MODULE V

Cellular Wireless Networks: Introduction, cellular telephone system, cellular concept and frequency reuse.

Wireless Network Topologies: First Generation (1G) Technology, Second Generation (2G) Technology, GSM Communications, GSM System architecture, Third Generation (3G) Technology, CDMA Technology, High-level architecture of LTE, Fourth Generation (4G) Technology, Wireless LAN, Bluetooth, Bluetooth Architecture.

Satellite Communication: Elements of Satellite Communication, Types of satellites – GEO, LEO, MEO.

Optical Fiber Communication: A fiber optic Communication system.

Microwave Communication: Introduction, Frequency modulated microwave communication system.

5.1 Cellular Wireless Networks

5.1.1 Introduction:

- To provide wireless communication within a geographic region, an integrated network of base stations must be installed to provide sufficient radio coverage to all mobile users.
- Base station must be connected to a central hub called Mobile Switching Center (MSC).
- Wireless service providers often start with a minimal infrastructure and antenna sites.
- The infrastructure expands with increasing number of users and technologies are also improved to increase the facilities and service quality.

5.1.2 Cellular Telephone System

- As shown in figure 5.1, a cellular system comprises the following basic components:

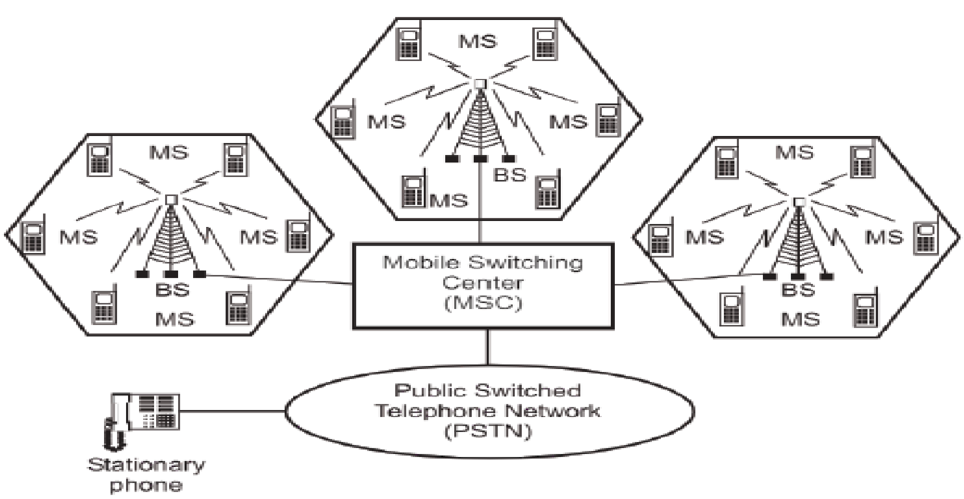


Fig. 5.1: Schematic diagram of a cellular telephone system

- **Mobile Station (MS):** Mobile handset, used by user to communicate with another user.
- **Cell:** Each cellular service area is divided into small regions called cell (5 to 20 Km).
- **Base Station (BS):** Each cell contains an antenna, which is controlled by a small office.
- **Mobile Switching Center (MSC):** Each base station is controlled by a switching office, called mobile switching center.

5.1.3 Cellular concept and frequency reuse

- The fundamental principle of the cellular concept is to divide the coverage area into a number of smaller areas which are served by their own radio base station.
- Radio channels are allocated to these smaller areas to cater the traffic loads in these areas called **cells**.
- The groups of cells in smaller areas are known as **clusters**.
- The cellular concept employs variable low power transmitters, which allow cells to be sized according to the subscriber density and demand of a given area.
- As the population grows, cells can be added to accommodate that growth.
- Frequencies used in one cell cluster can be reused in other cells.
- Small cells will increase the network capacity, but on the other hand will increase the **co-channel interference (CCI)**, therefore affect the **quality of service (QoS).**
- Figure 5.2 shows the concept of cells in wireless and mobile networks.

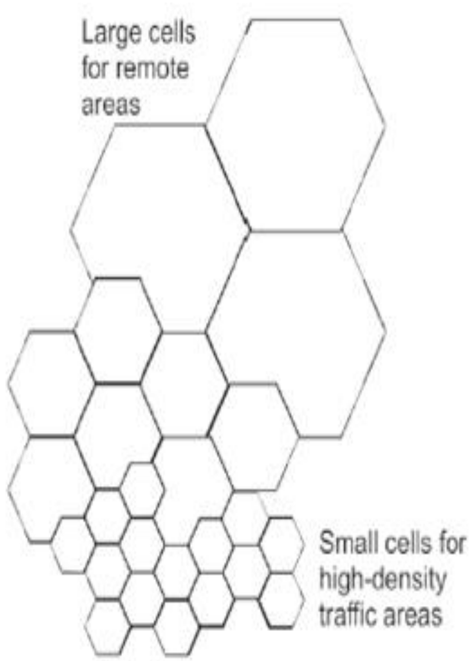


Fig. 5.2: Cellular concept in wireless and mobile networks

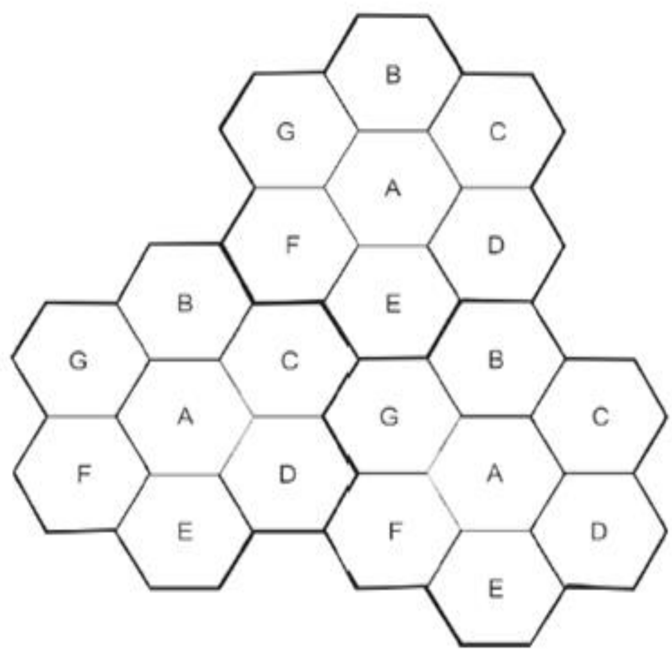


Fig. 5.3: Concept of frequency reuse

5.1.3.1 Frequency Reuse

- Frequency reuse is the core concept of the cellular mobile radio system.
- The total available channels are divided into a number of channel sets.
- Each channel set is assigned to a cell.
- Cells are assigned a group of channels that is different from neighbouring cell.
- Figure 5.3 illustrates the concept of frequency reuse.
- Cells with the same alphabet use the same channel set.
- The same set of channels can be reused in another cell provided that the reuse distance is fulfilled.
- The reuse distance D is the minimum separation of identical channels that have the same carrier frequency, given by $D = (\sqrt{3N})R$ Where N is the number of channel sets (in Fig. 5.3, N= 7), R is the radius of a cell.

5.1.4 Reduction of Interference

- Reusing an identical frequency channel in different cells is limited by co-channel interference between cells.
- Different ways to reduce co-channel interference (CCI) is:
    - To keep the separation between two co-channel cells by a sufficient distance.
    - To use directional antennas at the base station (BS), & is called as **cell sectoring**.

5.1.5 Transmitting and Receiving

Transmitting involves the following steps:

- A caller enters a 10-digit code (phone number) and presses the send button.
- MS scans the band to select free channel & sends signal to send the number entered
- The BS relays the number to the MSC.
- MSC in turn dispatches the request to all the BS's in the cellular system.
- Mobile Identification Number (MIN) is then broadcast over all the forward control channels throughout the cellular system. It is known as **paging**.
- MS responds by identifying itself over the reverse control channel.
- BS relays the acknowledgement sent by mobile & informs the MSC about handshake.
- MSC assigns an unused voice channel to the call and call is established.

