*Badji Mokhtar University Annaba*

*Electronics Department*

Level 3: Telecommunication

Module: Telecommunication systems and networks

# Lecture 1-2: Digital Transmission Systems

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# Course purpose and structure

### Digital transmission systems

- Standards Bodies
- Transmission Channels
- Principle of a Data Link
- General Structure of a Transmission Chain

### Data transmision

- Operating Modes
- Link Mode
- Transmission Mode
- Multiplexing
- Bandwidth, Modulation speed, bit rate.

### Modems and interfaces

- Features and standards
- Links between two systems
- Dialup modem
- ADSL

### Protection against errors

- Definitions
- Error rate
- Error detection
- Self-correctiing code

### Telecommunications networks

- Fixed, Wireless, Mobile Networks, etc,

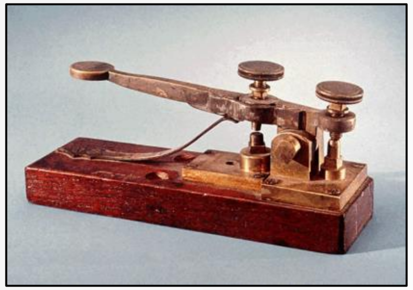
## Lecture Outline

- History of Telecommunication
- Standards Bodies
- General structure of a data communication system
- Transmission mediums
- Bandwidth and Bit rate

# History of Telecommunication

**1790**

**Claude Chappe**
Semaphore telegraph

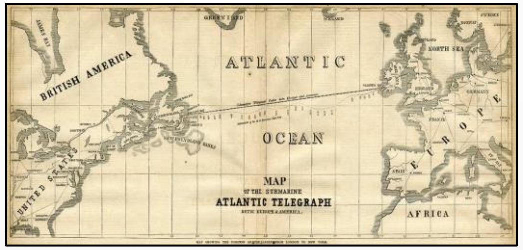


**1844**

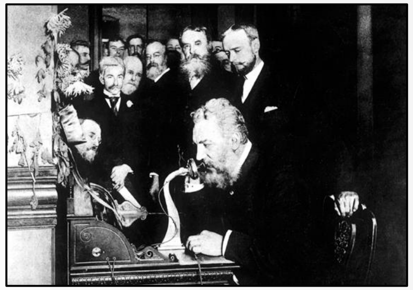
**Samuel Morse**
Morse Telegraph

**1858**

**Transatlantic Telegraph**
Under the Atlantic sea cable



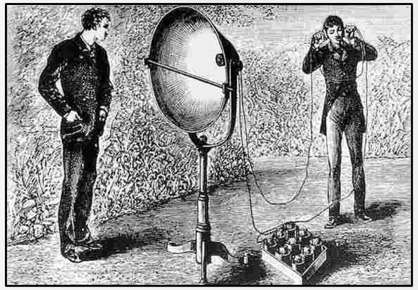

**1876**



**The Telephone**
Alexander Graham Bell

**1880**

**First wireless telephone**
Bell and Charles Sumner Tainter



# Standards Bodies

- The word Telecommunication was first introduced by Estauré (French enginneer) in 1904.
- The International Telegraphic Union was changed to the International Telecommunication Union ITU in Madrid 1932.
- **ITU**: is a specialised agancy of the UN. Membership of 193 countries. www.itu.int

**ITU-T**: Telecommunication standardisation sector, **ITU-R**: Radiocommunication sector, **ITU-D**: Telecommunication Development Sector.

Other standards bodies:
**ANSI**: America National standards Institute (recommendations for North America) www.ansi.org
**TTC**: Telecommunication Technology Committee (Japan) www.ttc.or.jp/e/
**IEEE**: Institute of Electrical and Electronics Engineers www.ieee.org

**ISO**: International Organisation for Standardisation www.iso.org
**IANOR**: L'institut Algérien de Normalisation www.ianor.dz

**Role**:

•**Consistency and Compatibility**: They define and establish technical standards to ensure products, procedures, and systems from different vendors or operators work seamlessly together.

•**Innovation and Growth**: By providing a common framework, they encourage innovation, as developers and researchers can build on existing standards rather than "reinventing the wheel."

•**Consumer Protection**: Standards often include safety and quality assurances, ensuring consumers get reliable, high-quality products and services.

**Objectives:**

Interoperability: One of the primary goals is to ensure that devices, systems, and services from different providers can work together without issues.

Global Reach: Many of these bodies aim to create international standards, ensuring products and services can operate and be marketed globally.

Continuous Improvement: As technology evolves, these organizations often revise standards to reflect the latest advancements, best practices, and emerging needs.

Stakeholder Collaboration: Bringing together experts from academia, industry, and governments to ensure all perspectives are considered in standard formulation.

**How They Work**:

•**Working Groups and Committees**: These bodies usually have specific working groups or committees focused on particular areas or topics. These groups consist of experts who contribute to the drafting and revising of standards.

•**Public Reviews**: Once a standard draft is prepared, it's often opened for public review. Feedback is gathered, considered, and incorporated if deemed necessary.

•**Consensus Building**: Standards are typically not finalized until there's a consensus among members. This ensures the standard is widely accepted and adhered to.

•**Publication and Adoption**: Once approved, the standard is published and promoted for adoption by industry, governments, and other stakeholders.

•**Continuous Monitoring**: As technology and industry needs evolve, standards are revisited and updated accordingly

**Examples**:

•**ITU (International Telecommunication Union)**: A specialized agency of the United Nations, ITU is responsible for international telecommunication regulations and standards. It's divided into various sectors, with ITU-T (Telecommunication Standardization Sector) being the most relevant for setting global telecommunication standards.

