UPES

UNIVERSITY OF TOMORROW

# Data communication and Networks

**Course Code: ECEG3074**


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# Quiz 2:

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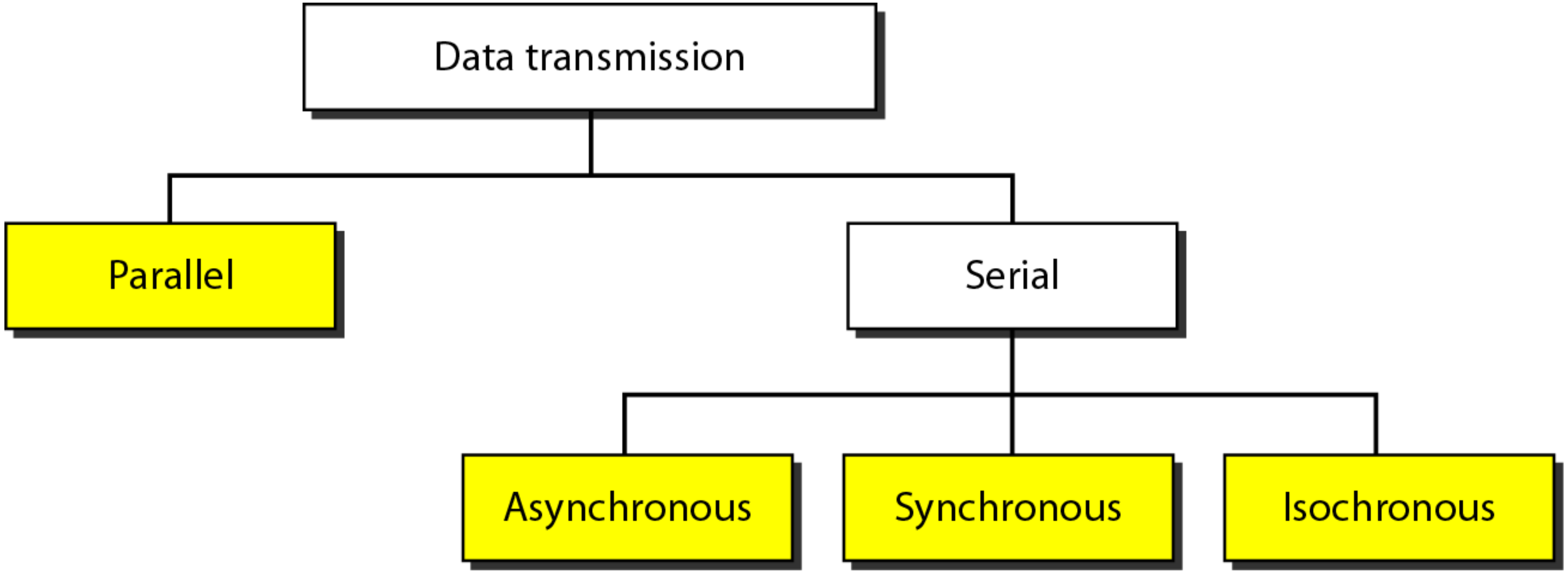
**If the signal-to-noise ratio given in decibels for a noisy channel is 20. What is the capacity of this channel, expressed in Kbps? It is known that the bandwidth of this channel is 10 KHz.**

# TRANSMISSION MODES

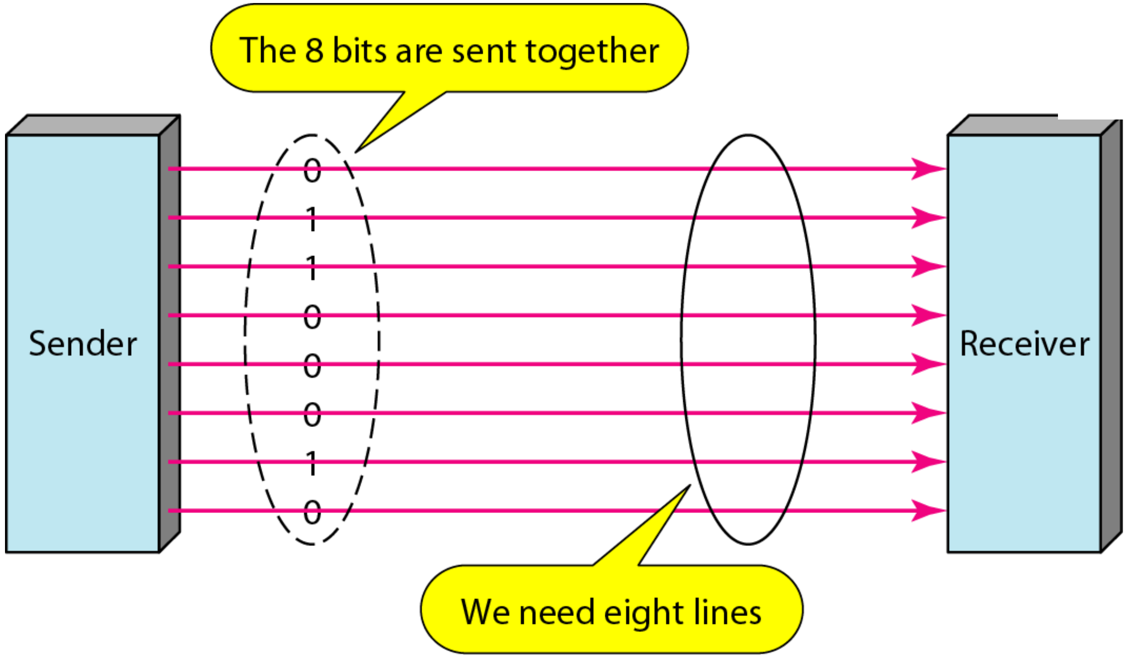
- *The **transmission of binary data** across a link can be accomplished in either **parallel** or **serial** mode.*
  1. *In parallel mode, **multiple bits are sent** with each clock tick.*
  2. *In serial mode, **1 bit is sent with each clock tick**.*

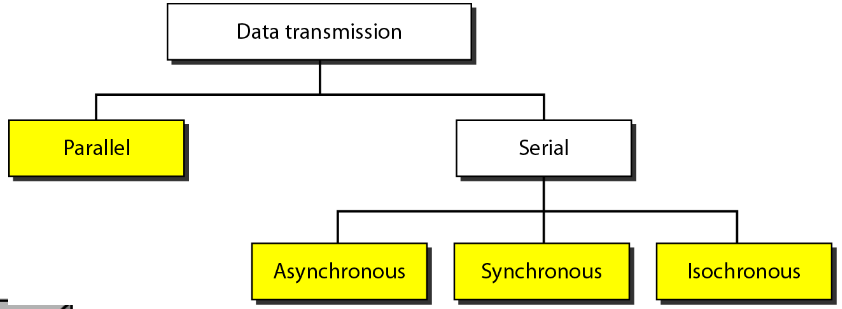
- *While there is only one way to send parallel data, there are three **subclasses of serial transmission**:*
  - ***asynchronous**,*
  - ***synchronous**, and*
  - ***isochronous**.*

