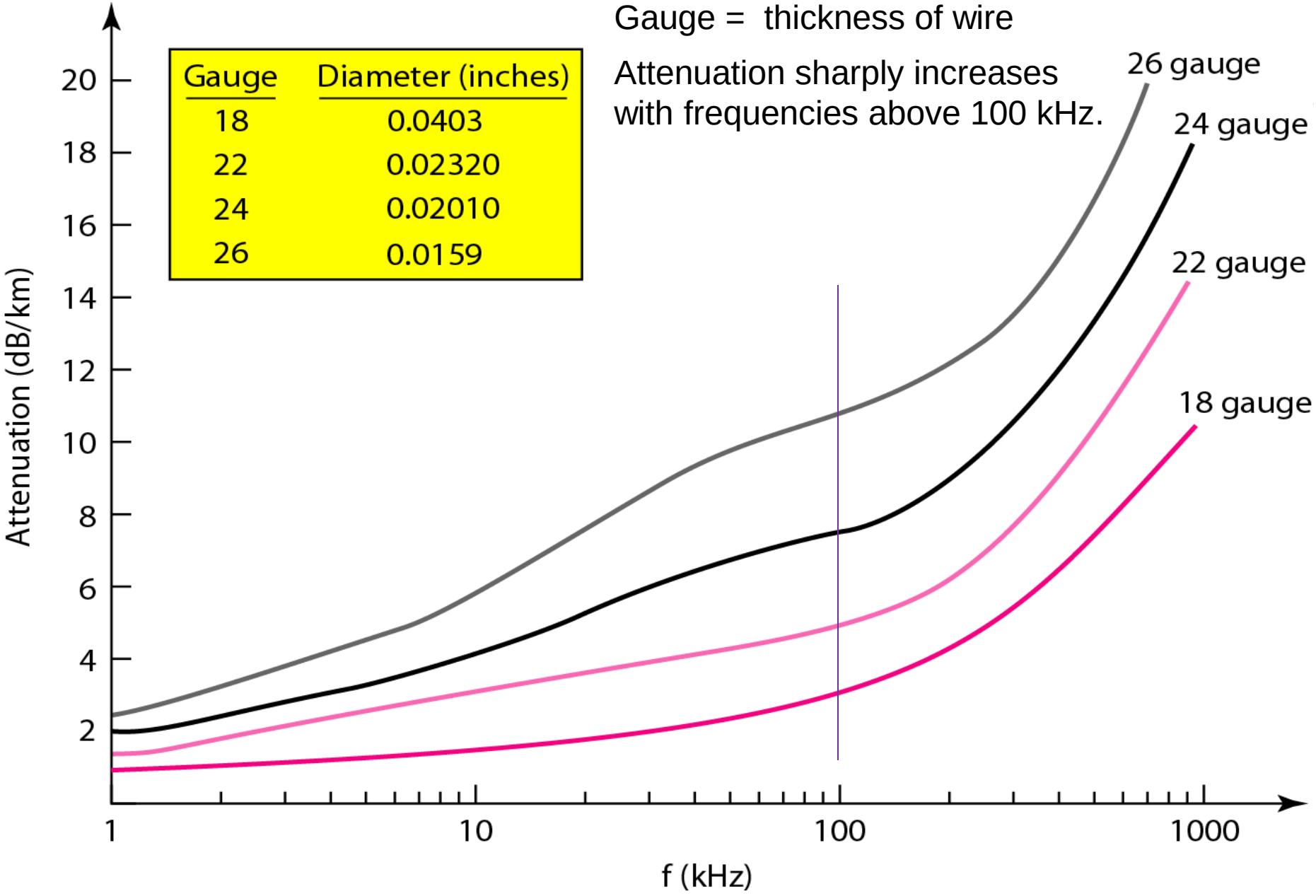


RJ-45 Male

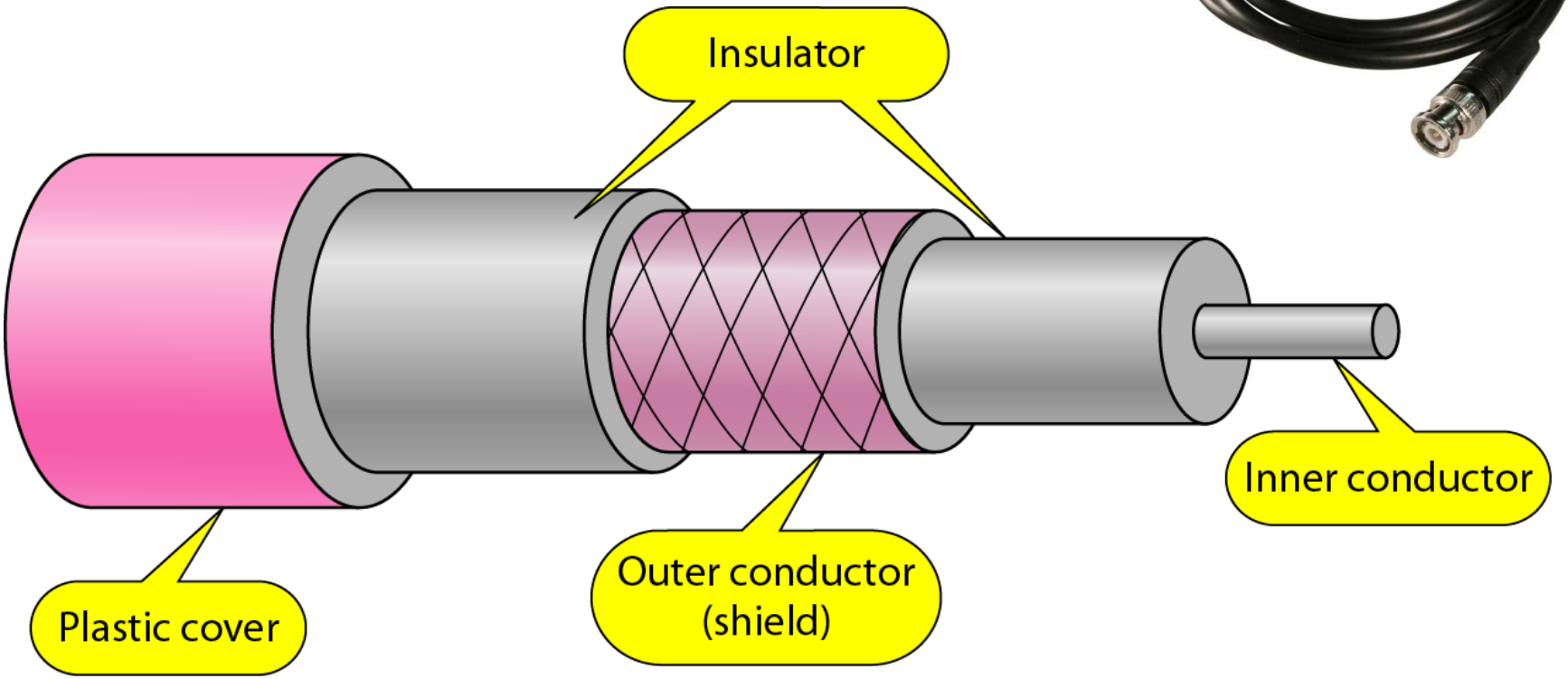
A keyed connector - can be inserted in only one way

Ethernet LAN, Cross Over Cable

UTP performance



Coaxial cable



central core = first conductor enclosed in an insulating sheath
outer conductor of metal foil or braid = second conductor

