Chapter 2
Transmission Media

- ***Outline:***

2.1 Network monitoring: delay, latency, throughput

2.2 Transmission media: Twisted pair, Coaxial, Fiber optic, Line-of-site, Satellite

2.3 Multiplexing, Circuit switching, Packet switching, VC Switching, Telecommunication switching system (Networking of Telephone exchanges)

2.4 ISDN: Architecture, Interface, and Signaling

Network Monitoring: Delay

- As a packet travels from one node to the subsequent node along the path, the packet suffers from several different types of delays at each node along the path.
- The most important of these delays are the
  - *Nodal processing delay /Processing Delay*
  - *Queuing delay*
  - *Transmission delay and*
  - *Propagation delay*
- ***Nodal processing delay /Processing Delay***
  - The time required to examine the packet's header and determine where to direct the packet is part of the processing delay.
  - The processing delay can also include other factors, such as the time needed to check for bit-level errors in the packet that occurred in transmitting the packet's bits from the upstream router to router.

Network Monitoring: Delay

- ***Queuing delay***
  - After this nodal processing, the router directs the packet to the queue that precedes the link to router B.
  - At the queue, the packet experiences a queuing delay as it waits to be transmitted onto the link.
  - The queuing delay of a specific packet will depend on the number of other, earlier-arriving packets that are queued and waiting for transmission across the link; the delay of a given packet can vary significantly from packet to packet.
  - If the queue is empty and no other packet is currently being transmitted, then our packet's queuing delay is zero.
- ***Transmission Delay***
  - The amount of time required to transmit all of the packet's bits into the link.

Network Monitoring

- ***Propagation Delay***
  - Propagation time measures the time required for a bit to travel from the source to the destination.
  - The propagation time is calculated by dividing the distance by the propagation speed.

Propagation Delay= Distance/ Propagation Speed

- ***Latency***
  - The latency or delay defines how long it takes for an entire message to completely arrive at the destination from the time the first bit is sent out from the source.

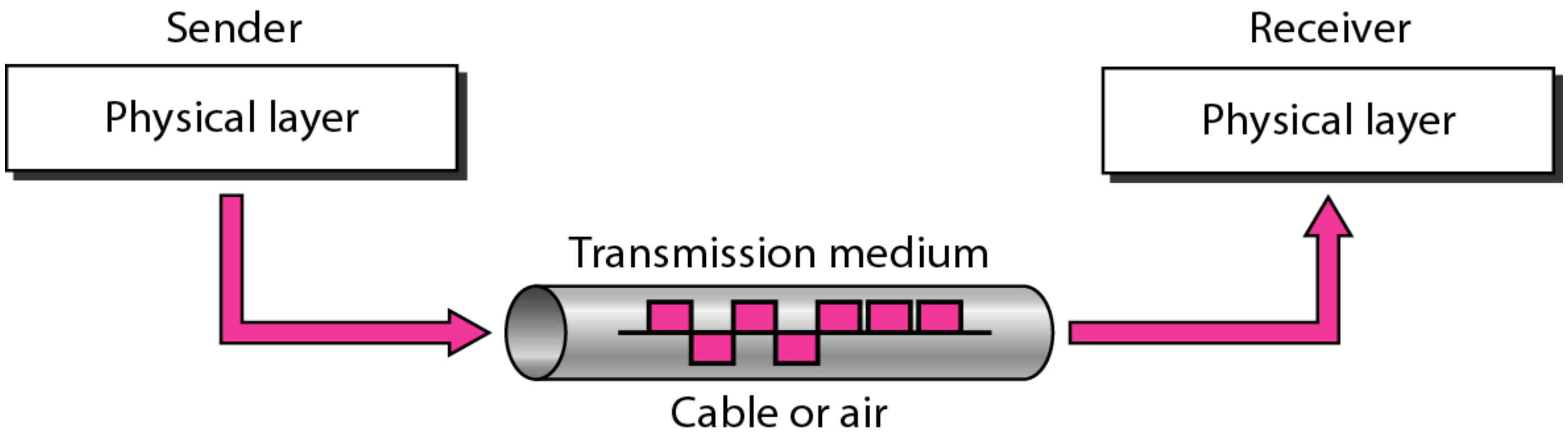
Latency =propagation time +transmission time +queuing time + processing delay

Network Monitoring

- ***Throughput***
  - Bandwidth defines as the net bit rate cannel capacity or the maximum throughput of a channel.
  - Where as throughput is the average rate of successful message delivery over a communication channel.
  - Measured in bits/second.
  - **Units**
    - Kbits/sec= 10^3 bps ,
    - Mbits/sec= 10^6 bps ,
    - Gbits/sec= 10^9 bps ,
    - Tbits/sec= 10^{12} bps

