Chapter 3
Transmission Media

Objectives

- Concept of Guided and Unguided Transmission Media.
- Types of Guided Media.
- Types of Unguided Media.

3.1 Introduction - Need of Transmission Media, Selection Criteria.

3.2 Types of Transmission Media-

1. **Guided Media**: Cable Characteristics, Types of Cable-Twisted Pair Cable, Co-axial Cable, Fiber Optic Cable.
2. **Unguided media**: Types of Communication Band, Microwave Communication, Radio-wave Communication, Satellite Communication, Infrared Communication.

3.3 Latest Technologies in Wireless Network-Bluetooth Architecture, Wi-Fi, Wi- Max.

3.4 Cellular (Mobile) Telephone - Band in Cellular Telephony, Calls using Mobile Phones, Transmitting/Receiving / Handoff operations.

3.1 Introduction

In a data transmission system, the **transmission medium** is the physical path between transmitter and receiver.

Transmission media carries the information from sender to receiver. We use different types of cables or waves to transmit data. Data is transmitted normally through electrical or electromagnetic signals.

An electrical signal is in the form of current. An electromagnetic signal is series of electromagnetic energy pulses at various frequencies. These signals can be transmitted through copper wires, optical fibers, atmosphere, water and vacuum. Transmission media is also called **Communication channel.**

Criteria for selection of Transmission Media.

Different Medias have different properties like **bandwidth, delay, cost and ease of installation and maintenance**. The data transmission capabilities of various Media vary depending upon the various factors. These factors are:

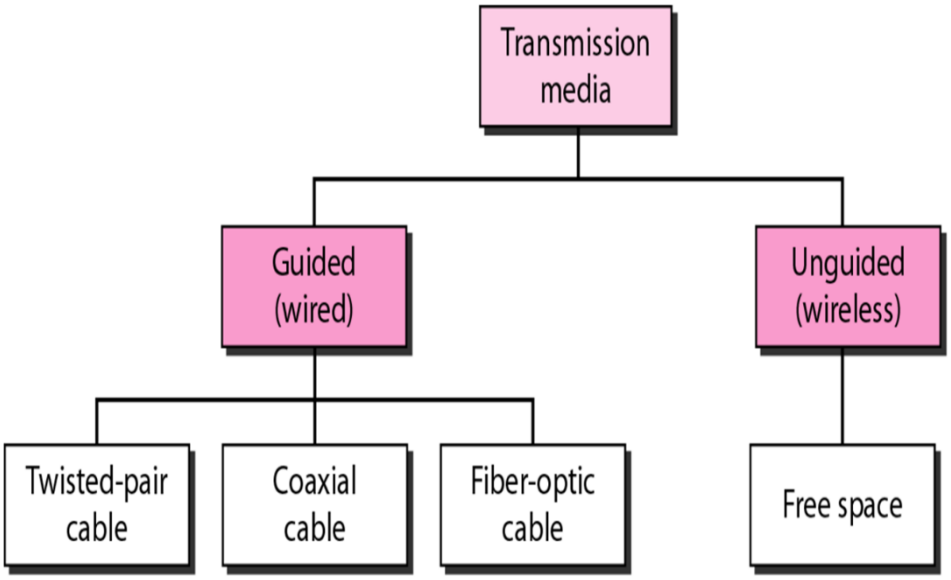
1. **Type of Media (Wired or Wireless).**

2. **Flexibility.** In order to expand network.
3. **Bandwidth**. It refers to the data carrying capacity of a channel or medium. Higher bandwidth communication channels support higher data rates.
4. **Reliability**. The consistency of transmission media (effect of weather conditions).
5. **Radiation**. It refers to the leakage of signal from the medium due to undesirable electrical characteristics of the medium.
6. **Noise Absorption**. It refers to the susceptibility of the media to external electrical noise that can cause distortion of data signal.
7. **Attenuation**. It refers to loss of energy as signal propagates outwards. The amount of energy lost depends on frequency.
8. **Number of receivers**. The number of users to be connected.
9. **Transmission Rate**.
10. **Cost and Ease of Installation**.
11. **Distances**, etc.

3.2 Types of Transmission Medias

There are two categories of transmission media used in computer communications.

1. **Guided Media (Wired)**
2. **Unguided Media (Wireless Media)**



1. Guided Media (Wired)

In a Guided transmission media the signals are sent through to a specific (solid) path using wire or cable. Guided media are made up of **copper conductor** bounded by **jacket (insulation)** material. Guided media is used high speed, good security and low cast requirements. Guided media is used in point to point communication.

Guided media are further divided in three Types.

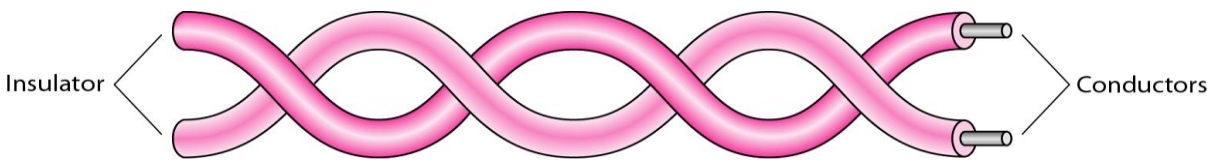
1. **Twisted Pairs Cable**
2. **Coaxial Cable**
3. **Fiber Optics Cable**

1. Twisted Pair cable

- The **least expensive** and **most widely used guided transmission medium.**
- It **is lightweight, cheap, can be installed easily**, and they support many different types of network.
- A twisted pair consists of **two insulated copper wires** arranged in a regular **spiral pattern**.
- Typically, a number of these pairs are bundled together into a cable by wrapping them in a tough protective sheath.
- Over longer distances, cables may contain hundreds of pairs.
- Twisted pair (TP) maybe used to **transmit both analog and digital signal**.
- For analog signals amplifiers are required about every 5 to 6 kms. For digital signals repeaters are required every 2 to 3kms.

Why twist a cable?

- The twisting tends to **decrease the crosstalk (EMI) interference** between adjacent pairs in a cable.
- Neighboring pairs in a bundle typically have somewhat different twist lengths to reduce the crosstalk interference.
- On long-distance links, the twist length typically varies from 5 to 15



Application:-

1. It is the most commonly used medium of telephone n/w.
2. In the telephone system individual residential telephone sets are connected to the local telephone exchange or to end office by twisted pair wire.
3. Twisted pair also the most common medium used for the digital signaling for connections to a digital data switch.
4. It is also commonly used within a building for LAN.

There are two types of twisted pair:-

A. Unshielded twisted pair (UTP).

B. Shielded twisted pair (STP).

Fig. UTP and STP cables

A. Unshielded Twisted Pair (UTP):-

- Usually consists of two copper wires wrapped in individual plastic insulation.
- UTP cables are the most common telecommunications medium.
- The frequency range of the twisted pair cables enable both voice and data transmission.
- UTP cables consist of 2 or 4 pairs of twisted cable. Cable with 2 pair use **RJ-11** connector and 4 pair cable use**RJ-45** connector.