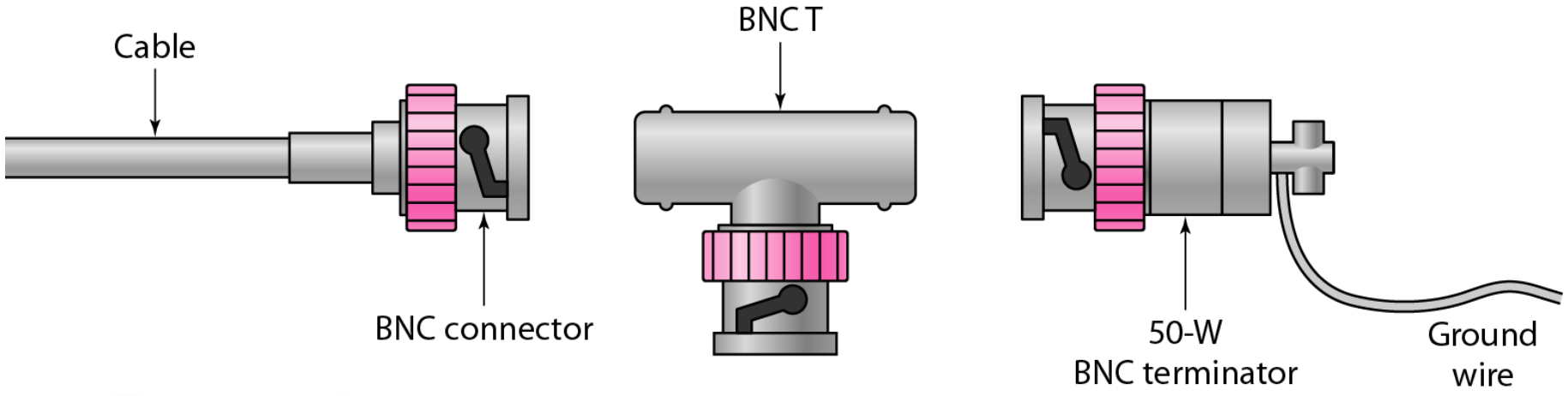
Coaxial Cable Categories

- Categorized by radio government (RG) ratings.
- RG number denotes wire gauge of inner conductor, thickness, type of inner insulator, construction of shield, size and type of the outer casing

Category	*Impedance*	*Use*
RG-59	75 Ω	Cable TV
RG-58	50 Ω	Thin Ethernet
RG-11	50 Ω	Thick Ethernet