# Data transmission and modes



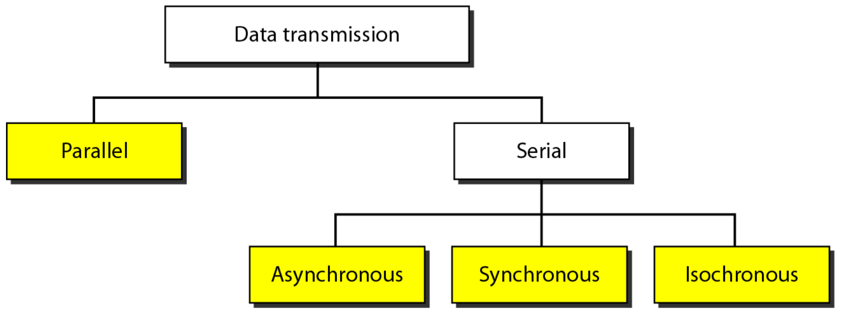
# Figure *Parallel transmission*

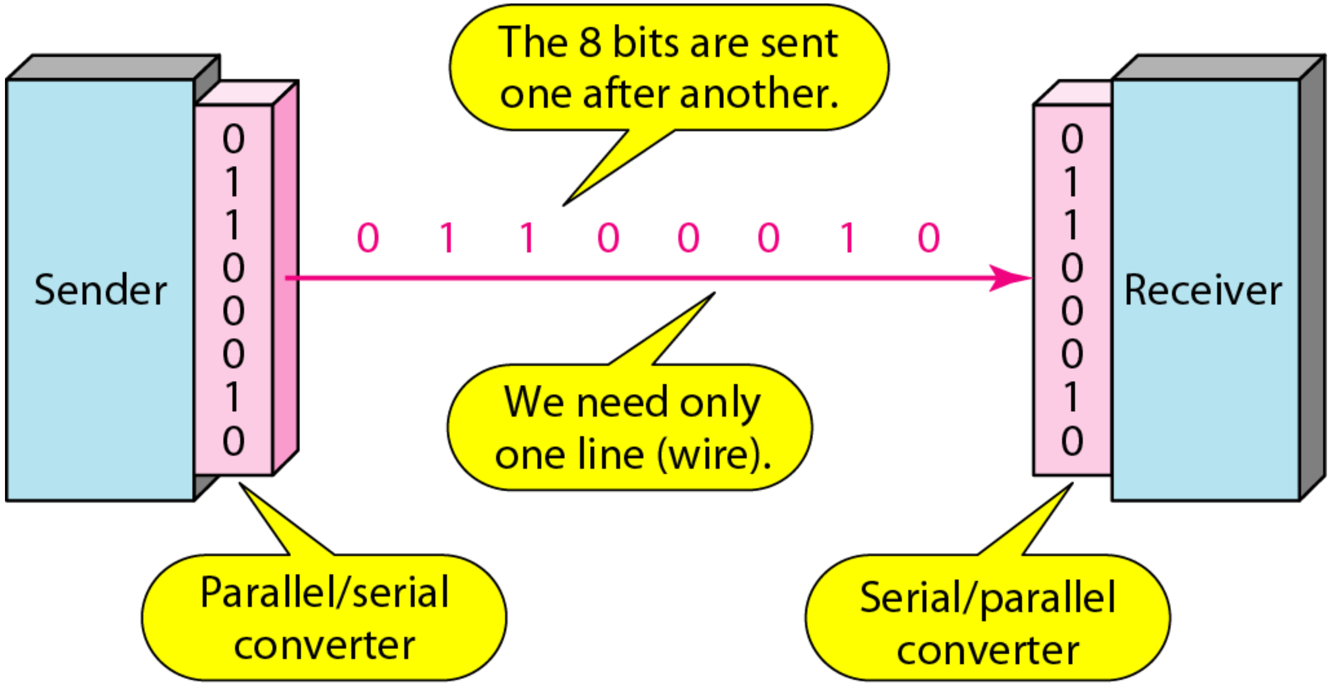



- In parallel data transmission, **multiple bits are sent simultaneously** across multiple channels.
- This means that each bit has its own separate wire or channel for transmission, allowing for faster data transfer rates over short distances.
- However, parallel transmission can suffer from issues like crosstalk and signal degradation over longer distances.
- Examples: Old Printer Cables, Memory Buses, IDE (Integrated Drive Electronics) Cables, etc.

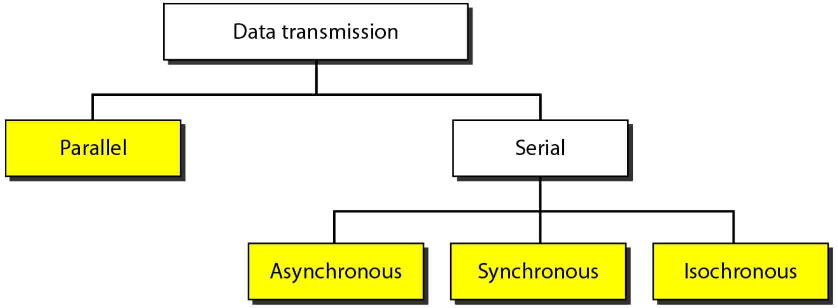
# Figure *Serial transmission*



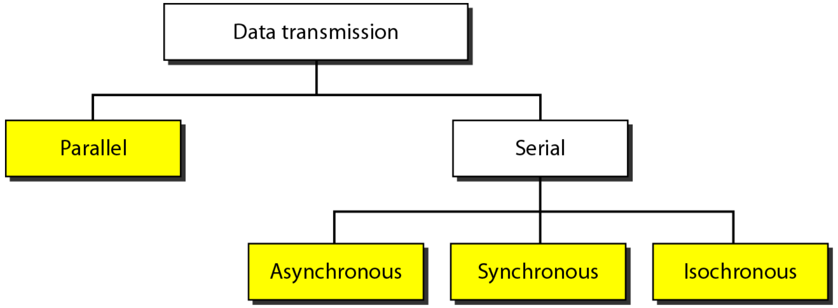

- Bits are sent sequentially over a single channel or wire.
- Although this method is slower compared to parallel transmission, it is **more reliable** over longer distances and **less** prone to issues like **crosstalk** and **signal degradation**.
- Examples: USB (Universal Serial Bus), RS-232, SATA (Serial ATA), HDMI (High-Definition Multimedia Interface), etc.

## Parallel transmission Vs. Serial transmission



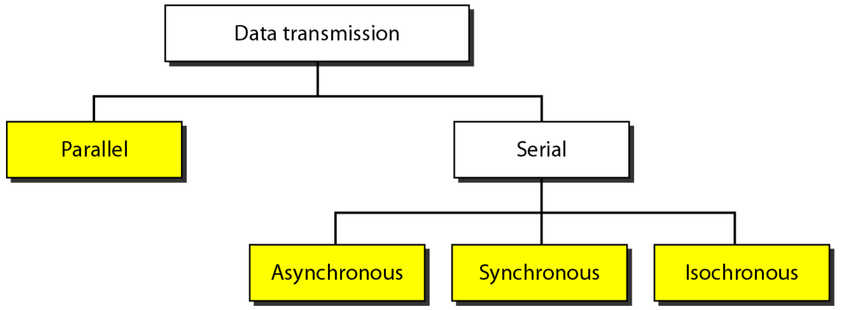

- The advantage of serial over parallel transmission is that with **only one communication channel**, serial transmission **reduces the cost of transmission** over parallel **by roughly a factor of *n***.
- Since communication within devices is parallel, **conversion devices** are **required** at the interface **between the sender and the line** (parallel-to-serial) and **between the line and the receiver** (serial-to-parallel).

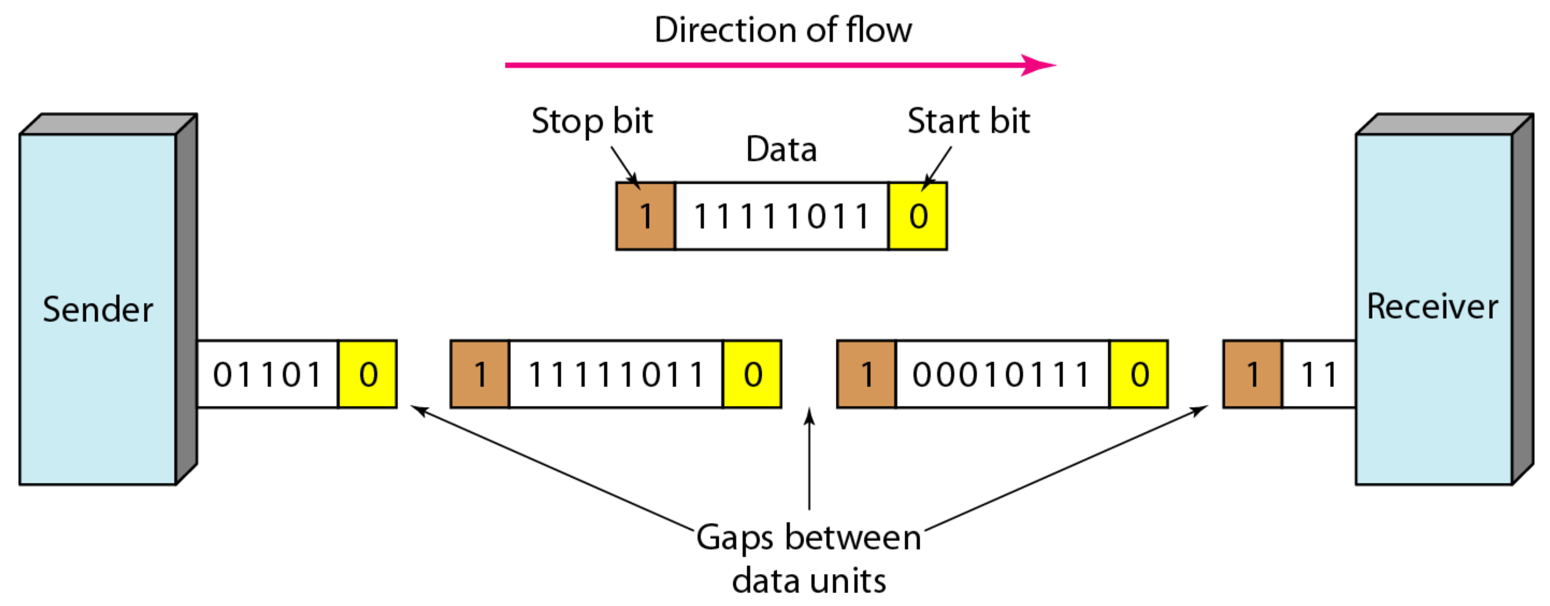
# Asynchronous Transmission




- The timing of a signal is **unimportant**.
- Information is received and **translated by agreed upon patterns**. As long as those patterns are followed, the receiving device can retrieve the information without regard to the rhythm in which it is sent.
- Each group, **usually 8 bits**, **is sent** along the link **as a unit**. The sending **system handles each group independently**, relaying it to the link whenever ready, without regard to a timer.
- **To alert the receiver** to the arrival of a new group, **an extra bit is added to the beginning** of each byte. **This bit, usually a 0**, is called **the start bit**.
- To let the receiver **know that the byte is finished**, 1 or more **additional bits are appended to the end** of the byte. These **bits, usually 1's**, are called **stop bits**.
- The transmission of each byte may then be **followed by a gap of varying duration**