(a)

There are five categories of UTPs:

- **Category 1:-** These originally used only for voice communication and can support only low data rates.
- **Category 2:-** Suitable for Voice and Data gives speed upto 4 mbps. This can't be used for high speed data communication. Older n/w's use this category.
- **Category 3:-** It is suitable for most PC n/w's support data rate of up to 16mbps currently most telephone n/w uses this.
- **Category 4:-** It offers data rate up to 20mbps.
- **Category 5:-**It offers data rate of 100mbps. Can be used for fast **Ethernet**. It requires more insulation and more twist per foot. It requires compatible equipment's.

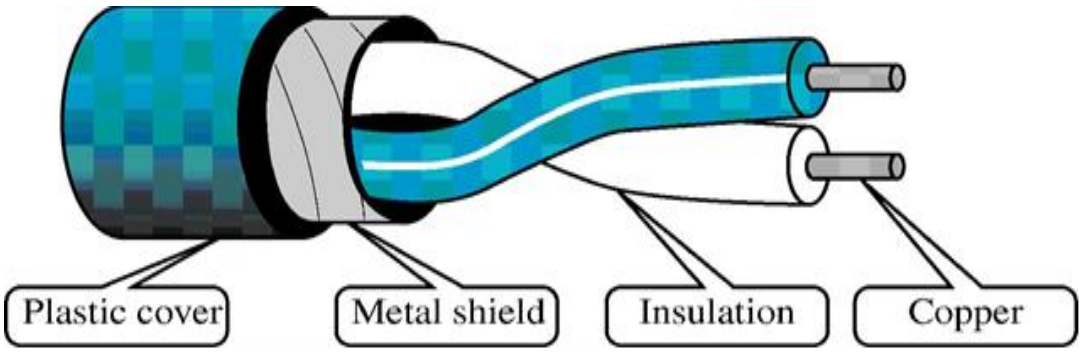
Advantages:

- Installation is easy
- Flexible
- Cheap
- It has high speed capacity,
- 100-meter limit
- Higher grades of UTP are used in LAN technologies like Ethernet.

Disadvantages:

- Bandwidth is low when compared with Coaxial Cable
- Provides less protection from interference (EMI).

2. Shielded twisted pair (STP).



- The only difference between STP and UTP is that STP cables have a shielding in usually of aluminum or polyester material between the outer jacket and wire.
- The shield makes STP less vulnerable to EMI, because the shield is electrically grounded.
- The metal mesh around the insulated wires eliminates **crosstalk**.
- **Crosstalk** occurs when one line picks up some of the other signals traveling down another line.

Advantages:

- Easy to install
- Performance is adequate
- Can be used for Analog or Digital transmission
- Increases the signaling rate
- Higher capacity than unshielded twisted pair
- Eliminates crosstalk

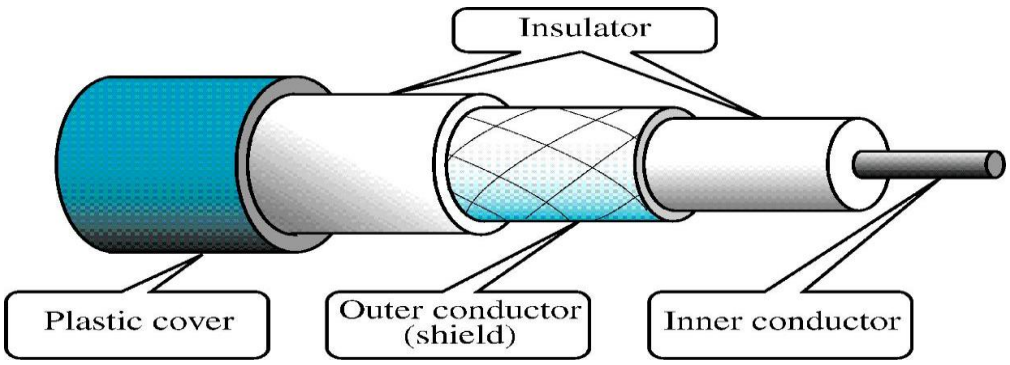
Disadvantages:

- Difficult to manufacture
- Heavy
- Expensive than UTP

Difference UTP vs STP

Factors	UTP	STP
Bandwidth	1-155MBps	1-155MBps
Node capacity per segment	2	2
Attenuation	High	Low
EMI	Very High	High
Installation	Easy	Fairly Easy
Cost	Low	Moderate

2. Co-axial cable



- The name coaxial is because it contains two conductors that are parallel to each other and share common axis.
- Inner conductor is made of copper which is surrounded by PVC insulation.
- The outer conductor is metal foil, mesh or both.
- Outer metallic conductor is used as a shield against noise.
- The outer conductor is also encased in an insulating sheath.
- The outermost part is the plastic cover which protects the whole cable.
- Co-axial cable is much less susceptible to interference and cross talk than the twisted pair.
- Co-axial cable is used to transmit both analog and digital signal.

Application –

Co-axial cable is widely used in the wide variety of applications. The most important of these are: -

1. **TV distribution: -**
   Co-axial cable is spreading rapidly as a means of distributing TV signals to individual homes –cables TV. A cable TV system can carry dozens or even hundreds of TV channels at ranges up to a few tens of miles.
2. **Long distance telephone transmission:-**
   Co-axial cable has traditionally been as important part of the long distance telephone n/w using FDM (frequency division multiplication) a co-axial cable can carry over 10,000 voice channels simultaneously.

3. **Short distance communication links: -**

Co-axial cable is also commonly used for short range connection between devices. E.g. can be used to provide high speed I/O channels for an PC system.

4. **LAN: -**

Co-axial cable can be support a large number of devices with a variety of data and traffic types over distance that covers single building or a complex of building.

Co-axial cables usually for data transmission are of two types.

- 10 base 2 thin net - Node capacity per segment for 10 base 2 is 30.
- 10 base 2 thick net- Node capacity for 10 base 5 is 100.

There are two types of Coaxial cables:

BaseBand

This is a 50 ohm (Ω) coaxial cable which is used for digital transmission. It is mostly used for LAN's. Baseband transmits a single signal at a time with very high speed. The major drawback is that it needs amplification after every 1000 feet.

BroadBand

This uses analog transmission on standard cable television cabling. It transmits several simultaneous signal using different frequencies. It covers large area when compared with Baseband Coaxial Cable.