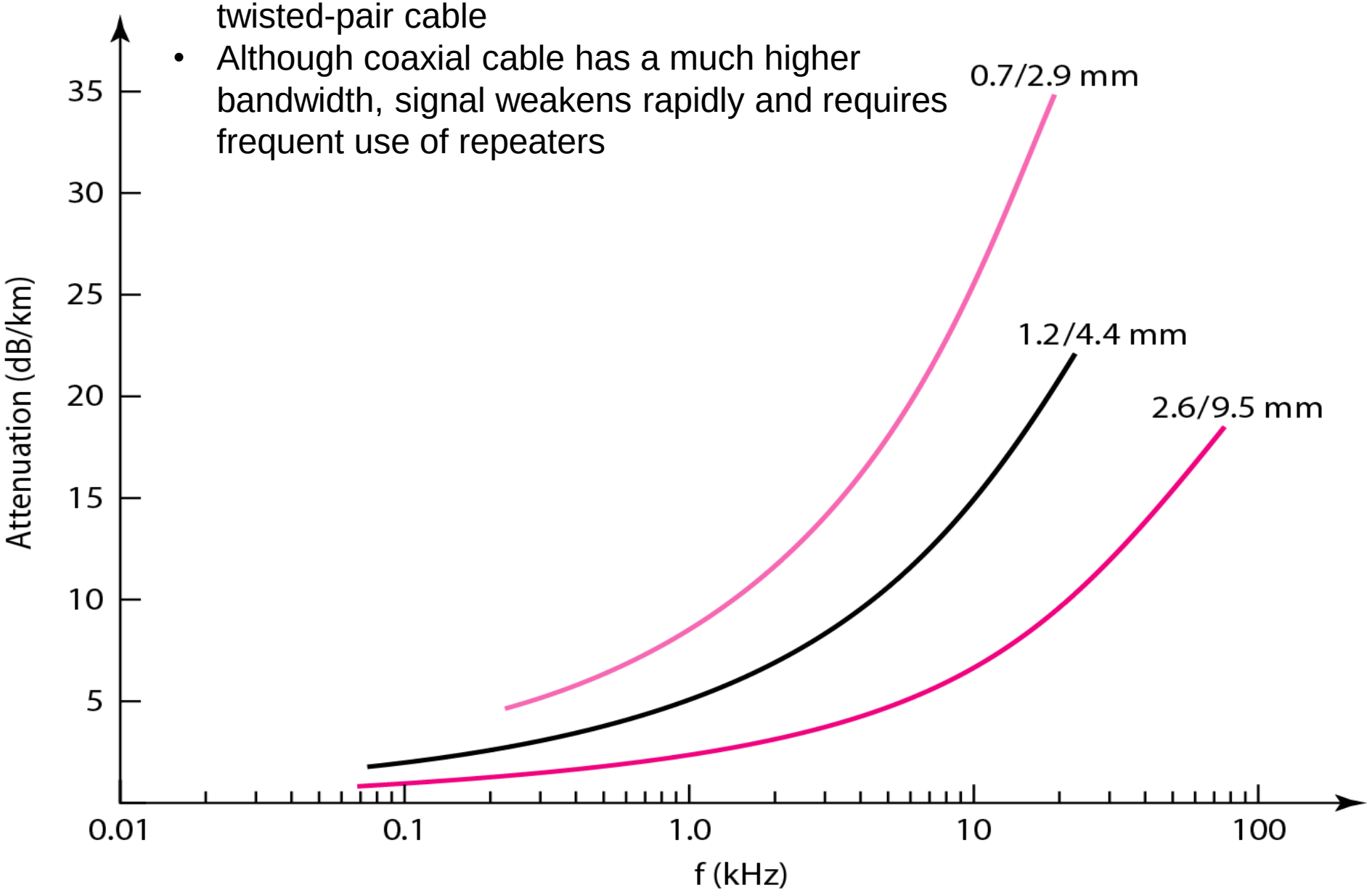
Coax Cable Connectors

BNC (Bayone-Neill-Concelman) connectors



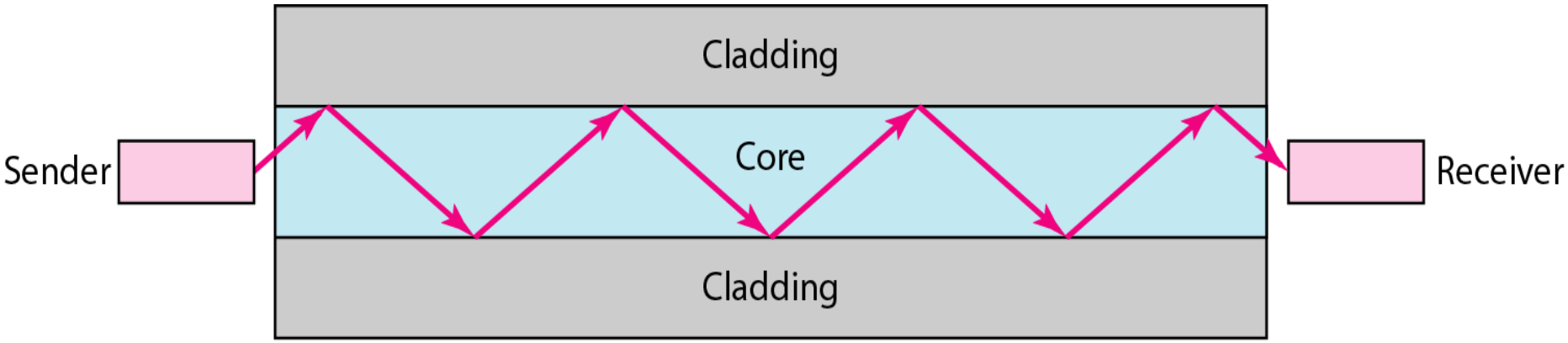
Coaxial cable performance

- Attenuation is higher in coaxial cables than in twisted-pair cable
- Although coaxial cable has a much higher bandwidth, signal weakens rapidly and requires frequent use of repeaters