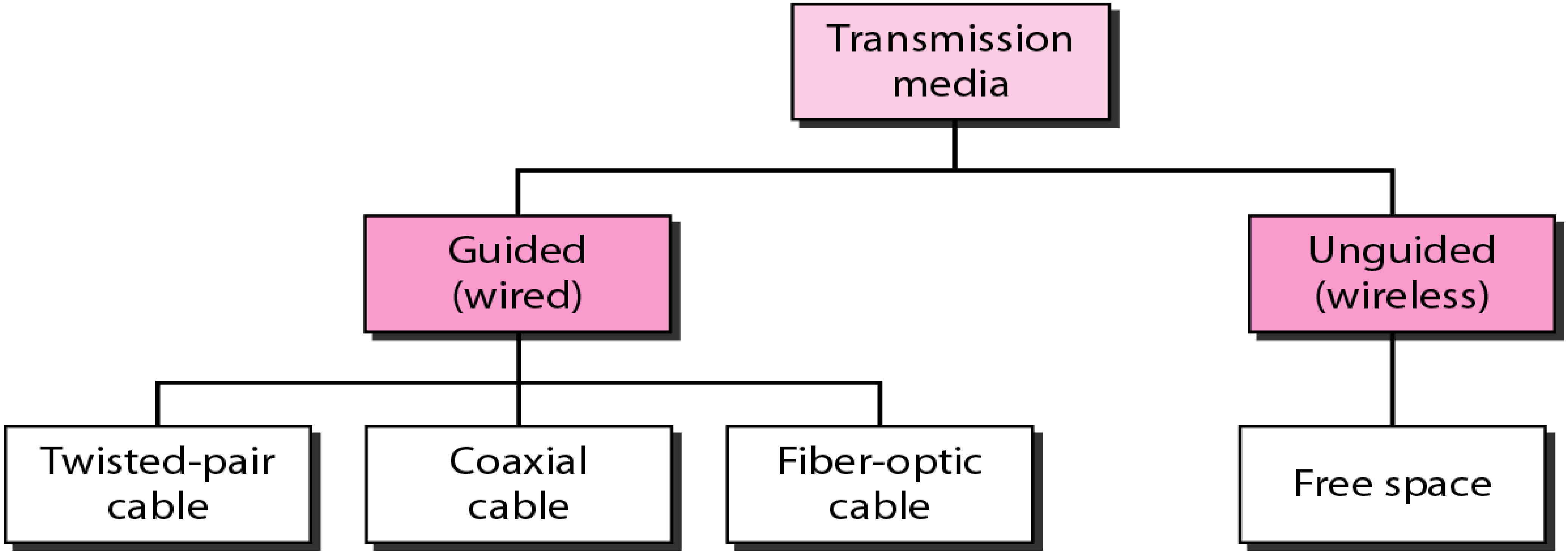
Transmission Media

- 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.
- In data communications, the transmission medium is usually free space, metallic cable, or fiber-optic cable.



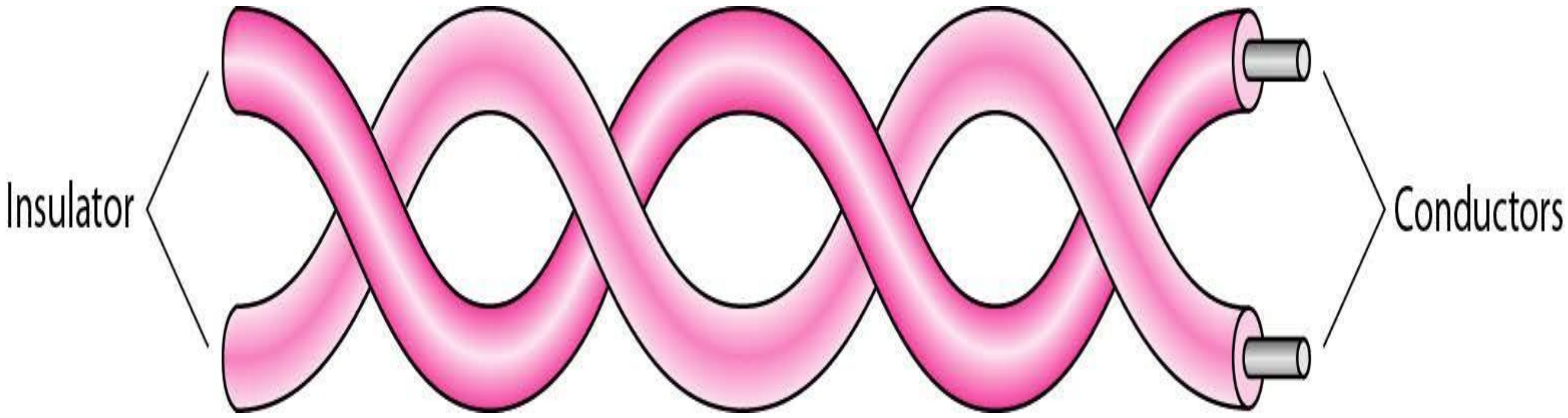
Transmission Media

- **Classes of transmission 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.
  - Unguided media transport electromagnetic waves without using a physical conductor. This type of communication is often referred to as wireless communication.



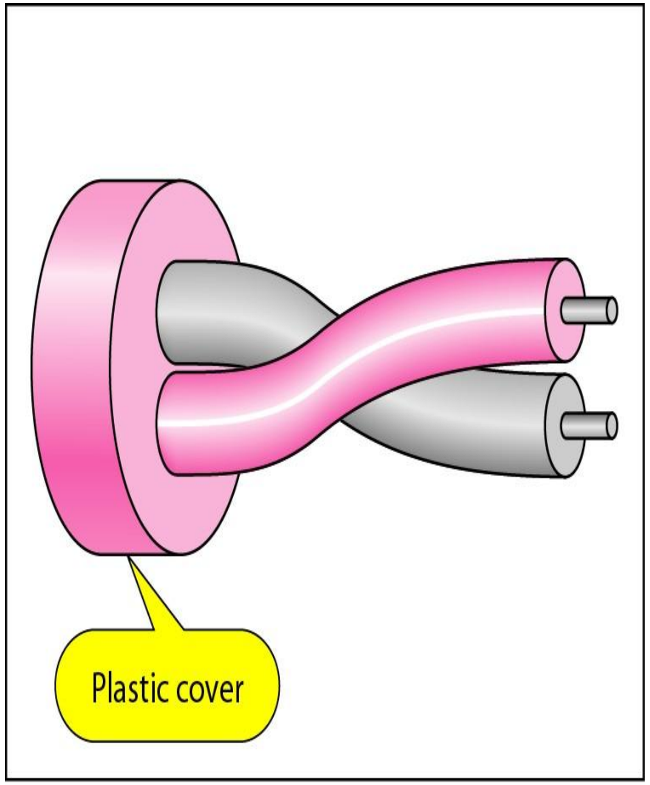
Transmission Media: Twisted-Pair Cable

- A twisted pair consists of two conductors (normally copper), each with its own plastic insulation, twisted together.
- One of the wires is used to carry signals to the receiver, and the other is used only as a ground reference.
- A signal is usually carried as the difference in voltage between the two wires in the pair. This provides better immunity to external noise because the noise tends to affect both wires the same, leaving the differential unchanged.