•**IEEE (Institute of Electrical and Electronics Engineers)**: While it covers a broad spectrum of electrical and electronics domains, it has specific working groups focused on telecommunication standards, like the IEEE 802 series for LAN/MAN standards, which includes the popular IEEE 802.11 for Wi-Fi..

IEEE Advancing Technology for Humanity

# Standards Bodies

**Examples**:

•**3GPP (3rd Generation Partnership Project)**: A collaboration between multiple telecommunications standards organizations, 3GPP is known for defining standards for mobile communication, such as 3G, 4G (LTE), and 5G.

•**ETSI (European Telecommunications Standards Institute)**: A non-profit organization that produces globally applicable standards for ICT, including fixed, mobile, radio, broadcast, and Internet technologies.

**Technologies standardized by various standardization bodies:**

**1. ITU (International Telecommunication Union):**

- **G-Series Recommendations:** Covering various aspects of voice and video communication. For example, the G.711 recommendation specifies the Pulse Code Modulation (PCM) method of voice frequencies.

- **H-Series Recommendations:** Focused on audiovisual services. H.264, for instance, is a very popular video coding standard widely used in streaming, video conferencing, and storage.

- **X.509:** A standard for the public key infrastructure (PKI) and Privilege Management Infrastructure (PMI), which are critical for digital certificates and network security.

**Technologies standardized by various standardization bodies:**

**2. IEEE (Institute of Electrical and Electronics Engineers)**:

•**IEEE 802.11**: This is the series of standards for wireless local area networks (WLANs) commonly referred to as Wi-Fi. Different letters after the "802.11" specify different versions of the technology, like 802.11b, 802.11ac, and 802.11ax.

•**IEEE 802.3**: Known as Ethernet, it's a standard for wired local area networks (LANs). Different versions specify various aspects like speeds, mediums, and transmission methods.

•**IEEE 802.15.1**: Standardized the technology known to most as Bluetooth.

**Technologies standardized by various standardization bodies:**

**3. 3GPP (3rd Generation Partnership Project)**:

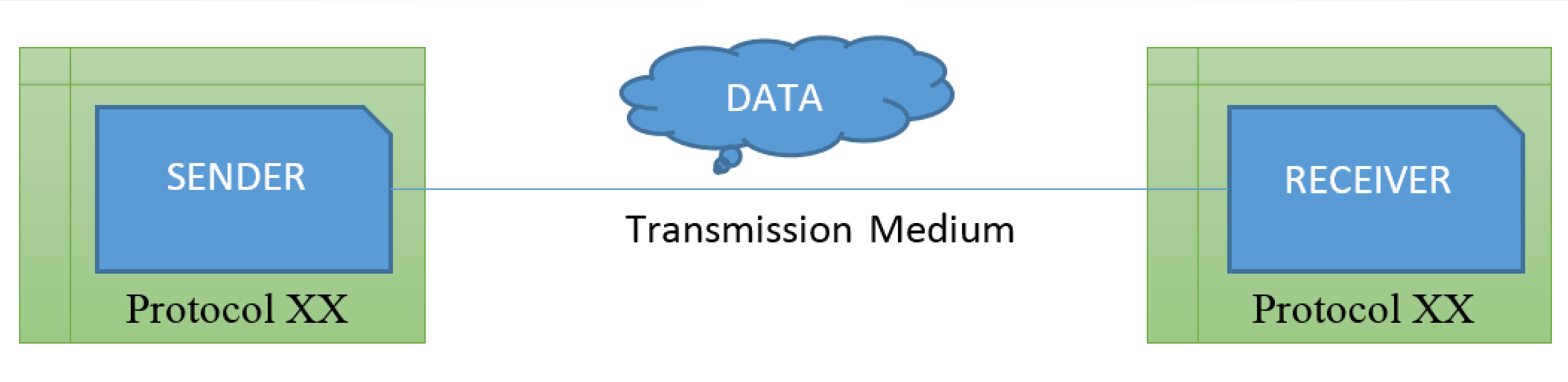
•**GSM (Global System for Mobile Communications)**: The primary standard for 2G mobile networks.

•**UMTS (Universal Mobile Telecommunications System)**: The core network standard for 3G mobile systems.

•**LTE (Long Term Evolution)**: Represents the 4G standard, providing faster data rates and improved system capacity.

•**5G NR (New Radio)**: The newest standard for 5G mobile networks, focusing on enhanced mobile broadband, ultra-reliable low latency communication, and massive machine-type communication.

A data communication system is designed to transmit data between two or more entities. The primary components of a data communication system can be broken down into five essential parts:



1. **Message**:
   1. **Definition**: The data or information that the sender wants to communicate to the receiver. This can be in the form of text, numbers, pictures, audio, video, or any combination thereof.
   2. **Importance**: The core purpose of the communication system is to ensure that the message is transmitted accurately and efficiently from the sender to the receiver.

2. **Sender (Source)**:
   1. **Definition**: The device or entity that generates the message and initiates its transmission. This can be a computer, smartphone, workstation, telephone handset, video camera, and so on.
   2. **Importance**: The sender is responsible for generating the data to be communicated and possibly converting it into a form suitable for transmission.

**3. Transmission Medium**:

**Definition**: The physical pathway over which the message travels from the sender to the receiver. This can include wired media such as coaxial cables or optical fibers, and wireless media such as radio waves or microwaves.

**Importance**: The transmission medium determines many characteristics of the communication, such as speed, distance, and reliability.

**4. Receiver (Destination)**:

**Definition**: The device or entity that receives the transmitted message from the sender. Like the sender, this can be a computer, smartphone, workstation, telephone handset, or any other device capable of receiving and interpreting the transmitted data.