Fiber-Optic Cable

- Made of glass or plastic
- Transmits signals in the form of light
- Use reflection to guide light through a channel.
- Glass/Plastic core is surrounded by a cladding of less dense glass or plastic.
- Difference in density of both is such that beam of light moving through the core is reflected off the cladding

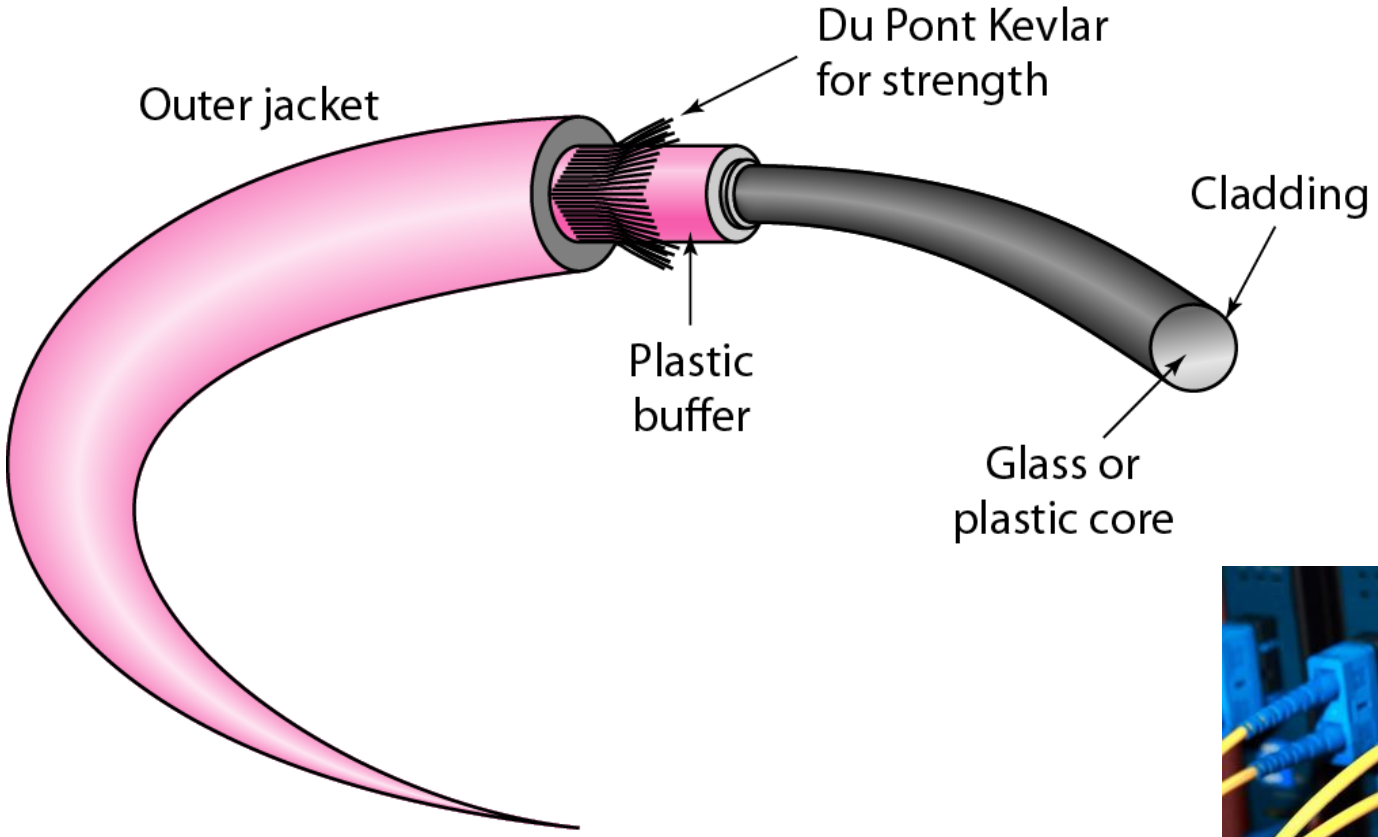


Fiber types

- Defined by ratio of diameter of their core to diameter of their cladding, both expressed in micrometers.

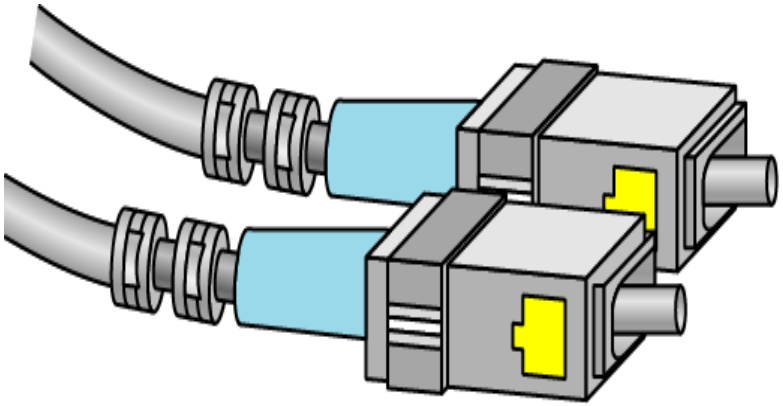
Type	*Core (μm)*	*Cladding (μm)*
50/125	50.0	125
62.5/125	62.5	125
100/125	100.0	125
7/125	7.0	125