Advantages:

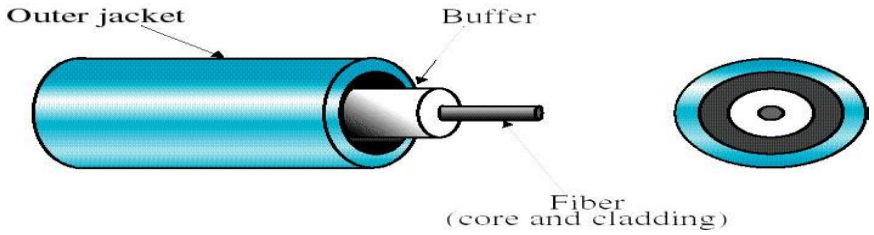
- Bandwidth is high
- Used in long distance telephone lines.
- Transmits digital signals at a very high rate of 10Mbps.
- Much higher noise immunity
- Data transmission without distortion.
- The can span to longer distance at higher speeds as they have better shielding when compared to twisted pair cable

Disadvantages :

- Single cable failure can fail the entire network.
- Difficult to install and expensive when compared with twisted pair.
- If the shield is imperfect, it can lead to grounded loop.

3. Optical Fiber or fiber optics

- A fiber-optic cable is made of glass or plastic and transmits signals in the form of light.
- A light pulse can be used to signal a one (1) bit.
- The absence of a pulse signals a zero(0).
- The bandwidth of an optical transmission system is potentially enormous.



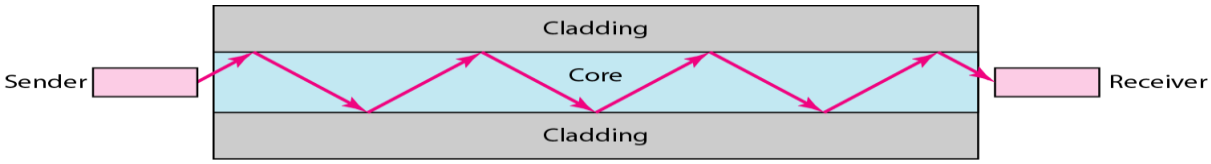
An optical fiber has an cylindrical shape and consists of 3 concentric section –

(i) Core
(ii) Cladding
(iii) Jacket

1. **Core:-** It's the inner most section is made of glass or plastic and is surrounded by its own cladding. The core diameter is in the range of **8 to 50 µm**.
2. **Cladding: -** A glass or plastic coating that has optical properties different from those of the core having a diameter **of 125 µm**. The cladding acts as **a reflector to light** that would otherwise escape the core.
3. **Jacket:** - The outer most layers surrounding caddied fiber is the jacket. Jacket is composed of plastic or other material layer to protect against moisture, cut, crushing and other environmental dangers.

Optical Fiber Communication

- A transmitter (Light Source) at senders end sends a Light across the fiber.
- A receiver at the other end makes use of Light Sensitive transistor to detect the absence or presence of light to indicate 0 or 1.



- The transmission medium is an ultra-thin fiber of glass.
- Light enters the cylindrical glass or plastic core at small angles are reflected and propagates along the fiber.
- The detector generates an electrical pulse when light falls on it.

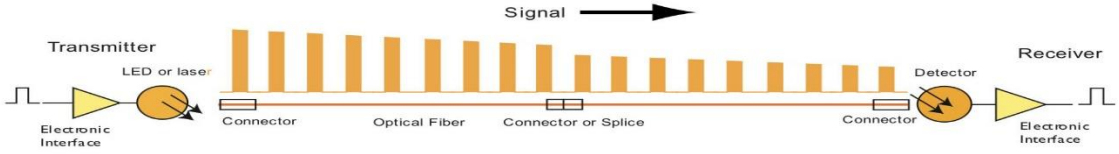


Fig. OFC Communication

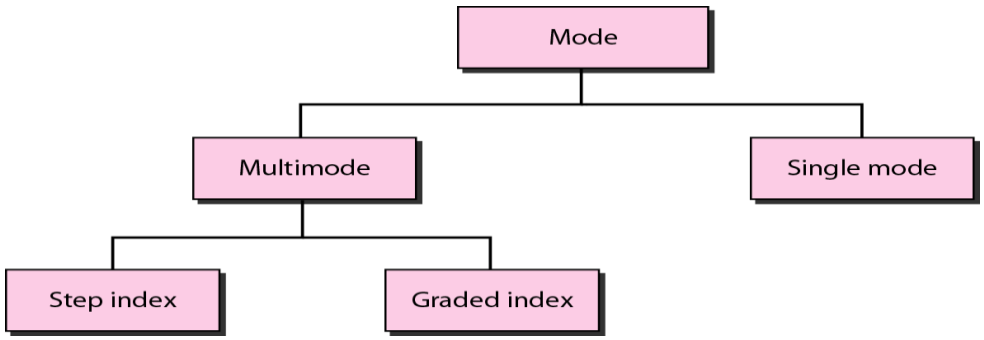
Two different types of **light sources** are used in fiber optic system.

- The Light Emitting Diode (LED)
- Injection Laser Diode (ILD)

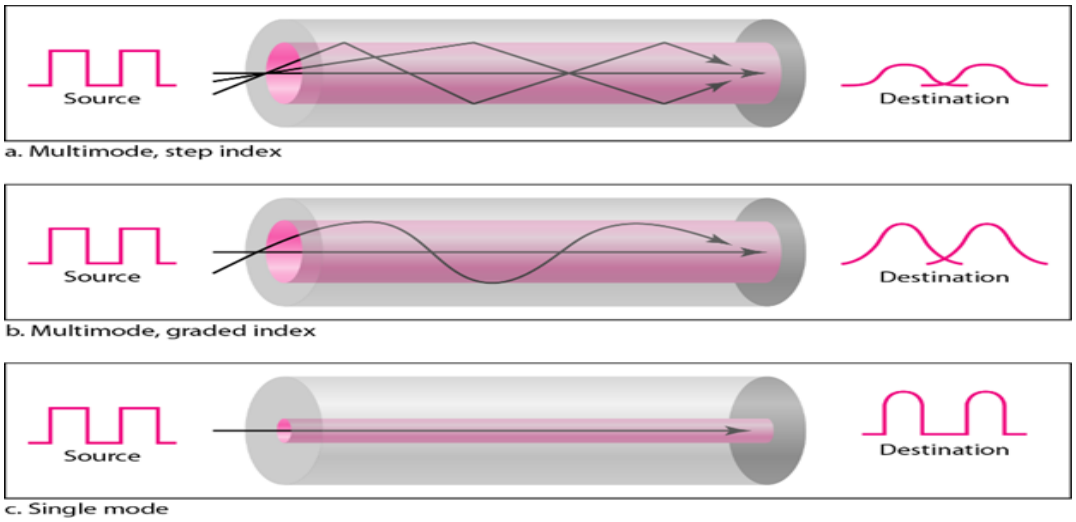
Both are semiconductor devices that emit a beam of light when voltage is applied. Led is less costly than ILD. ILD operates on laser principle, is more efficient, and can sustain greater data rate.

Types of Fiber Propagation Modes

- Optical fiber may be multi-mode or single mode.
- Single mode fibers allow a single light pass and are used with laser signaling. Single mode fibers can allow greater bandwidth and cable runs than multimode, but it is more expensive.
- Multimode fibers use multiple light pass the physical characteristics of the multiple mode fiber make all parts of the signal arrive at the same time appearing to the receiver as though they were one pulse.