Receiving involves the following steps:

- All the idle mobile stations continuously listens to the paging signal to detect messages directed at them.

- When a call is placed to a mobile station, a packet is sent to the callees home MSC to find out where it is.
- A packet is sent to the base station in its current cell, which then sends a broadcast on the paging channel.
- In response, a voice channel is assigned and ringing starts at the MS.

5.1.6 Mobility Management

- When an MS migrates out of its current BS into another, a procedure is performed to maintain service continuity, known as **Handoff management**.
- **Handoff:** When a mobile station moves out of a cell, the BS notices the MSs signal fading away & requests all neighbouring BSs to report the strength they are receiving.
- The BS then transfers ownership to the cell getting the strongest signal and the MSC changes the channel carrying the call. The process is called **handoff**.
- There are two types of handoff; **hard handoff** and **soft handoff**.
- In a **hard handoff**, a MS communicates with one BS. As a MS moves from cell A to cell B, the communication between the MS and base station of cell A is first broken before communication is started between the MS and the base station of B. As a consequence, the transition is not smooth.
- For smooth transition from one cell (say A) to another (say B), an MS continues to talk to both A and B. As the MS moves from cell A to cell B, at some point the communication is broken with the old base station of cell A. This is known as **soft handoff**.
- **Roaming:** Two fundamental operations are associated with location management are location update and paging.
- When a Mobile Station (MS) enters a new Location Area, it performs a location updating procedure by making an association between the foreign agent and the home agent.
- One of the BSs, in the newly visited Location Area is informed and the home directory of the MS is updated with its current location.
- When the home agent receives a message destined for the MS, it forwards the message to the MS via the foreign agent.

5.2 Wireless Network Topologies

- Wireless network topology is defined as the configuration in which a mobile terminal (MT) communicates with other mobile terminals.
- Basically, there are two types of topologies used in wireless networks as follows:

Ad-Hoc Network Topology:

- Ad-hoc wireless networks do not need any infrastructure to work. Each node can communicate directly with other nodes, so no base station is necessary.
- These networks are primarily used by military and also in a few commercial applications for voice and data transmission.
- Figure 5.4 shows a single-hop, ad-hoc network where every user terminal has the functional capability of communicating directly with any other user terminal.
- In some ad-hoc networking applications, where users may be distributed over a wide area, a given user terminal may be able to reach only a portion of the other users.
- In this situation, user terminals will have to cooperate in carrying messages across the network between widely separated stations.
- These networks are called multi hop ad-hoc networks as shown in Fig. 5.4 (b).

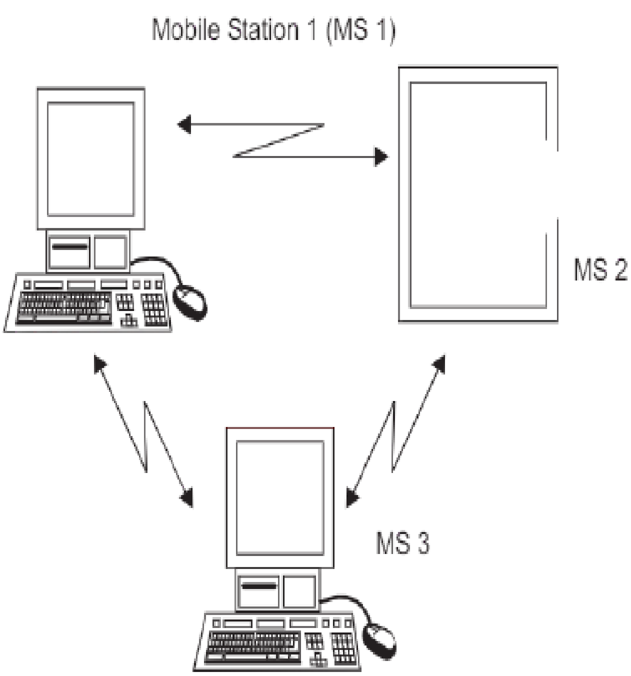
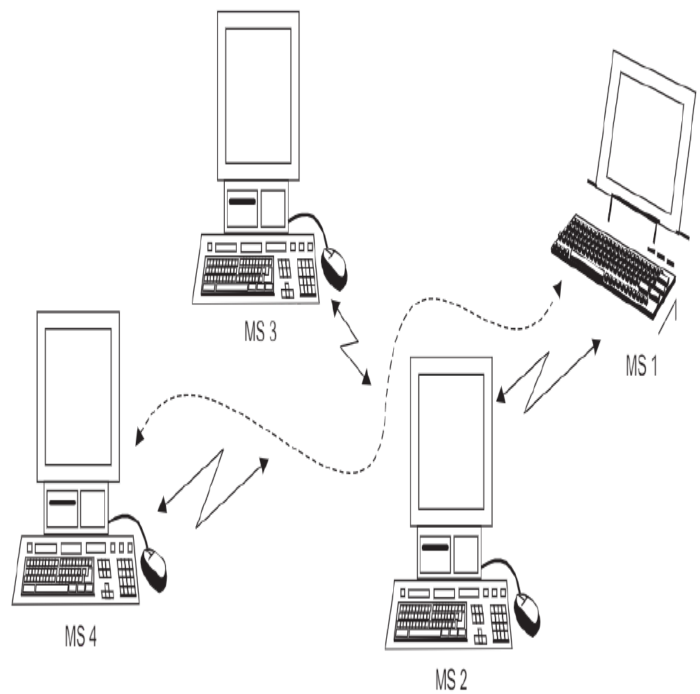


Fig. 5.4: Single hop ad-hoc network



(b): Multi hop ad-hoc network

Infrastructure Network Topology:

- In this topology, there is a fixed infrastructure that supports the communication between the mobile terminals and between mobile and fixed terminals.
- This topology is often designed for large coverage areas and multiple base stations (BS) or access point (AP) operations.
- Figure 5.5 shows the basic operation of an infrastructure network with a single BS.

