

Chapter No: 5

WIRELESS COMMUNICATION

IEEE Wireless Standards

- Wireless networks are standardized by IEEE.
- Under 802 LAN MAN standards committee.

The 802.11 standard is defined through several specifications of WLANs. It defines an over-the-air interface between a wireless client and a base station or between two wireless clients.

There are several specifications in the 802.11 family –

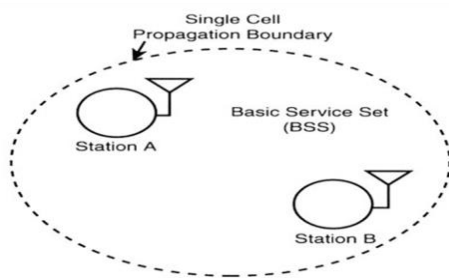
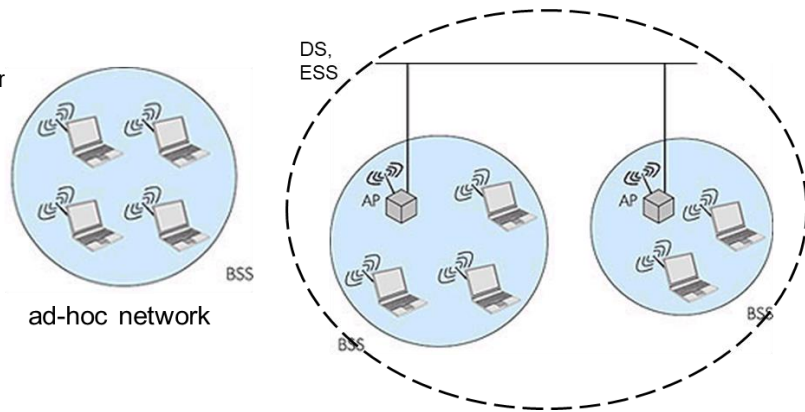
- **802.11** – This pertains to wireless LANs and provides 1 - or 2-Mbps transmission in the 2.4-GHz band using either frequency-hopping spread spectrum (FHSS) or direct-sequence spread spectrum (DSSS).
- **802.11a** – This is an extension to 802.11 that pertains to wireless LANs and goes as fast as 54 Mbps in the 5-GHz band. 802.11a employs the orthogonal frequency division multiplexing (OFDM) encoding scheme as opposed to either FHSS or DSSS.
- **802.11b** – The 802.11 high rate WiFi is an extension to 802.11 that pertains to wireless LANs and yields a connection as fast as 11 Mbps transmission (with a fallback to 5.5, 2, and 1 Mbps depending on strength of signal) in the 2.4-GHz band. The 802.11b specification uses only DSSS. Note that 802.11b was actually an amendment to the original 802.11 standard added in 1999 to permit wireless functionality to be analogous to hard-wired Ethernet connections.
- **802.11g** – This pertains to wireless LANs and provides 20+ Mbps in the 2.4-GHz band.
- **802.11n** — 802.11n builds upon previous 802.11 standards by adding *multiple input multiple-output* (MIMO). The additional transmitter and receiver antennas allow for increased data throughput through spatial multiplexing and increased range by exploiting the spatial diversity through coding schemes like Alamouti coding. The real speed would be 100 Mbit/s (even 250 Mbit/s in PHY level), and so up to 4-5 times faster than 802.11g.
- **802.11ac** — 802.11ac builds upon previous 802.11 standards, particularly the 802.11n standard, to deliver data rates of 433Mbps per spatial stream, or 1.3Gbps in a three-antenna (three stream) design. The 802.11ac specification operates only in the 5 GHz frequency range and features support for wider channels (80MHz and 160MHz) and beam forming capabilities by default to help achieve its higher wireless speeds.

Wireless LAN and IEEE 802.11

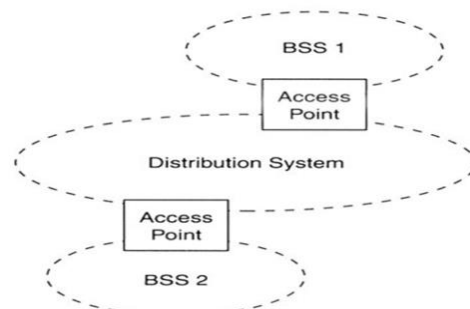
Wireless LANs are those Local Area Networks that use high frequency radio waves instead of cables for connecting the devices in LAN. Users connected by WLANs can move around within the area of network coverage. Most WLANs are based upon the standard IEEE 802.11 or WiFi.

IEEE 802.11 Architecture

LLC: Logical Link Control Layer
 MAC: Medium Access Control Layer
 PHY: Physical Layer
 FHSS: Frequency hopping SS
 DSSS: Direct sequence SS
 SS: Spread spectrum
 IR: Infrared light
 BSS: Basic Service Set
 ESS: Extended Service Set
 AP: Access Point
 DS: Distribution System



Basic (independent) service set (BSS)



Extended service set (ESS)

The components of an IEEE 802.11 architecture are as follows

1) Stations (STA): Stations comprise all devices and equipment's that are connected to the wireless LAN. A station can be of two types:

1. **Wireless Access Points (WAP):** WAPs or simply access points (AP) are generally wireless routers that form the base stations or access.
2. **Client. :** Clients are workstations, computers, laptops, printers, smartphones, etc.

Each station has a wireless network interface controller.

2) Basic Service Set (BSS): A basic service set is a group of stations communicating at physical layer level. BSS can be of two categories depending upon mode of operation:

1. **Infrastructure BSS:** Here, the devices communicate with other devices through access points.
2. **Independent BSS:** Here, the devices communicate in peer-to-peer basis in an ad hoc manner.

3) Extended Service Set (ESS): It is a set of all connected BSS.

4) Distribution System (DS): It connects access points in ESS.

Advantages of WLANs

1. They provide clutter free homes, offices and other networked places.
2. The LANs are scalable in nature, i.e. devices may be added or removed from the network at a greater ease than wired LANs.
3. The system is portable within the network coverage and access to the network is not bounded by the length of the cables.
4. Installation and setup is much easier than wired counterparts.
5. The equipment and setup costs are reduced.

Disadvantages of WLANs

1. Since radio waves are used for communications, the signals are noisier with more interference from nearby systems.
2. Greater care is needed for encrypting information. Also, they are more prone to errors. So, they require greater bandwidth than the wired LANs.
3. WLANs are slower than wired LANs.