# Figure *Asynchronous transmission*



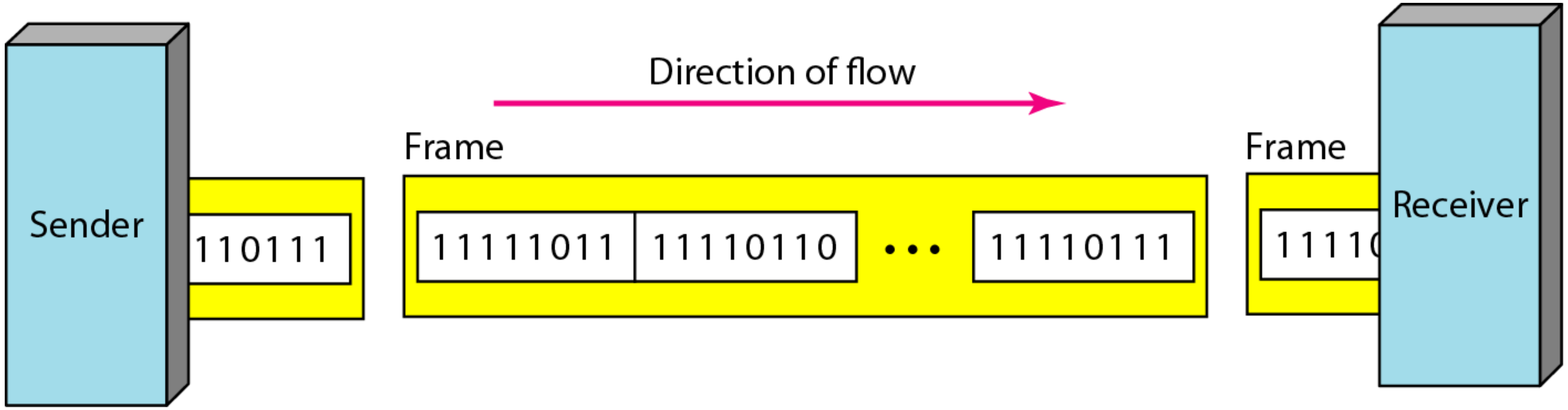

- The addition of **stop** and **start bits** and the **insertion of gaps** into the bit stream make asynchronous transmission **slower,** but it is cheap and effective for situations such as low-speed communication.
- **Example**: the connection of a keyboard to a computer is a natural application for asynchronous transmission. A user types only one character at a time, types extremely slowly compared to the CPU, and leaves unpredictable gaps of time between each character.

**Asynchronous here means “asynchronous at the byte level,” but the bits are still synchronized; their durations are the same.**

# Synchronous Transmission

- In synchronous transmission, the bit stream is **combined into longer "frames," which may contain multiple bytes**. Each byte, however, is introduced onto the **transmission link without a gap** between it and the next one.
- Left to the **receiver to separate the bit stream into bytes for decoding** purposes. In other words, data are transmitted as an unbroken string of 1's and O's, and the receiver separates that string into the bytes, or characters, it needs to reconstruct the information.
- Both the **sender and receiver operate on a synchronized clock**.

# Figure *Synchronous transmission*




- The sender puts its data onto the line as one long string. If the sender wishes to send data in separate bursts, the **gaps between bursts must be filled with a special sequence of O's and 1's that means *idle***.
- The **receiver counts** the **bits** as they arrive **and groups them in 8-bit units**.
- Without gaps and **start** and **stop** bits, there is no built-in mechanism to help the receiving device adjust its bit synchronization midstream.
- Therefore, **Timing becomes very important**, because the accuracy of the received information is completely **dependent on** the **ability of the receiving device** to keep an accurate count of the bits as they come in.

**In synchronous transmission, we send bits one after another without start or stop bits or gaps.**
**It is the responsibility of the receiver to group the bits.**

# Synchronous Transmission

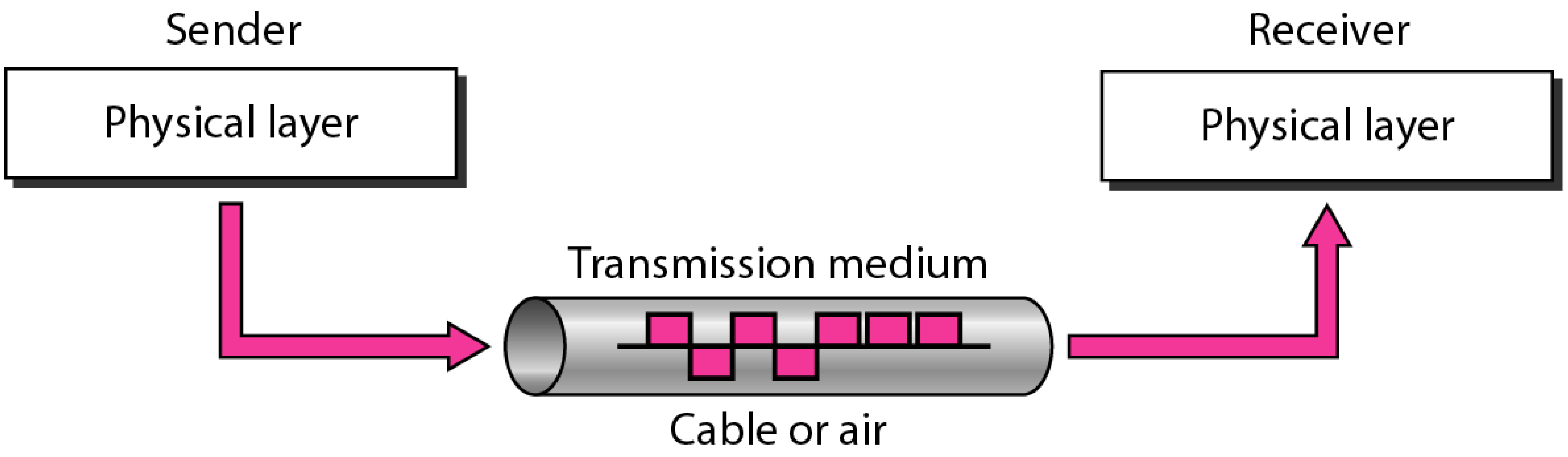
- The advantage of synchronous transmission is **speed**.
- With **no extra bits or gaps** to introduce at the sending end and remove at the receiving end, and, by extension, with fewer bits to move across the link.
- For this reason, it is **more useful** for high-speed applications such as the transmission of data from one computer to another.
- Byte **synchronization is accomplished in the data link layer**. Common protocols used include HDLC (High-Level Data Link Control), SDLC (Synchronous Data Link Control), and PPP (Point-to-Point Protocol).

# Isochronous Transmission

- In real-time audio and video, in which **uneven delays between frames are not acceptable**, synchronous transmission fails.
- **For example**, TV images are broadcast at the rate of 30 images per second; they must be viewed at the same rate. If each image is sent by using one or more frames, there should be no delays between frames. For this type of application, **synchronization between characters is not enough; the entire stream of bits must be synchronized**.
- The isochronous transmission guarantees that the data arrive at a fixed rate

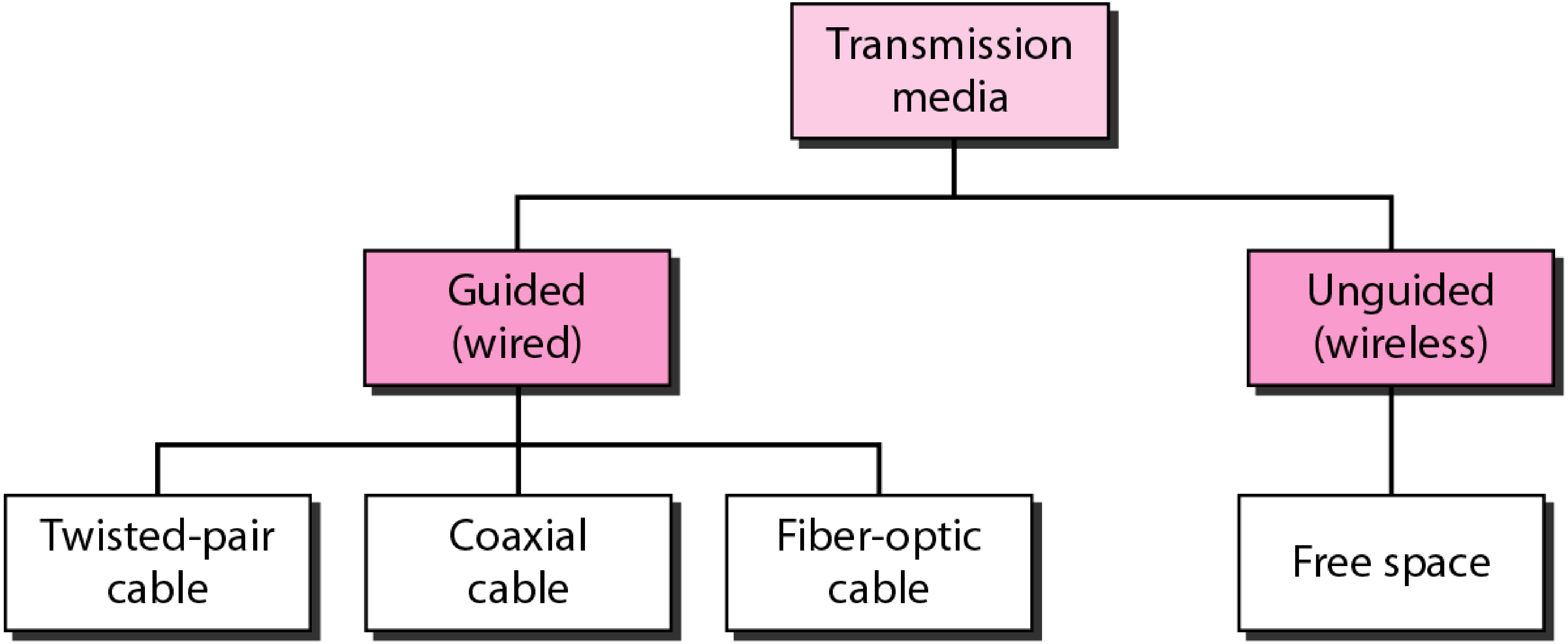
# Transmission medium

# Figure *Transmission medium and physical layer*




A transmission **medium** can be broadly defined as anything that can **carry information from a source to a destination**.