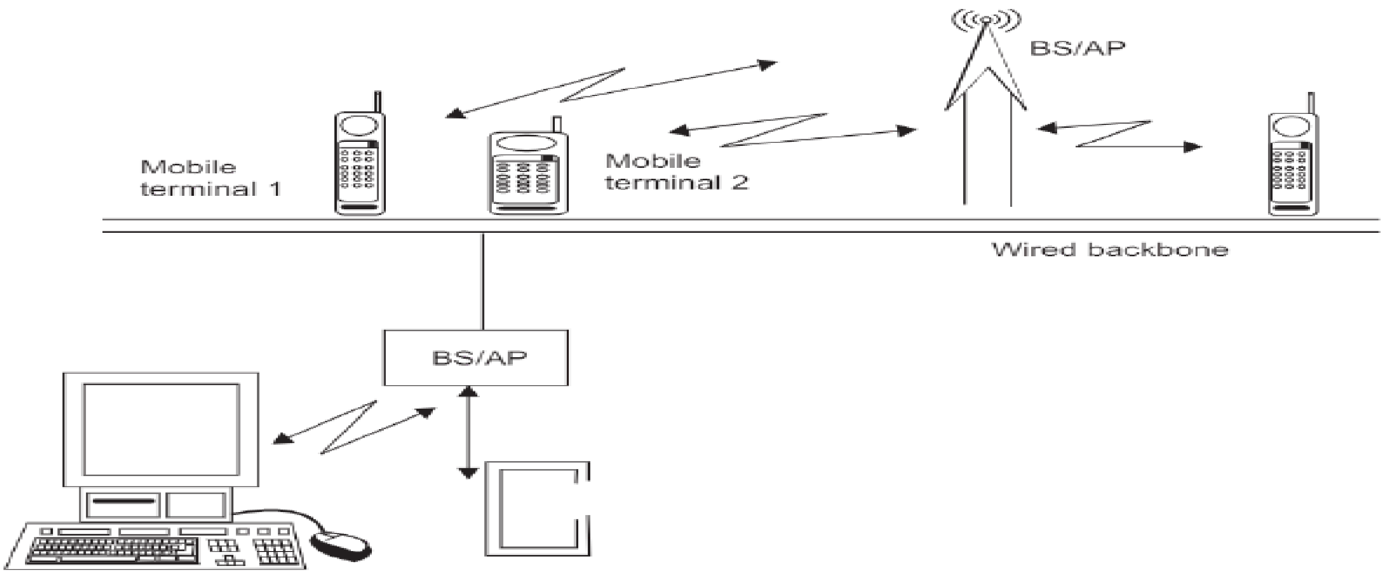


Fig. 5.5: Infrastructure network topology

5.2.1 FIRST GENERATION (1G) TECHNOLOGY

- 1G- First Generation of wireless telecommunication technology, known as cell phones.
- 1G technology featured mobile radio telephones and technologies such as Mobile Telephone System (MTS), Advanced Mobile Telephone System (AMTS), Improved Mobile Telephone Service (IMTS), and Push to Talk (PTT).
- 1G wireless networks used analog radio signals.
- Through 1G, a voice call gets modulated to a frequency of about 150 MHz using a technique called *Frequency-Division Multiple Access (FDMA).*
- Drawbacks:
  - Low capacity, unreliable handoff, poor voice links, and no security at all, making the calls susceptible to unwanted eavesdropping by third parties.
- 1G was designed for voice communication.
  - Eg: Advanced Mobile Phone System (AMPS).
- An AMP is an analog cellular phone system.
- It uses 800 MHz ISM band and two separate analog channels; forward and reverse analog channels.
- 824 to 849 MHz is used for reverse communication from MS to BS. 869 to 894 MHz is used for forward communication from BS to MS.
- Each band is divided in to 832 30-KHz channels as shown in Fig. 5.6.
- An AMP uses Frequency Division Multiple Access (FDMA) to divide each 25-MHz band into 30-KHz channels as shown in Fig. 5.7.

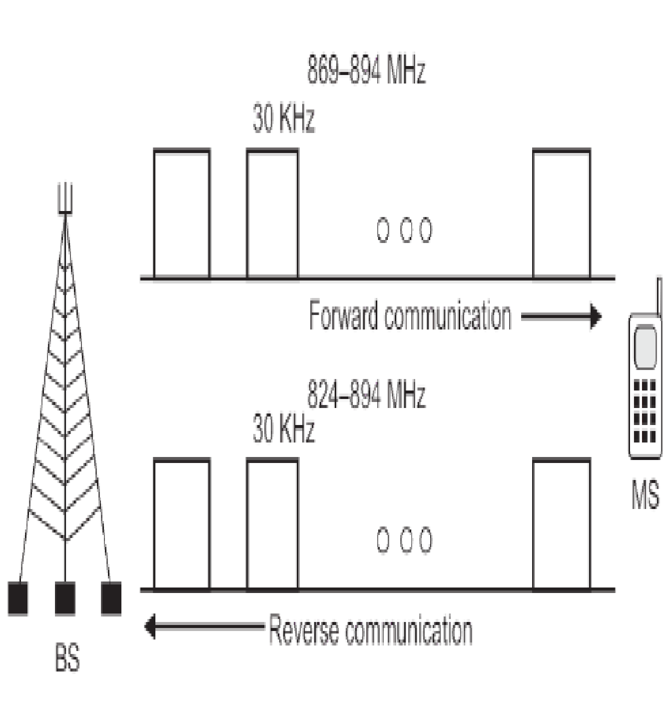


Fig. 5.6: Frequency bands used in AMPS system

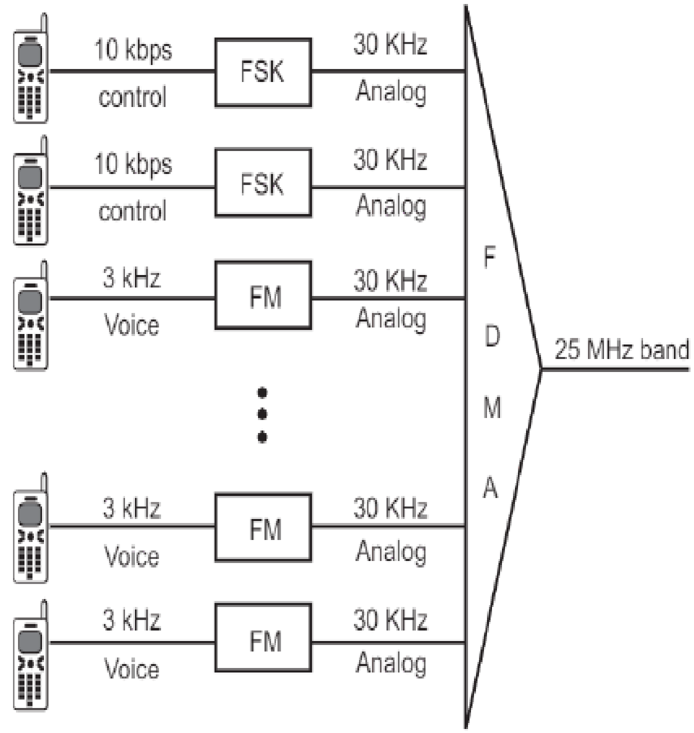


Fig. 5.7: FDMA medium access control technique used in AMPS

5.2.2 SECOND GENERATION (2G) TECHNOLOGY

- 2G was developed for digitized voice communication to provide better voice quality.
- SMS messaging was also available.
- 2G technologies can be divided into ***Time Division Multiple Access (TDMA)*** based and ***Code Division Multiple Access (CDMA)*** based standards.
- 2G makes use of a **CODEC (Compression-Decompression Algorithm)** to compress and multiplex digital voice data.
- 2G cell phone units were smaller than 1G units and emitted less radio power.
- Benefits:
  - Digital signals consume less battery power, helps mobile batteries to last long.
  - Digital coding improves the voice clarity and reduces noise.
  - Digital signals are environment friendly.
  - Digital encryption has provided secrecy and safety to the data and voice calls.
- Three major systems were evolved as follows:
  - IS- 136 (D-AMPS).
  - IS-95 (CDMA).
  - Global System for Mobile (GSM)

5.2.2.1 IS-136 (D–AMPS)

- Is a digital version of AMPS and it is backward compatible with AMPS.
- It uses the same bands and channels and uses the frequency reuse factor of 1/7.25 frames per second each of 1994 bits, divided in 6 slots shared by three channels.
- Each slot has 324 bits-159 data, 64 control, 101 error-correction as shown below.
- It uses both TDMA and FDMA medium access control techniques.

