UNIT - I

INTRODUCTION TO MOBILE COMPUTING

1.1 Concept of Mobile Communication

- Mobile communication allows transmitting and receiving data while moving from place to place.
- A wireless form of communication in which voice and data information is transmitted and received via microwaves is called mobile communication.
- Some examples of mobile devices include: cellular and digital cordless telephones, pagers, telephone answering devices, air-to-ground telecommunications, and satellite-based communications.

1.2 Different Generations of Wireless Technology

- The birth of wireless communications started from 1901 when M. G. Marconi successfully established a radio link between a land-based station and a tugboat.

1.2 Different Generations of Wireless Technology

- **1G TECHNOLOGY**
- 1G refers to the first generation of wireless telephone technology, mobile telecommunications which was first introduced in 1980s.
- It's Speed was upto 2.4kbps.
- It allows the voice calls in 1 country.
- 1G network use Analog Signal.
- AMPS (Advanced Mobile Phone Service) was first launched in USA in 1G mobile systems.

1.2 Different Generations of Wireless Technology

- **1G TECHNOLOGY (Drawbacks)**

- Poor Voice Quality
- Poor Battery Life
- Large Phone Size
- No Security
- Limited Capacity

1.2 Different Generations of Wireless Technology

- **2G TECHNOLOGY**

- 2G technology refers to the 2nd generation which is based on GSM.
- It was launched in Finland in the year 1991.
- 2G network use digital signals.
- It's data speed was upto 64kbps.

Features Includes:

- It enables services such as text messages, picture messages and MMS (multi media message).

- It provides better voice quality and capacity .

1.2 Different Generations of Wireless Technology

- **2G TECHNOLOGY (Drawbacks)**
- 2G requires strong digital signals to help mobile phones work. If there is no network coverage in any specific area , digital signals would weak.
- These systems are unable to handle complex data such as Videos.

1.2 Different Generations of Wireless Technology

- **3G TECHNOLOGY**

- 3G technology refer to third generation which was introduced in year 2000s.

- Data Transmission speed increased upto 2Mbps – 100 Mbps.

- Typically Devices called Smart Phones and features increased its bandwidth and data transfer rates to accommodate web-based applications, audio and video files.

1.2 Different Generations of Wireless Technology

- **3G TECHNOLOGY**
- **<u>Features Includes:</u>**

- Providing Faster Communication
- Send/Receive Large Email Messages
- High Speed Web access
- Video Conferencing
- 3D Gaming
- TV Streaming/ Mobile TV

1.2 Different Generations of Wireless Technology

- **3G TECHNOLOGY (Drawbacks)**

- High Bandwidth Requirement
- Expensive fees for 3G Licenses Services
- It was challenge to build the infrastructure for 3G
- Expensive 3G Phones.

1.2 Different Generations of Wireless Technology

- **4G TECHNOLOGY**

- 4G technology refer to short name of fourth Generation which was started from late 2010s.

- Capable of providing 100Mbps to 1Gbps speed.

- **Features Includes:**

- More Security
- High Speed
- Low Cost Per-bit

1.2 Different Generations of Wireless Technology

- **4G TECHNOLOGY (Drawbacks)**

- Battery usage is more
- Complex and difficult to implement
- Expensive equipment required to implement

1.2 Different Generations of Wireless Technology

- **5G TECHNOLOGY**

- 5G technology refer to short name of fifth Generation which will be started from 2020s.

- Complete wireless communication with almost no limitations.

- **Features Includes:**

- Supposed to have speed greater than 1 Gbps
- Faster and reliable than previous generations

1.2 Different Generations of Wireless Technology

Generation	Starts from	Data capacity	Technology	Standerd	Multiplexing	Switching	Service	Main network	Hand off	frequency
1G	1970-84	2kbps	Analog Wireless	AMPS	FDMA	Circuit	Voice only	PSTN	Horizontal	800-900MHz
2G	1990	10kbps	Digital Wireless	CDMA TDMA GSM	TDMA CDMA	Circuit Packet	Voice/data	PSTN	Horizontal	850-1900MHz(GS) 825-849MHz (CDMA)
2.5G	2000	200Kbps	GPRS	Supported TDMA/ GSM	TDMA CDMA	Packet Switch	MMS internet	GSM TDMA		850-1900MHz
2.75G	2003	473kbps	EDGE	GSM CDMA	TDMA CDMA	Packet Switch		WCDMA		850-1900MHz
3G	2001	384Kbps	Broadband / IP technology FDD TDD	CDMA/ WCDMA/ UMTS/ CDMA2000	CDMA	Packet& circuit	High speed voice/data/ video	Packet network	Horizontal	1.6-2.5GHz

1.2 Different Generations of Wireless Technology

Generation	Starts from	Data capacity	Technology	Standerd	Multiplexing	Switching	Service	Main network	Hand off	frequency
3.5G	2003	2Mbps	GSM/ 3GPP	HSDPA /HSUPA	CDMA	Packet	High speed voice/data/ video	GSM TDMA	Horizontal	1.6-2.5GHz
3.75G	2003	30Mbps		1xEVDO	CDMA	Packet	High speed internet /multimedia		Horizontal	1.6-2.5GHz
4G	2010	200Mbps -to- 1Gbps	LTE Wi MAX	IP-broadband LAN/WAN/ PAN	MC-CDMA OFAM	Packet	Voice, multimedia and internet over IP	Internet	Horizontal & Vertical	2-8GHz
5G	2015	>1Gbps	IP v6	IP-broadband LAN/WAN/ PAN & wwww	CDMA	All packet	Dyn.Infoaccess, wearable devices withAI capabilities	Internet	Horizontal & vertical	

1.3 Basics of Cell, Cluster and frequency reuse concept

- **Cellular Concepts and Basics**

- Early schemes for radio telephones schemes used a single central transmitter to cover a wide area.