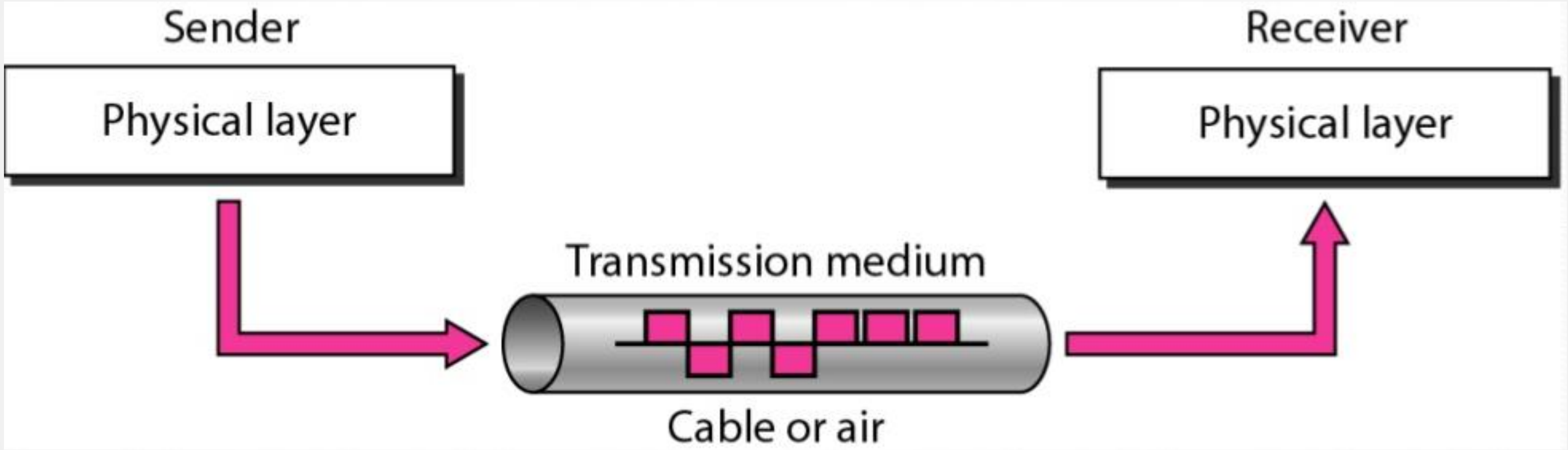
**Importance**: The receiver is responsible for capturing the incoming data from the transmission medium, possibly converting it back into its original form, and then processing or presenting it

**5. Protocol**:

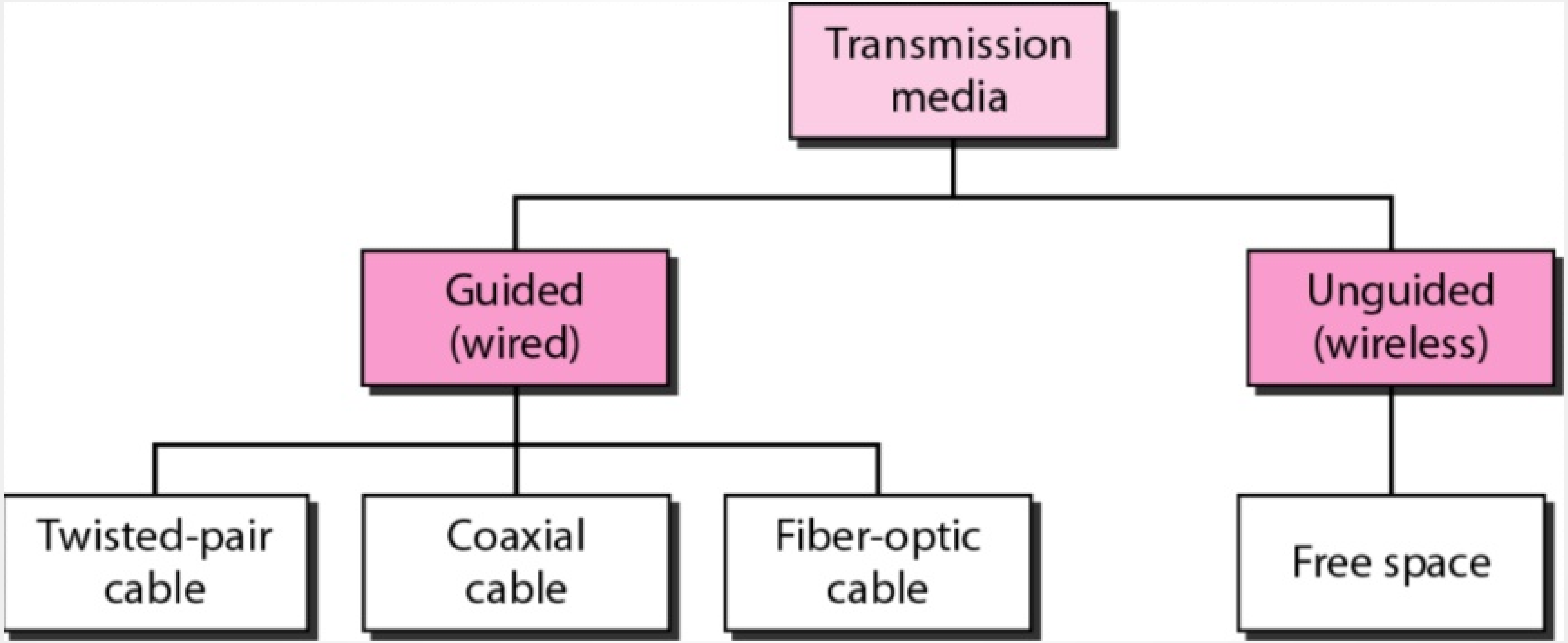
1. **Definition**: A set of rules and conventions that the sender and receiver follow to achieve proper data exchange. Protocols dictate aspects like data format, timing, sequencing, error handling, and more.
2. **Importance**: Protocols ensure that both the sender and receiver "speak the same language" and that data is communicated efficiently and accurately. They play a vital role in ensuring interoperability between different devices and systems.