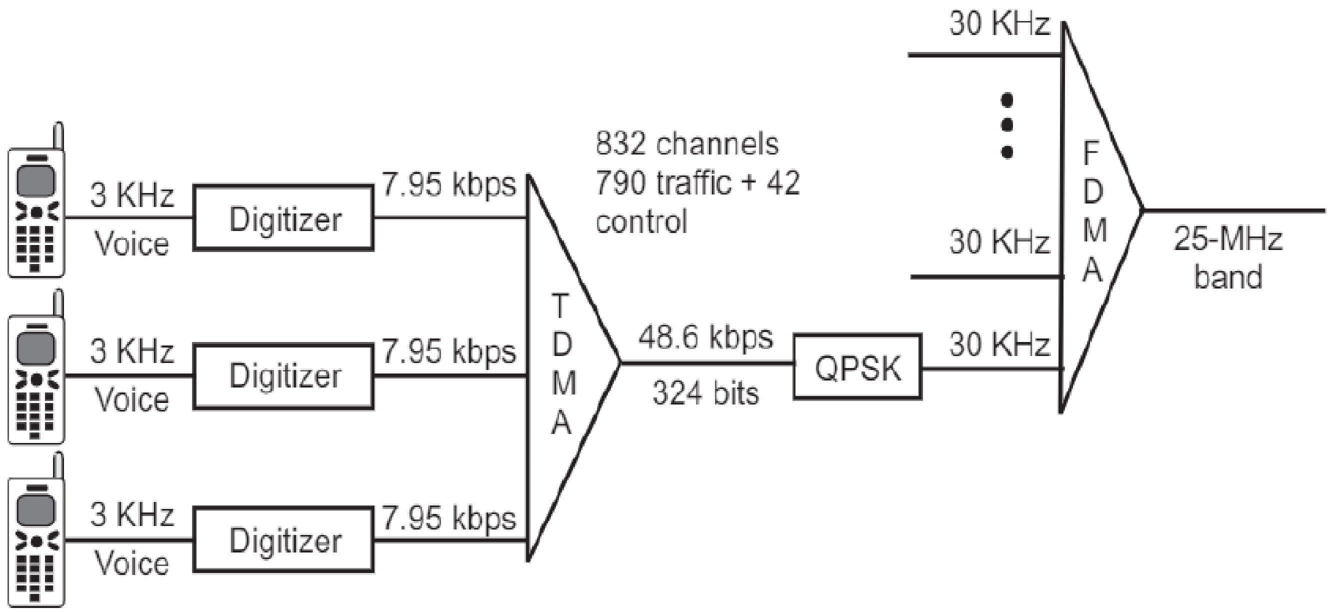


Fig. D-AMPS

5.2.2.2 IS-95 (CDMA)

IS-95 is based on CDMA/DS-SS and FDMA medium access control techniques.

5.2.2.2 GLOBAL SYSTEM FOR MOBILE (GSM) COMMUNICATIONS

- It is a European standard developed to replace 1G technology.
- Uses two bands for duplex communication.
- GSM-900 (Phase 1) operates in 900 MHz band for voice only.
- GSM – 1800 (Phase 2) included facsimile, video and data communication services.

GSM System Architecture

- Fig. 5.8 shows system architecture of GSM.
- Consists of 3 subsystems that interact with each other and with the subscribers.
    - Mobile Station (MS).
    - Base station subsystem (BSS).
    - Network & Switching subsystem (NSS).

- **Mobile Station (MS):**
  - MS consists of the physical equipment used by the subscriber.
  - MS includes Mobile Terminal (MT) and supports various Terminal Equipment (TE), and combinations of TE and Terminal Adaptor (TA) functions.
  - Types of MS: Vehicle mounted station, portable station, or handheld station etc.
  - MS is divided into 2 parts:
    - **Mobile equipment (ME):** Contains hardware and software to support radio and human interface functions.
    - **Subscriber Identity Module (SIM):** contains terminal/user specific data in the form of a smart card.
  - MS has a number of identities: International Mobile Equipment Identity (IMEI), International Mobile Subscriber Identity (IMSI), and ISDN.
  - SIM card contains all the subscriber-related information stored on the user's side.

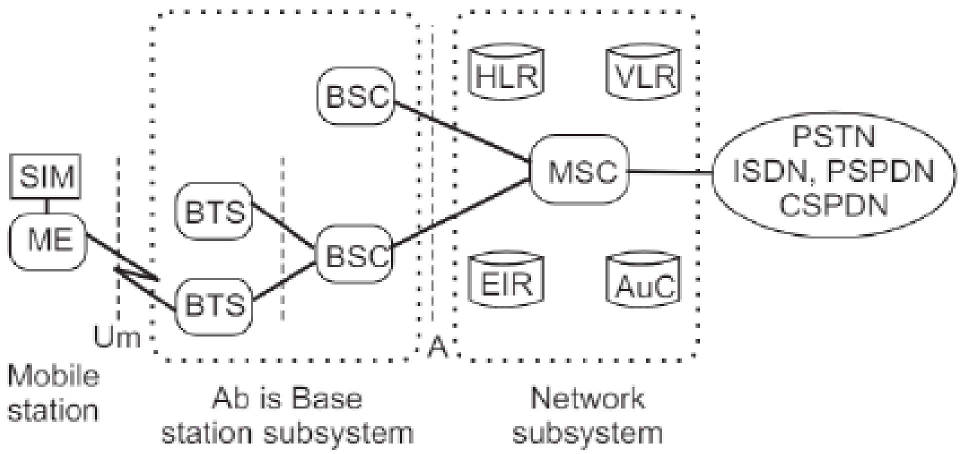


Fig. 5.8: GSM architecture

- **Base Station Subsystem (BSS):**
  - Physical equipment that provides radio coverage to prescribed geographical areas, known as the cells.
  - Contains equipment required to communicate with the MS.
    - **Base Station Controller (BSC):** for control function.
    - **Base Transmitting station (BTS):** for transmitting function.
  - BTS is the radio transmission equipment and covers each cell.
  - BSS can have multiple BTSs & can serve several cells.
  - BTS contains the Transcoder Rate Adapter Unit (TRAU).

- **Network and Switching Subsystem (NSS):**
  - NSS includes the main switching functions of GSM, databases required for the subscribers, and mobility management.
  - Main role is to manage the communications between GSM & other network users.
  - Subscriber information is kept in the home location register (HLR). The other database in the NSS is the visitor location register (VLR).
  - MSC monitors the mobility of its subscribers and manages necessary resources required to handle and update the location registration procedures and to carry out the handover functions.
  - MSC is involved in the interworking functions to communicate with other networks such as Public Switched Telephone Network (PSTN) and ISDN.
  - Call routing & control and echo control functions are also performed by the MSC.
- **Home location register (HLR):**
  - It is the functional unit used for management of mobile subscribers.
  - Two types of information are stored: subscriber information and part of the mobile information to allow incoming calls to be routed to the MSC for the particular MS.
  - HLR stores IMSI, MS ISDN number, VLR address, and subscriber data.
- **Visitor Location Register (VLR):**
  - VLR is linked to one or more MSCs.
  - VLR is the functional unit that dynamically stores subscriber information when the subscriber is located in the area covered by the VLR.
  - When a roaming MS enters an MSC area, the MSC informs the associated VLR about the MS; the MS goes through a registration procedure.

5.2.3 THIRD GENERATION (3G) TECHNOLOGY

- 3G systems support high speed packet switched data (up to 2Mbps).
- Two main 3G networks used are: UMTS (Universal Mobile Telecommunication System) and CDMA-2000.
- Both these systems use CDMA technology.

5.2.3.1 CDMA TECHNOLOGY

- CDMA offers several advantages over FDMA and TDMA like:
  - Error control coding, spreading of spectrum, soft handoffs & strict power control.
- CDMA is based on direct sequence-spread spectrum (DS-SS).

- In CDMA, all user data, the control channel and signaling information are transmitted on the same frequency at the same time.
- CDMA employs powerful error control codes.
- Quality of voice is also improved and the multipath & fading problems are also reduced.

5.2.3.2 FROM UMTS TO LTE

High Level Architecture of Long-Term Evolution (LTE)

- Figure 5.9 shows the LTE architecture and the way in which that architecture was developed from that of UMTS.
- In new architecture, the evolved packet core (EPC) is a direct replacement for the packet switched domain of UMTS and GSM.
- It distributes all types of information to the user, voice as well as data, using the packet switching technologies.
- There is no equivalent to the circuit switched domain: instead, voice calls are transported using voice over IP.
- The evolved UMTS terrestrial radio access network (E-UTRAN) handles the EPC's radio communications with the mobile.
- The new architecture was designed as part of two 3GPP work items, namely System Architecture Evolution (SAE), which covered the core network, and Long Term Evolution (LTE), which covered the radio access network, air interface and mobile.
- Officially, the whole system is known as the Evolved Packet System (EPS), while the acronym LTE refers only to the evolution of the air interface.