- These radio telephone systems suffered from the limited number of channels that were available.

- Often the waiting lists for connection were many times greater than the number of people that were actually connected.

- In view of these limitations this form of radio communications technology did not take off in a big way. Equipment was large and these radio communications systems were not convenient to use or carry around.

1.3 Basics of Cell, Cluster and frequency reuse concept

- **The need for a spectrum efficient system**

- To illustrate the need for efficient spectrum usage for a radio communications system, take the example where each user is allocated a channel.

- Each channel needs to have a bandwidth of around 25 kHz to enable sufficient audio quality to be carried as well as enabling there to be a guard band between adjacent signals to ensure there are no undue levels of interference.

- Using this concept it is only possible to accommodate 40 users in a frequency band 1 MHz wide.

- Even of 100 MHz were allocated to the system this would only enable 4000 users to have access to the system.

- Today cellular systems have millions of subscribers and therefore a far more efficient method of using the available spectrum is needed.

1.3 Basics of Cell, Cluster and frequency reuse concept

- **Cell Systems**

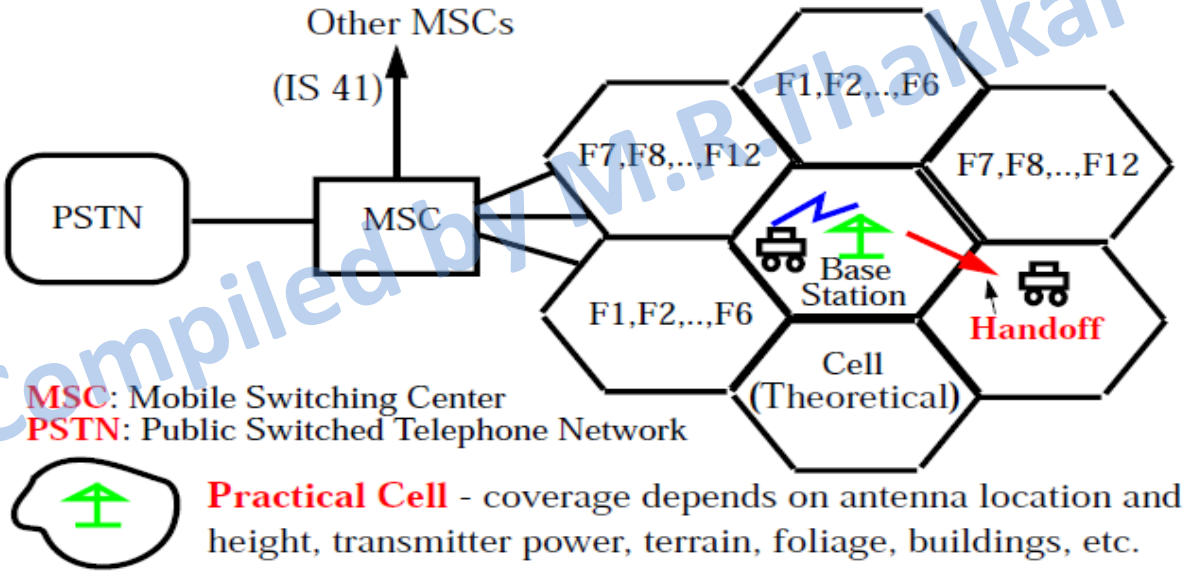
- Cellular systems accommodate a large number of users over a large geographic area, within a limited frequency spectrum.

- High capacity is achieved by limiting the coverage of each base station transmitter to a small geographic area called a cell so that the same radio channels may be reused by another base station located some distance away.

- The coverage area is divided into many cells. Replace a single, high power transmitter (large cell) with many low power transmitters (small cells) each providing coverage to only one cell area (a small portion of the service area).

1.3 Basics of Cell, Cluster and frequency reuse concept

- **Cell Systems**



1.3 Basics of Cell, Cluster and frequency reuse concept

- **Cell**

- Cell is the basic geographic unit of the cellular communication system.