1. Multimode **step-index fiber**
   - the reflective walls of the fiber move the light pulses to the receiver
2. Multimode **graded-index fiber**
   - acts to refract the light toward the center of the fiber by variations in the density
3. **Single mode fiber**
   - the light is guided down the center of an extremely narrow core



Advantages :

- Provides high quality transmission of signals at very high speed (bandwidth 2 Gbps)
- These are not affected by electromagnetic interference, so noise and distortion is very less.
- **Highly secure** due to tap difficulty and lack of signal radiation.
- Used for both analog and digital signals.
- **Smaller size** and **light weight**
- **Lower attenuation**

Disadvantages :

- It is expensive
- Difficult to install. requires **highly skilled installers**
- Maintenance is expensive and difficult.
- Do not allow complete routing of light signals.

Applications

- Telephones, including cellular wireless
- Internet
- LANs - local area networks
- CATV - for video, voice and Internet connections
- Utilities - management of power grid
- Security - closed-circuit TV and intrusion sensors
- Transportation – smart lights and highways
- Military – everywhere!

Characteristics of cable media:-

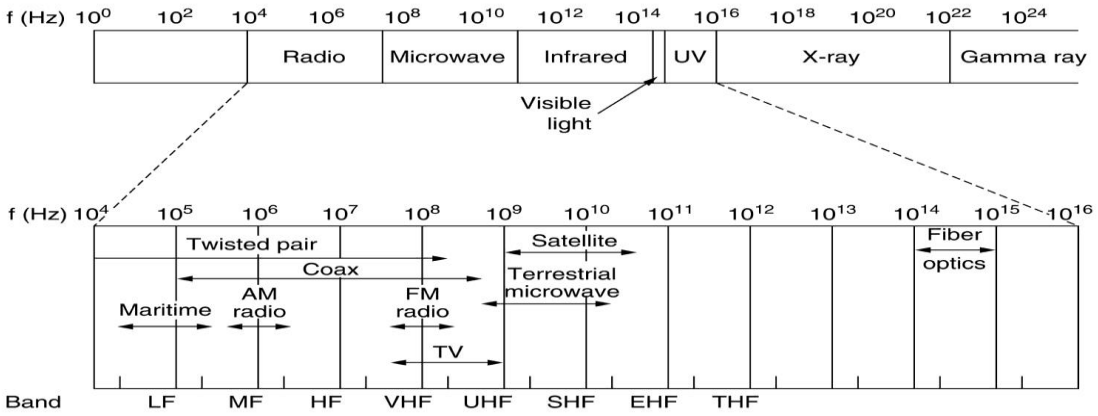
Factor	UTP	STP	Co-axial	Fiber optics
Cost	Low	Moderate	Moderate	Highest
Installation	Easy	Fairly easy	Fairly easy	Difficult
Data rate	1 to 155 mbps	1to 155 mbps	500 mbps	2 GBPS
Node capacity	2	2	30-100	2
Attenuation	High(100's of meter)	High(100's of meter)	Lower (range of few km's)	Lowest (10 Km's)
EMI	Most vulnerable	Less vulnerable than UTP	Less vulnerable than UTP	Not effected by EMI
Bandwidth	Low	Moderate	Moderatly high	Very high
Signals	Electrical	Electrical	Electrical	Light

2. Unguided Media

- Unguided media transmit electromagnetic waves without using a physical conductor.
- This is also called as wireless communication.
- Signals are normally broadcast through free space and thus are available to anyone who has **a device capable of receiving them.**

Electromagnetic Spectrum (Communication Band)

Electromagnetic spectrum is used for wireless communication. It is divided into various sub-bands.



The following table shows segmentation of electromagnetic spectrum.

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

Propagation Methods

Unguided signals can travel from the source to destination in several ways:

- Ground propagation,
- Sky-Propagation, and
- Line-of-Sight Propagation

1. Ground propagation mode:

- Radio waves **travel close to the earth**.
- These **low-frequency signals** proceed 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.

Ground propagation
(below 2 MHz)

2. Sky propagation mode:

- In this **high-frequency radio waves** radiate upward into the ionosphere where **they are reflected back** to earth.
- Ionosphere is the layer of atmosphere where **particles exist as ions**.
- This type of transmission allows for **greater distances with lower output power**.

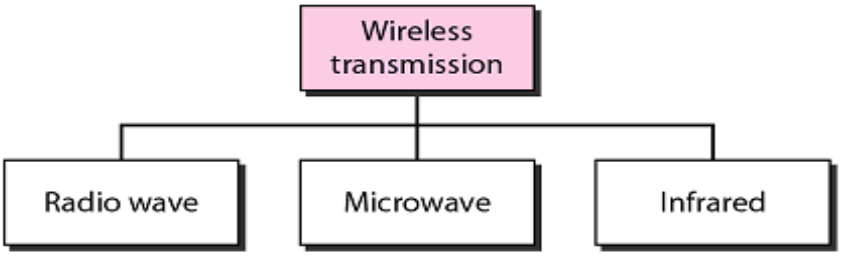
Sky propagation
(2–30 MHz)

3. Line-of-sight propagation mode:

- In this, **very high-frequency** signals are transmitted **in straight lines** directly from **antenna to antenna**.
- Antennas must be **directional**, facing each other and tall enough.
- Line-of-sight propagation **is tricky** because radio transmissions cannot be completely focused.

Line-of-sight propagation
(above 30 MHz)

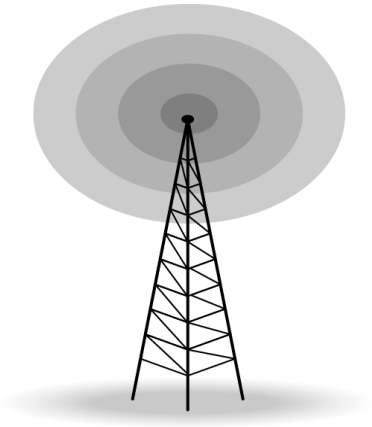
Classification of Wireless Media



- Wireless communication may be via:
  - **Radio frequency** communication
  - **Microwave** communication
  - **Infrared** short range communication

1. Radio Wave Transmission

- Electromagnetic waves ranging in frequency between **3 kHz and 1 GHz** are normally called radio waves.
- Radio waves, are **omnidirectional**, i.e. they are **propagated in all directions**.
- A sending antenna sends waves that can be received by **any receiving antenna**.



- Radio waves, particularly of **low and medium frequencies**, **<u>can penetrate walls</u>**.
- It is an **<u>advantage</u>** because, an **AM radio** can receive signals **inside a building**.
- It is a **<u>disadvantage</u>** because we **cannot isolate** a communication to just **<u>inside or outside a building</u>**.