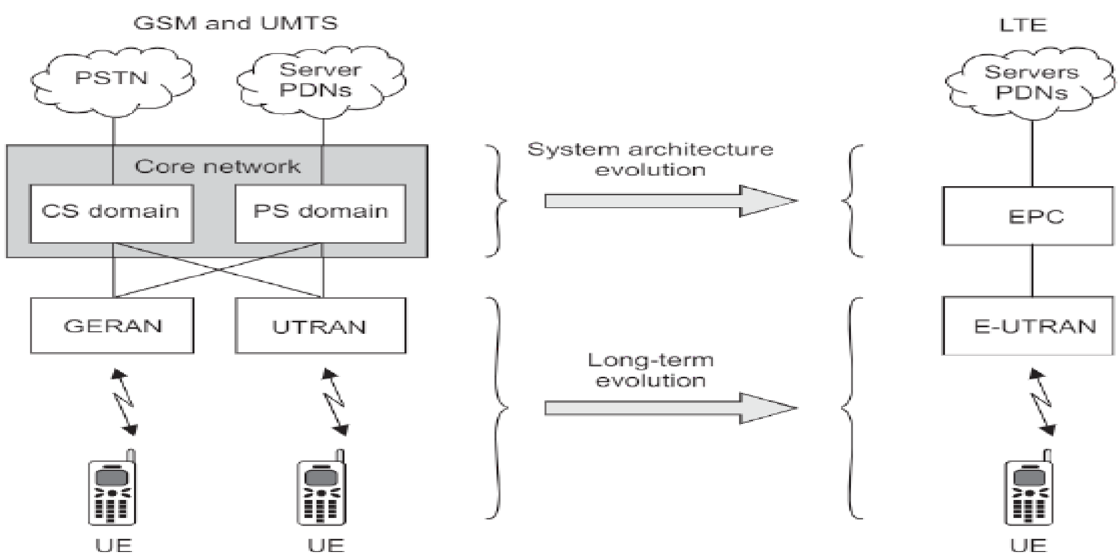


Fig. 5.9: Evolution of the system architecture from GSM and UMTS to LTE

5.2.4 FOURTH GENERATION (4G) TECHNOLOGY

- LTE or Long Term Evolution is the brand name given to 4G technology.
- The High Level requirements for a 4G technology were identified as:
  - Higher spectral efficiency.
  - Reduced cost per bit.
  - Increased service provisioning by lowering the cost and increasing efficiency.
  - Open interfaces as against closed technologies of the past.
  - Power consumption efficiency.
  - Scalable and flexible usage of frequency bands.
- LTE project include the use of Orthogonal Frequency Division Multiplexing (OFDM) and advanced antenna technologies such as MIMO (Multiple Input Multiple Output).
- It specifies downlink peak speeds of 326Mbps and uplink peak speeds of 86Mbps, both in a 20 MHz bandwidth.

LTE-A System Architecture

- Figure 5.10 gives a high-level description of the LTE-A network architecture.
- LTE architectures have NodeB's, Radio Network Controllers (RNC), and several different entities in the core network.

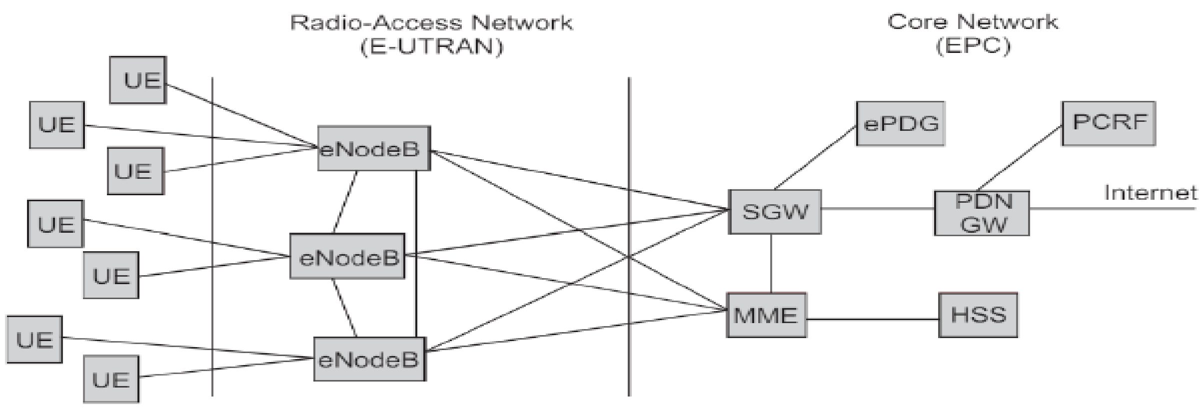


Fig. 5.10: LTE system architecture

5.2.5 WIRELESS LAN (WLAN)

- Wireless Area Network(WLAN) links more devices using wireless communication method.
- It usually provides connection through Access Point (AP) internet.
- Users can move within a local coverage area while still being connected to network.
- WLAN permits people to use their computers anywhere in the network area.
- The standards for WLANs are: IEEE 802.11 and HIPERLAN.

WLAN Specifications

- The IEEE 802.11 specifications were developed WLANs by the IEEE and include four subsets of Ethernet-based protocol standards: 802.11, 802.11a, 802.11b, and 802.11g.

802.11

- 802.11 operated in the 2.4 GHz range.
- Delivered 1 to 2 Mbps using the technology Phase-Shift Keying (PSK) modulation.
- No longer used and has largely been replaced by other forms of the 802.11 standard.

802.11a

- 802.11a operates in the 5-6 GHz range.
- Data rates are commonly in the 6 Mbps, 12 Mbps, or 24 Mbps range.
- Uses the Orthogonal Frequency Division Multiplexing (OFDM) standard.
- Data transfer rates can be as high as 54 Mbps.
- The 802.11a specification is also known as Wi-Fi5.
- It is not a global standard like 802.11b.

802.11b

- 802.11b standard (also known as Wi-Fi) operates in the 2.4 GHz range.
- Data rates up to 11 Mbps.
- 802.11b uses a technology known as Complementary Code Keying (CCK) modulation.
- The overall benefits include:
  - Up to twice the data rate of conventional 11 Mbps 802.11b standard products.
  - Greater WLAN coverage.
  - Improved security over standard 802.11b.

802.11g

- 802.11g is the most recent IEEE 802.11 standard and operates in the 2.4 GHz range.
- Data rates as high as 54 Mbps over a limited distance.

5.2.5.1 Advantages of WLAN over Wired LAN

- **Installation:**
  - Wireless LANs are very easy to install.
  - There is no requirement for wiring every workstation and every room.
- **Portability:**
  - If a company moves to a new location, the wireless system is much easier to move than that of a wired system.

5.2.6 BLUETOOTH

- Bluetooth is a standard used in links of radio of short scope.
- Bluetooth technology can be used at home, in the office, in the car, etc.
- This technology allows to the users instantaneous connections of voice and information between several devices in real time.
- Bluetooth is a small microchip that operates in a band of available frequency throughout the world.
- The standard Bluetooth operates in the band of 2.4 GHz.

Bluetooth Architecture - Piconets and Scatternets

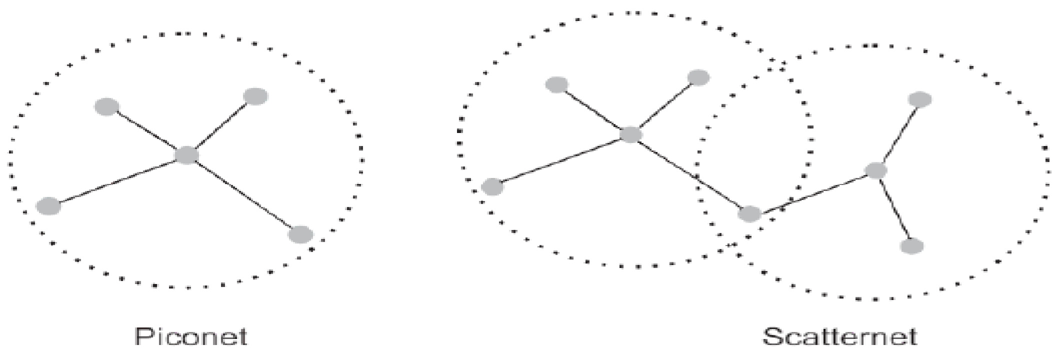


Fig. 5.11: Illustration of the concept of piconet and scatternet in bluetooth

- Up to seven slaves can be active and served simultaneously by the master.
- Bluetooth applications involve local communication among small groups of devices. A piconet configuration consisting of two, three, or up to eight devices is ideally suited to meet the communication needs of such applications.
- When many groups of devices need to be active simultaneously, each group can form a separate piconet.
- Piconets with overlapping coverage can coexist and operate independently.
- Bluetooth defines a structure called scatternet to facilitate interpiconet communication.
- A scatternet is formed by interconnecting multiple piconets.