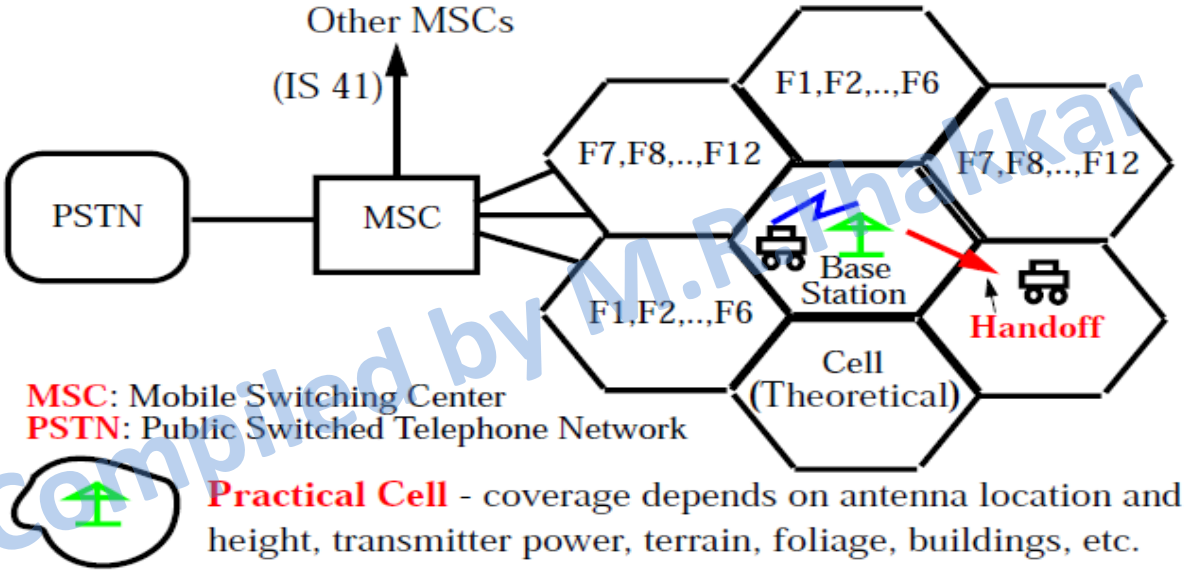
- In reality cell can be of any shape, but generally it is represented in the form of hexagon.

- The base station is placed at the center of the cell.

- The size of the cell may vary depending upon the geographical region to be covered.

1.3 Basics of Cell, Cluster and frequency reuse concept

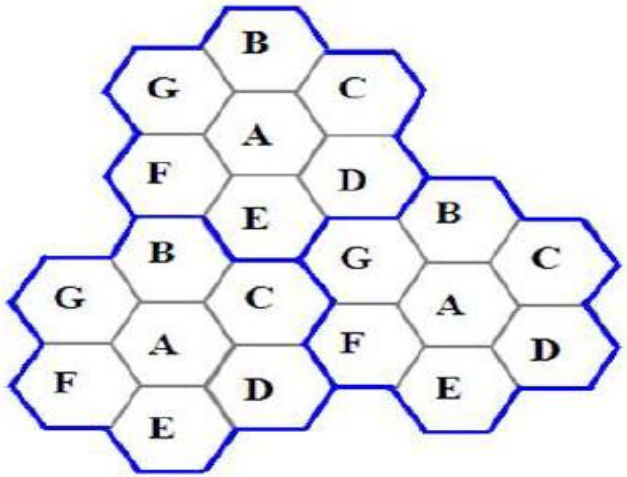
- **Cell**



1.3 Basics of Cell, Cluster and frequency reuse concept

- **Cell clusters**

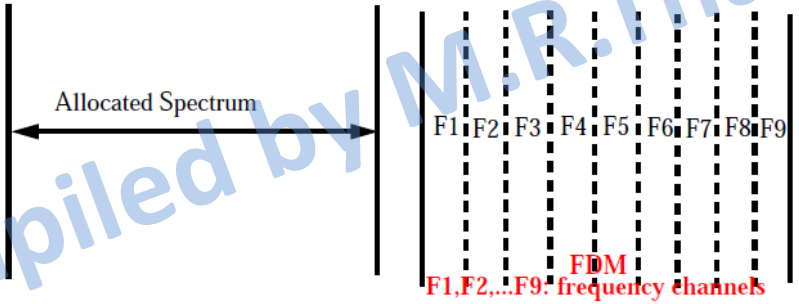
- Cell cluster is a group of cells in which cells are arranged such that no frequency channels are reused.
- The size of cluster is defined by number of cells in the cluster.
- Following figure shows three clusters with size of 7.



1.3 Basics of Cell, Cluster and frequency reuse concept

- **Spectrum and Frequency Re-use**

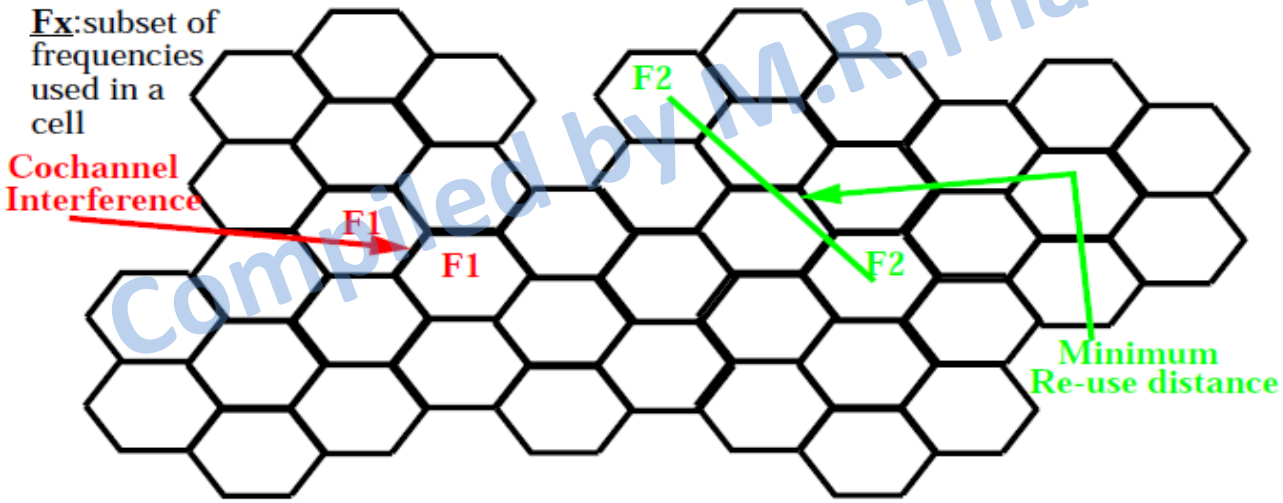
- The available spectrum is limited. The design process of selecting and allocating channel groups for all cellular base stations within a system is called frequency reuse or frequency planning.