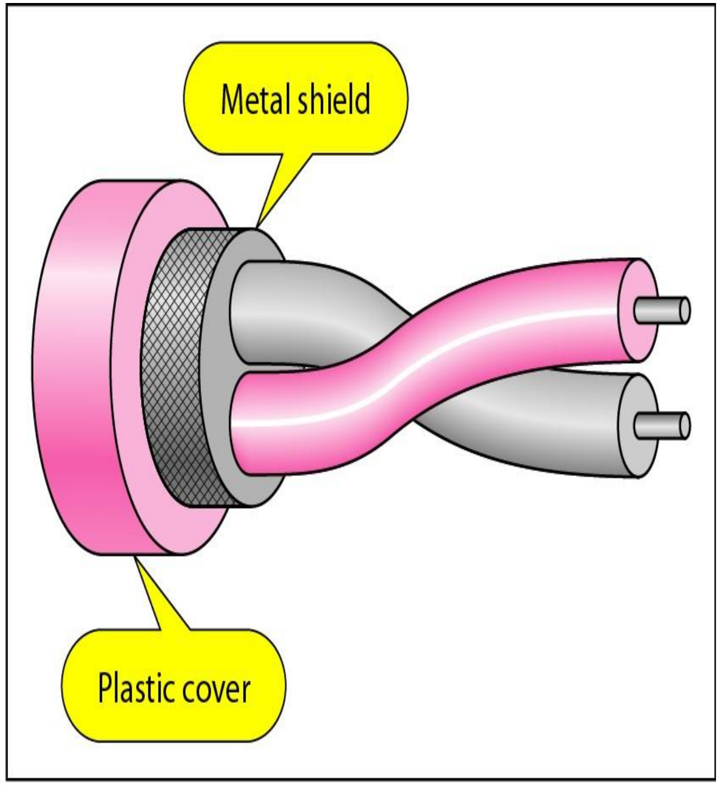


Transmission Media: Twisted-Pair Cable

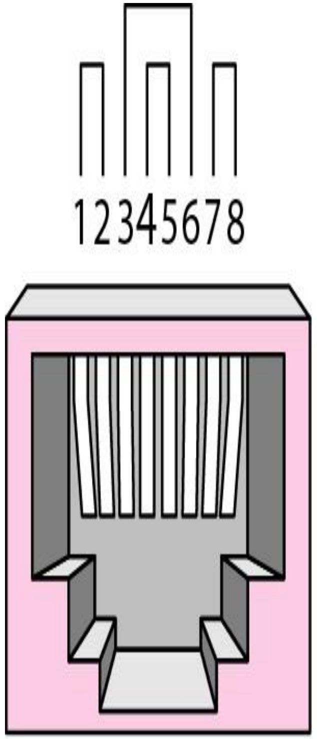
- Two primary types of Twisted-pair cable
  - *Unshielded twisted-pair (UTP)*
  - *Shielded twisted pair (STP)*



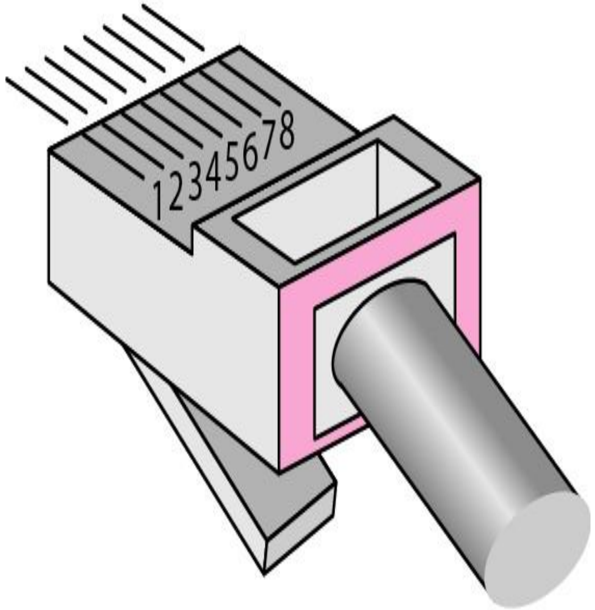
a. UTP



b. STP



RJ-45 Female



RJ-45 Male

Transmission media: Twisted-Pair Cable

- **Unshielded twisted-pair (UTP)**
  - The most common twisted-pair cable used in communications is referred to as unshielded twisted-pair (UTP).
  - UTP contains no shielding and is more susceptible to external noise but is the most frequently used ***because it is inexpensive and easier to install.***
  - Each pair is twisted with different number of twists per inch to help eliminate interface from adjacent pairs and other electrical devices.
  - The higher the twist per inch higher the supported transmission.
  - The cable has four pairs of wires inside the jacket.
  - ***The Electronic Industries Association (EIA)*** has developed standards to classify unshielded twisted-pair cable into seven categories.
  - Categories are determined by cable quality, with 1 as the lowest and 7 as the highest. Each EIA category is suitable for specific uses.
  - The most common UTP connector is RJ45 (RJ stands for registered jack).

Transmission media: Twisted-pair Cable

- **Unshielded twisted-pair (UTP)**
  - Maximum cable length without repeater 100m

Category	Data Rate (Mbps)	Primary Application
CAT 1	< 0.1	the lowest quality, only good for voice networks
CAT 2	2	Voice and low-speed data networks less than 4 Mbps
CAT 3	10	Voice and data networks from 4 to 10 Mbps Ethernet. LANs
CAT 4	20	16-Mbps Token Ring. LANs
CAT 5 (e)	125	100-Mbps Fast Ethernet. .Common for networks targeted for high-speed data communications. LANs
CAT 6	200	1000-Mbps Gigabit Ethernet. LANs

Transmission media: Twisted-pair Cable

- **Cabling Standards (used for UTP):**
  - EIA/TIA 568 A color coding –g G o B b O br Br
  - EIA/TIA 568 B color coding –o O g B b G br Br

    Where g- light green or Stripped green (wire)

    G-Solid Green (wire) . Similar For other wire as well.
- **Straight through Connection**: A-A or B-B setting, used to connect Different device, *e.g. Switch to router, Switch to PC or server , Hub to PC or server*
- **Cross-over Connection**: A-B or B-A setting, used to connect same device, e.g. *Switch to switch, Switch to hub, Hub to hub, Router to router, Router Ethernet port to PC NIC, PC to PC*