5.3 Satellite Communication

5.3.1 Introduction

- Satellites are specifically made for telecommunication purpose.
- They are used for mobile applications such as communication to ships, vehicles, planes, hand-held terminals and for TV and radio broadcasting.
- Figure 5.12 shows satellites orbit around the earth.

- Depending on the application, these orbits can be circular or elliptical.
- Satellites in circular orbits always keep the same distance to earth's surface.

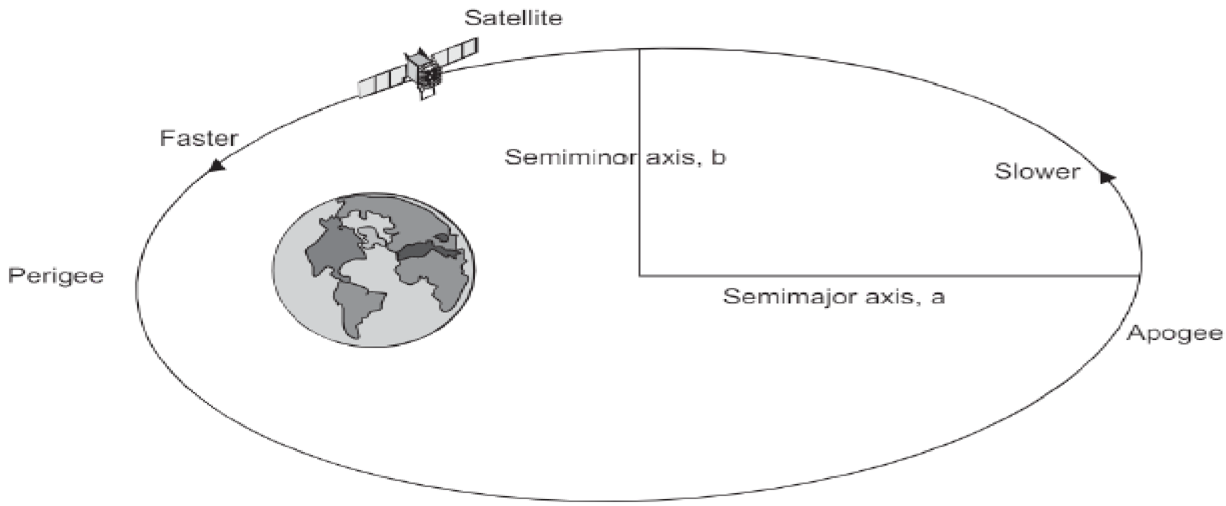


Fig. 5.12: Satellite orbit around the Earth

5.3.2 ELEMENTS OF SATELLITE COMMUNICATION

The basic elements of a satellite communication system (Fig. 9.4) are:

- **User:** The user generates the baseband signal that proceeds through a terrestrial network and transmitted to a satellite at the earth station.
- **Satellite:** It consists of a large number of repeaters in the space that perform the reception of modulated RF carrier in its uplink frequency spectrum. They retransmit them back to the earth stations in the down link frequency spectrum.

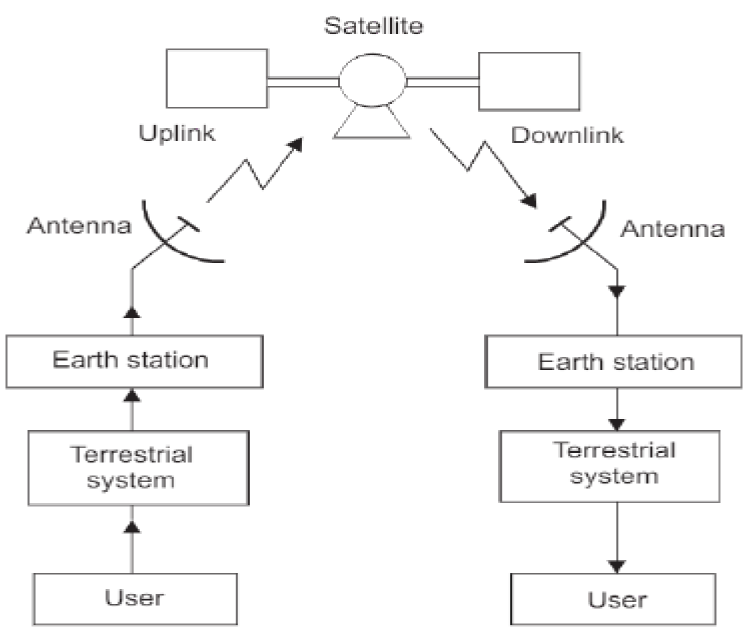


Fig. 5.13: Basic elements of a satellite communication system

- **Terrestrial network:** This is a network on the ground which carries the signal from user to earth station. It can be a telephone switch or a dedicated link between the user and the earth station.
- **Earth Station:** It's a radio station located on the earth and used for relaying signals from satellites. It governs all the activities happening in the satellite communication.

5.3.3 TYPES OF SATELLITES (BASED ON ORBITS)

5.3.3.1 Geostationary Earth Orbit (GEO) Satellites

- GEO satellites are synchronous with respect to earth, looking from a fixed point from earth; these satellites appear to be stationary.
- These satellites are placed in the space in such a way that only three satellites are sufficient to provide connection throughout the surface of the Earth.
- The orbit of these satellites is circular.
- There are three conditions which lead to geostationary satellites:
    - Should be placed 37,786 kms (approx. 36000kms) above the surface of the earth.
    - These satellites must travel in the rotational speed of earth, and in the direction of motion of earth, that is eastward.
    - The inclination of satellite with respect to earth must be 00.
- Lifetime expectancy of these satellites is 15 years.
- Geostationary satellite in practical is termed as geosynchronous as there are multiple factors which make these satellites shift from the ideal geostationary condition:
    - Gravitational pull of sun and moon makes these satellites deviate from their orbit. Over the period of time, they go through a drag.
    - These satellites experience the centrifugal force due to the rotation of Earth, making them deviate from their orbit.
    - The non-circular shape of the earth leads to continuous adjustment of speed of satellite from the earth station.
- These satellites are used for TV and radio broadcast, weather forecast and also, these satellites are operating as backbones for the telephone networks.

5.3.3.2 Low Earth Orbit (LEO) Satellites

- These satellites are placed 500-1500 kms above the surface of the earth.
- As LEO satellites circulate on a lower orbit, hence they exhibit a much shorter period that is 95 to 120 minutes.

- LEO systems try to ensure a high elevation for every spot on earth to provide a high quality communication link.
- Each LEO satellite will only be visible from the earth for around ten minutes.
- Using advanced compression schemes, transmission rates of about 2,400 bit/s can be enough for voice communication.
- LEOs even provide this bandwidth for mobile terminals with omni directional antennas using low transmit power in the range of 1W.
- These satellites are mainly used in remote sensing and mobile communication services.

Disadvantages:

- Many satellites are needed if global coverage is to be reached.
- High number of satellites results in a high complexity of the whole satellite system.
- The short time of visibility requires additional mechanisms for connection handover between different satellites.
- Short lifetime of about five to eight years.
- Other factors are the need for routing of data packets from satellite to if a user wants to communicate around the world.

5.3.3.3 Medium Earth Orbit (MEO) Satellites

- MEO satellites can be positioned somewhere between LEOs and GEOs, both in terms of their orbit and due to their advantages and disadvantages.
- Using orbits around 10,000 km, the system only requires a dozen satellites which is more than a GEO system, but much less than a LEO system.
- Moves more slowly relative to the Earth's rotation allowing a simpler system design.
- They have an orbital period of 6 to 12 hours.
- MEO can cover larger populations, requiring fewer handovers.