- To be able to increase the capacity of the system, frequencies must be re-used in the cellular layout (unless we are using spread spectrum techniques). Frequencies cannot be re-used in adjacent cells because of co-channel interference. The cells using the same frequencies must be dispersed across the cellular layout.

1.3 Basics of Cell, Cluster and frequency reuse concept

- **Spectrum and Frequency Re-use**



1.4 Noise and its effects on Mobile

- Noise is unwanted disturbances superimposed on a useful signal, which tends to degrade its information content.

- **Types and sources of noise**

- There are many types of noise; however, the four most important to the telecommunication/data communication technologist are:

  - Thermal noise
  - Inter-modulation noise
  - Crosstalk and
  - Impulse noise

1.4 Noise and its effects on Mobile

- *Thermal noise* : Thermal noise occurs in all transmission media and communication equipment, including passive devices.

- It arises from random electron motion and is characterized by a uniform distribution of energy over the frequency spectrum with a Gaussian distribution of levels.

- Every equipment element and the transmission medium itself contribute thermal noise to a communication system if the temperature of that element or medium is above absolute zero. Whenever molecules heat above absolute zero, thermal noise will be present.

- The more heat generated or applied, the greater the level of thermal noise.

1.4 Noise and its effects on Mobile

- *Inter-modulation (IM) noise:* Inter-modulation noise is the result of the presence of inter-modulation products.

- If two signals of frequencies F1 and F2 are passed through a nonlinear device or medium, the result will contain IM products that are spurious frequency energy components.

- These components may be inside or outside the frequency band of interest for a particular device. IM products may be produced from harmonics of the desired signals in question, either as products between the harmonics or between a harmonic of one of the signals and the other basic signal or between both signals themselves. The products result when two (or more) signals beat together or "mix."

1.4 Noise and its effects on Mobile

- *Crosstalk:* Crosstalk refers to unwanted coupling between signal paths.

- There are essentially three causes of crosstalk: (1) electrical coupling between transmission media, such as between wire pairs on a voice-frequency (VF) cable, (2) poor control of frequency response (i.e., defective filters or poor filter design) and (3) nonlinear performance in analog (FDM) multiplex systems.

1.4 Noise and its effects on Mobile

- *Impulse noise:* Impulse noise is a discontinuous series of irregular pulses or noise "spikes" of short duration, broad spectral density and of relatively high amplitude.

- In the language of the trade, these spikes are often called "hits."

- Impulse noise degrades telephony only marginally, if at all. However, it may seriously corrupt error performance of a data circuit.

1.5 Understanding GSM & CDMA

- GSM and CDMA refer to cellular communication standards that are adopted by carriers.

- **GSM**

- More than 6 billion people worldwide use the Global System for Mobile Communications (GSM) technologies.

- GSM is the most widely used wireless technology in the world, available in more than 219 countries and territories worldwide, with a market share of more than 90 percent.

1.5 Understanding GSM & CDMA

- With GSM, all subscriber and wireless provider information is stored on interchangeable modules known as SIM (Subscriber Identification Module) cards.

- By swapping out the SIM card, users can painlessly switch phones or providers.

- For this and other reasons, GSM is enormously popular and well-supported throughout the world, making it particular suited for international roaming.

- However, the 850 MHz and 1900 MHz bands are used in North America, while the 900-MHz and 1800-MHz bands are used everywhere else.

1.5 Understanding GSM & CDMA

- There are several reasons why GSM is so popular among operators and their customers:

  - **Clear voice quality**
  - **International roaming**
  - **security**
  - **Subscriber Identity Module (SIM) cards**
  - **Product selection**
  - **Research and development**

1.5 Understanding GSM & CDMA

- **CDMA**

- The term "CDMA" (Code Division Multiple Access) refers to both a spread spectrum technique and a cellular standard popular in North America.

- Initially it was restricted to the armed forces, this technology was commercially launched in 1995 by Qualcomm Telecommunications.

1.5 Understanding GSM & CDMA

- **CDMA**
- **What CDMA Means?**

- **Code:** It refers to the string of binary sequence that the transmitter and the receiver share. This code encodes the information into a low frequency signal before it is transmitted over a channel. This same code is used by the receiver to decode the information. The receiver gets the code with the help of the nearest base station.

- **Division:** In CDMA a single channel is divided into numerous slots which can be used by multiple users. This is possible because of the use of unique code.

- **Multiple Accesses:** Due to code based communication, multiple users can communicate and access the same channel simultaneously without any undesirable interference and loses.

1.5 Understanding GSM & CDMA

- **CDMA**

- The goal of CDMA is to break up a finite radio frequency so that multiple users can access it at the same time.

- Through randomization of frequencies, CDMA divides the radio frequency spectrum to share the space for multiple users using a code to accomplish the multiplexing instead of time or frequency division.