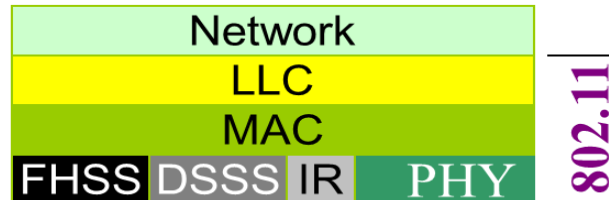


Fig: LAN Architecture

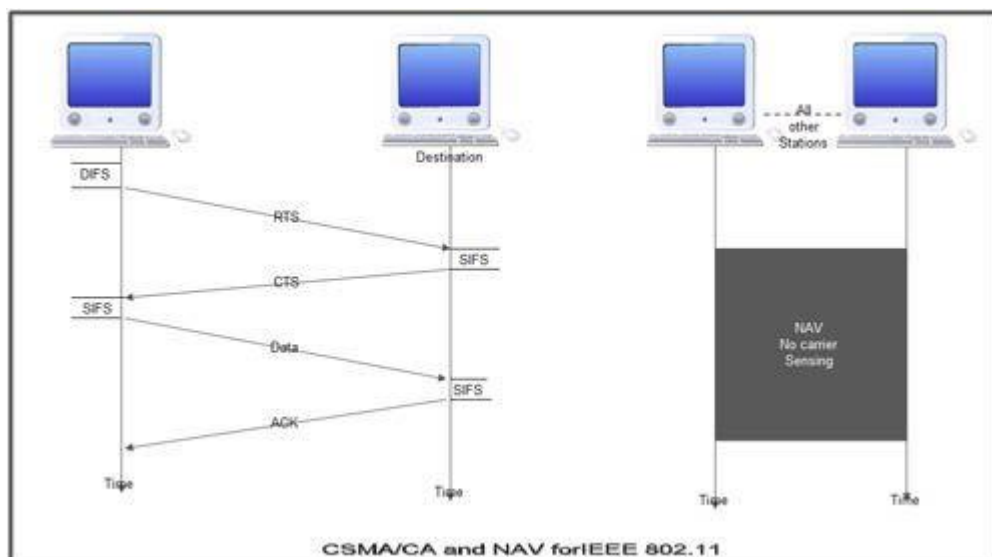
MAC sublayer Functions

802.11 support two different modes of operations. These are:

1. Distributed Coordination Function (DCF)
2. Point Coordination Function (PCF)

1. Distributed Coordination Function

- The DCF is used in BSS having no access point.
- DCF uses CSMA/CA [protocol](#) for transmission.
- The following steps are followed in this method.



1. When a station wants to transmit, it senses the channel to see whether it is free or not.
2. If the channel is not free the station waits for back off time.

3. If the station finds a channel to be idle, the station waits for a period of time called distributed interframe space (DIFS).
4. The station then sends control frame called request to send (RTS) as shown in figure.
5. The destination station receives the frame and waits for a short period of time called short interframe space (SIFS).
6. The destination station then sends a control frame called clear to send (CTS) to the source station. This frame indicates that the destination station is ready to receive data.
7. The sender then waits for SIFS time and sends data.
8. The destination waits for SIFS time and sends acknowledgement for the received frame.

2. Point Coordination Function

- PCF method is used in infrastructure network. In this Access point is used to control the network activity.
- It is implemented on top of the DCF and IS used for time sensitive transmissions.
- PCF uses centralized, contention free polling access method.
- The AP performs polling for stations that wants to transmit data. The various stations are polled one after the other.
- To give priority to PCF over DCF, another interframe space called PIFS is defined. PIFS (PCF IFS) is shorter than DIFS.
- If at the same time, a station is using DCF and AP is using PCF, then AP is given priority over the station.
- Due to this priority of PCF over DCF, stations that only use DCF may not gain access to the channel.
- To overcome this problem, a repetition interval is defined that is repeated continuously. This repetition interval starts with a special control frame called beacon frame.
- When a station hears beacon frame, it start their NAV for the duration of the period of the repetition interval.

802.11 Addressing

- There are four different addressing cases depending upon the value of *To DS* And *from DS* subfields of FC field.
- Each flag can be 0 or 1, resulting in 4 different situations.
 1. If *To DS* = 0 and *From DS* = 0, it indicates that frame is not going to distribution system and is not coming from a distribution system. The frame is going from one station in a BSS to another.
 2. If *To DS* = 0 and *From DS* = 1, it indicates that the frame is coming from a distribution system. The frame is coming from an AP and is going to a station. The address 3 contains original sender of the frame (in another BSS).
 3. If *To DS* = 1 and *From DS* = 0, it indicates that the frame is going to a distribution system. The frame is going from a station to an AP. The address 3 field contains the final destination of the frame.

4. If $To DS = 1$ and $From DS = 1$, it indicates that frame is going from one AP to another AP in a wireless distributed system.

The table below specifies the addresses of all four cases.

TO DS	From DS	Address 1	Address 2	Address3	Address 4
0	0	Destination	Source	BSS ID	N/A
0	1	Destination	Sending AP	Source	N/A
1	0	Receiving AP	Source	Destination	N/A
1	1	Receiving AP	Sending AP	Destination	Source

Question: Explain the concept of piconet and scatter net of Bluetooth.

Bluetooth:

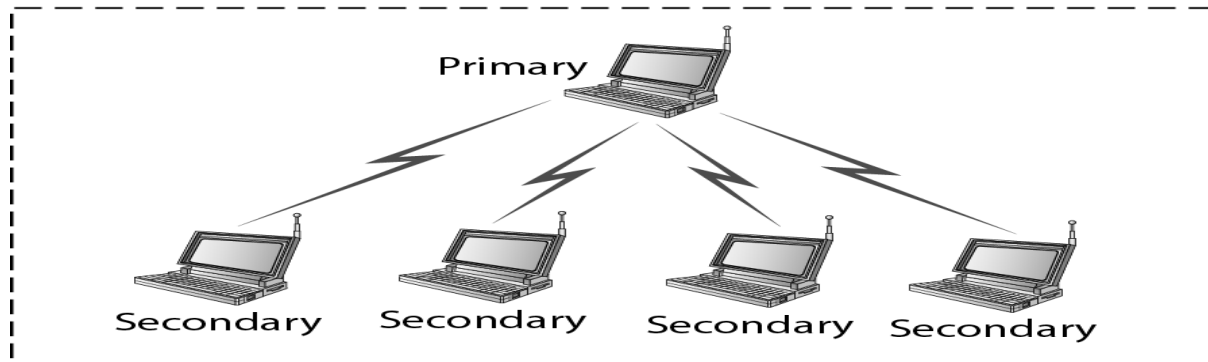
Bluetooth is an open specification for short range wireless transmission of voice and data. It provides a simple, Low cost seamless wireless connectivity between personal digital assistants, cellular phone laptops, and other portable handheld devices.