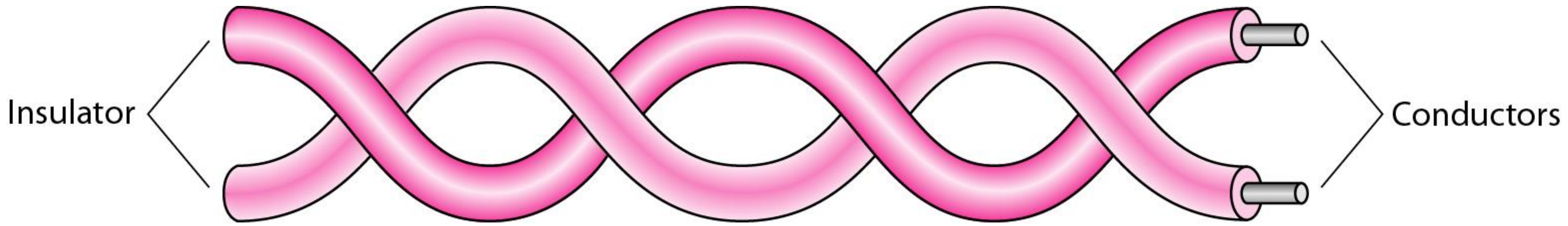
# Figure *Classes of transmission media*



# GUIDED MEDIA

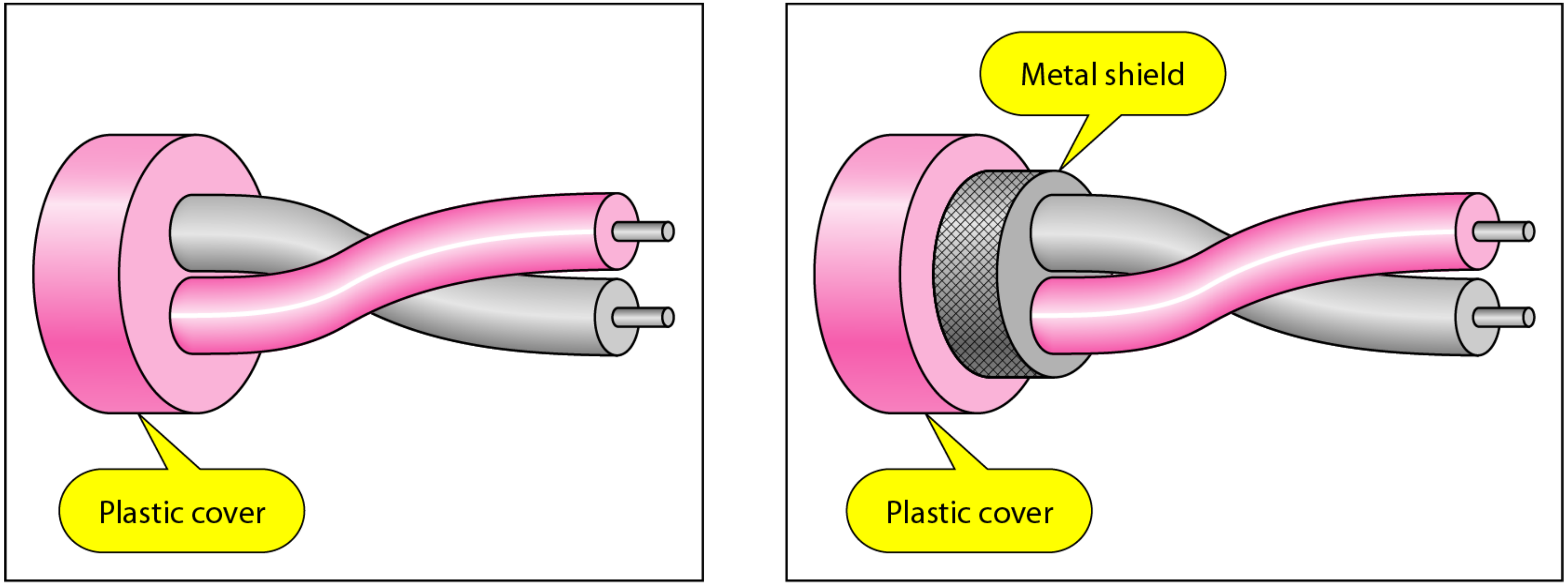
- *Guided media, which are those that provide a conduit from* ***one device to another****, include:*
  - *twisted-pair cable,*
  - *coaxial cable, and*
  - *fiber-optic cable.*

# Figure *Twisted-pair cable*



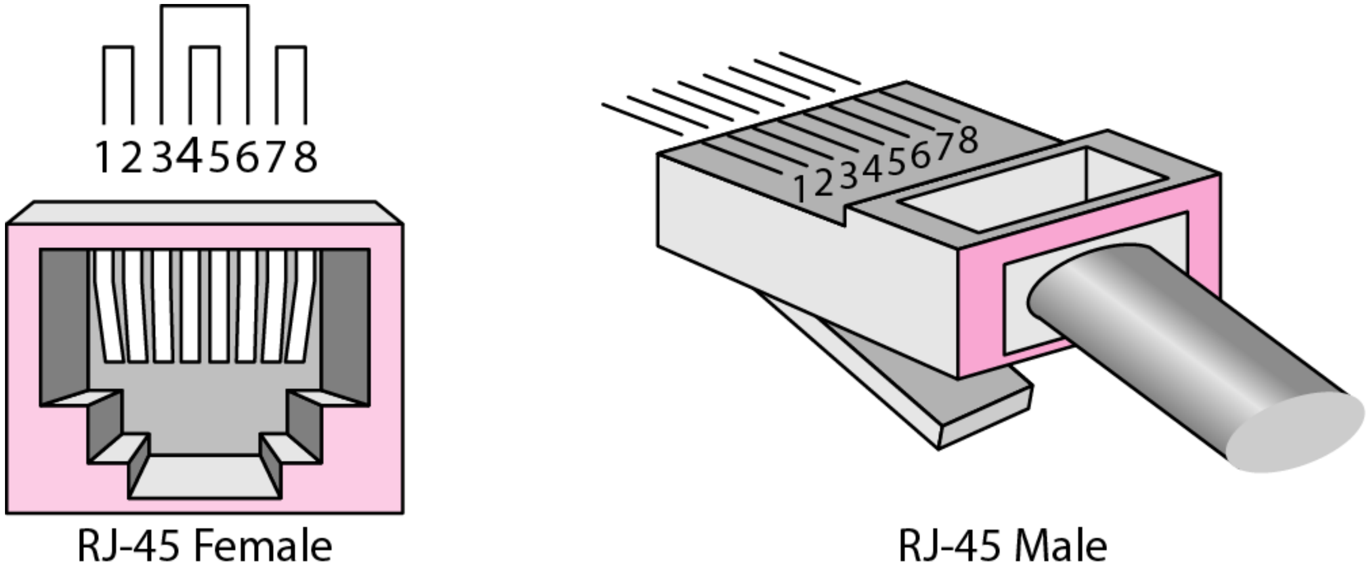

- A twisted pair consists of two conductors (normally copper), each with its own plastic insulation, twisted together.
- **Twisting the wires ensures that both wires are equally exposed to noise sources** over the length of the cable, making the noise picked up by each wire more similar.
- The receiver compares the signals from **the two wires and cancels out the noise** because the noise induced in each twist is balanced and can be negated, resulting in a clearer signal.

