UNIT V MULTI-USER RADIO COMMUNICATION INTRODUCTION:
Global system for mobile communication (GSM) is a globally accepted standard for digital cellular communication. GSM is the name of a standardization group established in 1982 to create a common European mobile telephone standard that would formulate specifications for a pan-European mobile cellular radio system operating at 900 MHz. It is estimated that many countries outside of Europe will join the GSM partnership.
Subscriber Identity Module (SIM). It is a memory device that stores information such as the subscribers identification number, the networks and countries where the subscriber is entitled to service, privacy tax and other user specific information A subscriber uses the SIM with a four digit personal ID number to activate service from GSM phone.

Advanced Mobile Phone Services (AMPS).

AMPS is a Standard Cellular Telephone Service (CTS). The AMPS system uses a seven cell reuse pattern with provisions for sectoring and cell splitting to increase channel when needed. AMPS uses frequency modulation and frequency division duplex for radio transmission.

- Advanced Mobile Phone Service (AMPS) is a standard system for analog signal cellular telephone service in the United States and is also used in other countries.
- It is based on the initial electromagnetic radiation spectrum allocation for cellular service by the Federal Communications Commission (FCC) in 1970. Introduced by AT&T in 1983, AMPS became one of the most widely deployed cellular system in the United States.
- AMPS allocates frequency ranges within the 800 and 900 Megahertz (MHz) spectrum to cellular telephone. Each service provider can use half of the 824-849 MHz range for receiving signals from cellular phones and half the 869-894 MHz range for transmitting to cellular phones.
- The bands are divided into 30 kHz sub-bands, called channels. The receiving channels are called reverse channels and the sending channels are called forward channels. The division of the spectrum into sub-band channels is achieved by using frequency division multiple access (FDMA).
- The signals received from a transmitter cover an area called a cell. As a user moves out of the cell's area into an adjacent cell, the user begins to pick up the new cell's signals without any noticeable transition.
- The signals in the adjacent cell are sent and received on different channels than the previous cell's signals to so that the signals don't interfere with each other.
- The analog service of AMPS has been updated with digital cellular service by adding to FDMA a further subdivision of each channel using time division multiple access (TDMA). This service is known as digital AMPS (D-AMPS). Although AMPS and D-AMPS originated for the North American cellular telephone market , they are now used worldwide with over 74 million subscribers, according to Ericsson, one of the major cellular phone manufacturers.

Handoffs

• When a user/call moves to a new cell, then a new base station and new channel should be assigned (handoff)
• Handoffs should be transparent to users, while their number should be kept to minimum

• A threshold in the received power (Pr, handoff) should be determined to trigger the handoff process. This threshold value should be larger than the minimum acceptable received power (Pr, acceptable)
• Define: Δ=Pr,handoff - Pr,acceptable
– If Δ is large then too many handoffs
– If Δ is small then insufficient time to complete a handoff
• In order to correctly determine the beginning of handoff, we need to determine that a drop in the signal strength is not due to the momentary (temporary) bad channel condition, but it is due to the fact that the mobile is moving away from BS.
• Thus the BS needs to monitor the signal level for a certain period of time before initiating a handoff. The length of the time (running average measurements of signal) and handoff process depends on speed and moving pattern.
• First generation systems typical time interval to make a handoff was 10 seconds (large Δ). Second generations and after typical time interval to make a handoff is 1-2 seconds (small Δ).
• **First generation systems:** handoff decision was made by BS by measuring the signal strength in reverse channels.
• **Second generation and after:** Mobile Assisted Hand-Off (MAHO).
Mobiles measure the signal strength from different neighboring BSs. Handoff is initiated if the signal strength from a neighboring BS is higher than the current BS's signal strength.

Cell Dwell Time

• It is the time over which a call maybe maintained within a cell (without handoff).
• It depends on: propagation, interference, distance between BS and MS, speed and moving pattern (direction), etc.
• Highway moving pattern: the cell dwell time is ar.v. with distribution highly concentrated around the mean.
• Other micro-cell moving patterns mix of different user types with large variations of dwell time (around the mean).

Prioritizing Handoffs

• **Guard Channels:** Fraction of total bandwidth in a cell is reserved for exclusive use of handoff calls. Therefore, total carried traffic is reduced if fixed channel assignment is used. However, if dynamic channel assignment is used the guard channel mechanisms may offer efficient spectrum utilization.
– Number of channels to be reserved: If it is low (under-reservation) the QoS on handoff call blocking probability can not be met. If reservation is high (over-reservation) may result in waste of resources and rejection of large number of new calls.
– Static and Dynamic schemes: Advantage of static scheme is its simplicity since no communication and computation overheads are involved.
• However problems of under- reservation and over reservations may occur if traffic does not conform to prior knowledge.

• Dynamic schemes may adjust better to changing traffic conditions.

Prioritizing Handoffs

• **Queuing Handoffs:** The objective is to decrease the probability of forced determination of a call due to lack of available channels. When a handoff call (and in some schemes a new call) can not be granted the required resources at the time of its arrival, the request is put in a queue waiting for its admitting conditions to be met.

– This is achieved because there is a finite time interval between the time that the signal of a call drops below the handoff threshold, and the time that the call is terminated due to low (unacceptable) signal level. Queuing and size of buffer depends on traffic and QoS. Queueing in wireless systems is possible because signaling is done on separate control channels (without affecting the data transmission channels).

• According to the types of calls that are queued, queuing priority schemes are classified as: handoff call queuing, new call queuing and handoff/new call queuing (handoff calls are given non-preemptive priority over new calls).

Practical Issues (Capacity/Handoff)

• To increase capacity, use more cells (add extra sites).