Together, these components form the backbone of any data communication system, allowing for the structured and reliable exchange of information between entities. Whether considering the vast expanse of the internet or a simple local area network (LAN), these five components remain central to the concept of data communication.

# Transmission mediums



# Transmission mediums



## Design Factors

The design of a transmission medium is influenced by several critical factors. These design factors determine the medium's suitability for specific applications, its performance characteristics, and its overall efficiency. Here are the primary design factors for transmission media:

1. **Bandwidth**:

   The range of frequencies that the medium can support. A higher bandwidth means that more data can be transmitted over the medium in a given time period. It's a crucial factor in determining the data rate of the communication.

2. **Propagation Delay**:

   The time it takes for a signal to travel from the sender to the receiver across the medium. This delay can affect real-time communication, like voice and video calls.

3. **Attenuation**:

   Refers to the reduction in signal strength as it travels over distance. The design of the medium should consider how quickly attenuation occurs and over what distance, which subsequently influences the need for signal repeaters or amplifiers.

Design Factors

**4. Noise and Interference**:

External signals can interfere with the primary signal in the transmission medium. The medium's design should minimize susceptibility to various types of noise, like thermal noise, crosstalk, or electromagnetic interference.

**5. Cost and Ease of Installation**:

The materials used, the complexity of deployment, and maintenance requirements influence the cost of the medium. The design might need to strike a balance between performance and cost-effectiveness.

**5. Physical Durability**:

The medium's resilience to physical damage, environmental factors (like water, heat, or chemicals), and wear and tear over time.

**6. Security**:

Some media are more prone to eavesdropping or signal interception than others. For instance, wired media like optical fiber offer better security against eavesdropping compared to wireless media like radio waves.

Design Factors

**8. Distance/Range**:

The maximum distance over which the medium can effectively transmit data without significant loss of signal quality.

**9. Flexibility and Scalability**:

How easily can the medium adapt to changing requirements or be expanded to accommodate growing data demands?

**10. Connectivity and Compatibility**:

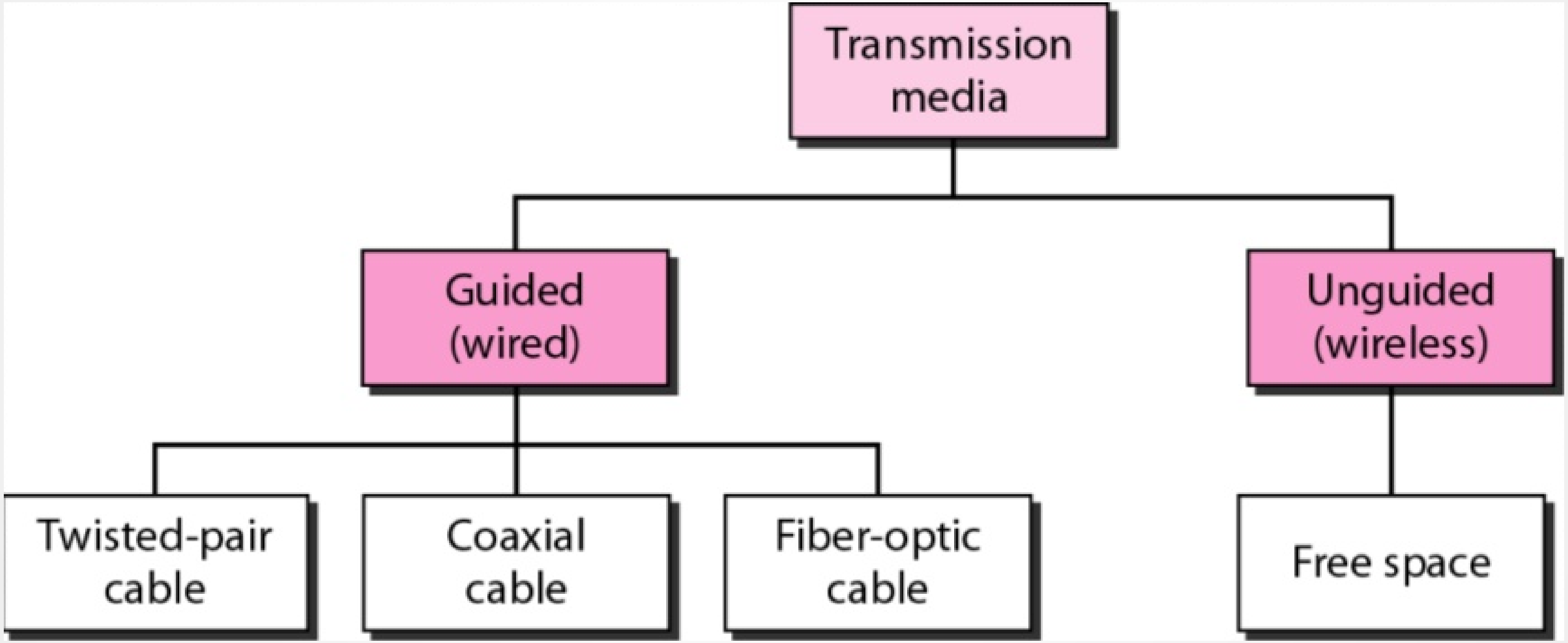
The design should consider how the medium will interface with devices, equipment, and other types of media. This includes connectors, junctions, and compatibility with existing infrastructure.