# Figure *UTP and STP cables*

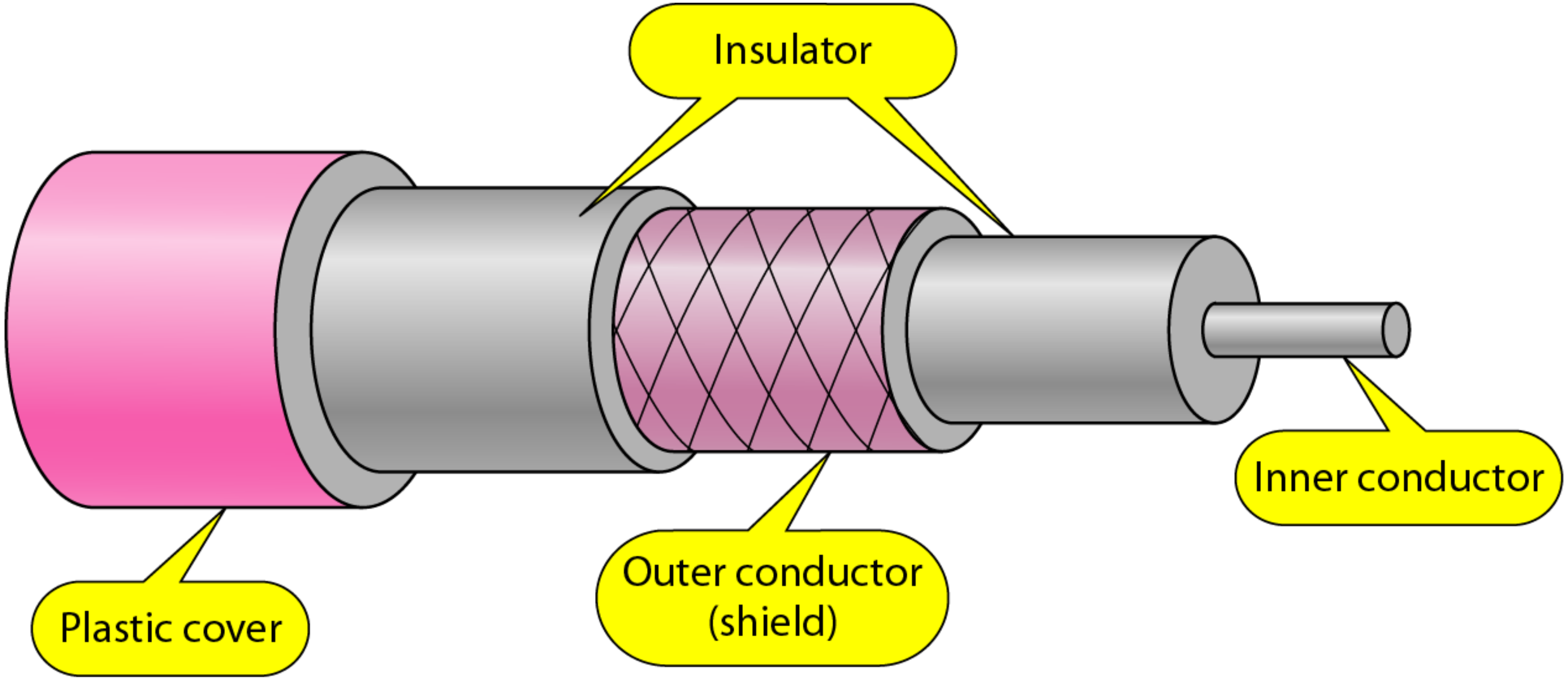



a. UTP b. STP

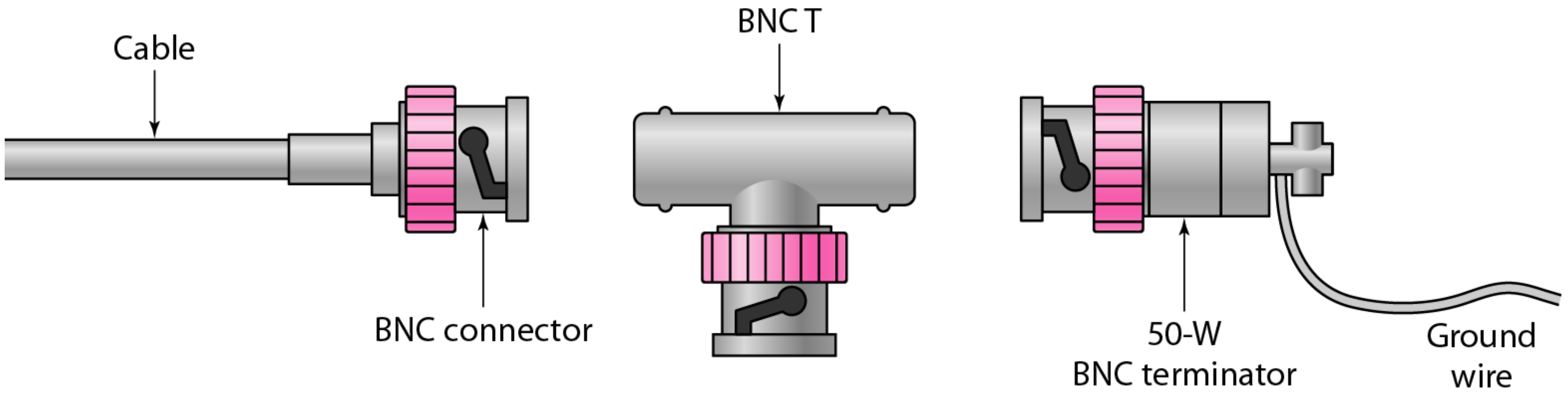
# Figure *UTP connector*



# Figure *Coaxial cable*

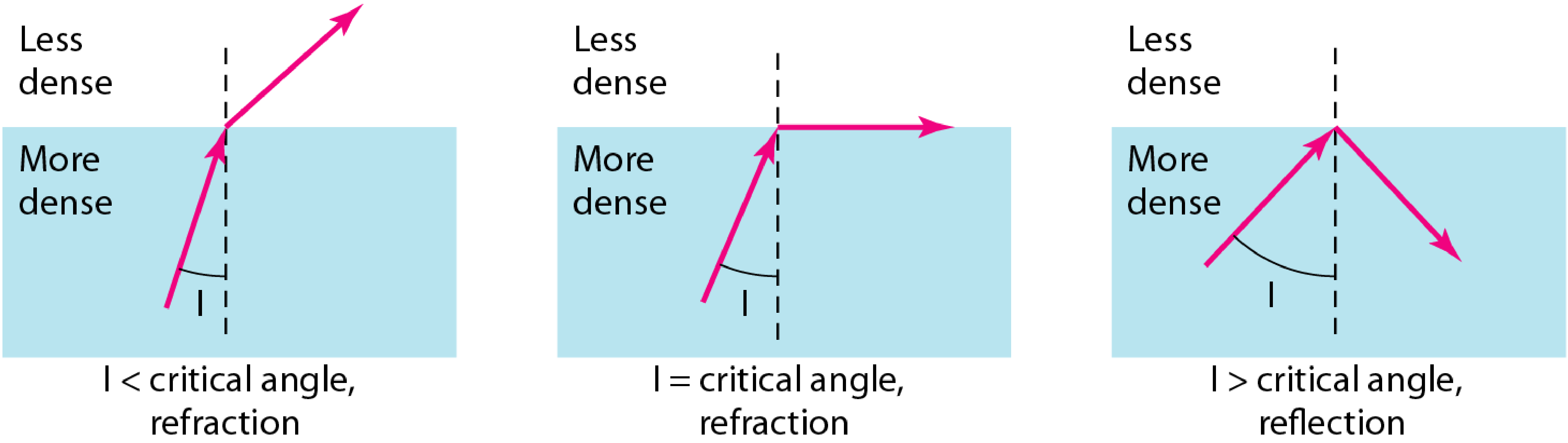


# Figure *BNC connectors*



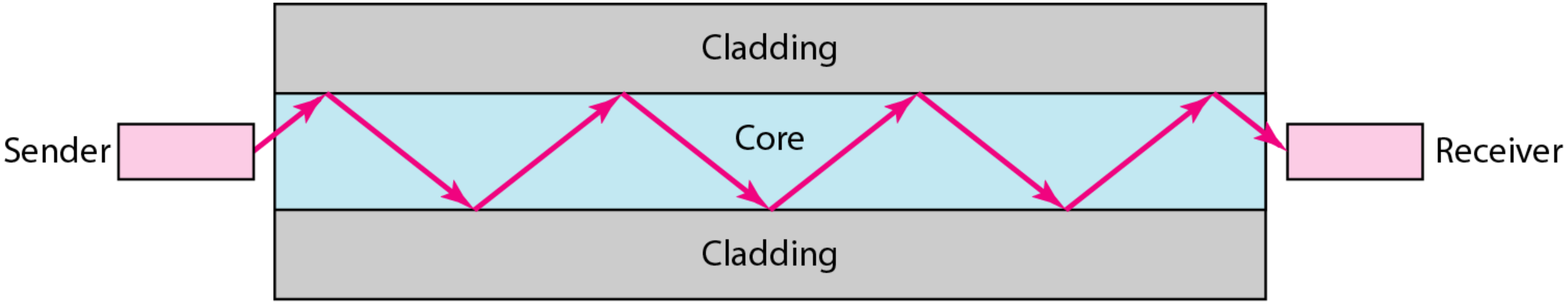

- To connect coaxial cable to devices, we need coaxial connectors.
- The most common type of connector used today is the Bayone-Neill-Concelman (BNe), connector.
- Three popular types of these connectors: the BNC connector, the BNC T connector, and the BNC terminator.
- Used in: TV set (BNC).
- The BNC T connector is used in Ethernet networks to branch out to a connection to a computer or other device. The BNC terminator is used at the end of the cable to prevent the reflection of the signal.

# Figure *Bending of light ray*




- 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.