Bluetooth is low power consuming technology with transmission distances of up to 30 feet and a throughput of about 1 Mbps.

- Bluetooth defines two types of networks: **1. Piconet** **2. Scatternet**

1. Piconet:

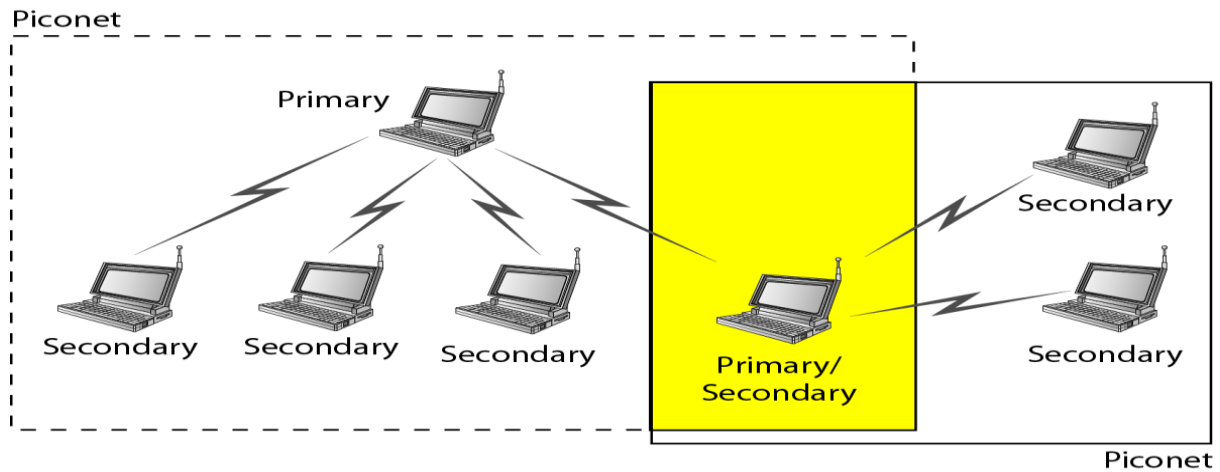
Piconet



- **Piconet** is a Bluetooth network that consists of one **primary (master)** node and seven active **secondary (slave)** nodes.
- All Slave stations are **synchronized** with Master.
- Thus, piconet can have up to **eight** active nodes (1 master and 7 slaves) or stations within the distance of 10 meters.
- There can be only one primary or master station in each piconet.
- The communication between the primary and the secondary can be one-to-one or one-to-many.
- All communication is between master and a slave. **Salve-slave communication is not possible.**

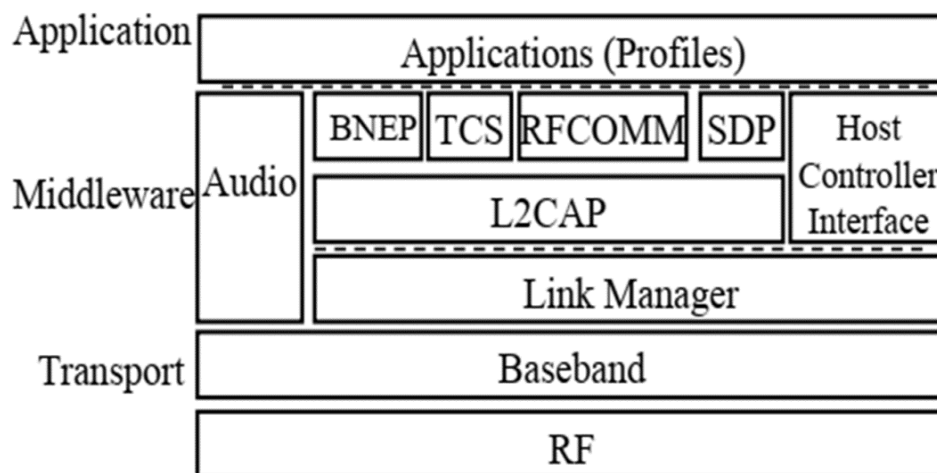
- In addition to seven active slave stations, a piconet can have up to **255 parked nodes**. These parked nodes are secondary or slave stations and cannot take part in communication until it is moved from parked state to active state.

2. Scatternet :



- **Scatternet** is formed by combining various piconets.
- A **slave** in one piconet can act as a **master** or **primary** in other piconet.
- Such a station or node can receive messages from the master in the first piconet and deliver the message to its slaves in other piconet where it is acting as master. This node is also called bridge slave.
- Thus a station can be a member of two piconets.
- A station cannot be a master in two piconets.

Bluetooth Protocol Stack



The protocols in this group are designed to

- Allow devices to locate and connect
- Carry audio and data traffic where audio traffic has higher priority.

- Support synchronous and asynchronous transmission for telephony grade voice communication
- Manage physical and logical links between devices so that layers above and applications can pass data through connections.
- The following protocols are in this group:
 - i. Logical link control and adaptation protocol layer (L2CAP)
 - All data traffic is routed through this layer.
 - This layer shields higher layers from details of lower layers.
 - It segments larger packets from higher layers into smaller packets that can be easily handled by lower layers.
 - It facilitates maintenance of desired grade of service in two peer devices.
 - ii. Link manager layer (LML)
 - It negotiates properties of Bluetooth air interface between communicating devices.
 - These properties may be bandwidth allocation, support services of particular type, etc.
 - This layer also supervises devices pairing.
 - Device pairing generates and stores authentication key specific to a device
 - It is also responsible for power control and may request adjustments in power levels.
 - iii. Baseband and radio layers
 - The baseband layer is responsible for searching other devices, assigning master and slave roles.
 - This layer also controls Bluetooth unit's synchronization and transmission frequency hopping sequence. It manages link between devices and determines packet types supported for synchronous and asynchronous traffic.
 - iv. Host Controller Interface (HCI)
 - The HCI allows higher layers of stack, including applications, to access the baseband, link manager, etc., through a single standard interface.
 - It serves the purpose of interoperability between host devices and Bluetooth modules.
 - HCI commands, module may enter certain modes of operation. Higher layers are informed about certain events through HCI.