Fiber construction



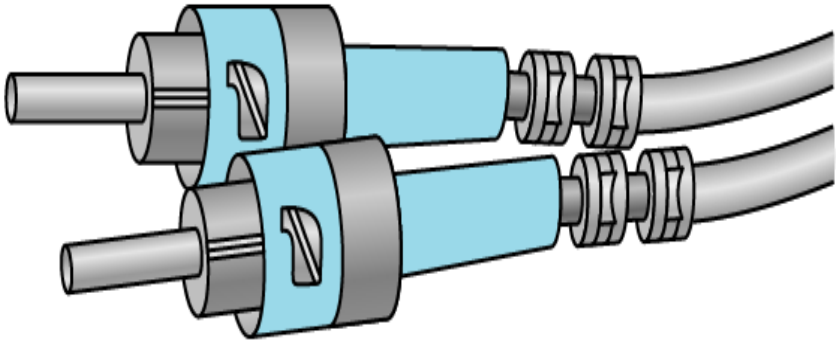
- Outer jacket of either PVC or Teflon
- Inside jacket of Kevlar (used in bulletproof vests) strands to strengthen the cable
- Below Kevlar is another plastic coating to cushion the fiber
- Fiber at center of cable, and it consists of cladding and core.

Fiber-optic cable connectors



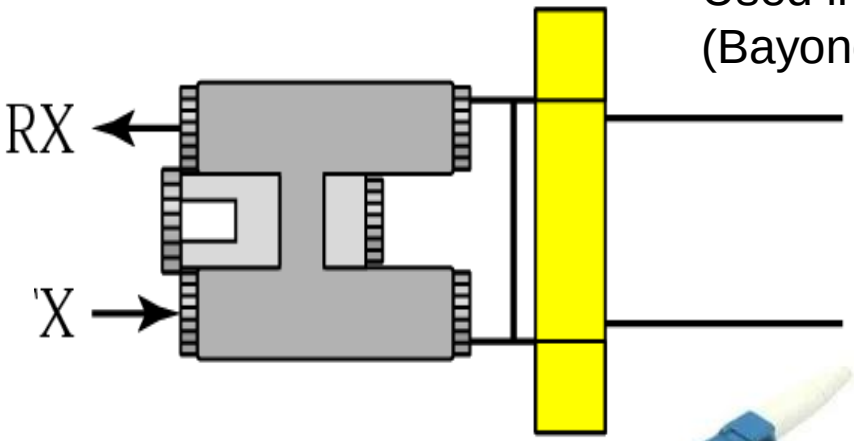
SC connector

Subscriber Channel (SC)
Used in Cable TV



ST connector

Straight Tip (ST)
Used in Networking devices
(Bayonet locking system)