Disadvantages:

- Due to the larger distance to the earth, delay increases to about 70-80 ms.
- These satellites need higher transmit power & special antennas for smaller footprints.

5.4 FIBER-OPTIC COMMUNICATION SYSTEM

A generalized configuration of a fiber-optic communication system is shown in figure 5.14.

Information Input

- Input can be in any of the several physical forms, e.g., voice, video, or data.
- An input transducer is required for converting non-electrical input into an electrical

input. For example, a microphone converts a sound signal into an electrical current.

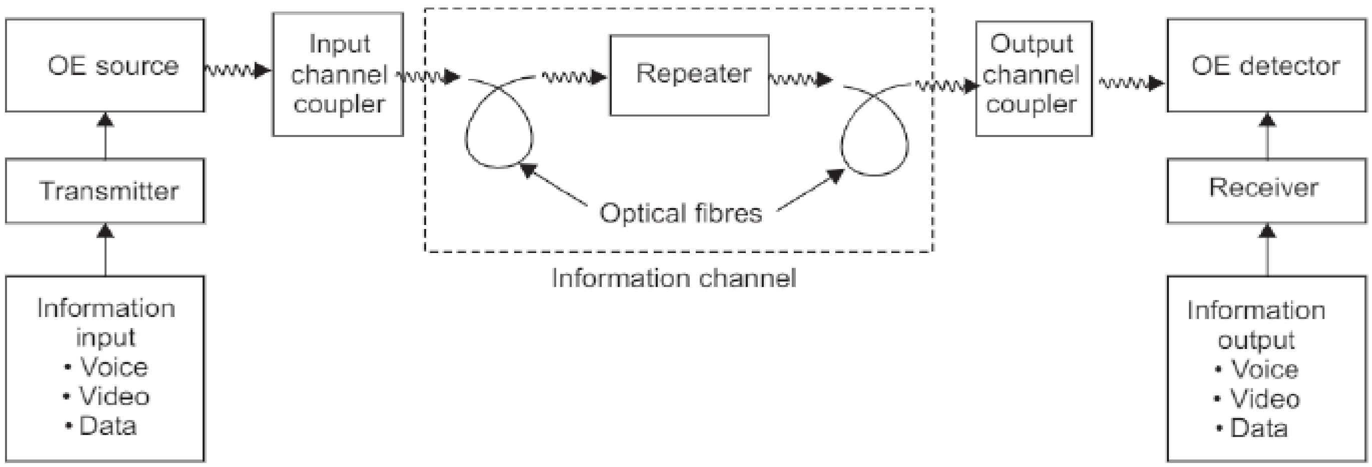


Fig. 5.14: Generalized configuration of a fiber-optic communication system

Transmitter

- The transmitter (or the modulator) comprises an electronic stage which:
    - Converts the electric signal into the proper form.
    - Impresses this signal onto the electromagnetic wave generated by OE source.

Optoelectronic Source

- OE source generates an electromagnetic wave in the optical range, which serves as an information carrier.
- Common sources are the light-emitting diode (LED) and the injection laser diode (ILD).

Channel Couplers

- The coupler is simply a connector for attaching the transmitter to the cable.
- Its function is to collect the light signal from the OE source and send it efficiently to the optical fiber cable. Several designs are possible.
- At the end of the link again a coupler is required to collect the signal and direct it onto the photodetector.

Fiber-optic Information Channel

- Information channel refers to the path between the transmitter and the receiver.
- The optical fiber cable serves as an information channel.
- The optical fiber cable is an extremely thin strand of ultra-pure glass designed to transmit optical signals from the OE source to OE detector.
- It consists of two main regions:

- A solid cylindrical region of diameter 8-100 um called the core.
- A coaxial cylindrical region of diameter normally 125 um called the cladding.

Repeater

- As the optical signals propagate along the length of the fiber, they get attenuated and broadened which causes the signals to become weak and indistinguishable. Hence the strength and shape of the signal must be restored.
- This can be done by using either a regenerator or an optical amplifier at an appropriate point along the length of the fiber.

Optoelectronic Detector

- Reconversion of an optical signal into an electrical signal takes place at the OE detector.
- Semiconductor pin or avalanche photodiodes are employed for this purpose.

Receiver

- For analog transmission, the output photocurrent of the detector is filtered and amplified if needed by the receiver module.
- For digital transmission, in addition to the filter and amplifier, the receiver may include decision circuits.
- If original information is in analog form, a digital-to-analog converter may be required.

Information Output

- Information must be presented in a form that can be interpreted by a human observer.
- For example, it may be required to transform the electrical output into a sound wave.
- Suitable output transducers are used for achieving this transformation.

5.5 MICROWAVE COMMUNICATION

5.5.1 Introduction

- The term microwaves used to identify e_m waves in the frequency spectrum ranging approximately from 1 GHz to 30 GHz (wavelengths from 30cm to 1cm).
- The advantage with the use of microwaves for communications is their large bandwidth. A 10% bandwidth at 3 GHz implies availability of 30 MHz spectrum.
- Microwave communications are widely used for telephone networks, in broad cast and television systems and other communication application by services, railways, etc. They also find application in RADAR.
- Microwave communication systems cover distances ranging from 15 miles to 4000 miles.
- Traditional microwave systems used frequency division multiplexed channels for voice.

- The recent advanced systems use pulse code modulated time division multiplexed voice channels. They generally use advanced modulation techniques such as phase shift keying (PSK) or quadrature amplitude modulation (QAM).

5.5.2 FREQUENCY MODULATED MICROWAVE COMMUNICATION SYSTEM

- The baseband signal is first applied to the preemphasis network that provides extra amplification to high frequency baseband signals.
- When the signal from preemphasis circuit is applied to the FM modulator, the low frequencies get frequency modulated by the Intermediate Frequency (IF) carrier and the high frequencies get phase modulated.
- The output from FM deviator is passed through the IF amplifier to the mixer. The mixer then converts the signal to microwave frequencies.
- The output of the mixer is passed through the band pass filter (BPF) to band limit the signal and then to the channel-combining network. Finally, the signal is fed to the transmitter antenna.
- Fig. 5.14 shows the simplified transmitter block diagram of a microwave FM transmitter.