2. Middleware protocol group

- The protocols in this group are needed for existing applications to operate over Bluetooth links.
- These protocols may be third party protocols (Industry standard) or developed by 'simple interest group (SIG)' specifically for Bluetooth.
- Some of the protocols in this group:
 - i. RFCOMM layer
 - It provides a virtual serial port for applications needed for scenarios like dial-up networking, etc.
 - This eliminates the use of cables.
 - ii. Service Discovery protocol layer (SDP)
 - The SDP is a standard method for Bluetooth devices to discover and learn about the services offered by other device once a connection is established with it.

iii. Infrared data association(IrDA) interoperability protocols

- The SIG has adopted some IrDA protocols to ensure interoperability between applications to exchange a wide variety of data.

iv. Object exchange protocol (OBEX)

- It is developed by IrDA to exchange objects simple and spontaneous manner.
- It uses client-server model.
- It is independent of transport mechanism and transport ‘Application programming Interface (API)’, provided it realizes a reliable transport base.
- It defines a folder-listing object, which is used to browse contents of folders on a remote device.

v. Networking layers

- Bluetooth wireless technology uses peer-to-peer network topology.
- Dial-up networking uses AT commands.
- In most cases, network accessed is IP network with use of standard protocols like TCP, UDP, HTTP
- A device can connect to IP network using network access point. The internet PPP is used to connect to access point.

vi. Telephone control specifications layer (TCS) and audio

- This layer is designed to set up voice calls. It supports functions like call control and group management.
- TCS can also be used to set up data calls.
- TCS protocols are compatible with ITU Specifications.
- Bluetooth audio communication takes place at rate of 64Kbps using one of two encoding schemes: 8-bit logarithmic PCM or continuous variable slope delta modulation.

3. Application group

- This group consists of actual applications that make use of Bluetooth links and refers to software that exists above protocol stack.
- The Bluetooth-SIG does not define any application protocols nor does it specify any API. Bluetooth profiles are developed to establish a base point for use of a protocol stack to accomplish a given usage case.

Bluetooth Devices:

- Every Bluetooth device consists of a built in short range **radio transmitter**. The current data rate is 1 Mbps.
- So an interface between the IEEE 802.11 wireless LAN and Bluetooth LAN is possible.
- Bluetooth specification standard defines a short-range(10 meter) radio link.
- The devices carrying Bluetooth-enabled chips can easily transfer data through walls, clothing and luggage bags.
- The interaction between devices occurs by itself without direct human intervention whenever they are within each other’s range.

- Each Bluetooth-enabled device contains a 1.5 inch square transceiver chip operating in the ISM band of 2.40 GHz to 2.48 GHz.
- The ISM band is divided into 79 channels with each carrying a bandwidth of 1 MHz.

Bluetooth Applications:

1. It is used for providing communication between peripheral devices like wireless mouse or keyboard with the computer.
2. It is used by modern healthcare devices to send signals to monitors.
3. It is used by modern communicating devices like mobile phone, PDAs, palmtops etc to transfer data rapidly.
4. It is used for dial up networking. Thus allowing a notebook computer to call via a mobile phone.
5. It is used for cordless telephoning to connect a handset and its local base station.
6. It also allows hands-free voice communication with headset.
7. It also enables a mobile computer to connect to a fixed LAN.
8. It can also be used for file transfer operations from one mobile phone to another.

Advantages of Bluetooth:

- Bluetooth is inexpensive
- Bluetooth provides low interference
- It require low energy consumption
- It allows sharing of data
- It is cheaper in cost
- Easy to use
- Disadvantage of Bluetooth
- It only allows short range (30 feet) communication between devices.
- Bluetooth only offers 1 mbps data transfer rate.

Question: In Bluetooth communication calculate the length of frame for following scenarios:

(i) Three slot (ii) Five slot

Answer: Assume data rate = 1 mbps

In Bluetooth communication, when the link speed or data rate is

1Mbps each slot length is $625\mu\text{s}$ or 1600 hops/sec Packets can be of 1, 3, 5 slots.

i) Since each slot length is $625\mu\text{s}$, Total length of the frame containing three slots is $625*3=1875\mu\text{s}$, Or $1600*3=4800$ hops/sec

ii) Since each slot length is $625\mu\text{s}$, Total length of the frame containing five slots is $625*5=3125\mu\text{s}$, Or $1600*=8000$ hops/sec.

Smart Bluetooth

- In 2010, Sony started the development of a Bluetooth version called smart Bluetooth, a smaller low powered version of Bluetooth, which targeted the market of fitness and healthcare.
- Smart Bluetooth needed to be small and power efficient.
- However small and power efficiency is loved by all so a part of the Sony development became a part of the Bluetooth version 4.0 standard.
- This standard is also known as BLE which stands for Bluetooth low energy.
- Bluetooth low energy is a wireless personal area network technology designed and marketed by the Bluetooth special interest group.
- Mobile operating systems including iOS, Android, windows phone, blackberry, as well as macOS, Linux, windows 8 and windows 10 natively support Bluetooth low energy.
- There are two trademarks from the Bluetooth SIG as bellow

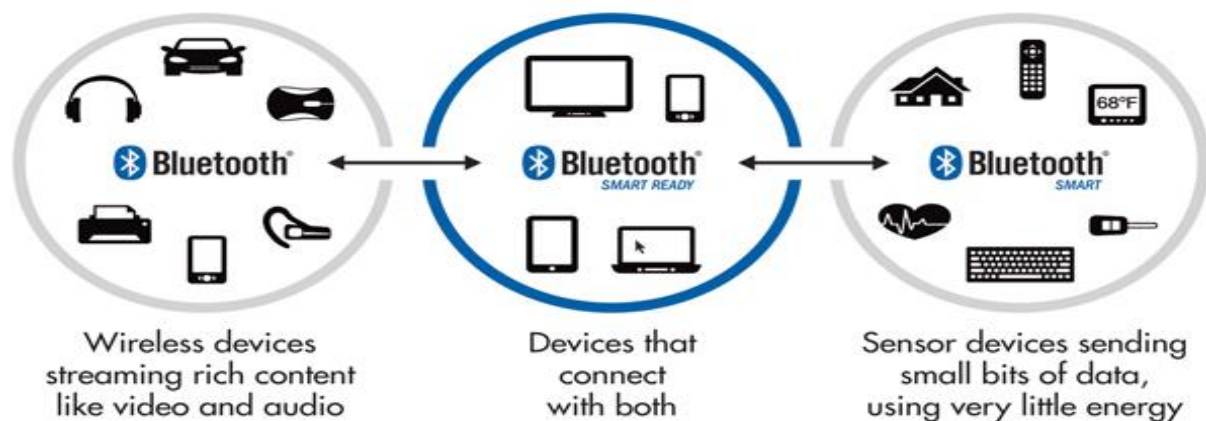
1. Bluetooth Smart Ready (HUBS):

- Bluetooth Smart Ready devices are the devices that receive data sent from the classic Bluetooth and Bluetooth smart devices and give it to applications that make use of that data
- The applications could be running on these devices themselves or could be running anywhere else on the internet
- E.g. phones, tablets PCs etc

2. Bluetooth smart (sensor type devices):-

- Bluetooth smart devices are sensor type devices that are used to collect a specific piece of information.
- After collecting this information these devices send it to the Bluetooth smart ready devices.
- Eg heart rate monitor, thermometers, sports equipment etc.