Applications

- The omnidirectional characteristics of radio waves make them useful for **multicasting**, in which there is **one sender but many receivers**.
- **AM and FM radio**,
- **Television**,
- **Maritime radio**,
- **Cordless phones** and **paging**.

2. Microwave Transmission

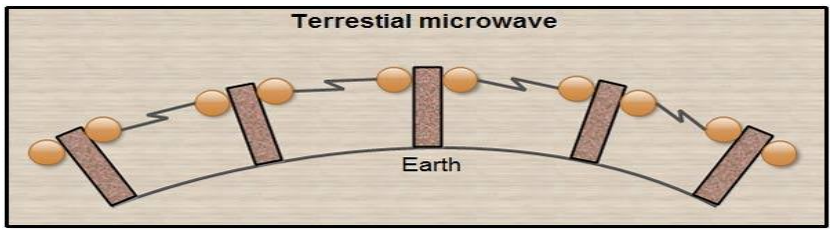
- Electromagnetic waves having frequencies between **1GHz and 300 GHz** are called microwaves.

- Microwaves are **unidirectional**.
- When an antenna transmits microwave waves, they can be **narrowly focused**.
- This means that the **sending and receiving antennas need to be aligned**.
- The unidirectional property has an obvious advantage.
    - A pair of antennas can be aligned without interfering with another pair of aligned antennas.
- **Microwaves use line-of-sight transmission**.
- This means that microwaves must be transmitted in straight line and no obstructions, such as buildings or mountains, between microwave stations.
- To avoid possible obstructions, microwave antennas often are positioned on the **tops of buildings**, **towers**, or **mountains.**

Microwave transmission is divided into two types

A. Terrestrial Microwave

- Used for **long-distance telephone service.**
- Uses radio frequency spectrum, from **2 to 40 GHz**.
- Parabolic dish transmitter, mounted high.
- Requires **unobstructed line of sight** between source and receiver
- Curvature of the earth requires stations (**repeaters**) 30 miles apart



Advantages:

- Effect of noise is reduced because of repeaters.
- Maintenance is less as compared to cable.
- No interference with other transmission channels.

Disadvantages:

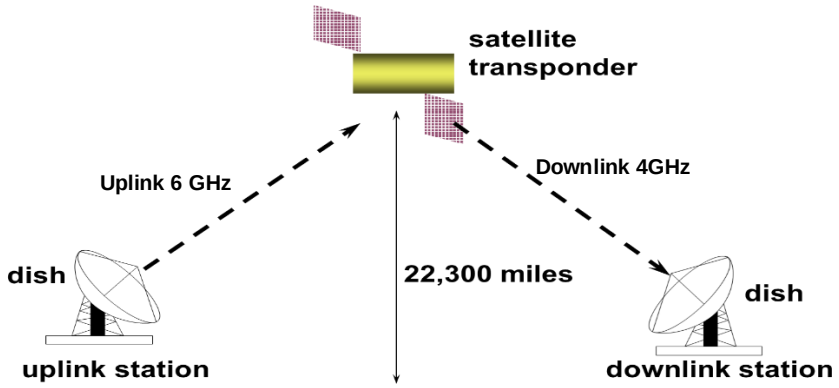
- Communication can be affected because of atmospheric phenomenon and passing airplanes and rain
- Line of sight requirement
- Expensive towers and repeaters.

Application:-

- Long-distance telecommunication service
    - requires fewer amplifiers or repeaters than coaxial cable
    - Example
        - telephone system
        - TV distribution
- Short point-to-point links
  • Data link between local area network
  • Closed-Circuit TV
- **By passing n/w:-** Microwave can also be used for bypass application. A business can establish a microwave link to long a distance telecommunication facility in the same city, by passing the local telephone company.

B. Satellite microwave:-

- A communication satellite acts like a microwave station.
- It is used to link two or more ground waves microwave transmitter or receiver known as earth stations.
- The satellite receives transmission on one frequency band (uplink), amplifies or repeats the signal and transmit it on another frequency (down link).
- A single orbiting satellite will operate on no. of frequency bands called transponder channels or simply transponder.



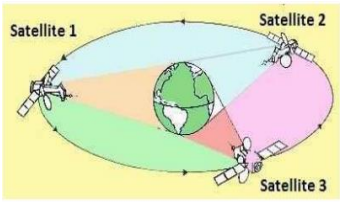
- In the fig the satellite is being used to provide a point to point link between two distant grounds based antenna.
- The signal, a beam of **modulated microwaves** is sent towards the satellite called **UPLINK (6 Ghz).**
- Then the satellite processes the signal and send it back to the receiver's antenna present on the earth's surface called as **DOWNLINK (4Ghz).**
- The satellite has to **receive, process** and **transmit** the signal.
- A unit called as Satellite Transponder performs all these functions.
- The communication satellite has two sets of transponders.
- Each set having **12 transponders**.
- Each transponder has a bandwidth of 36MHz.

Types of Satellite by there purpose

- Communication Satellite
- Weather satellite
- Remote- Sensing Satellite
- Scientific Satellite

Geostationary Earth Orbit (GEO)

- These satellites are in orbit 35,863 km above the earth's surface along the equator.
- Objects in Geostationary orbit revolve around the earth at the same speed as the earth rotates.
- This means GEO satellites remain in the same position relative to the surface of earth.



- **Principal Satellite Transmission Bands**
- **C band:**
    - 4(downlink) - 6(uplink) GHz
    - the first to be designated
- **Ku band:**
    - 12(downlink) -14(uplink) GHz
    - rain interference is the major problem
- **Ka band:**
    - 19(downlink) - 29(uplink) GHz
    - equipment needed to use the band is still very expensive

Application:-

- **Television** distribution
    - A network provides programming from a central location
    - Direct broadcast satellite (DBS)
- Long-distance **telephone** transmission
    - High-usage international trunks
- Private business networks
- **Military** Applications
- Other applications
    - **digital** cinema
    - Satellite **radio**
    - Satellite **internet access**

3. Infrared

- Infrared waves, with frequencies from **300 GHz to 400 THz** (wavelengths from **1 mm to 770 nm**),
- Used for **short-range communication**.
- Infrared communication is achieved using transmitters/receivers (Transceivers) that modulate non-coherent infrared light.
- Transceiver must be in line of sight of each other either directly or via reflection from light colored surface such as the sealing of the room.
- One important difference between infrared and microwave transmission is that they don't penetrate walls.
- The **remote controls** used for televisions, VCRs, and stereos all use infrared communication.
- They are relatively directional, cheap, and easy to build.

Applications

- TV Remote control
- Guidance in weapon system
- Wireless keyboards and mouse.

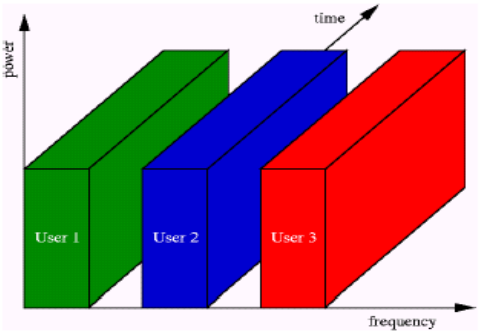
Multiple Access Methods

In wireless communications, it is necessary to utilize limited frequency bands at the same time, allowing multiple users to share radio channel simultaneously.