- This ability to use codes to divide up the signal provides CDMA with a great advantage over GSM and other wireless technologies because it can support more users on the available bandwidth.

1.5 Understanding GSM & CDMA

- **CDMA**
- CDMA networks have greater range and clarity than GSM.
- However, it is more difficult for users to switch phones and carriers, since subscriber information is programmed directly into the phone rather than on a SIM card.
- International roaming is also not possible, since CDMA has not been implemented in many countries.

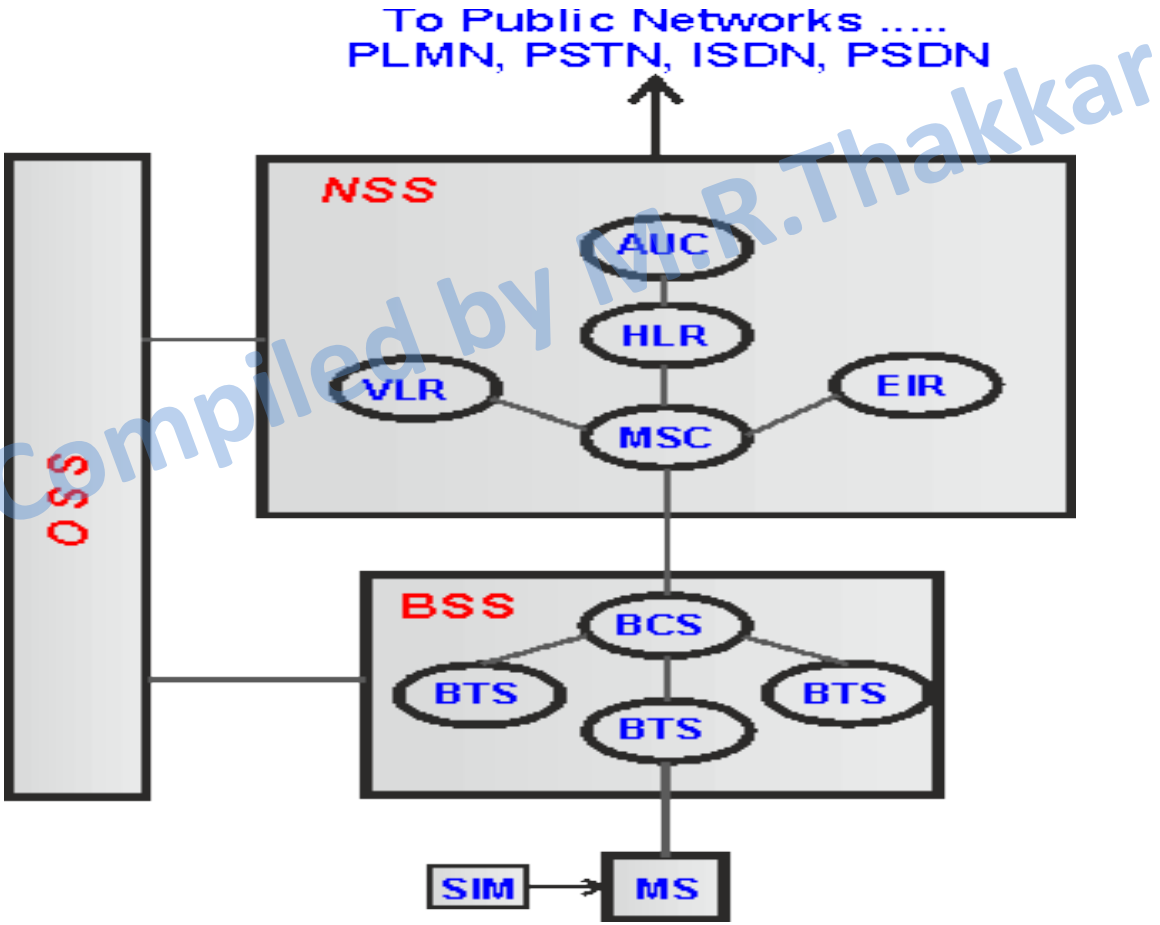
1.5 Understanding GSM & CDMA

- **Differentiate CDMA and GSM**

CDMA	GSM
Code Division Multiple Access	Global System for Mobile communication
Storage type : internal memory	SIM memory
Global market share : 25%	75%
Dominant standard in the U.S.	Dominant standard worldwide except the U.S.
There is one physical channel and a special code for every device in the coverage network. Using this code, the signal of the device is multiplexed, and the same physical channel is used to send the signal	Every cell has a corresponding network tower, which serves the mobile phones in that cellular area.
Less Accessible	Most Accessible
Frequency band : Single(850 MHz)	Multiple(850/900/1800/1900 MHz)
Handset specific	SIM specific. User has option to select handset of his choice.
Emits less radiation	Emits 28 times more radiations than CDMA

1.6 Basics of GSM Architecture & Services

- A GSM network comprises of many functional units. Following figure shows the architecture of GSM:



1.6 Basics of GSM Architecture & Services

- The GSM network can be broadly divided into:
  - The Mobile Station (MS)
  - The Base Station Subsystem (BSS)
  - The Network Switching Subsystem (NSS)

1.6 Basics of GSM Architecture & Services

- **Mobile Station (MS) :** The Mobile Station is a technical name which is used to represent Mobile Phones with Subscriber Identity Module (SIM).