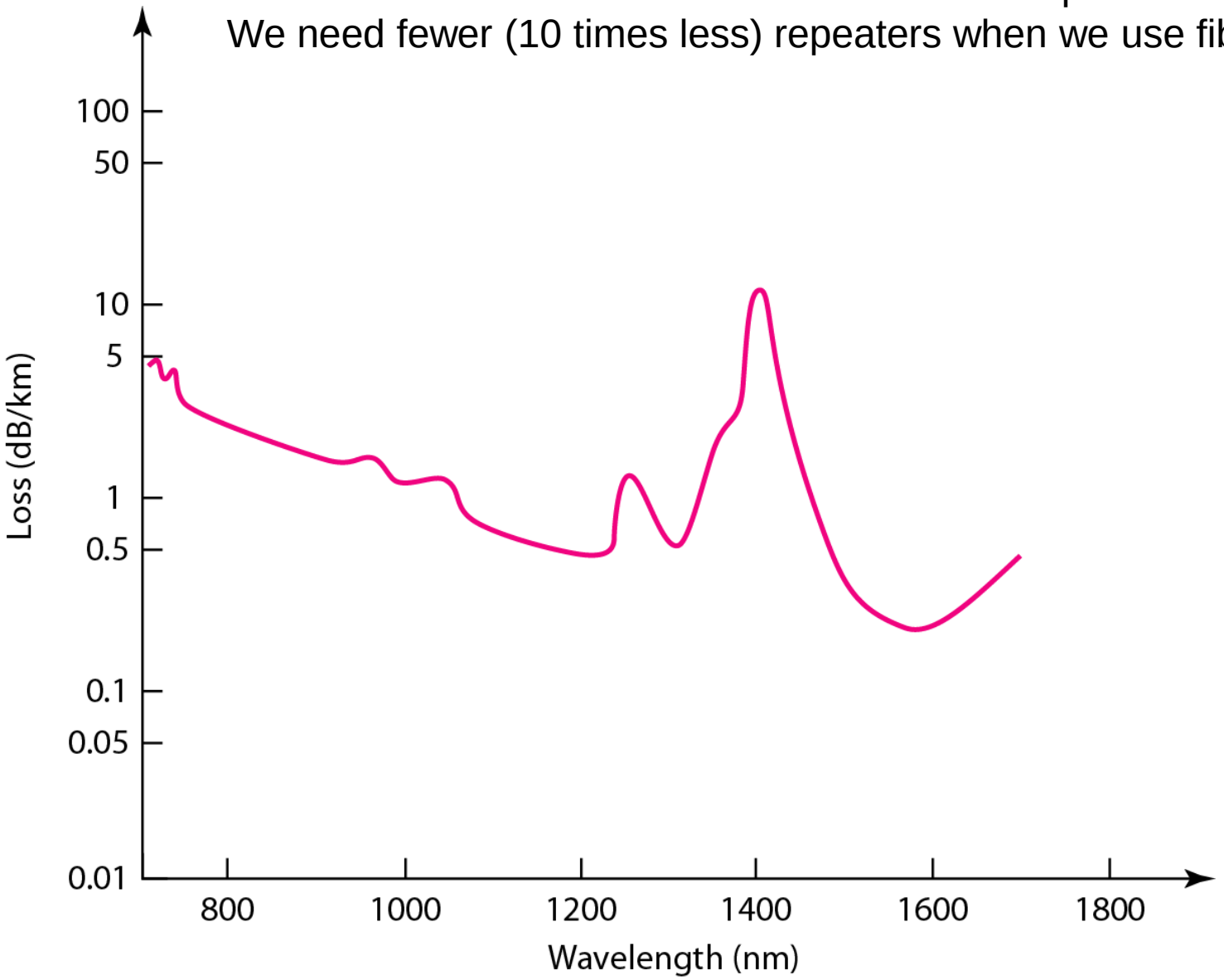


MT-RJ connector

Size as RJ 45

Optical fiber performance

Attenuation is flatter than in the case of twisted-pair/coaxial cable.
We need fewer (10 times less) repeaters when we use fiber-optic cable.



Uses of Fiber Optic Cable

- In backbone networks because its wide bandwidth is cost-effective
- Cable TV companies use a combination of optical fiber and coaxial cable
- Optical fiber provides backbone structure while coaxial cable provides the connection to the user premises (FTTC-Fiber to the Curb)
- 100Base-FX network (Fast Ethernet) and 1000Base-X

Advantages of Fiber-optic cable

- Higher bandwidth. Fiber-optic cable can support dramatically higher bandwidths (and hence data rates) than either twisted-pair or coaxial cable
- Less signal attenuation Signal can run for 50 km without requiring regeneration
- Immunity to electromagnetic interference. Electromagnetic noise cannot affect fiber-optic cables.
- Resistance to corrosive materials. Glass is more resistant to corrosive materials than copper
- Light weight. Fiber-optic cables are much lighter than copper cables.
- Greater immunity to tapping. Copper cables create antenna effects that can easily be tapped.

Disadvantages of Fiber-optic cable

- Installation and maintenance require expertise
- Unidirectional light propagation. If we need bidirectional communication, two fibers are needed.
- Cost. The cable and the interfaces are relatively more expensive

Problems with wired media

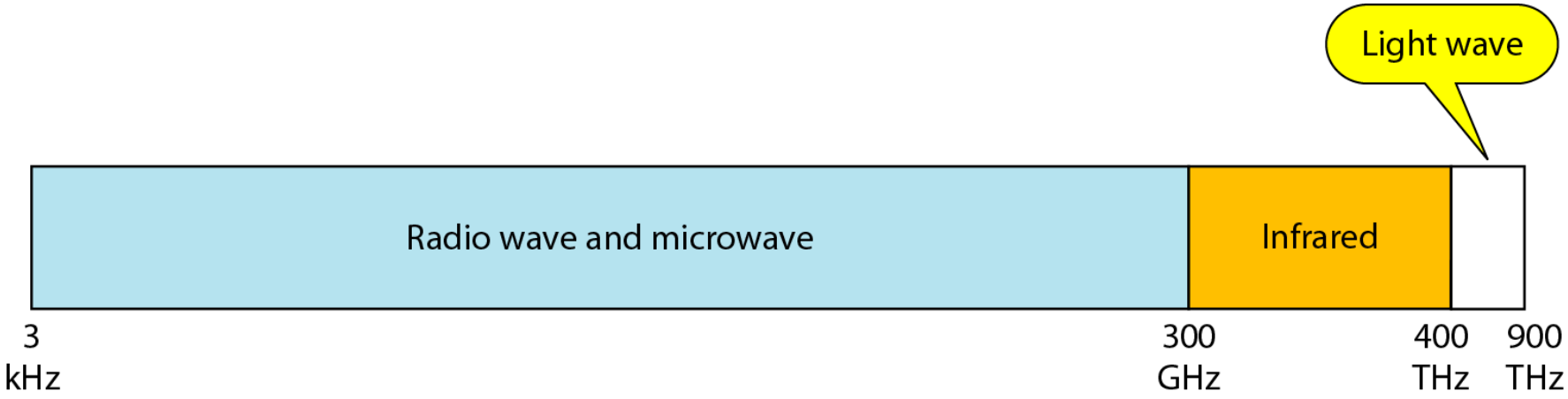
- Difficult due to terrain (mountains, jungles..)
- A “Tethered” Communication
- System becomes bulky
- Not suited for Mobile users
- Future is : Fiber and Wireless