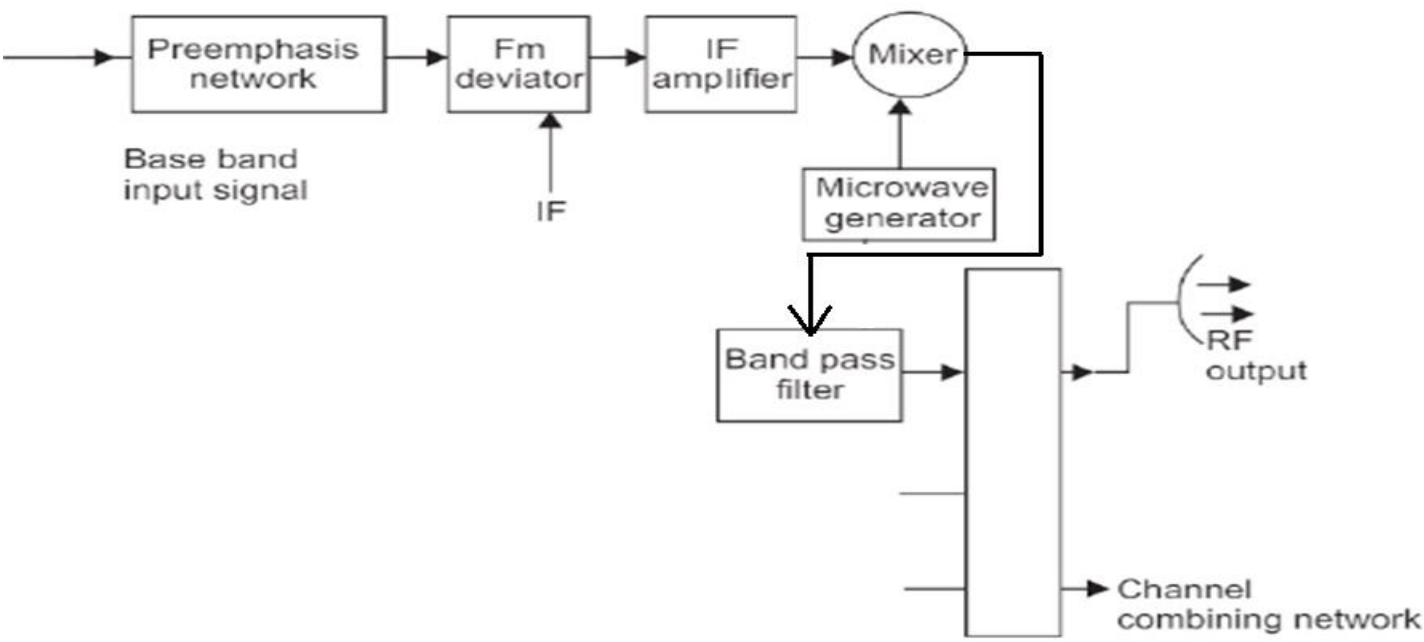


Fig. 5.15: Block diagram of FM transmitter

- In Fig. 5.16, the RF signal picked by the receiving antenna is passed to the channel separation network, which separates the individual channels.
- **BPF** then filters out any frequencies that fall outside the bandwidth of required signal.
- The mixer employs the same RF oscillator frequency as used at the transmitter and

converts the RF signal to the IF band.

- FM detector demodulates the signal which is then passed to deemphasis network.
- The de-emphasis network applies inverse functionality of the preemphasis network at the transmitting end, to finally restoring the original baseband signal.
- Figure 11.19 shows the microwave FM receiver block diagram.

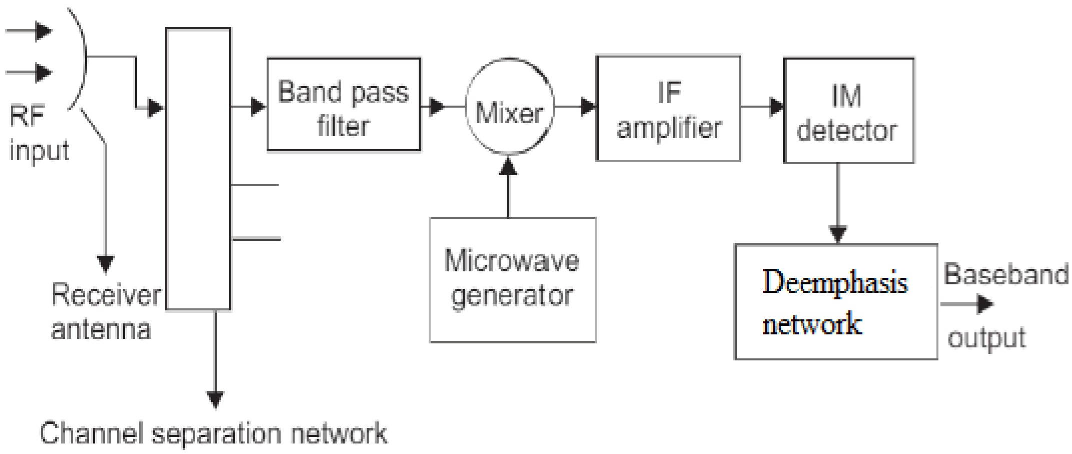


Fig. 5.16: Block diagram of FM receiver

- If the distance between the transmitter and the receiver is very large and if line of sight path is not maintained, then intermediate stations are required, to process and retransmit the signals.
- These intermediate stations are called the repeaters.
- By appropriately placing the repeaters, a virtual line of sight is achieved along the path transmitter-repeater A-repeater B-receiver as shown in figure 5.17.

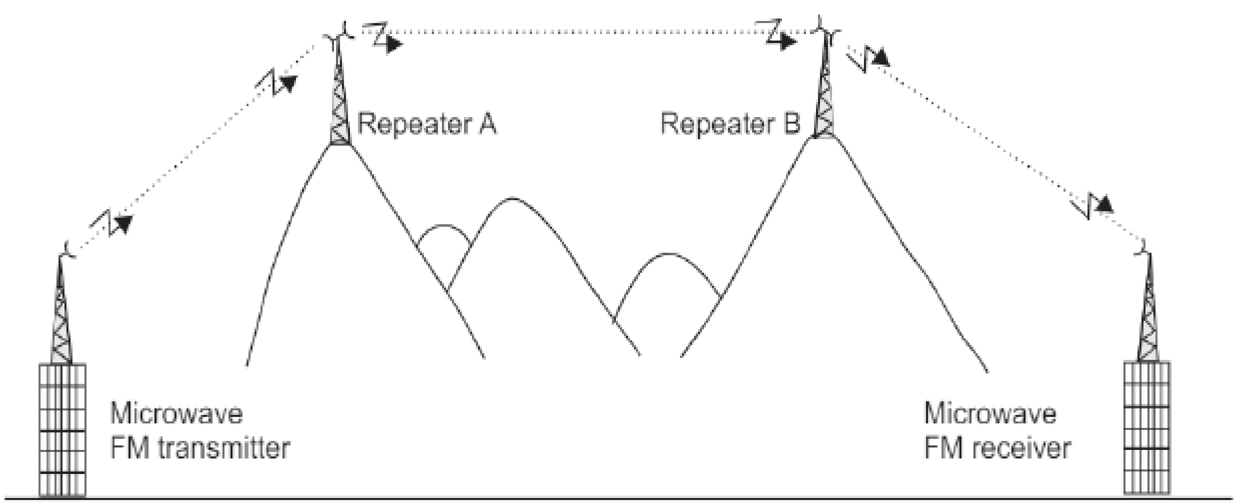


Fig. 5.18: Virtual line of sight for microwave FM transmission using Repeaters

QUESTION BANK

1. Draw a schematic diagram of cellular telephone system & explain its basic components.
2. Define the terms cell & cluster in a cellular system. And explain the cellular concept in wireless mobile networks.
3. Explain the concept of frequency reuse technique?
4. Discuss the steps involved in transmission of data in a cellular telephone network.
5. What is Mobility management? Explain Handoff & Roaming in Mobility management.
6. With the help of diagrams, discuss the following types of network topologies.
    a. Ad-Hoc Network Topology
    b. Infrastructure Network Topology
7. Describe the first generation of wireless telecommunication technology.
8. List the major systems evolved in 2G wireless telephone technology.
9. Draw the architecture of GSM system and explain the important features of it.
10. Define the following terms with respect to GSM system.
    a. Mobile Station (MS)
    b. Base Station Subsystem (BSS)
    c. Network & Switching System (NSS)
11. With the help of architecture figures explain the evolution from GSM to LTE.
12. List the requirements identified for the 4G technology.
13. Draw the LTE – system architecture and define the important terms.
14. Discuss the following IEEE standards:
    i) IEEE 802.11a. ii) IEEE 802.11b iii) IEEE 802.11g
15. Write a short note on Bluetooth technology.
16. Draw the block diagram showing the basic elements of a satellite communication system and briefly explain them.
19. Based on orbits, discuss the different types of satellites.
20. With the help of a block diagram explain the generalized configuration of a fiber – optic communication system.
21. With the help of block diagram explain the microwave FM transmitter.
22. With the help of block diagram explain the microwave FM receiver.
23. What is the need for repeaters in FM transmission? Explain with figure.

YouTube links:

Mobile Communication:

https://www.youtube.com/watch?v=1JZG9x_VOwA

https://youtu.be/tt1-Ohe9QQU

https://www.youtube.com/watch?v=NUovkXWe15s&t=30s

Satellite Communication:

https://www.youtube.com/watch?v=hXa3bTcIGPU

https://www.youtube.com/watch?v=n70zjMvm8L0

Fibre Optic Communication:

https://www.youtube.com/watch?v=aqazAcE19vw

Microwave Communication:

https://www.youtube.com/watch?v=0FnLfVPNZ2E