- System uses different carrier frequency – FDMA system.
- System uses distinct time – TDMA system.
- System uses different code – CDMA system.

Frequency Division Multiple Access (FDMA)

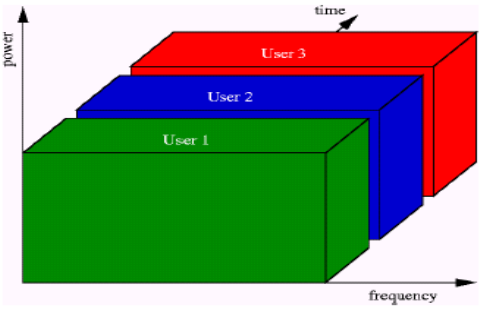
- Simplest
- Best suited for analog links.
- Each station has its own frequency band, separated by guard bands.
- Receivers tune to the right frequency.



- Individual channels are assigned to individual users for the time of an ongoing communication
- Inefficient if customer does not use the channel (voice call)
- In case of FDD a pair of frequencies is formed to a channel
- No equalization needed (symbol time > delay spread)
- No synchronization and framing bits are needed as in TDMA systems
- Continuous transmission
- AMPS first analog cellular system in the US uses FDMA/FDD

Time Division Multiple Access (TDMA)

- All stations transmit data **on same frequency**, but at **different times**
- Needs **time synchronization**
  - Spectrum is divided into time slots, where only one user is allowed to send per slot
  - Cyclic usage of the slots (1, N+1, N+2, etc), N slots per frame
  - Each frame and slot starts with preamble containing synchronization information
  - Non-continuous transmission
  - Guard times needed
  - Data transmission in bursts result in low battery consumption
  - Multiple slots per user possible
  - Easy handoff because of idle times

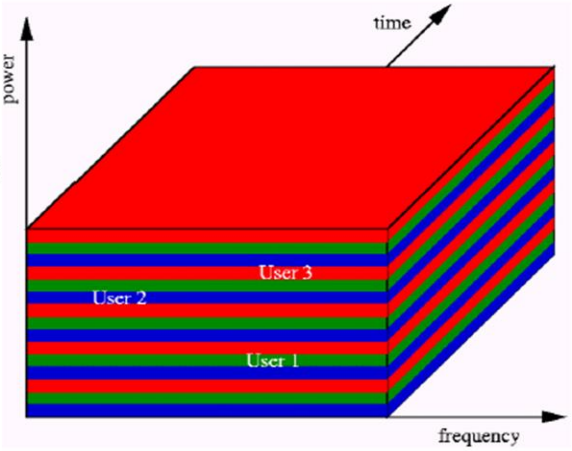


- **Pros**
  - users can be given different amounts of bandwidth
  - mobiles can use idle times to determine best base station
  - can switch off power when not transmitting
- Cons
  - synchronization overhead
  - greater problems with multipath interference on wireless links

Code Division Multiple Access (CDMA)

- Users separated both by time and frequency
- Send at a different frequency at each time slot (*frequency hopping*)
- Or, convert a single bit to a code (*direct sequence*)
    - receiver can decipher bit by inverse process

- The user's signal is spread by an unique sequence
- All user share the same bandwidth with different sequences
- A communication is identify by the sequence
- Sender and receiver know the sequence in advance
- Other ongoing communication appears to be noise
- Power control needed to avoid near far effect
- Soft capacity limit
- Multi-path is reduced due to spreading sequence



- **Pros**
    - hard to spy
    - immune from narrowband noise
    - no need for all stations to synchronize
    - no hard limit on capacity of a cell
    - all cells can use all frequencies
- **Cons**
    - Implementation complexity
    - Need for power control
        - to avoid capture
    - Need for a large contiguous frequency band (for direct sequence)
    - Problems installing in the field

3.3 Latest Technologies in Wireless Network-Bluetooth Architecture, Wi-Fi, Wi- Max.

1. Bluetooth Architecture

- Named after the Danish king, Harold Bluetooth.
- Bluetooth was the first to connect, several devices like mobile phones, PDA's, headsets, keyboards, mice, medical equipment and even cars now come with this feature.

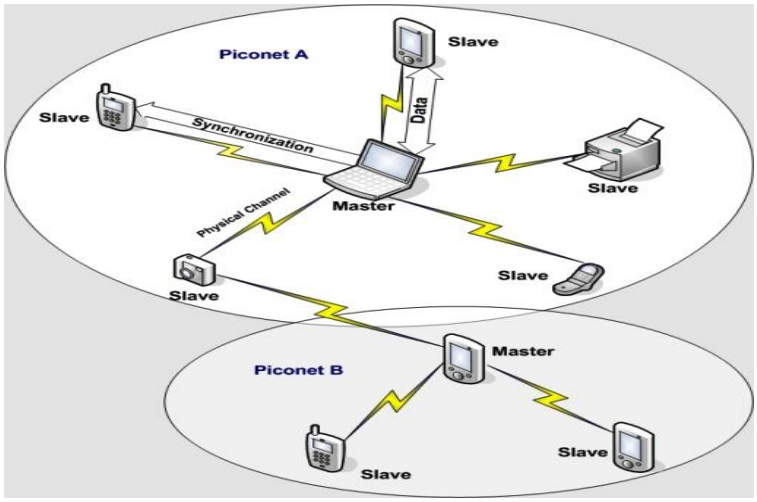
- Due to its low cost, manufacturers are willing to implement this technology in most devices.
- Uses the radio range of 2.45 GHz 5. Theoretical maximum bandwidth is 1 Mb/s
- It is designed for short range communications with a range of about 10m.
- As a result, it consumes less power and are suited for very small battery powered devices and portable devices.
- Problems associated when devices communicate via infrared or cables are removed. Infrared requires a line of sight, bluetooth only needs to be in reasonable vicinity.
- As cables are not required, it would be less cumbersome carrying a personal bluetooth device and space would be less cluttered.
- As bluetooth devices automatically communicate with each other, it requires very little from the user.
- Bluetooth allows for a wireless Personal Area Network (PAN) with it's short range.

Piconet:

- A network of devices connected in an ad hoc fashion using Bluetooth technology.
- A piconet is formed when at least two devices, such as a portable PC and a cellular phone, connect. A piconet can support up to eight devices.
- When a piconet is formed, one device acts as the master while the others act as slaves for the duration of the piconet connection.
- A piconet is sometimes called a PAN.
- "Piconet" is a combination of the prefix "**pico**," meaning very small or one trillionth, and **net**work.

Scatternet:

- A group of independent and non-synchronized piconets that share at least one common Bluetooth device.
- Bluetooth devices must have point-to-multipoint capability to engage in scatternet communication.