UNGUIDED MEDIA: WIRELESS

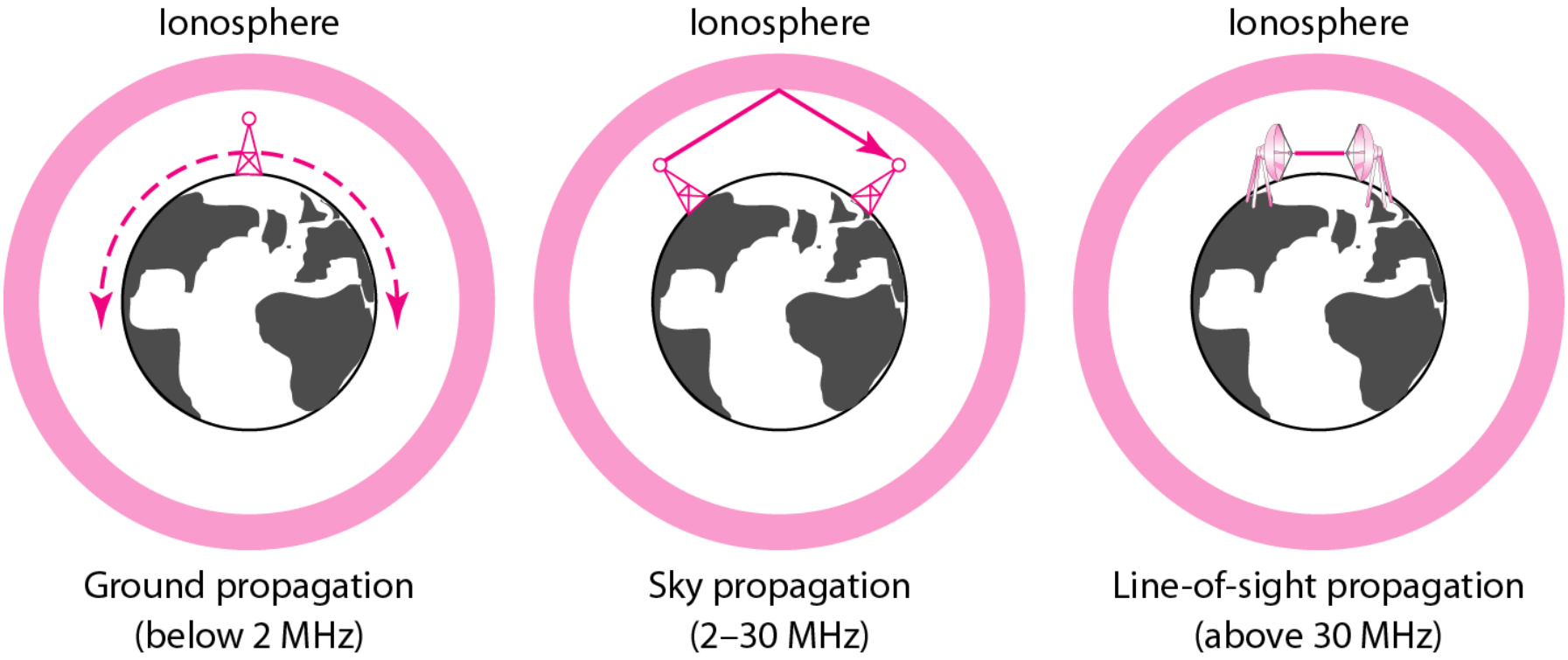
Unguided media transport electromagnetic waves without using a physical conductor.

1. Radio Waves (3KHz-1GHz)
2. Microwaves (1GHz-300GHz)
3. Infrared (300GHz-400THz)
4. Light (400THz-900THz)

Electromagnetic spectrum for wireless communication Scarce recourse



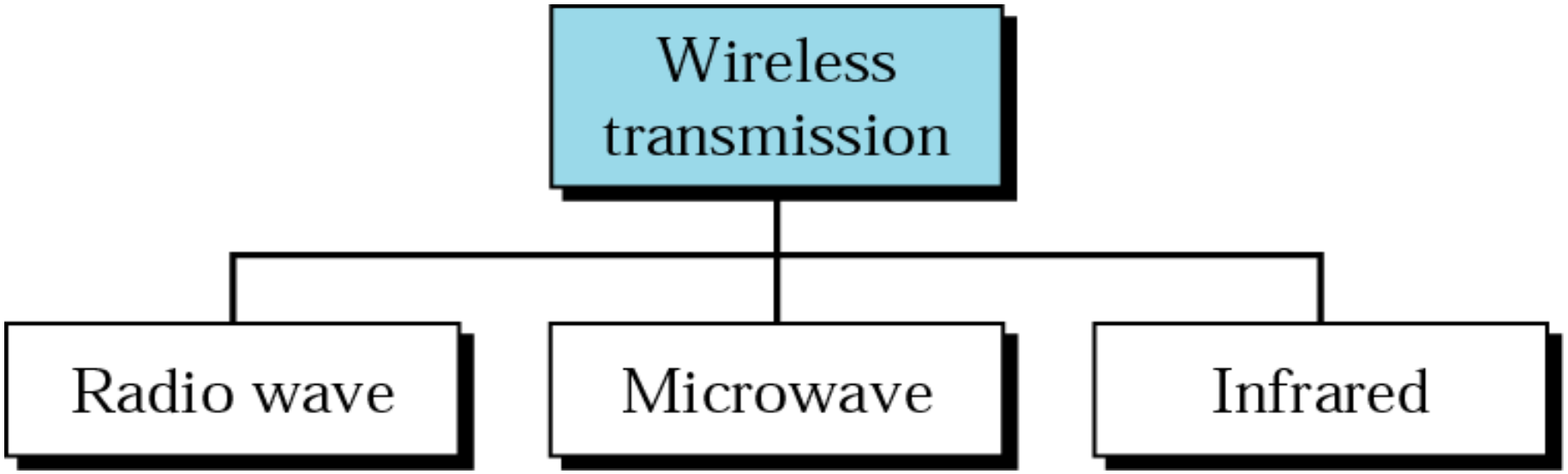
Propagation methods



- Ground - Propagation of radio waves (low frequency) through lowest portion of atmosphere (hugging the earth)
- Sky - radio waves (higher-frequency) radiate upward into ionosphere where they are reflected back to earth
- LOS - very high-frequency signals are transmitted in straight lines directly from antenna to antenna