- **The Base Station Subsystem (BSS) :** Base Station Subsystem consist of:
  - Base Transceiver Station
  - Base Station Controller

  - **Base Transceiver Station :** Each BTS defines single cell and includes radio antenna, radio transceiver and a link to base station controller (BSC).

  - **Base Station Controller:** BSC is responsible for reserving radio frequencies and manage hand off of mobile units from one cell to another.

1.6 Basics of GSM Architecture & Services

- **The Network Switching Subsystem (NSS):** The NSS consist of:
  - Mobile Switching services Centre (MSC):
  - Home Location Register (HLR)
  - Visitor Location Register (VLR):
  - Equipment Identity Register (EIR):
  - Authentication Centre (AuC):

1.6 Basics of GSM Architecture & Services

- **Mobile Switching Services Centre (MSC):** The MSC performs the telephony switching functions of the system. It controls call to and from other telephone and four database system.

- **Home Location Register (HLR) :** HLR is database which used to store information about each subscriber.

- **Visitor Location Register (VLR):** VLR is database which is used to determine the position of the subscriber in which subscriber has entered.

- **Equipment Identity Register (EIR):** EIR is database which keeps track of the equipment that exist at the mobile station, i.e. It can be IMEI number used for the tracking of the device.

- **Authentication Centre (AuC):** AuC is database which is used to hold authentication and encryption keys for all the subscribers.

1.6 Basics of GSM Architecture & Services

- **GSM Services**

- GSM has much more to offer than voice telephony.
- Additional services allow you greater flexibility in where and when you use your phone.

- Basic services offered through GSM are:
  - Short Message Service (SMS)
  - Multimedia Message Service (MMS)
  - Location Based Service (LBS)
  - Value added Service (VAS)

1.7 Different modes used for Mobile Communication

- The different modes of mobile communication include:
  - Infrared (IR) wireless communication
  - Broadcast Radio
  - Microwave Radio
  - Communications Satellites

1.8 Architecture of Mobile Computing

- Mobile Computing architecture uses the concept of 3 – tier architecture.

- The three tiers of Mobile Computing Architecture are:

  1. Presentation Tier
  2. Application Tier
  3. Data Tier

1.8 Architecture of Mobile Computing

- **Presentation Tier:**

- The first tier of the mobile computing architecture is Presentation Tier.
- This tier includes various applications that run on client machine.
- This tier is responsible for presenting Graphical User Interface(GUI) using which information can be collected from the user or information can be presented to the user.

1.8 Architecture of Mobile Computing

- **Application Tier:**

- The second tier of the mobile computing architecture is application tier.
- This tier is responsible for performing business logic and process management task.
- Business logic is responsible for obtaining information, validating information, processing information and presenting information to user.

1.8 Architecture of Mobile Computing

- **Data Tier :**

- The third tier of the mobile computing architecture is Data tier.
- This tier is responsible for storing and accessing data needed by the application.
- The data can be stored in database or files such as XML or text file.

1.9 Design Consideration for Mobile Computing

- The design consideration for developing mobile application is different than developing desktop application.

- Following are some of the design considerations for mobile application

  - Type of Application (Native or Mobile Web)
  - Target Device
  - User Experience
  - Resource Constraint
  - Multiple Platforms
  - Security
  - Network Communication

1.10 Characteristics of Mobile Communication

- Following are some of the characteristics of Mobile Computing:
  - User Mobility
  - Device Mobility
  - Network Mobility
  - Bearer Mobility
  - Session Mobility

1.11 Application of Mobile Communication

- In today's world almost all the people required mobile computing services in one or another way.
- Following are the application of Mobile Computing:
  - Manage Personal Record
  - Social Media and Group Message
  - Transaction
  - Mobile Shopping
  - Tele Banking
  - Entertainment
  - Alert & Notification
  - GPS Based Service
  - News & Media
  - Weather Forecast

1.12 Security Concerns related to Mobile Computing

- Mobile computing allows the facility of computing and communicating while moving from one place to another place.

- This can be achieved using wireless networks. So the security issues introduced in mobile computing are classified into following two categories:

1. Wireless Network Security issue
2. Mobile Device Security issue

1.12 Security Concerns related to Mobile Computing

1. Wireless Network Security issue :

- Denial of Service
- Traffic Analysis
- Eavesdropping
- Session Interception and Message Modification
- Spoofing
- Captured and Retransmitted Message
- Information Leakage

1.12 Security Concerns related to Mobile Computing

2. Mobile Device Security issue:

- Pull Attacks
- Push Attacks
- Forced De-authantication
- Multi protocol communication
- Mobility and Roaming
- Disconnections

1.13 Middleware & Gateway required for Mobile Computing

- **Middle Ware:** Middleware is software that provides a link between separate software applications.

- It is a layer that lies between the operating system and applications.

- **Usage:**

  - Provide the interaction with another service or application.
  - Filter the data to make them friendly usable.
  - Make an application independent from network services.
  - Make an application reliable and always available.
  - Add complementary attributes like semantics.

1.13 Middleware & Gateway required for Mobile Computing

- **Types of Middleware:**
  - Communication
  - Message Oriented
  - Object Oriented
  - Remote Procedure Call
  - Database Middleware
  - Transaction
  - Embedded
  - Content - Centric

1.13 Middleware & Gateway required for Mobile Computing

- **GateWay:**

- Gateways are required when the networks between device and middleware having different set of protocols.

- For example, An IVR Gateway is used to interface voice with Computer.

- WAP Gateway is used to access the internet on Mobile Phones.