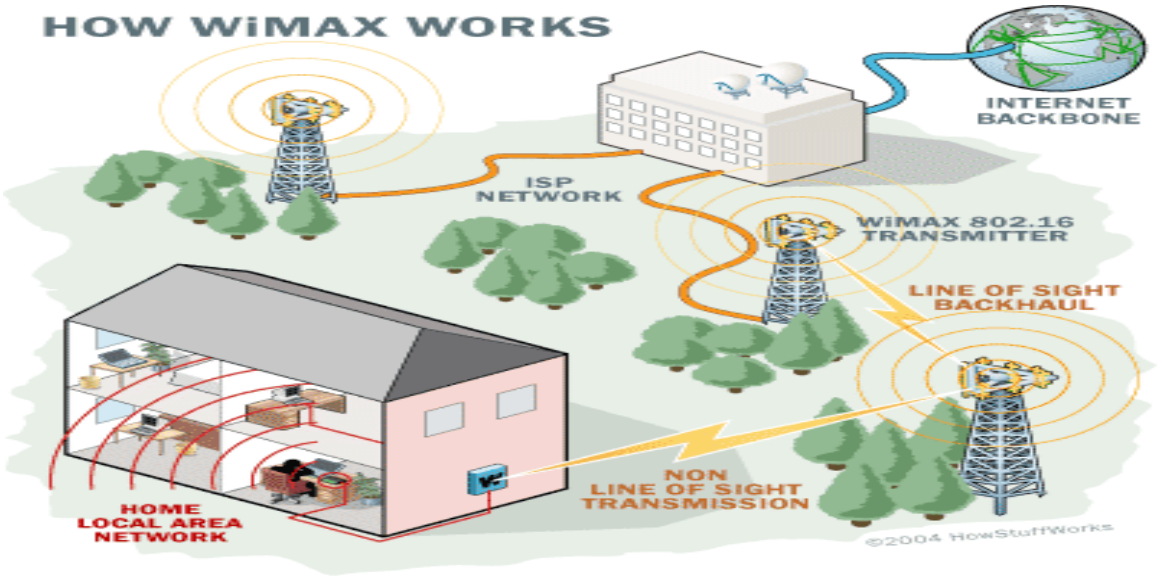
2. Wi-Fi

- Wi-Fi or **Wireless Fidelity** has a range of about 100m and allows for faster data transfer rate between 10 - 54Mbps.
- There are three different wireless standards under Wi-Fi, 802.11a, 802.11b and 802.11g.
- 802.11 being the wireless standard set by The Institute of Electrical and Electronic Engineers (IEEE).
- Wi-Fi is used to create wireless Local Area Networks (WLAN).
- The most widely used standard is 802.11b and 802.11g is expected to grow rapidly.
- These two standards are relatively inexpensive and can be found providing wireless connectivity in airports, railway stations, cafes, bars, restaurants and other public areas.
- The main difference between the two is the speed. 802.11b has data transfer rate of upto 11Mbps and 802.11g has a rate of upto 54Mbps.
- 802.11g is a relatively new and has yet to be adopted widely. 802.11a is more expensive and as a result it not available for public access.

3. WiMax

- WiMAX is Worldwide Interoperability for Microwave Access.
- The IEEE standard for WiMAX is 802.16 and falls under the category of wireless Metropolitan Area Network (WMAN).
- WiMAX operates on two frequency bands, 2 - 11GHz and 10 - 66GHz and has a range of about 50km with speeds of upto 80Mbps.
- This enables smaller wireless LANs to be interconnected by WiMAX creating a large wireless MAN.
- Networking between cities can be achieved without the need for expensive cabling.

- It is also able to provide high speed wireless broadband access to users.
- As it can operate in two frequency bands WiMAX can work by line-of-sight and non-line-of-sight.
- At the 2 - 11GHz frquency range it works by non-line-of-sight, where a computer inside a building communicates with a tower/antenna outside the building.
- Short frequency transmissions are not easily disrupted by physical obstructions.
- Higher frequency transmissions are used for non-line-of-sight service.
- This enables to towers/antennae to communicate with each other over a greater distance.
- Due to infrastructure and costs involved it would be more suited to provide the backbone services for ISPs and large corporations providing wireless networking and internet access.

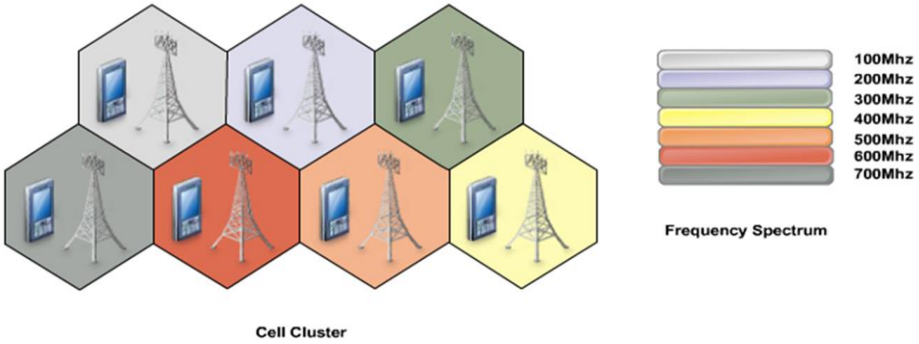


Comparison of Wireless Technologies

	Bluetooth	WiFi (a)	WiFi (b)	WiFi (g)	WiMAX
Standard	802.15	802.11a	802.11b	802.11g	802.16
Frequency (GHz)	2.45	5	2.4	2.4	2 - 66
Speed (Mbps)	0.72	54	11	54	80
Range	10m	50m	100m	100m	50km
Advantages	Low Cost	Speed	Low Cost	Speed	Speed, Range
Disadvantages	Range	Cost	Speed	Cost, Range	Cost

3.4 Cellular (Mobile) Telephone - Band in Cellular Telephony, Calls using Mobile Phones, Transmitting/Receiving / Handoff operations.

- Cellular communication is designed to provide communications between two moving units, or between one mobile unit and one stationary phone or land unit (PSTN).
- The entire network coverage area is divided into cells based on the principle of frequency reuse
- **A Cell** -basic geographical unit of a cellular network; **is the area around an antenna** where a specific frequency range is used;
- Cell is represented graphically as a **hexagonal shape**, but in reality it is irregular in shape.
- **A cluster** is a group of adjacent cells, **usually 7 cells**; no frequency reuse is done within a cluster
- In heavy traffic zones cells are smaller, while in isolated zones cells are larger.