Bands

Band	*Range*	*Propagation*	*Application*
VLF (very low frequency)	3–30 kHz	Ground	Long-range radio navigation
LF (low frequency)	30–300 kHz	Ground	Radio beacons and navigational locators
MF (middle frequency)	300 kHz–3 MHz	Sky	AM radio
HF (high frequency)	3–30 MHz	Sky	Citizens band (CB), ship/aircraft communication
VHF (very high frequency)	30–300 MHz	Sky and line-of-sight	VHF TV, FM radio
UHF (ultrahigh frequency)	300 MHz–3 GHz	Line-of-sight	UHF TV, cellular phones, paging, satellite
SHF (superhigh frequency)	3–30 GHz	Line-of-sight	Satellite communication
EHF (extremely high frequency)	30–300 GHz	Line-of-sight	Radar, satellite


Wireless transmission
Radio wave
Microwave
Infrared

Radio waves

- *EM waves ranging in frequencies 3 kHz - 1 GHz*
- *for the most part, are omnidirectional*
- *Sending/receiving antennas do not have to be aligned*
- *used for multicast communications, - radio*
- *propagate in the sky mode, penetrates wall*
- *waves transmitted by antenna are susceptible to interference by another antenna that may send signals using the same frequency or band.*

Microwaves

- *waves ranging in frequencies between 1 -300 GHz*
- *Unidirectional*
- *propagation is LOS*
- *towers with antennas that are far apart need to be very tall*
- *used for unicast communication such as cellular telephones, satellite networks, Wireless LANs*

Infrared

- *frequencies from 300 GHz to 400 THz*
- *used for short-range communication in a closed area using line-of-sight propagation.*
- *Can't penetrate walls*
- *Sun rays contain infrared waves*
- *IrDA - established standards – IrDA ports*
- *KB, mice, printer, PC, digital data at 75 kbps for 8m, 4 Mbps possible*

Two parties A and B are located 10 KM apart. Both parties want to transfer data of 10GB/Day to each other. The parties have following options:

1. A pair of Coaxial Cable with bandwidth of 200Mbps in both direction with attenuation of 1.5 dB per 500 meters and overall one-time installation cost of ₹ 50/10 meters. (amplifier required at every 3 dB attenuation)
2. A single fiber cable with end points data rate support of 750 Mbps with attenuation of 0.01 dB per 1 KM and overall one-time installation cost of ₹500/1 meter.
3. A box of DVD, which carries, 10 DVDs of 1 GB capacity each, in it. It has one time cost of ₹15/DVD and also has 45 minutes of average time to travel between two parties.

- *Evaluate these options based on: Cost/Bit (for per day data), Throughput, Latency and amplifier requirements.*

Throughput and Amplifier Requirement

Throughput:

Coax: Throughput = Bandwidth = 200 Mbps (given)

Fiber: Throughput = Bandwidth = 750 Mbps (given)

DVD: 10 x10^9 bits/ 45 X 60 secs = 3.7 Mbps (storage media)

Amplifier requirement :

Amplifier is required at every 3 dB attenuation (signal strength goes half)

Coax: Attenuation of 1.5 dB per 500 mts, 3 db per 1000 mts, one amplifier per 1000 mts, 9 amplifier from Tx to Rx

Fiber: No amplifier required

DVD: No amplifier required

Cost per bit (We are to consider per day data only)

Coax:

mts: ₹

10:50

10,000:?

50 x 10,000 /10 = 50,000

Fiber:

mts: ₹

1: 500

10,000:?

10,000/500= ₹ 50,00,000

DVD:

DVD: ₹

1:15

10:?

15x10= ₹ 150

Option	Calculation	Cost (₹)/bit
Coax	$50,000/10x10^9$	5e-6
Fiber	$50,00,000/10x10^9$	5e-4
DVD	$150/10x10^9$	1.5e-8

Latency=Transmission Time + Propagation Time

Coax:
10 GB/200 Mbps + 10 KM/$2x10^8$ m/s = 50.000005 S

Fiber:
10 GB/750 Mbps + 10 KM/ 3 X 10^8 m/s= 10.330003 S

DVD:
45 minutes

A file of 12 Mbytes is to be transmitted. A network with bandwidth of 10Mbps
can pass only an average of 12000 frames of 1000 bytes per minute.

1. What is the throughput of the network?
2. What will be the propagation delay if the distance between the Tx and Rx is 1000 km and propagation speed is 10×10^7 m/s in the cable?
3. If queuing time is 2 ms then assuming the processing time as zero, what will be the latency?

Thank You!