# Figure *Optical fiber*



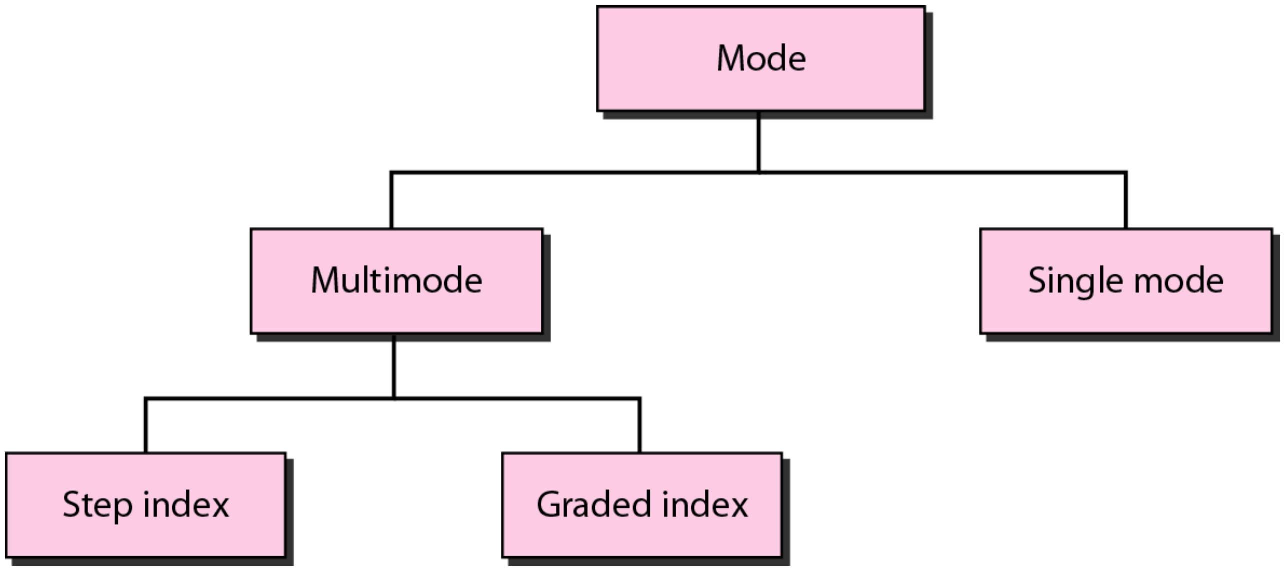
## Figure *Fiber-optic cable connectors*

SC Connector

ST Connector

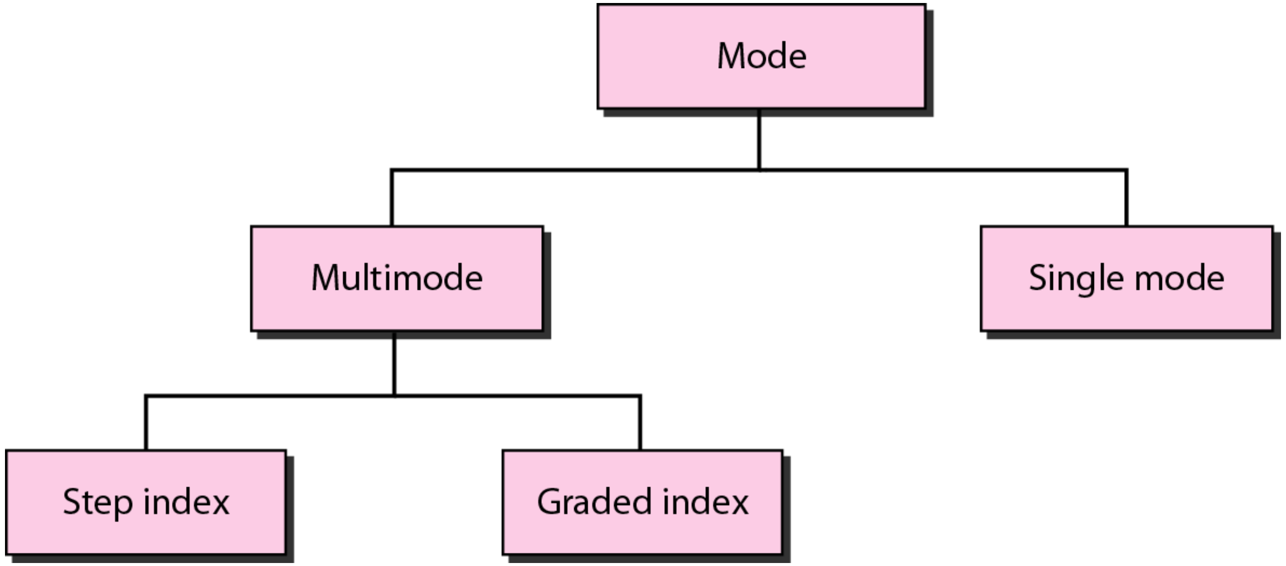
MTRJ Connector

# *Propagation modes*



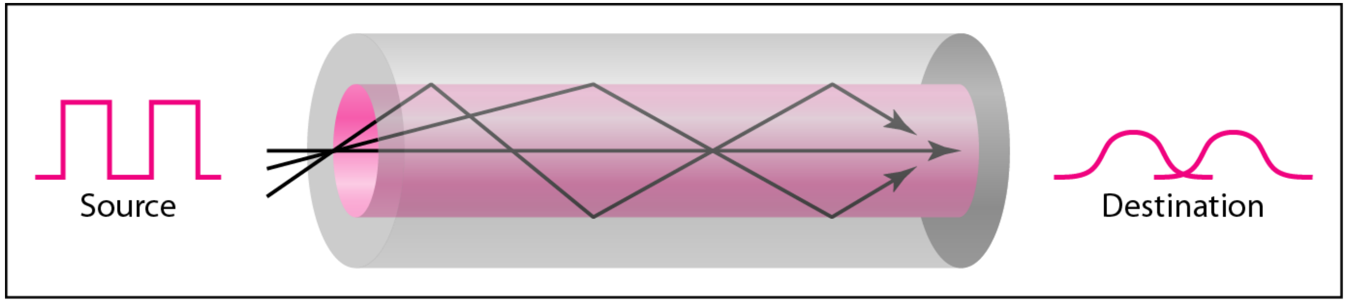

- Current technology supports two modes (multimode and single mode) for propagating light along optical channels, each requiring fiber with different physical characteristics.
- Multimode can be implemented in two forms: step-index or graded-index

# *Propagation modes*

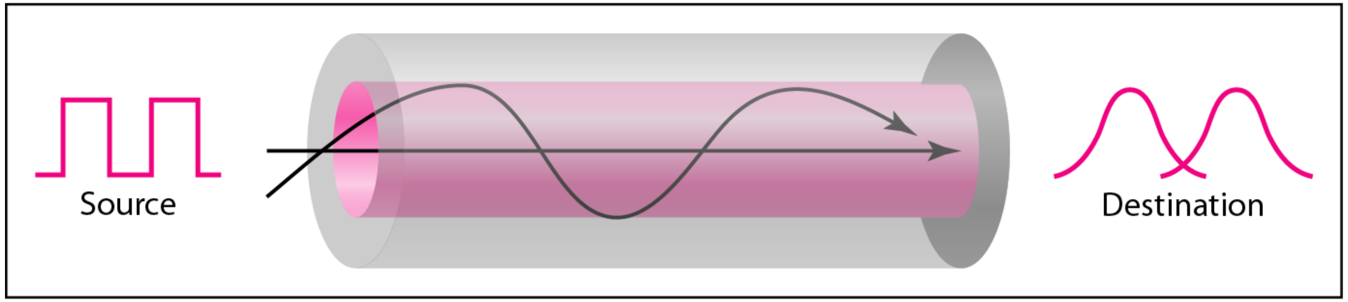



- In multimode **step-index** fiber, the **density of the core remains constant** from the center to the edges. A beam of light moves through this constant density in a straight line until it reaches the interface of the core and the cladding.
- **At the interface**, there is an **abrupt change** due to a lower density; this alters the angle of the beam's motion. The term ***step index*** refers to the suddenness of this change, which contributes to the distortion of the signal as it passes through the fiber.