Design Factors

**- Environmental and Safety Considerations**:
Some media might have environmental implications, like the materials used in their construction or the energy consumed during operation. Additionally, safety considerations, especially for media transmitting high energy or operating in public spaces, are crucial.

The design of a transmission medium is a complex task that requires balancing various technical, economic, and environmental considerations. The chosen design directly impacts the medium's performance, reliability, and overall suitability for its intended application.

# Transmission mediums



# Twisted Pair cable


- Cheap and easy to install
- Consists of two conductors (copper)
- Frequency range 0: to 3.5KHz
- Typical attenuation: 0.2 dB/Km @ 1Khz
- Typical delay: 50 µs/km
- Repeater spacing: 2Km.

**Twisted Pair cable is of two types:**

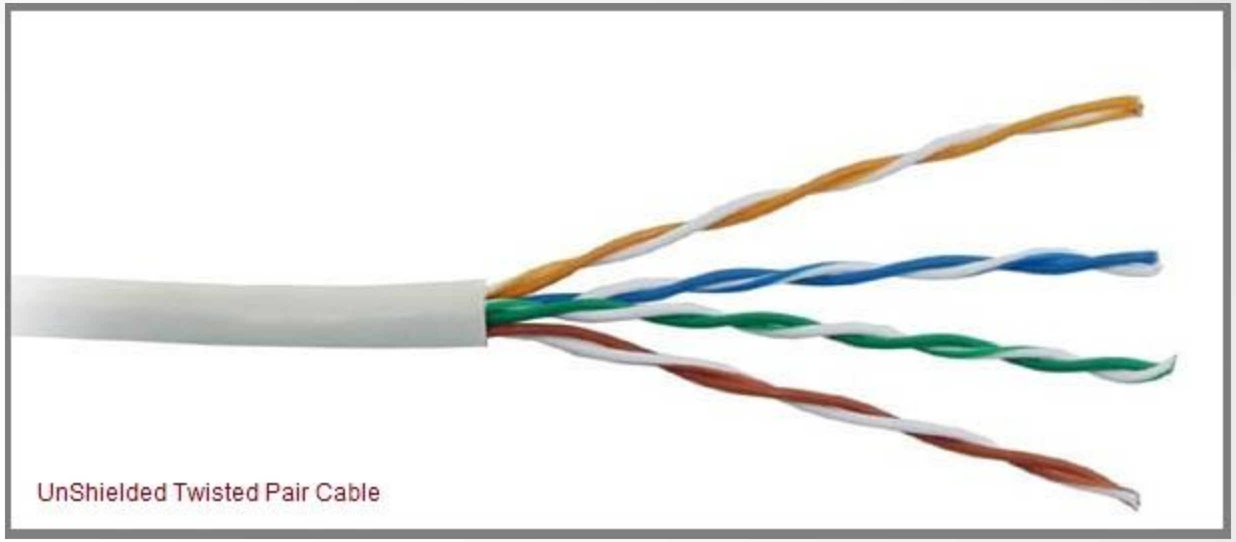
- Unshielded  Twisted Pair (UTP)
- Shielded Twisted Pair (STP)

**Applications :**

- Telephone network
- Local Area Networks

# Twisted Pair cable

**Unshielded Twisted Pair Cable**




**Advantage:** Easy Instalation, Flexible, cheap, 100 meter limit and used in LAN technologies (eg: Ethernet).

**Disadvantage:**

- Low bandwidth compared to the coaxial cable.
- Less protected from interference

UTP cables consist of 2 or 4 pairs of twisted cable:

- **RJ-11 connector (2 pairs)**
- **RJ-45 connector (4 pairs)**

**Shielded Twisted Pair Cable (STP)**


**Advantage:** Easy Instalation, used in analog and digital transmission, Increases the signalling rate, higher capacity than UTP.

**Disadvantage:**

Heavy and difficult to manifacture.

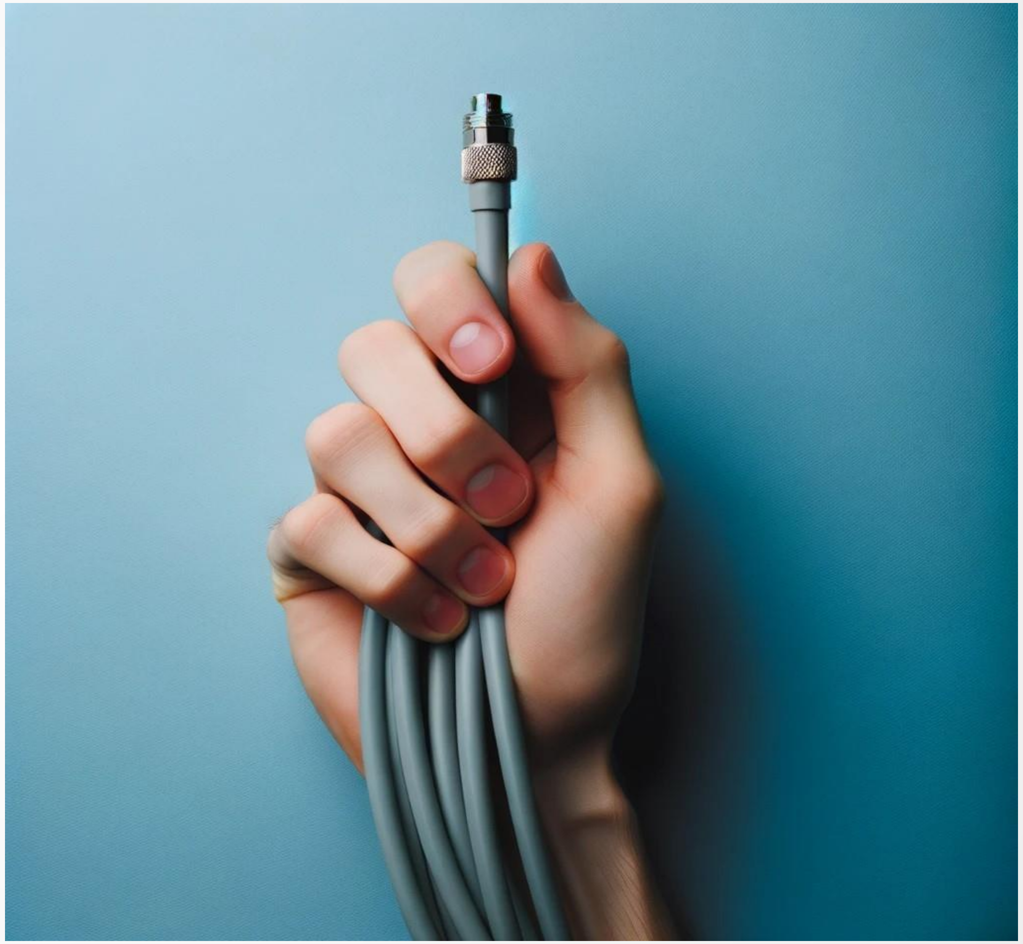
UTP cables consist of 2 or 4 pairs of twisted cable:

- **RJ-11 connector (2 pairs)**
- **RJ-45 connector (4 pairs)**

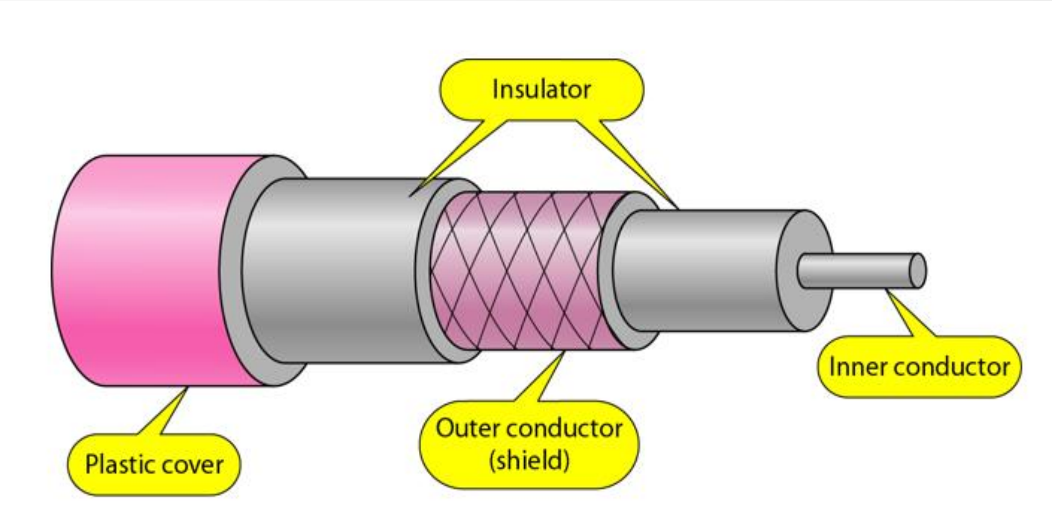
# Twisted Pair cable

| Category | Transmission Speed | Technologies/Usage | Transmission Distance |
|---|---|---|---|
| Cat 1 | Primarily for voice (telephony) | Traditional telephone lines (POTS). | Not specified for data. |
| Cat 2 | Up to 4 Mbps | Used in token ring networks. | Up to 100 meters (typically) |
| Cat 3 | Up to 10 Mbps | 10BASE-T Ethernet. | Up to 100 meters |
| Cat 4 | Up to 16 Mbps | Token ring networks. | Up to 100 meters |
| Cat 5 | Up to 100 Mbps | 100BASE-TX Fast Ethernet. | Up to 100 meters |
| Cat 5e | Up to 1 Gbps | Gigabit Ethernet (1000BASE-T). | Up to 100 meters |
| Cat 6 | Up to 1 Gbps (10 Gbps at shorter distances) | Gigabit Ethernet (1000BASE-T) and 10-Gigabit Ethernet | Up to 100 meters (1 Gbps), Up to 55 meters (10 Gbps) |
| Cat 6a | Up to 10 Gbps | 10-Gigabit Ethernet (10GBASE-T up to 100 meters) | Up to 100 meters |
| Cat 7 | Up to 10 Gbps | 10-Gigabit Ethernet with TERA connectors. | Up to 100 meters |
| Cat 7a | Up to 10 Gbps (potential for greater bandwidth) | Enhanced Cat 7. | Up to 100 meters |
| Cat 8 | Up to 25-40 Gbps (up to 30 meters) | Data centers. | Up to 30 meters |


# Coaxial Cable



# Coaxial Cable




**Advantage:**

Provide High bandwidth,

Used in long distance telephone lines.

Eliminate distortion. and digital transmission, Increases the signalling rate, higher capacity than UTP.

**Disadvantage:**

Single cable failure affects the entire network.