T A/E A 568A Wiring

1 white and Green
2
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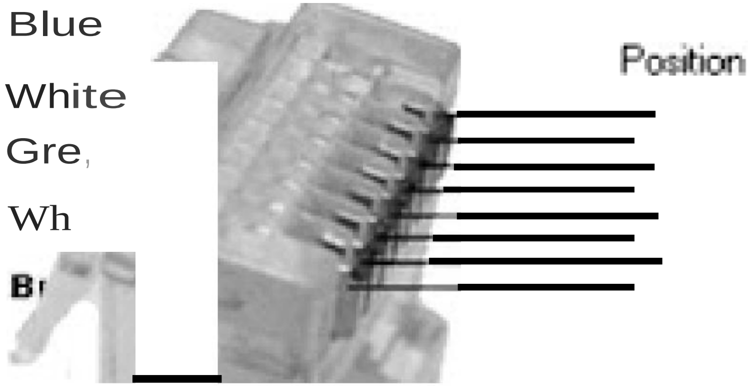
TIA/EIA 5688 Wiring

I white nd Orange
2 Oran e
3 White nd Grean
4 Blue
5 White
6 Gre,
7 Wh
a B

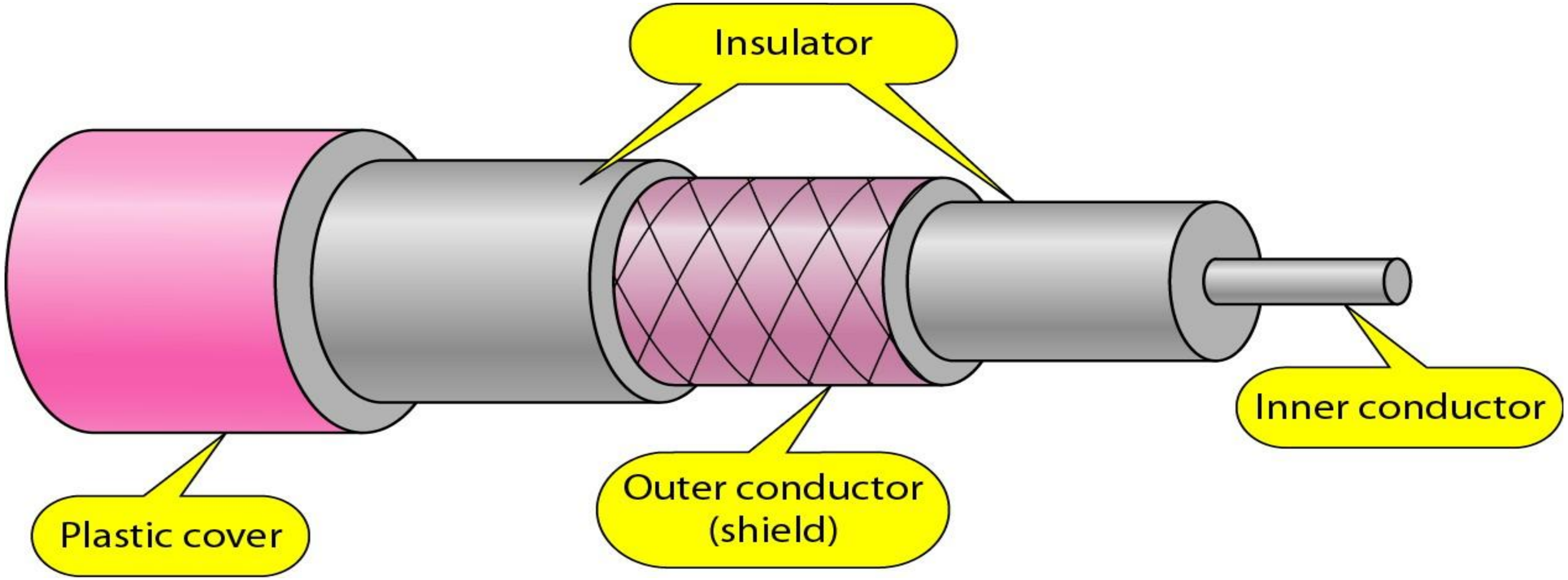


Transmission media: Twisted-pair Cable

- **Shielded twisted-pair (STP)**
  - IBM has also produced a version of twisted-pair cable for its use called shielded twisted-pair (STP).
  - STP cable contains an outer conductive shield that is electrically grounded to insulate the signals from external electrical noise.
  - STP also uses inner foil shields to protect each wire pair from noise generated by the other pairs.
  - Thus Shielded twisted pair is suitable for the environments with electrical interference; however, the extra shielding can make the ***cables quite bulky as well as bit expensive***.

Transmission media: Coaxial Cable

- Coaxial cable carries signals of higher frequency ranges than those in twisted pair cable.
- 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. This outer conductor is also enclosed in an insulating sheath, and the whole cable is protected by a plastic cover.