These devices collect a specific piece of information like heart rate or temperature and then relay it to the Bluetooth smart ready devices



- As shown in fig the mobile phone is the smart ready devices and it is communicating to two devices at the same time.

1. Streaming audio data to a Bluetooth headset.

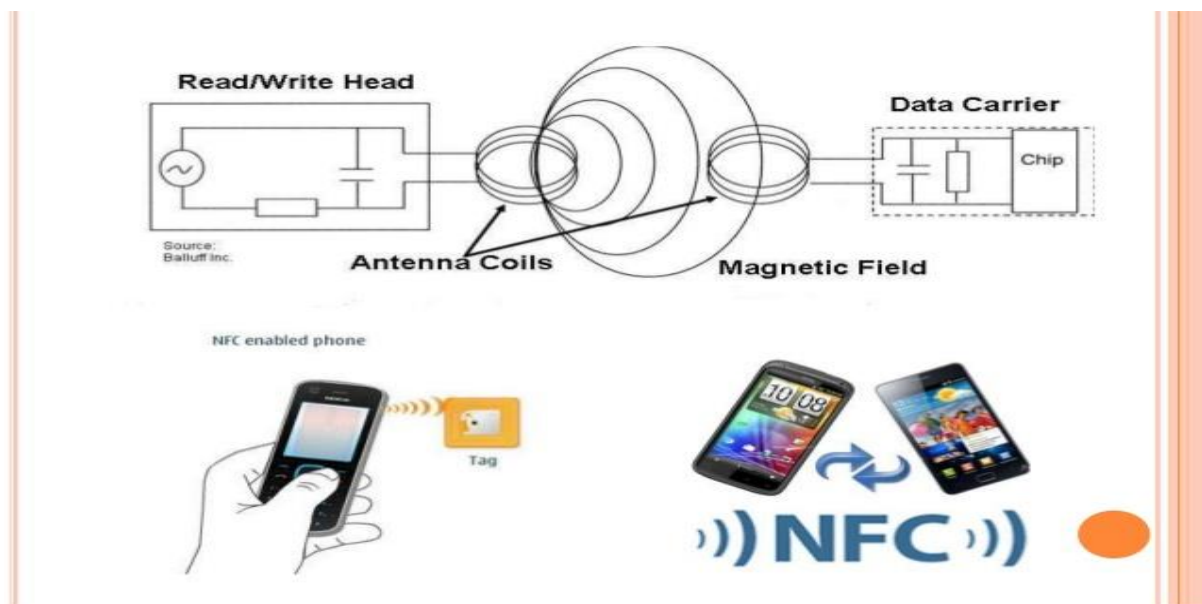
2. Collecting temperature information from a Bluetooth smart thermometer and acting as a hub to relay that information to a server located in the hospital. The server can then take the appropriate action like informing the doctor or pharmacist.

2. Near Field Communication (NFC)

- NFC is a currently emerging and yet promising area which will have an enormous impact on the mobile technology throughout the world within just a few years

- NFC refers to wireless communication technology over short distance (less than 10 cm)
- NFC is a simple but profound technology that is fast evolving along with other mobile technologies in the market.
- This technology enables interaction between the virtual mobile world and the physical world.
- NFC is a wireless communication technology that potentially facilitates mobile phone usage of billions of people throughout the world offers an enormous number of use cases including credit cards, debit cards, loyalty cards, car keys, access keys for hotels, offices and houses, e-payments, e-ticketing, smart advertising, data money transfer and social services, eventually integrating all such materials into single mobile phone.
- NFC is a short range, high frequency, low bandwidth and wireless communication technology between two NFC enabled devices.
- Communication between NFC devices occurs at 13.56MHz high frequency which was originally used by radio frequency identification (RFID)

There are two different roles that a device can play in NFC which can be illustrated as a “request and reply” concept as shown in fig.

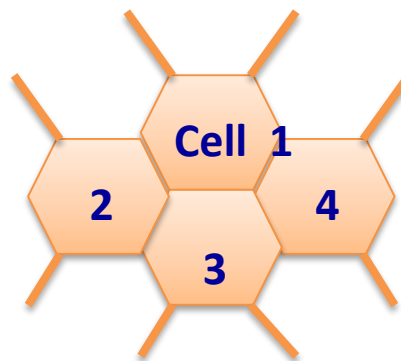


- The initiator sends a request message to a target and the target replies by sending a message back to the initiator.
- In this case the role of the initiator is to start the communication.
- The role of the target is to respond to the requests coming from the initiator.
- An active device can act as both an initiator and a target. However, a passive device cannot be an initiator.

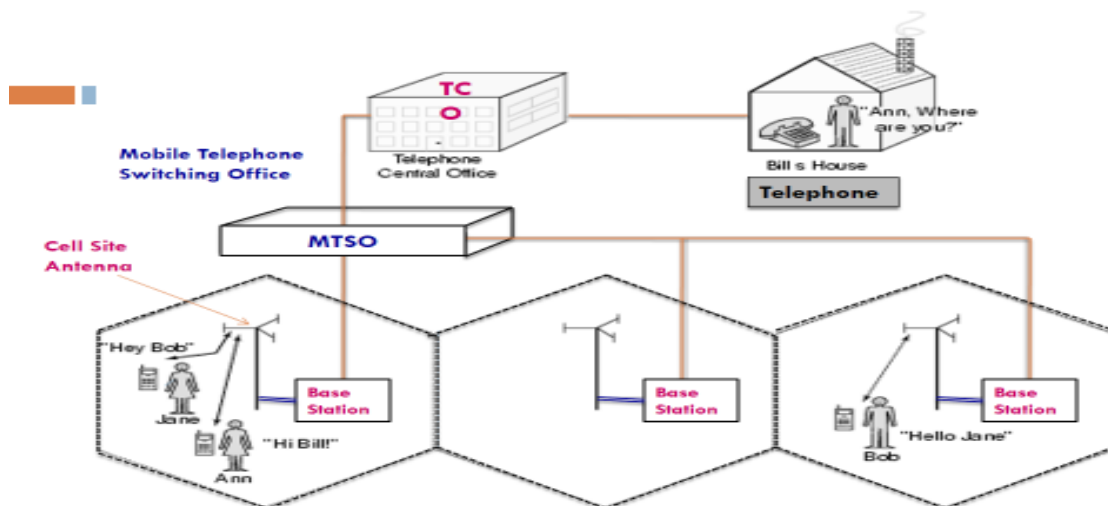
Mobile Telephone System

Basic Concept

- **Mobile or Cellular phone** is wireless communication just like cordless phone.
- In cell phone distance is not restricted to within home but one can travel in the city or even outside the city without interruption in communication.
- The demand for cellular phone is increasing at alarming level and is likely that wired communication will be replaced by wireless technology.
- In the cellular system city is divided into small areas called 'Cells'. Each cell is around 10 square kilometer. (Depends upon power of base station)