Difficult to install and expensive / TP cable

Possible grounded loop if shield is imperfect

Coaxial cables are of two types:

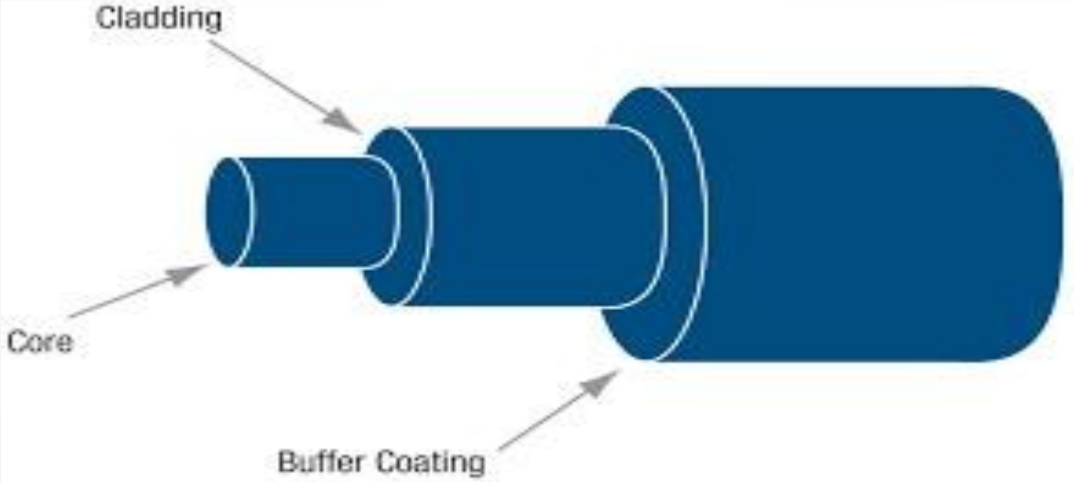
- **Baseband** (LAN)
- **Broadband** (television cabling)

**1. Basic Structure:**

•**Core**: The central part of the fiber where light is transmitted. Made of silica glass or plastic.

•**Cladding**: A layer of material surrounding the core, with a different refractive index. It reflects the light back into the core.

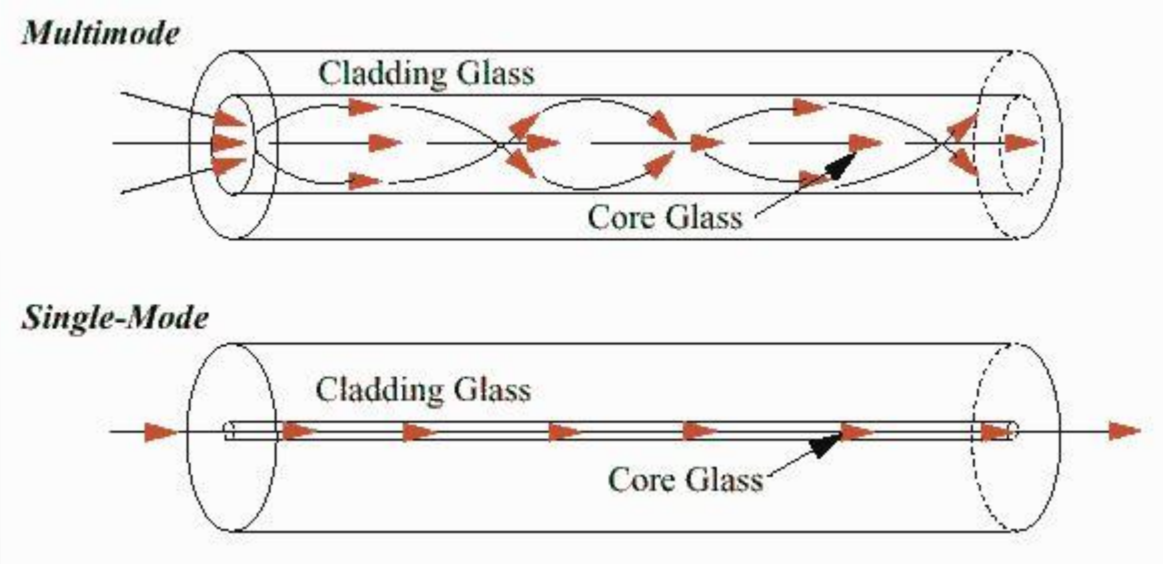
•**Buffer Coating**: Protects the core and cladding from damage and moisture.



## 2. Types of Optical Fiber:

•**Single-Mode Fiber (SMF)**: Has a small core, typically 8-10 micrometers in diameter, and is designed for one mode (path) of light. Ideal for long-distance transmission because it experiences less modal dispersion.

•**Multi-Mode Fiber (MMF)**: Has a larger core, typically 50 or 62.5 micrometers in diameter, and can propagate multiple modes of light. It's generally used for shorter distances, like within a building or on a campus.



**6. Attenuation:**

•The reduction in signal strength as it travels through the fiber. Measured in decibels per kilometer (dB/km).

•Causes include absorption by impurities in the fiber, scattering, and bending losses.

**5. Optical Fiber Connectors:**

•Used to connect two optical fibers. Examples include SC, ST, LC, and MTP/MPO connectors.

**6. Transmission Speed and Distance:**

•Optical fibers can transmit data at speeds of up to 100 Gbps or even higher.

•Depending on the type of fiber and the equipment used, optical fibers can transmit data over distances ranging from a few meters (e.g., in data centers) to thousands of kilometers (e.g., in transcontinental networks).

**7. Advantages of Optical Fiber:**

•High bandwidth, allowing for very high data rates.

•Low signal attenuation compared to other mediums, which means fewer repeaters/amplifiers are needed over long distances.

•Higher security against eavesdropping.

•Lightweight and thin, allowing for high density in cabling ducts.

**8. Disadvantages:**

•More expensive compared to other mediums like copper.

•Requires specialized equipment and skills for installation and repair.

•Physical bending or excessive twisting can cause signal loss.