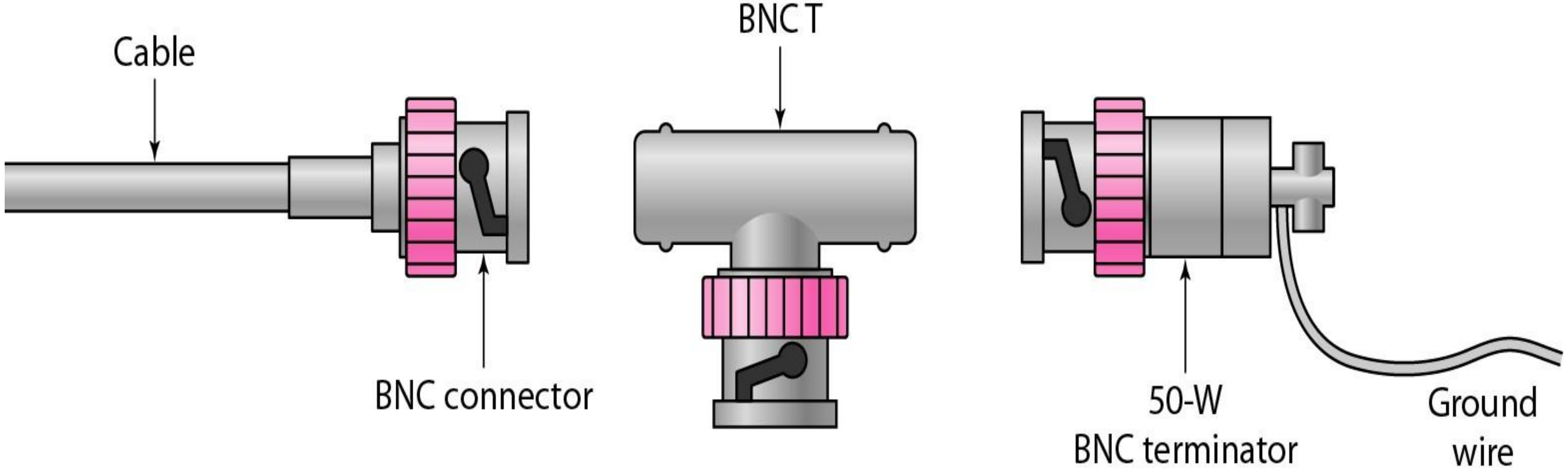
Transmission media: Coaxial Cable

- Coaxial cables are categorized by their radio government (RG) ratings.
- Each RG number denotes a unique set of physical specifications, including the wire gauge of the inner conductor, the thickness and type of the inner insulator, the construction of the shield, and the size and type of the outer casing.
- **Categories of coaxial cables**

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

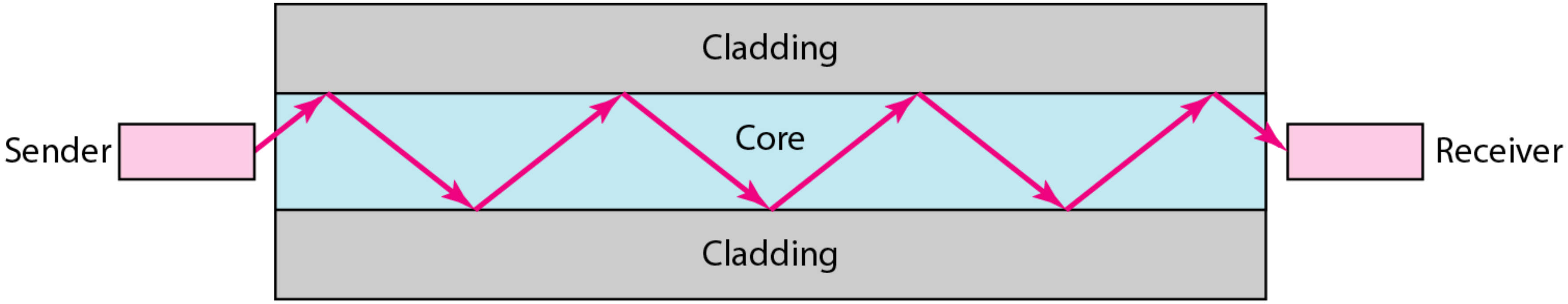
Transmission media: Coaxial Cable

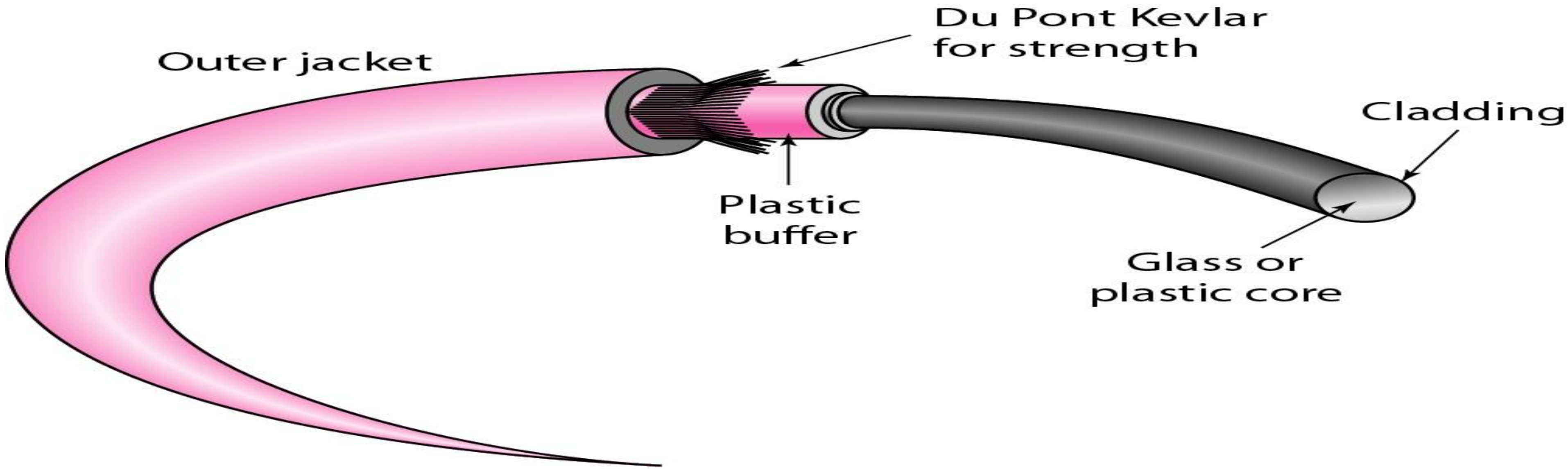
- **Thick Ethernet:** Thick Ethernet is also called 10base5 cable which is of 50 ohm. 10 represents the data rate transfer which is 10Mbps and the last number 5 represents the maximum length which is 500m with out using the repeaters. You can extend the cable by using the repeaters.
- **Thin Ethernet:** Thick Ethernet is also called 10base2 cable which is of 50 ohm. 10 represents the data rate transfer which is 10Mbps and the last number 2 represents the maximum length which is 185m with out using the repeaters. You can extend the cable by using the repeaters.
- The most common type of connector used today is the Bayone-Neill-Concelman connector.