- The cells are normally thought of hexagons. Because cell phones and base stations use low power transmitters, the same frequencies can be reused in non-adjacent cell.



- The Cellular network is as shown in figure.
- A cellular network system is formed by connecting the following five components

1. Mobile Station (MS):-

- MS are usually a mobile phone. Each mobile phone contains a transceiver (transmitter and receiver) an antenna and control circuitry.
- Antenna converts the transmitted RF signal into an EM wave and the received EM waves into an RF.

- The same antenna is used for both transmission and reception so there is a duplex switch to multiplex the same antenna.

2. Base Station:-

- At the cell site **base station** is equipped to transmit, receive, and switch calls to and from any mobile unit within the cell to the MTSO.
- The cell just covers only few square kilometer areas, thus reducing the power requirement necessary to communicate with cellular phones

3. MTSO:-

- Each cell is linked to central location called the **Mobile Telephone Switching Office (MTSO)**.
- MTSO coordinates all mobile calls between an area comprised of several cell sites and the central office. Time and billing information for each mobile unit is accounted for by MTSO.

4. Base station controller:-

- A number of BS are connected to a BSC.
- An important function of BSC is that it manages the “handoff” from one BS to another as a subscriber moves from cell to cell
- The BSC contains logic to control each of the BSs

5. PSTN (Public switched Telephone Network):-

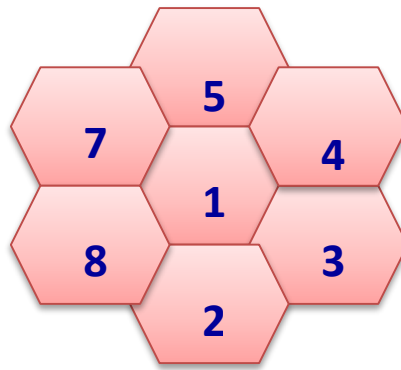
- It is a cellular network that can be viewed as an interface between mobile units and a telecommunication infrastructure. Therefore the PSTN network is nothing but the land based section of the network.
- It is necessary that the BSs are to be connected to a switching network and that network is to be connected to other networks such as the PSTN so that calls can be made to and from mobile subscribers.

6. Cell:

- The basic geographic unit of a cellular communication system is called as a **Cell**.
- Its shape is hexagonal.
- The size of cell is not fixed.
- Practically the shape of the cell may not be a perfect hexagon.

7. Cluster:

- A group of cells is called as a **Cluster**.
- The cluster size(n) is not fixed.
- It depends on the requirement of a particular area.
- Fig. shows the cluster of SEVEN cells or a SEVEN cell cluster (n=7).

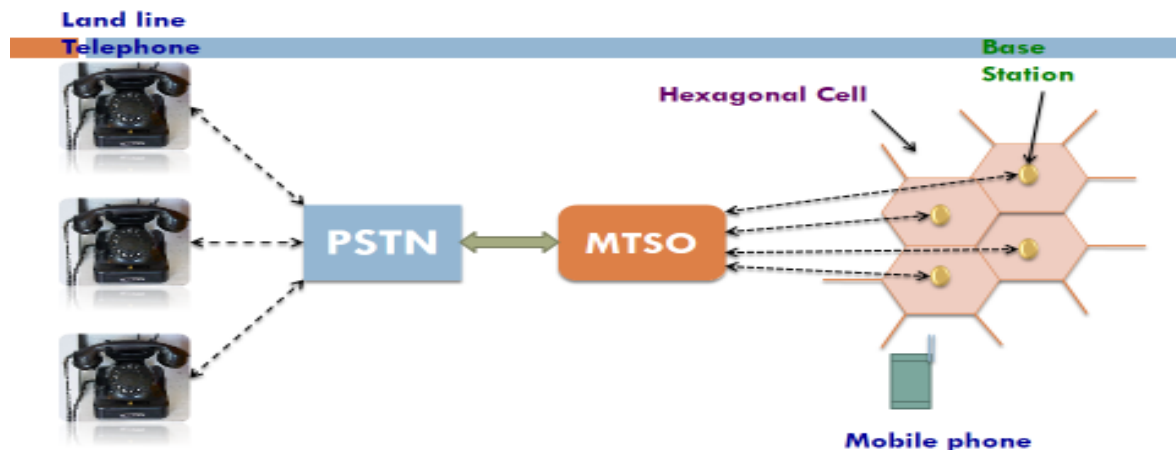


Bands in Cellular Telephony

- Classically analog communication is used for the cellular telephony. Frequency Modulation (FM) is used for communication between the mobile phone and the cell office.
- Generally two frequency bands are allocated for this purpose. One for the communication initiated by the cell phone and for the land phone.
- For cellular communication, the FCC has appointed 40 MHz of the frequency spectrum from 825 to 845 MHz and 870 to 890 MHz . Full-duplex operation is possible by separating transmit and receive signals into separate frequency bands. Cellular phone units transmit in the lower band of frequencies, 825 to 845 MHz, and receive in the higher band, 870 to 890 MHz.
- The opposite frequency bands are used by the base units at the cell sites. Within these two bands, 666 separate channels (333 channels per band) have been assigned for voice and control. Each channel occupies a bandwidth of 30 KHz.

Basic Structure of the Mobile Phone System

- In the **mobile communication** system either the transmitter or the receiver or both are going to be movable. As the points between which the communication takes place are movable, the communication channel is essentially air, which means it is a wireless communication.
- The structure of the mobile phone network along with the PSTN is shown in figure.