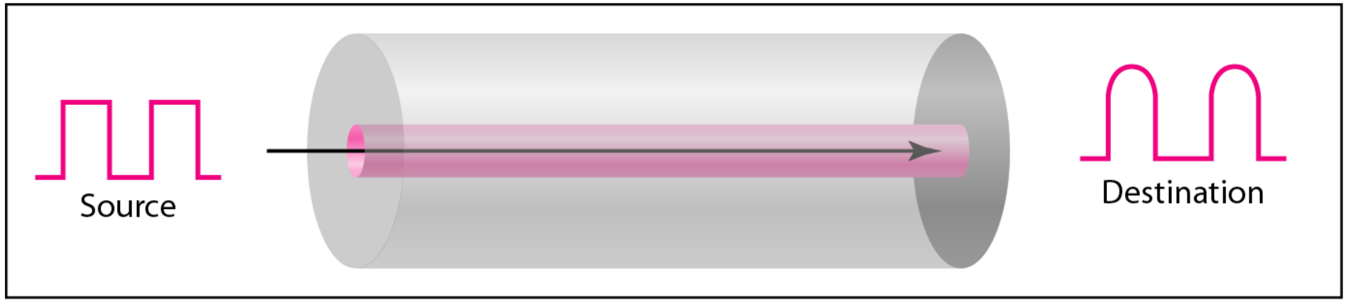
# *Propagation modes*




a. Multimode, step index




b. Multimode, graded index




c. Single mode

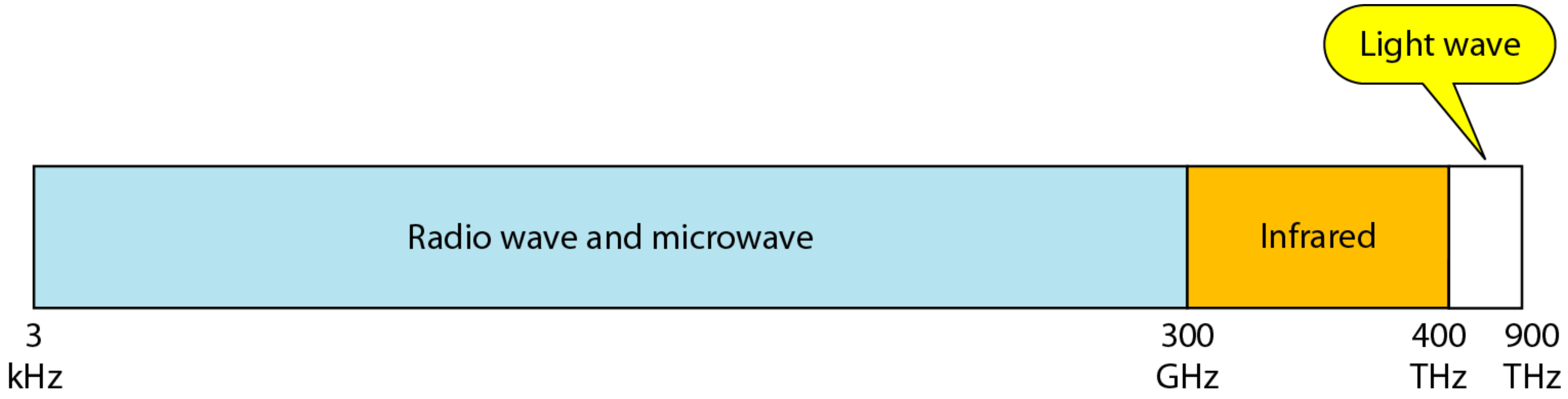
- A second type of fiber, called **multimode graded-index** fiber, decreases this distortion of the signal through the cable. The word ***index* here refers to the index of refraction**, and **the index of refraction is related to density**.
- A **graded-index fiber**, therefore, **is one with varying densities**.
- Density is highest at the center of the core and decreases gradually to its lowest at the edge.

# UNGUIDED MEDIA: **WIRELESS**

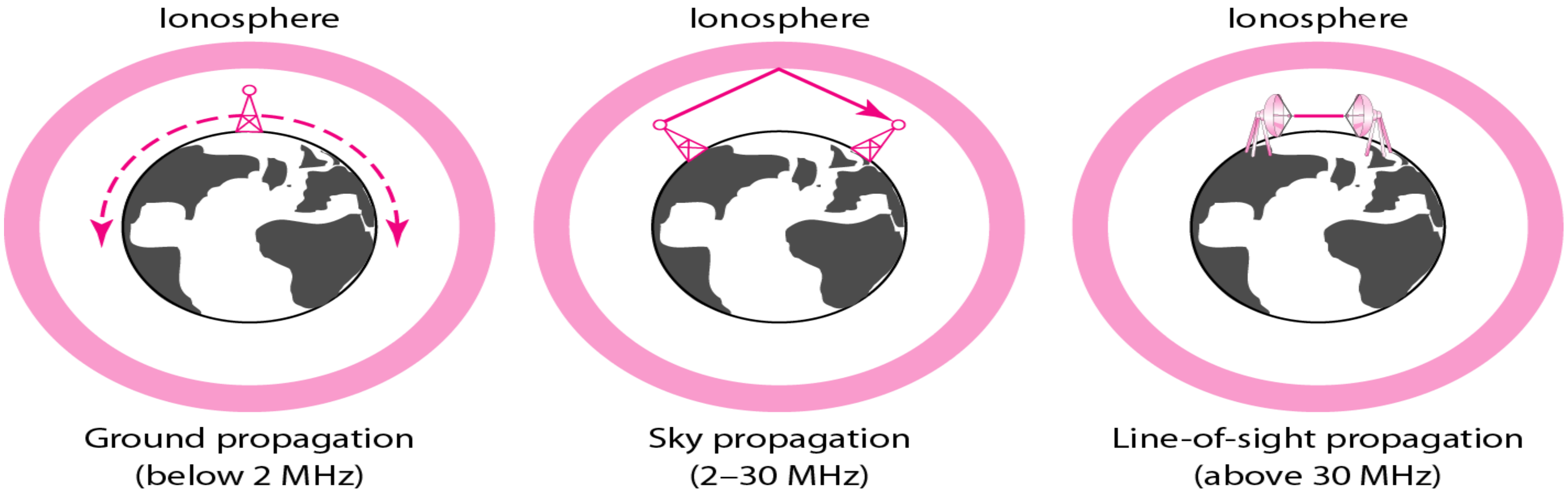
*Unguided media* ***transport electromagnetic waves without using a physical conductor****. This type of communication is often referred to as wireless communication.*

Radio Waves
Microwaves
Infrared

# Figure *Electromagnetic spectrum for wireless communication*



# Figure *Propagation methods*

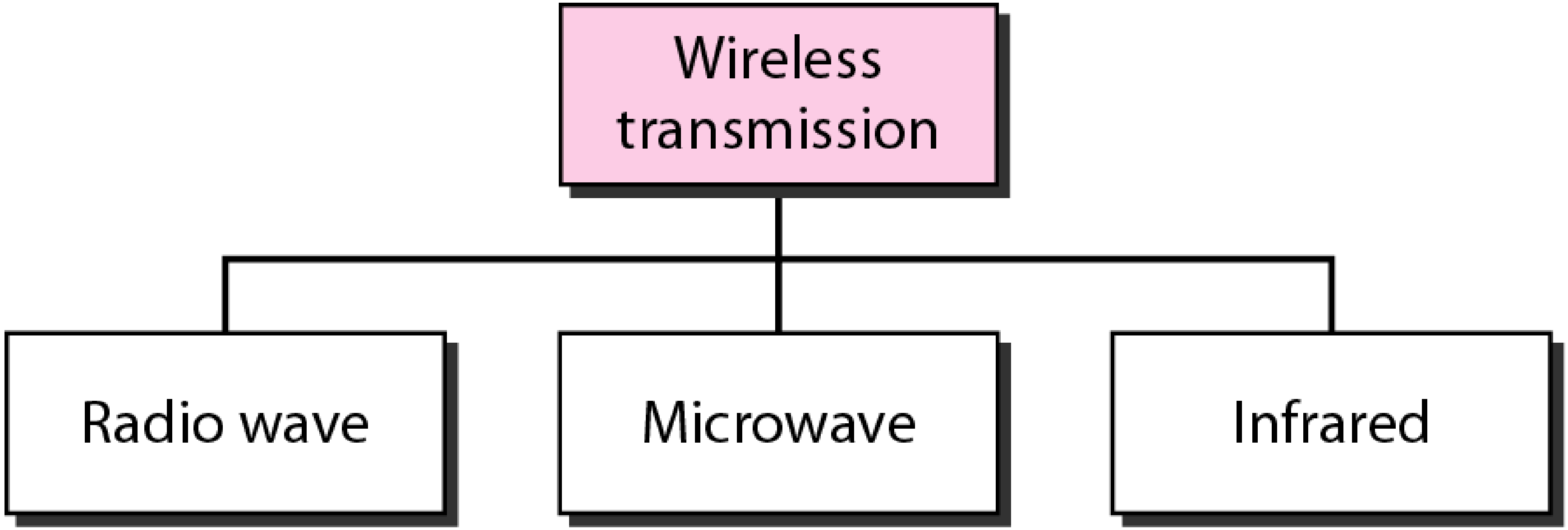



- In **ground propagation**, radio waves travel through the lowest portion of the atmosphere, hugging the earth. These low-frequency signals emanate in all directions from the transmitting antenna and follow the curvature of the planet. Distance depends on the amount of power in the signal: The greater the power, the greater the distance.
- In **sky propagation**, higher-frequency radio waves radiate upward into the ionosphere (the layer of atmosphere where particles exist as **ions**) where **they are reflected back to earth**. **This type of transmission allows for greater distances** with lower output power.
- In **line-or-sight propagation**, very high-frequency signals are transmitted in straight lines directly from antenna to antenna.

# Table *Bands*

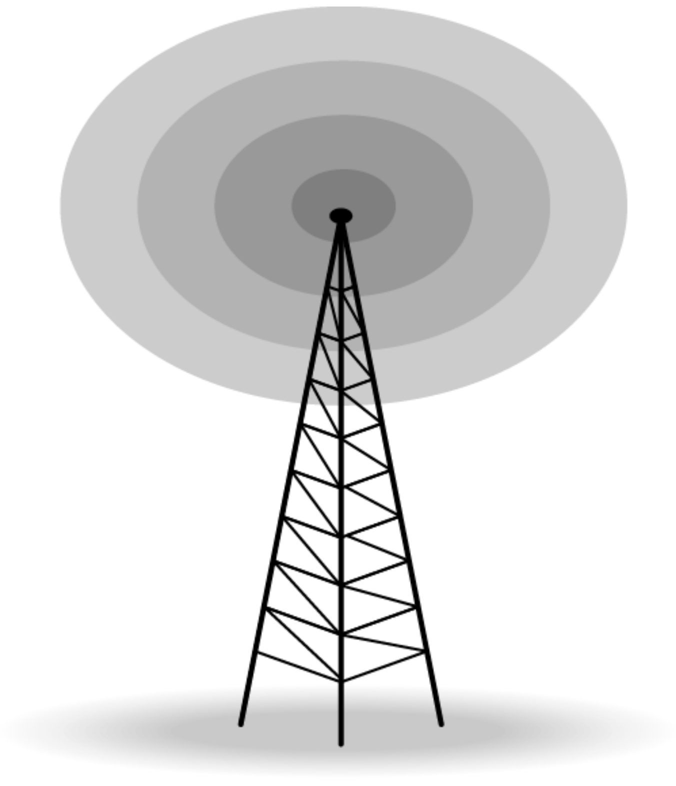
| *Band* | *Range* | *Propagation* | *Application* |
|---|---|---|---|
| VLF (very low frequency) | 3–30 kHz | Ground | Long-range radio navigation |
| LF (low frequency) | 30–300 kHz | Ground | Radio beacons and navigational locators |
| MF (middle frequency) | 300 kHz–3 MHz | Sky | AM radio |
| HF (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 |