Transmission media: Fiber optics

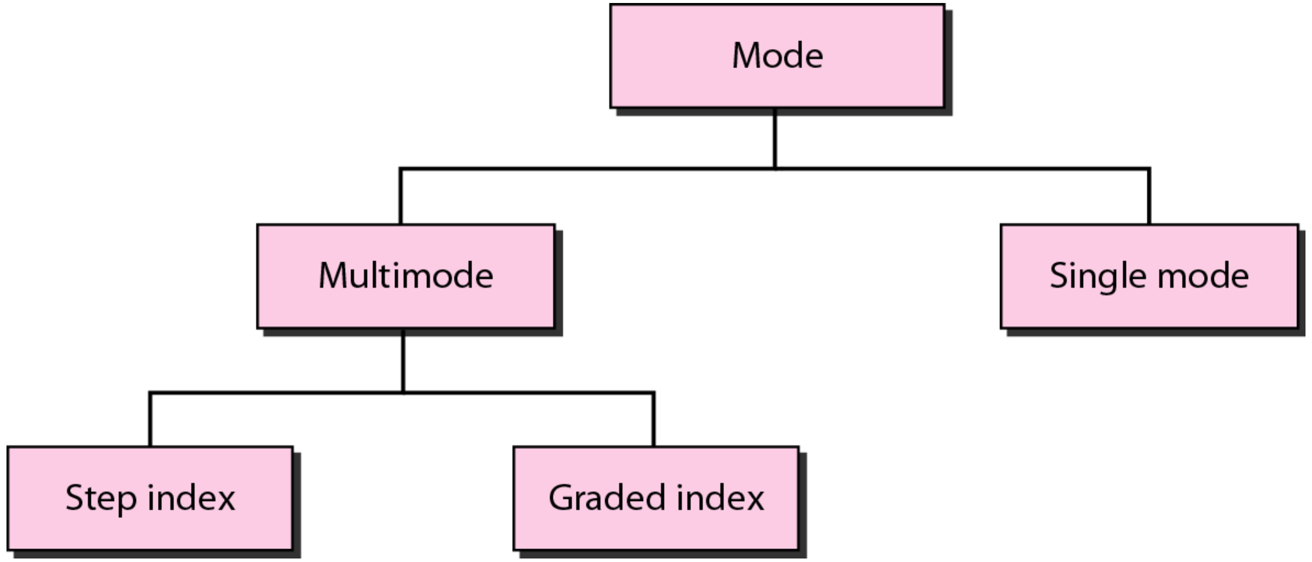
- A fiber-optic cable is made of glass or plastic and transmits signals in the form of light.
- An optical fiber consists of a core (denser material) and a cladding (less dense material).
- Each core passes signals in only one direction.



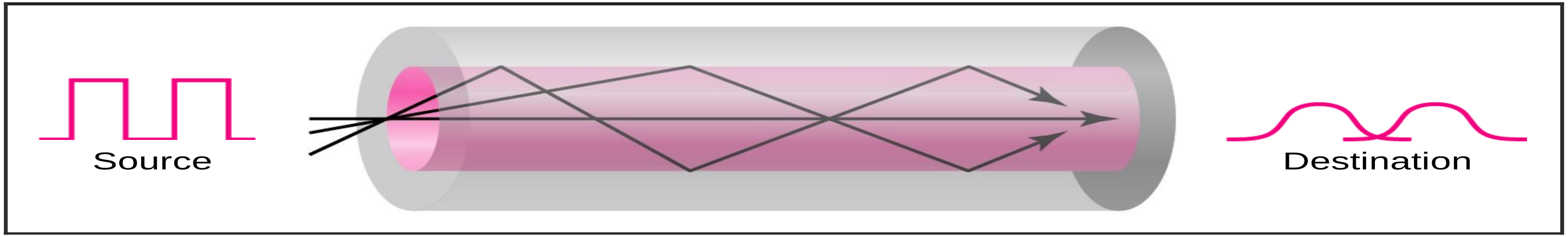


Transmission media: Fiber optics

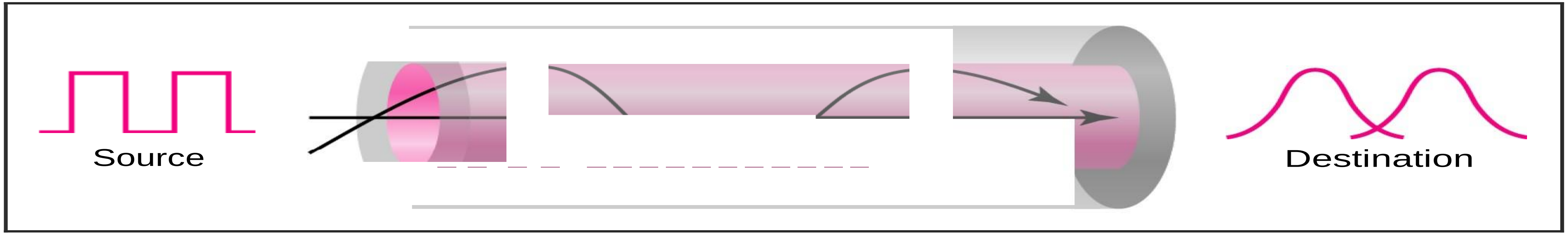
- ***Multimode*** is so named because multiple beams from a light source move through the core in different paths. How these beams move within the cable depends on the structure of the core.
- ***In multimode step-index fiber***, the density of the core remains constant from the center to the edges. A beam of light moves through this constant density in a straight line until it reaches the interface of the core and the cladding. At the interface, there is an abrupt change due to a lower density; this alters the angle of the beam's motion.
- ***In multimode graded-index fiber,*** density is highest at the center of the core and decreases gradually to its lowest at the edge.