- Each cell has a Base station situated at the center.
- The task of the Base stations is to act as an interface between the mobile phone and the cellular radio system.
- The Base station of all the cells is connected to the MTSO.
- The interface is a bi-directional [i.e. Exchange of information between MTSO and Base station is a two way].
- The MTSO acts as the interface between the PSTN and the Base station. PSTN performs the supervision and control operations in the mobile communication system.
- The communication can take place between two Mobile subscribers or between a mobile subscriber and a Landline Telephone.
- If a mobile subscriber travels from one cell area to the other then it automatically gets connected to the Base station of that cell. Thus the service provided to a mobile subscriber is continuous without any break.

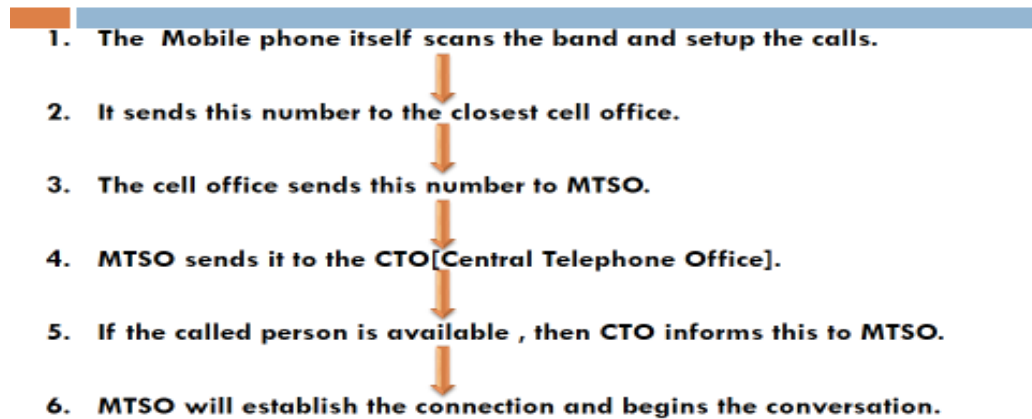
Function of MTSO:

- The MTSO control all the cells and provides the interface between each cell and the main telephone office.
- As the vehicle moves from one cell to the next the system automatically switches from one cell to the next.
- The MTSO switches from the vehicle to the stronger cell within a very short time.

Calls using Mobile Phones

Case 1 : Call initiated by a mobile phone :

- When we make a call from the mobile by entering the required 10 digit phone number the sequence of events takes place as follows:



Transmitting/Receiving/Handoff Operations

Hand off Procedure:

- During the conversation, if a Mobile phone crosses the exiting cell, the signal became weak.
- The MTSO is checking the signal level continuously, so if it finds signal level low then it immediately switch the call which can improve the signal strength.
- The MTSO will then change the cell carrying channel very smoothly without interrupting the call or changing user.
- This process of handling the signal of Old channel to the new channel is called as **Hand-off / Handover** Procedure.
- The user can continue talking without even noticing that the Hand-off Procedure has taken place.

Different types of Hand Offs:

Following are various types of handoffs supported by a Mobile Station:

1. Hard Hand off
2. Soft Hand off
3. Delayed Hand off
4. Forced Hand off
5. Queued Hand off



1. Hard Hand Off:

- The hand off is known as Hard Handoff if a mobile station transmits between two base stations having different frequency assignments.

2. Soft Hand Off:

- The hand off is known as soft handoff if the mobile station starts communication with a new base station without stopping the communication with the older base station.

3. Delayed Hand Off:

- In many situations, instead of one level, a two level handoff procedure is used, in order to provide a high opportunity for a successful handoff.
- A hand off can be delayed if no available cell could take the call.
- If due to some reason the mobile unit is in a hole (Place in a cell with low signal level) or neighboring cell is busy then the handoff is requested after every 5 seconds. But if the signal strength becomes lower and reaches the second handoff level then the handoff will take place without any condition, immediately this process is called **Delayed Handoff**.

4. Forced Hand Off:

- A forced hand off is defined as the hand off which could normally occur but is prevented from happening or a hand off that should not occur but is forced to happen.

5. Queued Hand Off:

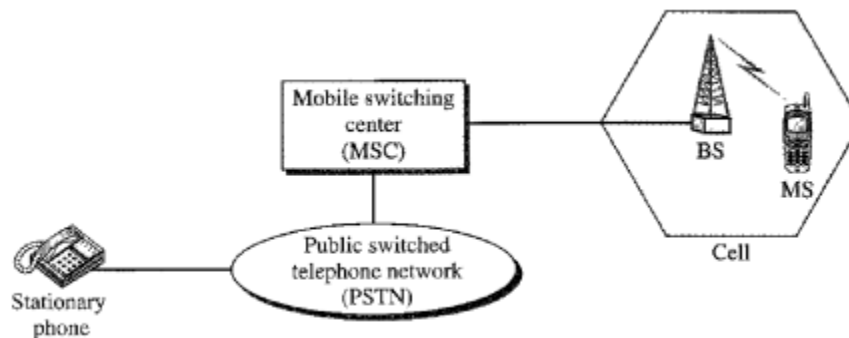
- In the queued hand off process, the MTSO arranges the hand off requests in a queue instead of rejecting them, if the new cell sites are busy.
- These hand off requests are then entertained in a sequential manner. Queuing of hand offs is more effective than the two threshold hand off. Also, a queuing scheme is effective only when the hand off requests arrive at the MTSO in batches or bundles.

Question: Draw and explain Mobile Telephone System Architecture.

Answer:

Cellular telephony is designed to provide communications between two moving units, called mobile stations (MSs), or between one mobile unit and one stationary unit, often called a land unit. A service provider must be able to locate and track a caller, assign a channel to the call, and transfer the channel from base station to base station as the caller moves out of range.

To make this tracking possible, each cellular service area is divided into small regions called cells. Each cell contains an antenna and is controlled by a solar or AC powered network station, called the base station (BS). Each base station, in turn, is controlled by a switching office, called a mobile switching center (MSC). The MSC coordinates communication between all the base stations and the telephone central office. It is a computerized center that is responsible of connecting calls, recording call information, and billing.



Cell size is not fixed and can be increased or decreased on the population of the area. The typical radius of a cell is 1 to 12mi. High density areas require more, geographically smaller cells to meet traffic demands than do low-density areas. Once determined, cell size to optimize to prevent the interference of adjacent cell signals. The transmission power of each cell is kept low to prevent its signal from interfering with those of other cells.

Generations of Mobile Telephone System

In the past few decades, mobile wireless technologies have experience 4 or 5 generations of technology revolution and evolution, namely from 0G to 4G. Current research in mobile wireless technology concentrates on advance implementation of 4G technology and 5G technology. Currently 5G termis not officially used.