# Figure *Wireless transmission waves*



# Radio Waves

Figure ***Omnidirectional** antenna*

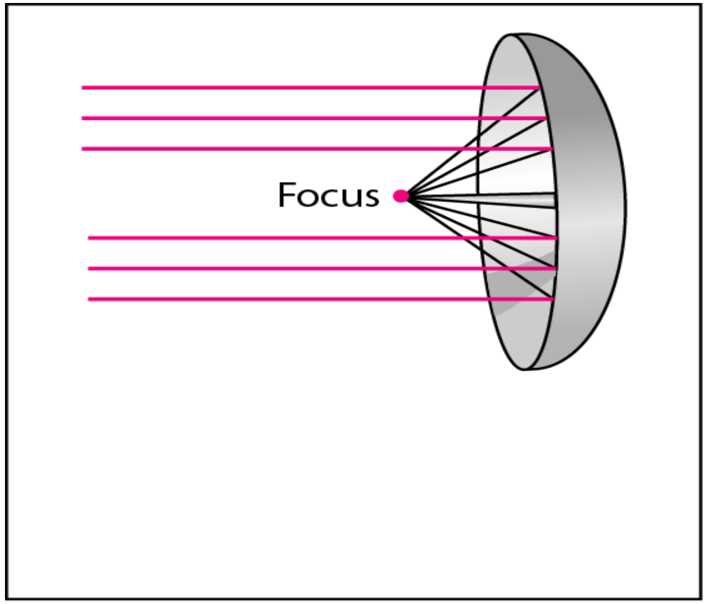


- No clear-cut demarcation between radio waves and microwaves, **electromagnetic waves ranging** in **frequencies between 3 kHz and 1 GHz** are normally called **radio waves**;
- Waves ranging in frequencies **between 1 and 300 GHz** are called **microwaves**.
- A sending antenna sends waves that can be received by any receiving antenna.
- Radio waves, particularly those waves that propagate in the **sky mode, can travel long distances**.
- This makes radio waves a **good candidate for long-distance broadcasting** such as AM radio.

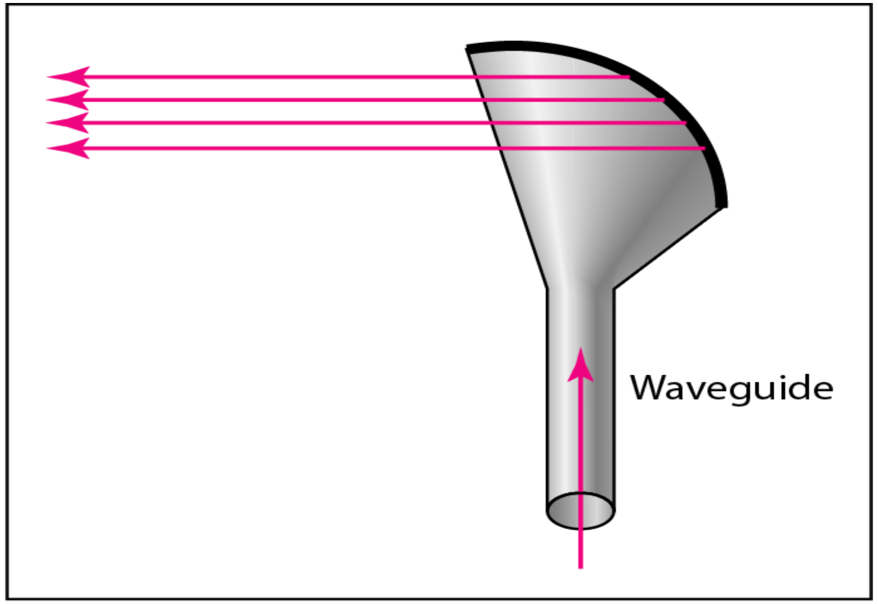
Radio waves are useful for multicast communications (one sender but many receivers), such as radio (AM and FM radio) and television, mari-time radio, cordless phones, and paging systems.

# Figure *Unidirectional antennas*

- **Microwaves** need unidirectional antennas that send out signals in one direction.
- Two types of antennas are used for microwave communications: the **parabolic dish** and the **horn**.

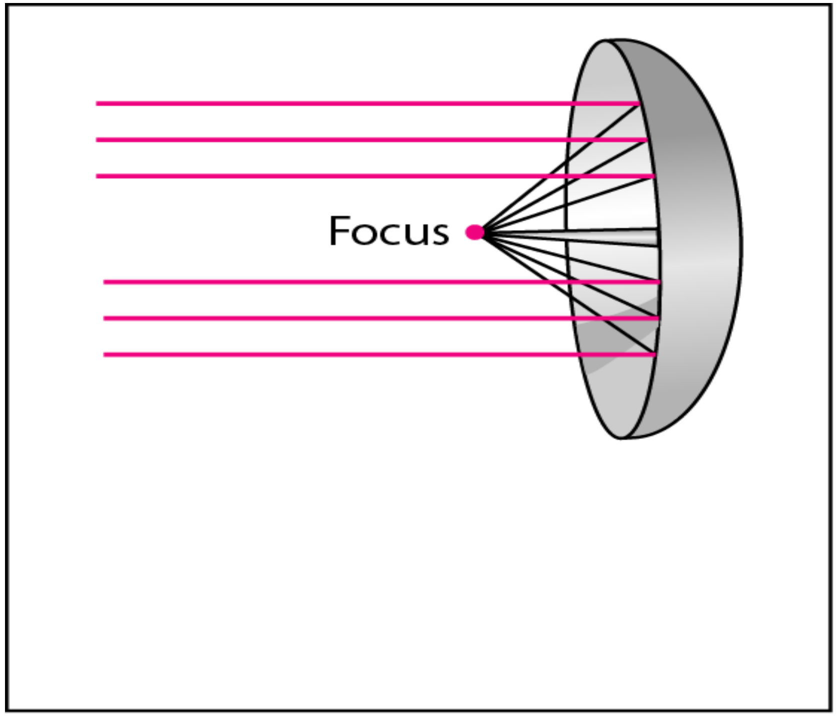



a. Dish antenna




b. Horn antenna

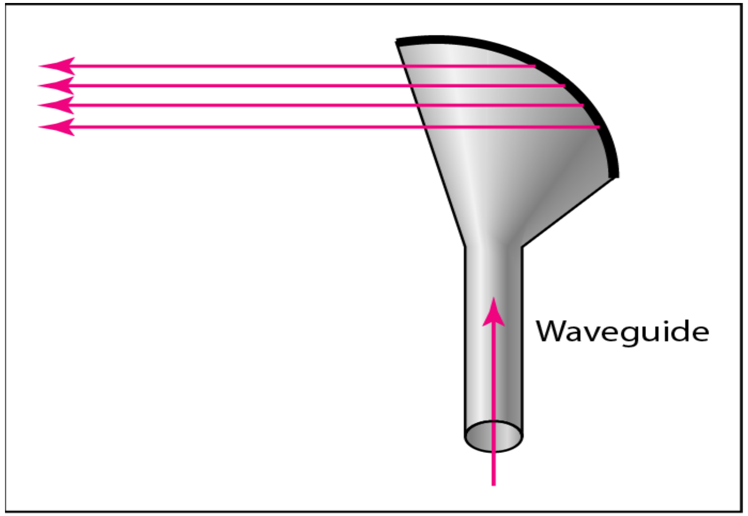
# Figure *Unidirectional antennas*



a. Dish antenna

- A parabolic dish antenna has a shape of a parabola: Every line parallel to the line of symmetry (**line of sight**) reflects off the curve at angles such that all the lines intersect in a common point called the focus.
- The parabolic dish works as a funnel, catching a wide range of waves and directing them to a common point. **In this way, more of the signal is recovered** than would be possible with a single-point receiver.

# Figure *Unidirectional antennas*




b. Horn antenna

- **Outgoing transmissions are broadcast through a horn aimed at the dish**.
- The microwaves hit the dish and are deflected outward in a reversal of the receipt path.
- A **horn antenna looks like a gigantic scoop**. Outgoing transmissions are broadcast
- Up a stem (resembling a handle) and **deflected outward in a series of narrow parallel beams** by the curved head.
- **Received transmissions** are **collected by** the **scooped shape of the** horn, in a manner similar to the parabolic dish, **and are deflected down into the stem**

Microwaves are useful for unicast communication due to their unidirectional properties, such as cellular telephones, satellite networks,
and wireless LANs.

# Infrared Waves

- Infrared waves, with frequencies from **300 GHz to 400 THz**, can be used for short-range communication.
- Infrared waves, having high frequencies, cannot penetrate walls. This advantageous characteristic prevents interference between one system and another; a **short-range communication system in one room cannot be affected by another system in the next room**.
- However, this same characteristic makes infrared signals useless for long-range communication. In addition, **we cannot use infrared waves outside a building because the sun's rays contain infrared waves that can interfere** with the communication.

Infrared signals can be used for **short-range communication in a closed area using line-of-sight** propagation.

# Further Readings

Textbooks


1. Behrouz A. Fourouzan, Data Communications and Networking, 2/e Tat McGrawhill,2000
2. Andrew S. Tanenbaum, Computer Networks , 4/e, Pearson education, 2003