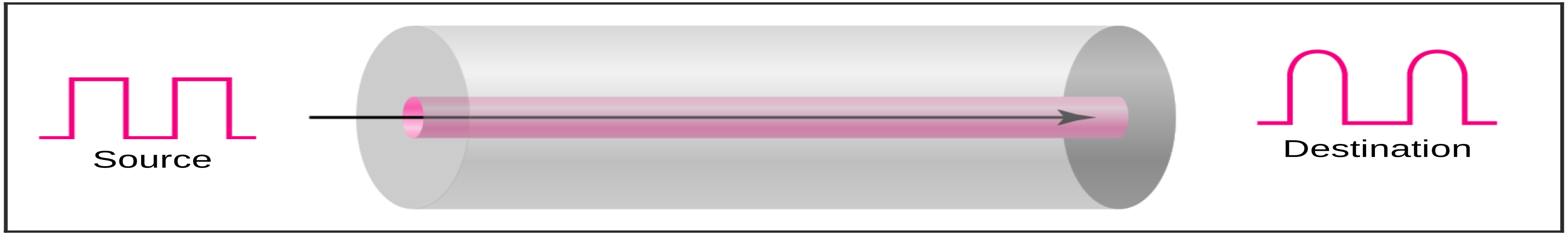
Transmission media: Fiber optics



a. Multirnode, step index



b. Multirnode, graded index



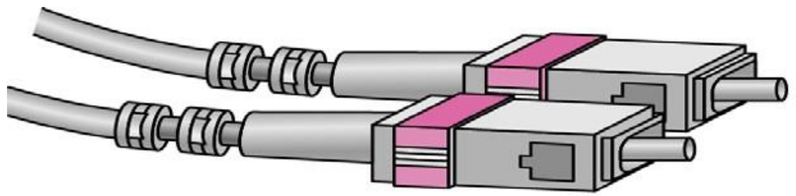
c. Single rnode

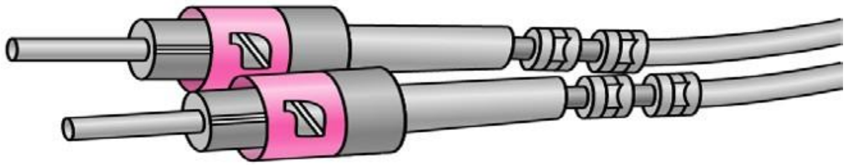
Transmission media: Fiber optics

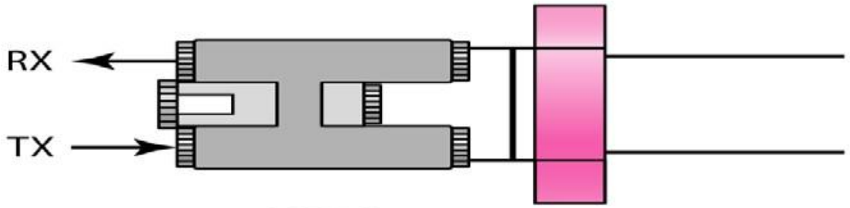
- Optical fibers are defined by the ratio of the diameter of their core to the diameter of their cladding, both expressed in micrometers.

Type	*Core (μm)*	*Cladding (μm)*	*Mode*
50/125	50.0	125	Multimode, graded index
62.5/125	62.5	125	Multimode, graded index
100/125	100.0	125	Multimode, graded index
7/125	7.0	125	Single mode

- ***Fiber-optic cable connectors***


SC connector


ST connector



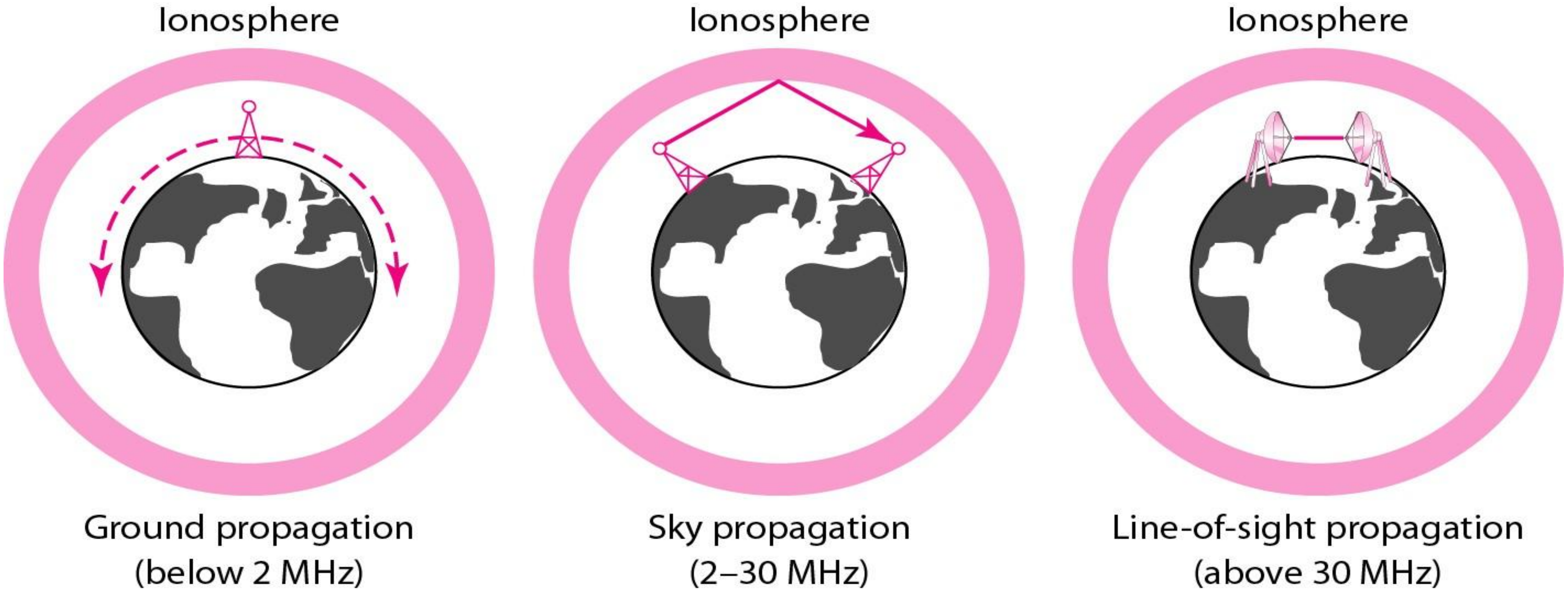
MT-RJ connector

Transmission media: Fiber optics

- ***Advantages of Optical Fiber***
  - Higher bandwidth
  - Less signal attenuation: A 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. Fiber-optic cables are more immune to tapping than copper cables.
- ***Disadvantages of Optical Fiber***
  - Installation and maintenance: Its installation and maintenance require expertise that is not yet available everywhere.
  - Unidirectional light propagation
  - Cost: the cable and the interfaces are relatively more expensive than those of other guided media.