0G Wireless technology

0G refers to pre-cell phone mobile telephony technology, such as radio telephones that some had in cars before the advent of cell phones. Mobile radio telephone systems preceded modern cellular mobile telephony technology. Since they were the predecessors of the first generation of cellular telephones, these systems are called 0G (zero generation) systems.

1G: Analog Cellular Networks

The main technological development that distinguished the First Generation mobile phones from the previous generation was the use of multiple cell sites, and the ability to transfer calls from one site to the next as the user travelled between cells during a conversation. The first commercially automated cellular network (the 1G generations) was launched in Japan by NTT in 1979.

In 1984, Bell Labs developed modern commercial cellular technology, which employed multiple, centrally controlled base stations (cell sites), each providing service to a small area (a cell). The cell sites would be set up such that cells partially overlapped. In a cellular system, a signal between a base station (cell site) and a terminal (phone) only need be strong enough to reach between the two, so the same channel can be used simultaneously for separate conversations in different cells.

As the system expanded and neared capacity, the ability to reduce transmission power allowed new cells to be added, resulting in more, smaller cells and thus more capacity.

2G: Digital Networks

In the 1990s, the 'second generation' (2G) mobile phone systems emerged, primarily using the GSM standard. These 2G phone systems differed from the previous generation in their use of digital transmission instead of analog transmission, and also by the introduction of advanced and fast phone-to-network signaling. The rise in mobile phone usage as a result of 2G was explosive and this era also saw the advent of prepaid mobile phones.

The second generation introduced a new variant to communication, as SMS text messaging became possible, initially on GSM networks and eventually on all digital networks. Soon SMS became the communication method of preference for the youth. Today in many advanced markets the general public prefers sending text messages to placing voice calls.

Some benefits of 2G were Digital signals require consume less battery power, so it helps mobile batteries to last long. Digital coding improves the voice clarity and reduces noise in the line. Digital signals are considered environment friendly. Digital encryption has provided secrecy and safety to the data and voice calls. The use of 2G technology requires strong digital signals to help mobile phones work properly.

“2.5G” using GPRS (General Packet Radio Service) technology is a cellular wireless technology developed in between its predecessor, 2G, and its successor, 3G. GPRS could provide data rates from 56 kbit/s up to 115 kbit/s. It can be used for services such as Wireless Application Protocol (WAP) access, Multimedia Messaging Service (MMS), and for Internet communication services such as email and World Wide Web access.

2.75 – EDGE is an abbreviation for Enhanced Data rates for GSM Evolution. EDGE technology is an extended version of GSM. It allows the clear and fast transmission of data and information up to 384kbit/s speed.

3G : High speed IP data networks

As the use of 2G phones became more widespread and people began to use mobile phones in their daily lives, it became clear that demand for data services (such as access to the internet) was growing. Furthermore, if the experience from fixed broadband services was anything to go by, there would also be a demand for ever greater data speeds. The 2G technology was nowhere near up to the job, so the industry began to work on the next generation of technology known as 3G. The main technological difference that distinguishes 3G technology from 2G technology is the use of packet switching rather than circuit switching for data transmission.

The high connection speeds of 3G technology enabled a transformation in the industry: for the first time, media streaming of radio and even television content to 3G handsets became possible. In the mid 2000s an evolution of 3G technology begun to be implemented, namely High-Speed

Downlink Packet Access (HSDPA). It is an enhanced 3G mobile telephony communications protocol in the High-Speed Packet Access (HSPA) family, also coined 3.5G, 3G+ or turbo 3G, which allows networks based on Universal Mobile Telecommunications System (UMTS) to have higher data transfer speeds and capacity. Current HSDPA deployments support down-link speeds of 1.8, 3.6, 7.2 and 14.0 Mbit/s. Further speed increases are available with HSPA+, which provides speeds of up to 42 Mbit/s downlink and 84 Mbit/s with Release 9 of the 3GPP standards.

4G: Growth of mobile broadband

Consequently, the industry began looking to data-optimized 4th-generation technologies, with the promise of speed improvements up to 10-fold over existing 3G technologies. It is basically the extension in the 3G technology with more bandwidth and services offers in the 3G. The expectation for the 4G technology is basically the high quality audio/video streaming over end to end Internet Protocol. The first two commercially available technologies billed as 4G were the WiMAX standard and the LTE standard.

One of the main ways in which 4G differed technologically from 3G was in its elimination of circuit switching, instead employing an all-IP network. Thus, 4G ushered in a treatment of voice calls just like any other type of streaming audio media, utilizing packet switching over internet, LAN or WAN networks via VoIP.

4G LTE data transfer speed can reach peak download 100 Mbit/s, peak upload 50 Mbit/s, WiMAX offers peak data rates of 128 Mbit/s downlink and 56 Mbit/s uplink.

What is VoLTE?

VoLTE stands for voice over Long Term Evolution. Utilising IMS technology, it is a digital packet voice service that is delivered over IP via an LTE access network.

Voice calls over LTE are recognised as the industry-agreed progression of voice services across mobile networks, deploying LTE radio access technology.

What are the benefits of VoLTE?

The implementation of VoLTE offers many benefits, both in terms of cost and operation. VoLTE:

- Provides a more efficient use of spectrum than traditional voice;
- Meets the rising demand for richer, more reliable services;
- Eliminates the need to have voice on one network and data on another;
- Unlocks new revenue potential, utilising IMS as the common service platform;
- Can be deployed in parallel with video calls over LTE and RCS multimedia services, including video share, multimedia messaging, chat and file transfer;
- Ensures that video services are fully interoperable across the operator community, just as voice services are, as demand for video calls grows;
- Increases handset battery life by 40 per cent (compared with VoIP);
- Delivers an unusually clear calling experience; and
- Provides rapid call establishment time.

Question: Enlist generations of mobile telephone system.

Answer: Generations of mobile telephone system:

- First Generation
- Second Generation:2.5G, 2.75G
- Third Generation:3.5, 3.75G
- Fourth Generation
- Fifth Generation

Question: Compare first, second, third and fourth generation mobile telephone systems (any 3 points).

Technology	1G	2G/2.5G	3G	4G
Bandwidth	2Kbps	14-64kbps	2Mbps	200Mbps
Technology	Analog cellular	Digital cellular	Broadband width/CDMA/IP Technology	Unified IP and seamless combo of LAN/WLAN/WLAN
Service	Mobile telephony	Digital voice, Short messaging	Integrated high quality audio, video and data	Dynamic information access, variable devices.
Multiplexing	FDMA	TDMA/CDMA	CDMA	CDMA
Switching	Circuit	Circuit/circuit for access network and air	Packet except for air interface	All packet