- **Bands in Cellular Telephony**

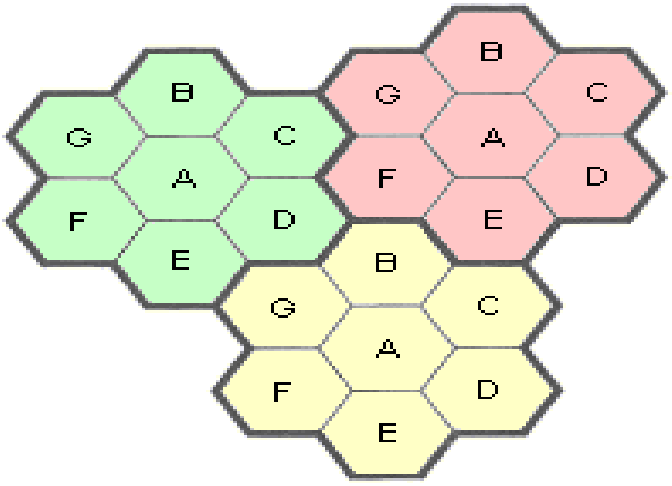
Analog transmission is used for cellular telephony. Frequency modulation is used for communication between the mobile phone and cell office. Two frequency bands are allocated for this purpose. One band of them is for the communication that is initiated by mobile phone & the other band for the land phone. Each channel requires a full-duplex dialog.

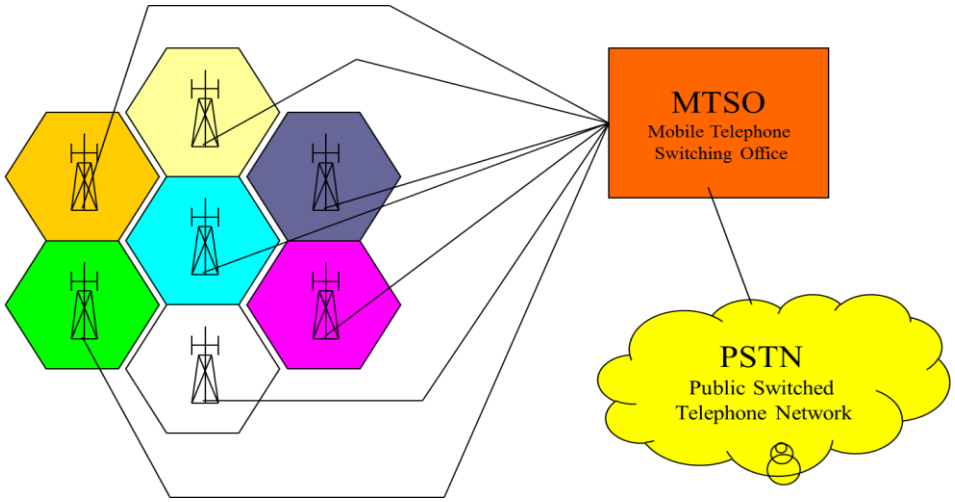
For preventing interference, adjacent channels are rarely allocated; some of them are also required for control purposes. This reduces the number of channels available for each cell.

- GSM uses FDMA and TDMA to transmit voice and data
- The **uplink channel** - between the cell phone and the BTS uses FDMA
- The **downlink channel-** between the BTS and the cell phone uses a TDMA technique
- uplink and downlink channels have a bandwidth of 25 MHz
- Each uplink and downlink frequency bands is further split up as **Control Channel** (used to set up and manage calls) and **Traffic Channel** (used to carry voice).

GSM Frequency band	Uplink/BTS Transmit	Downlink/BTS Receive
900 MHz	935-960 MHz	890-915 MHz
1800 MHz	1805-1880 MHz	1710-1785 MHz
1900 MHz	1930-1990 MHz	1850-1910 MHz

The same frequency band can be used for multiple non-adjacent cells as shown in fig.





- **Calls using Mobile phones:**

1. Call is made from the mobile phone by entering 10-digit phone number;
2. the mobile phone itself scans the band & seeks a channel for setting up the call.
3. After seeking, it sends this number to the closest cell office, which in turn, sends it to the CTO.
4. If the called party is available, CTO lets MTSO (mobile telephone switching office) know.
5. At this point, MTSO allocates an empty voice channel to the cell to establish the connection.
6. The mobile phone adjust its tuning to the new channel & the dialog begins.

- **When a land phone places a call to a mobile phone**,

1. The telephone central office sends the number to the MTSO.
2. The MTSO performs a lookup to see where the mobile phone is currently placed by sending appropriate query signal to all the cells.
3. This process is known paging.
4. The cell where the mobile phone is currently located responds to the MTSO. Incoming calls work differently.
5. To start with idle phone is continuously listen to paging channel to detect messages at directed at them.
6. The MTSO then transmit the incoming call signal to that mobile phone & when the mobile phone is answered, the MTSO assigns a voice channel to the call, thus enabling the conversation.

- **Transmitting/Receiving/Handoff Operation**

Define the process of hand-over

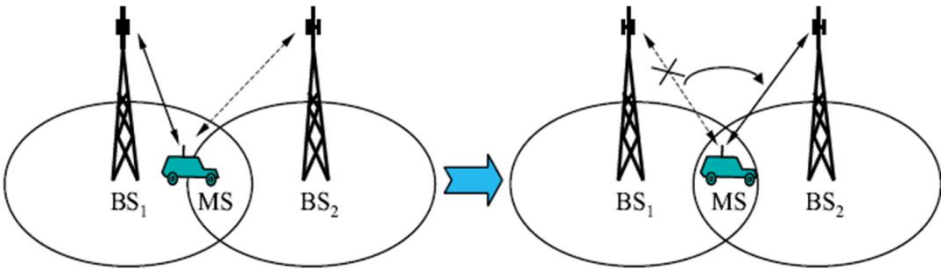
- When a mobile moves into a different cell while a conversation is in progress, the MSC automatically transfers the call to a new channel belonging to the new base station.
- This handoff operation not only involves identifying a new base station, but also requires that the voice and control signals be allocated to channels associated with the new base station.
- Processing handoffs is an important task in any cellular radio system.

Handoff

- When a mobile user is engaged in conversation, the MS is connected to a BS via a radio link.
- If the mobile user moves to the coverage area of another BS, the radio link to the old BS is eventually disconnected, and a radio link to the new BS should be established to continue the conversation.
- This process is referred to as **automatic link transfer**, **handover, or handoff.**

1. Hard Hand Off

- In Hard Hand Off a mobile station only communicates with one base station.
- When the (mobile handset) MS moves from one cell to another, communication must first be broken with the previous base station before communication can reestablished with the new one.
- This may create a rough transition.
- Hard hand off was used in earlier systems.



a. Before handoff b. After handoff

2. Soft Hand Off

- In this case, a mobile station can communicate with two base stations at the same time this means that, during Hand off a mobile station may continue with the new base station before breaking off from the old one.
- This is used in new systems.
- This provides seamless connectivity while roaming from one cell to another.

Roaming

- Roaming refers to a wireless network service extension in an area that differs from the registered home network location.
- Roaming enables a mobile device to access the Internet and other mobile services when out of its normal coverage area.
- It also gives a mobile device the ability to move from one access point to another.