1.14 Making Existing application Mobile Enable

- Because of the introduction of Smart phones and Tablets, it is required to make existing applications mobile enabled so they can be accessed using Smart Phones and Tablets.

- An existing application can be made mobile enabled using different ways:
  - Create a New Application
  - Enhance or Upgrade new Application
  - Buy an application from Vendors
  - Take an application on rent
  - Use Middleware

1.15 Mobile IP

- Mobile IP allows user to keep same IP address while roaming from home network to foreign network.

- **Components of Mobile IP network:**

1. **Mobile Node:** It is a device such as mobile phone, tablet or laptop having network roaming capabilities.
2. **Home Agent:** It is a router on the home network. It works as an anchor point for communication with mobile node.
3. **Foreign Agent:** It is a router on the foreign network. It works as a point of attachment for the mobile node when it roams to a foreign network.

1.15 Mobile IP

- **Working of Mobile IP**

- The working of Mobile IP involves following three basic functionalities:

➢ **Agent Discovery:** In this phase a Mobile Node discovers its Foreign and Home agents.

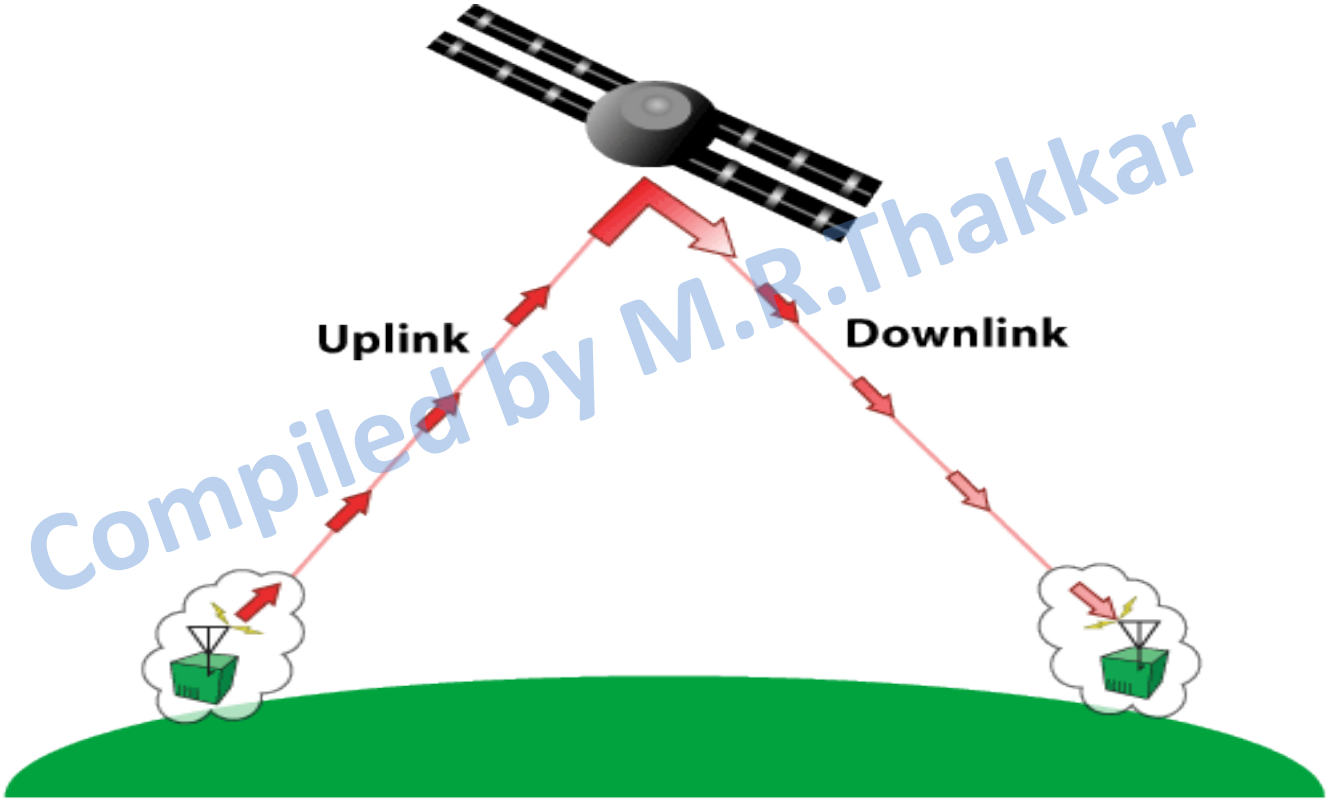
➢ **Registration:** In this Phase, Mobile Node registers its current location with Foreign agent and Home agent.

➢ **Tunneling:** During this phase, a tunnel is setup by the Home agent to the current location of the Mobile node on the foreign network to route packets to mobile node while roaming.

1.16 Mobile Communication via Satellite

- In satellite communication, signal transfer between sender and receiver through satellite.
- It requires transmitter station and receiver station to be setup on earth.
- Transmitter station on the earth send signals in the space towards satellite. This process is known as uplink.
- Upon receiving the signal from transmitter station, the satellite amplifies the signals and send back to receiver station on the earth. This process is known as downlink.