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**9. Applications:**

- Long-haul telecommunication networks.
- Local area networks (LANs) in businesses and organizations.
- Cable TV distribution.
- High-speed internet backbone.
- Medical imaging, sensors, and military applications.

Optical fiber technology has revolutionized the world of telecommunications and data transfer, offering unparalleled speed and reliability, especially for long-distance communications.

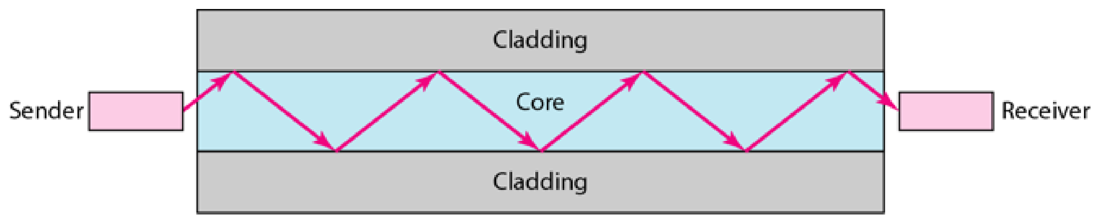
FO Cable is made of glass or plastic and transmits signals in form of light.

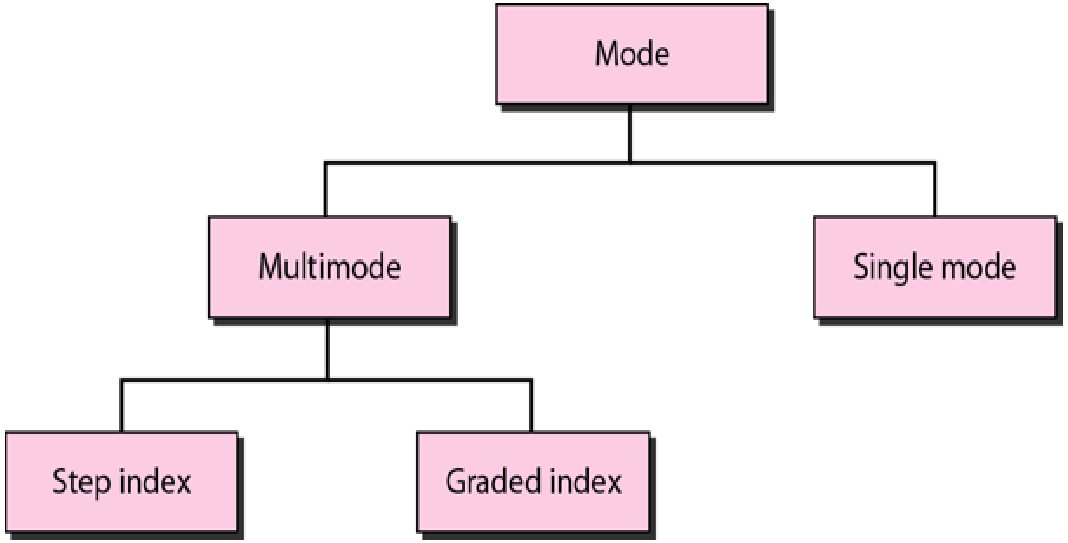
**Advantage:**

- Higher bandwidth ( hundreds of Gbps)
- Smaller size and weight
- Lower attenuation
- Electromagnetic Isolation
- Fewer repeaters.

**Disadvantage:**

- High cost
- Manufacturing and maintenance

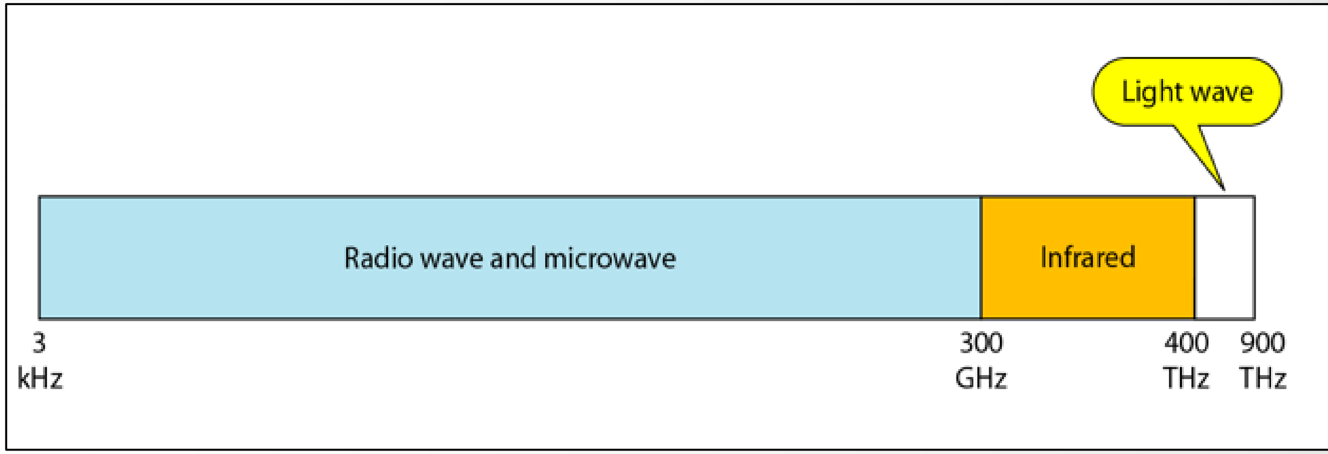


Unguided medium transport electromagnetic waves without using a physical conductor.

We can divide wireless transmission into three broad groups:

- Radio waves
- Microwaves
- Infrared waves




The electromagnetic spectrum, ranging from 3 kHz to 900 THz, used for wireless communication.