Transmission media: Fiber optics

- Unguided media transport electromagnetic waves without using a physical conductor.
- Often referred to as wireless communication.
- Unguided signals can travel from the source to destination in several ways: *ground propagation, sky propagation, and line-of-sight propagation*



Band	*Range*	*Propagation*	*Application*
VLF (very low frequency)	3–30kHz	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

- **Line-of-sight propagation**
  - Line-of-sight propagation refers to electro-magnetic radiation or acoustic wave propagation.
  - Electromagnetic transmission includes light emissions traveling in a straight line.
  - The rays or waves may be diffracted, refracted, reflected, or absorbed by atmosphere and obstructions with material and generally cannot travel over the horizon or behind obstacles.
  - In wireless channels, not only does radiation loss occur, but also one antenna may not "see" another because of the earth's curvature.
- **Geostationary Satellites**
  - At altitude approx. 36000Km above equatorial plane, satellite rotation period is 24hrs.
  - Satellite is stationary with respect to Earth.
  - With current technology, it is unwise to have geostationary satellites spaced much closer than 2 degrees in the 360-degree equatorial plane, to avoid interference.
  - With a spacing of 2 degrees, there can only be 360/2 = 180 of these satellites in the sky at once.
  - However, each transponder can use multiple frequencies and polarizations to increase the available bandwidth.

- **Medium-Earth Orbit Satellites**
  - At much lower altitudes, between the two Van Allen belts, we find the MEO (Medium-Earth Orbit) satellites.
  - As viewed from the earth, these drift slowly in longitude, taking something like 6 hours to circle the earth. Accordingly, they must be tracked as they move through the sky. Because they are lower than the GEOs, they have a smaller footprint on the ground and require less powerful transmitters to reach them.
  - GPS (Global Positioning System) satellites orbiting at about 18,000 km are examples of MEO satellites.
- **Low-Earth Orbit Satellites**
  - Moving down in altitude, we come to the LEO (Low-Earth Orbit) satellites.
  - Due to their rapid motion, large numbers of them are needed for a complete system.
  - On the other hand, because the satellites are so close to the earth, the ground stations do not need much power, and the round-trip delay is only a few milliseconds.

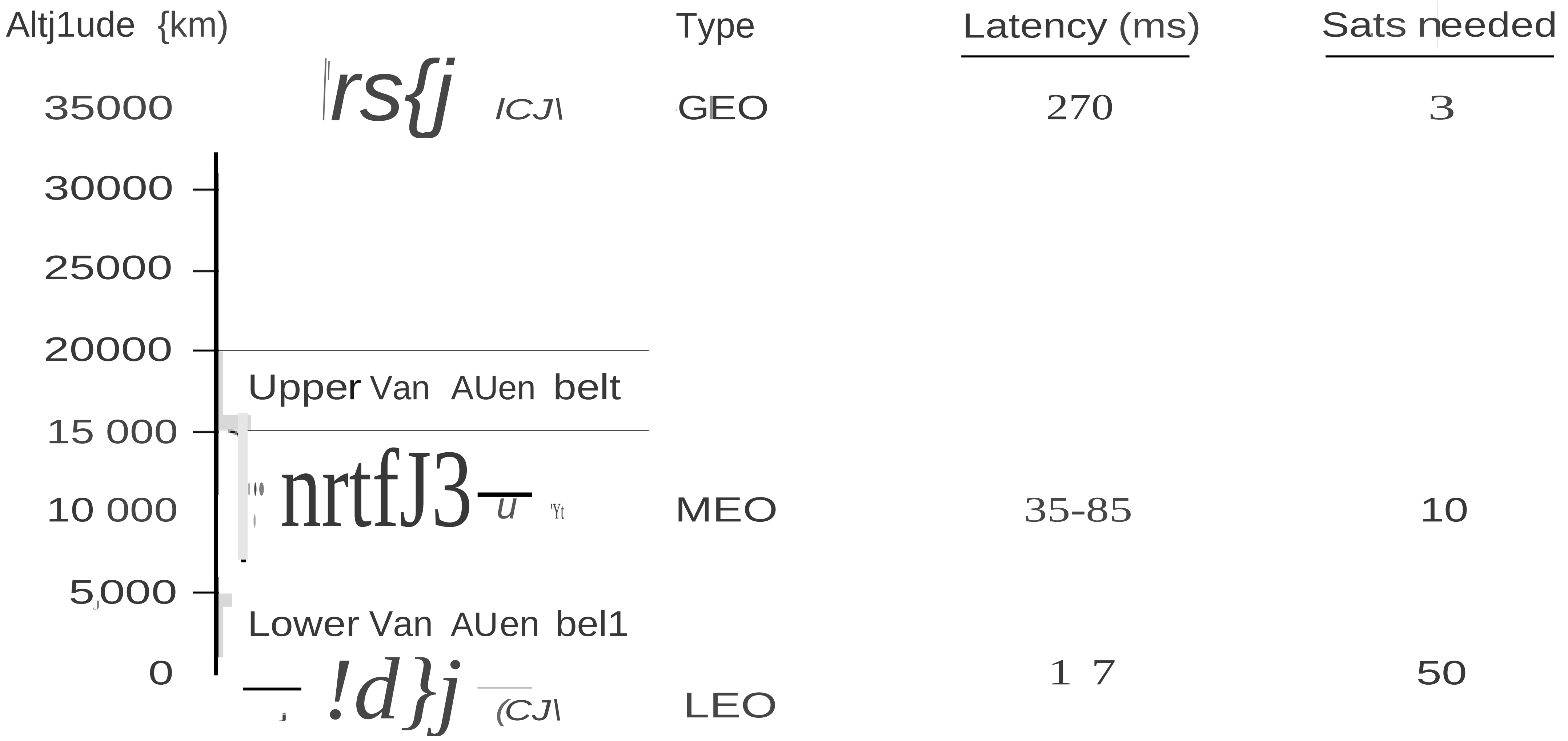


Figure 2-15. Commutlicatjon satellites and sotne of their properties including altitude above the earth, roundl tripdeillay time, and nutnber of satellires needed for global coverage.

Thank You

References:

- Data Communications and Networking “ Behrouz A. Forouzan” Fourth Edition.
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