1.16 Mobile Communication via Satellite



1.16 Mobile Communication via Satellite

❑ Advantages of Satellite Communication

- **Flexibility** : It provides communication without the need of installing any fixed assets.
- **Mobility** : It can reach up to all the areas in the globe.
- **Global Coverage**: It can provide global coverage.
- **Fast Deployment**: Deployment of the satellite communication system is

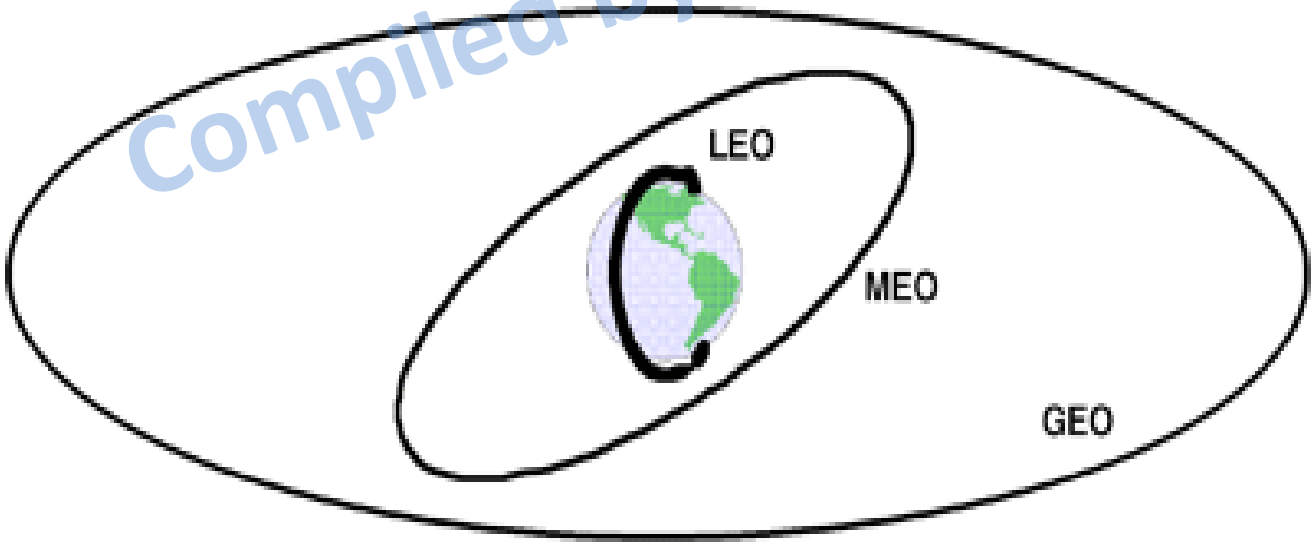
❑ Disadvantages of Satellite Communication

- **Costly** : It is very costly to build satellite, place them in space and maintain them.
- **Propagation Delay** : As it covers large distance, there might be an issue of propagation delay.
- **Requirement of Special Terminal** : It require special terminal to be set up in order to communicate with satellite.

1.16 Mobile Communication via Satellite

❑ Types of Satellite

- Low Earth Orbit (LEO) Satellite
- Medium Earth Orbit (MEO) Satellite
- Geostationary Earth Orbit (GEO) Satellite



1.16 Mobile Communication via Satellite

- 1.16.1 Low orbit Satellite

- The LEO satellite orbits in the range of 500 to 1500 km above the surface of earth.

- The orbital period of LEO satellite is about 10 to 40 minutes.

- As its orbital position is lower from the surface of the earth, it requires about 40 to 80 satellites to provide continuous coverage.

- LEO is used in telecommunication system to provide data communication such as email, video conferencing.

1.16 Mobile Communication via Satellite

- 1.16.2 Medium orbit Satellite

- The MEO satellite orbits in the range of 5000 to 12000 km above the surface of the earth.

- It orbits higher than LEO and lower than GEO, so it is known as Intermediate Circular Orbit (ICO).

- The orbital period of the MEO satellite is about 2 to 8 hours.

- As its orbital position is higher from the surface of the earth, it requires about 8 to 20 such satellites to provide continuous coverage.

- MEO is used for the Navigation.

1.16 Mobile Communication via Satellite

- 1.16.3 Geo stationary Satellite
- The GEO satellite orbits at the height of 36000 km above the surface of the earth.
- The orbital period of the GEO satellite is about 24 hours.
- As its orbital position is very high from the surface of the earth, it requires about 3 such satellites to provide continuous coverage.
- GEO satellite is used to handle communication up to large distance.

1.17 Satellite Phone Systems

- Three main satellite phone systems in use are:

  1. Iridium
  2. Global Star
  3. Thuraya

1.17 Satellite Phone systems

1. Iridium

- The Iridium satellite phone system uses total 66 active satellites in Low Earth Orbit.
- It is placed approximately 486 miles above the surface of the earth. So it provides orbiting time of 100 minutes.
- This system is used to provide voice and data communication to satellite phones.

1.17 Satellite Phone systems

2. Globalstar

- The Globalstar satellite system uses total 48 satellites in Low Earth Orbit.
- It is placed approximately 878 miles above the surface of the earth. So it provides an orbiting time of 2 hours.
- This system is used to provide voice and data communication to satellite phones.

1.17 Satellite Phone systems

3. Thuraya

- Thuraya satellite phone system uses only one satellite in Geostationary Earth Orbit instead of Low Earth Orbit satellite.
- It provides services through the network of service providers.
- Thuraya operates in dual mode operation. It does not operate only in satellite mode but also operates in GSM network.
- It is the system that provides services only in Asia and Africa.

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