• Using different antenna heights and powers, we can provide ―large‖ and ―small‖ cells co-located at a signal location (it is used especially to handle high speed users and low speed users simultaneously.

• Reuse partitioning (use of different reuse patterns)

• Cell splitting: Change cell radius R and keep co-channel reuse ratio (D/R) unchanged. If R‘=R/2 than the transmit power needs to be changed by (1/2)4 = 1/16.

• Another way is to keep cell radius R unchanged and decrease D/R ratio required (that is decrease the number of cells in a cluster). To do this it is required to decrease interference without decreasing transmit power.

• Sectoring: Use directional antennas (instead of omni-directional) and therefore you receive interference from only a fraction of the neighboring cells.

• Hard handoffs vs. soft handoffs: more than one BSs handle the call during handoff phase (used in CDMA systems)

Super audio tone (SAT): SAT is superimposed on the voice signal on both the forward and reverse link and is barely audible to the user

• The particular frequency of the SAT denotes the particular base station location for a given channel and is assigned by the MSC for each call.

Global System for Mobile Communications (GSM)

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Throughout the evolution of cellular telecommunications, various systems havebeen developed without the benefit of standardized specificat ions. This presented many problems directly related to compatibility, especially with the development of digital radio technology. The GSM standard is intended to address these problems.

GSM network elements

GSM SERVICES

• Telephone Services

• Data Services

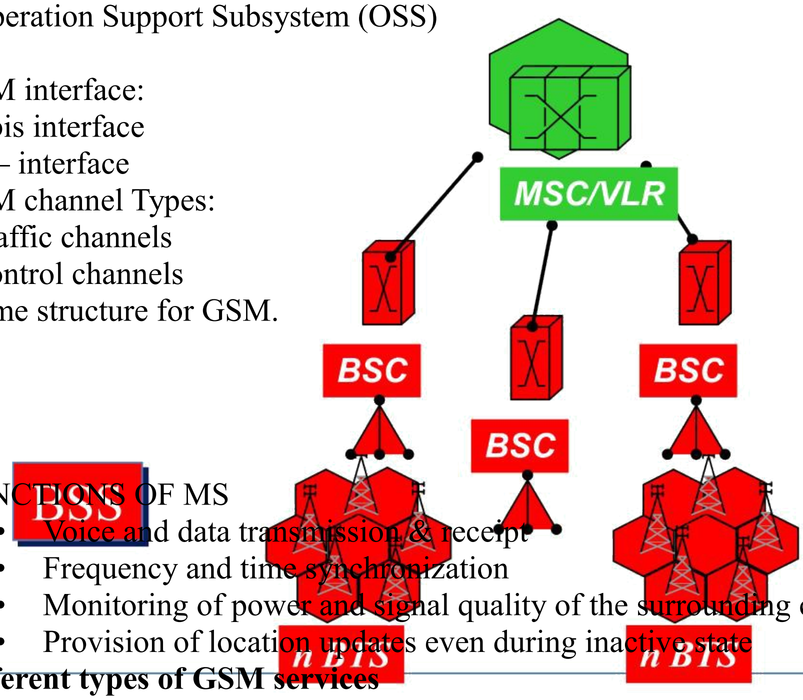
• Supplementary Services GSM Features:

GSM System Architecture:

• Base Station Subsystem (BSS)

• Network and Switching Subsystems (NSS)

BASE STATION SYSTEM (BSS)



• Operation Support Subsystem (OSS)

GSM interface:
• Abis interface
• A – interface
GSM channel Types:
• Traffic channels
• Control channels
Frame structure for GSM.

FUNCTIONS OF MS

- Voice and data transmission & receipt
- Frequency and time synchronization
- Monitoring of power and signal quality of the surrounding cells
- Provision of location updates even during inactive state

Different types of GSM services
• Telephone services
• Data services
• Supplementary services

Signaling tone :
The signaling tone is a 10 kbps data base which signals call termination by the subscriber. It is a special end of call message consisting of alternating 1s and 0s which is sent on the RVC by the subscriber unit for 200ms. The signaling tone alerts the base station that a subscriber has ended the call.

Telephone services in GSM: Teleservices provides communication between two end user applications according to a standard protocol. GSM mainly focuses on voice oriented tele services. This service includes emergency calling and facsimile. GSM also supports video text and tele text.

Features of CDMA
• Frequency reuse
• Soft capacity
• Multipath fading
• Data Rate
• Soft Handoff
• Self Jamming
• Flexibility.

SATELLITE COMMUNICATION

TYPES OF SATELLITES (BASED ON ORBITS) Geostationary or geosynchronous earth orbit (GEO)
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 (that is; their footprint is covering almost 1/3rd of the Earth). The orbit of these satellites is circular.

There are three conditions which lead to geostationary satellites. Lifetime expectancy of these satellites is 15 years.

1) The satellite should be placed 37,786 kms (approximated to 36,000 kms) above the surface of the earth.

2) These satellites must travel in the rotational speed of earth, and in the direction of motion of earth, that is eastward.

3) The inclination of satellite with respect to earth must be 00.

Geostationary satellite in practical is termed as geosynchronous as there are multiple factors which make these satellites shift from the ideal geostationary condition.

1) Gravitational pull of sun and moon makes these satellites deviate from their orbit. Over the period of time, they go through a drag. (Earth"s gravitational force has no effect on these satellites due to their distance from the surface of the Earth.)

2) These satellites experience the centrifugal force due to the rotation of Earth, making them deviate from their orbit.

3) 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.

Disadvantages of GEO:

Northern or southern regions of the Earth (poles) have more problems receiving these satellites due to the low elevation above a latitude of 60°, i.e., larger antennas are needed in this case. Shading of the signals is seen in cities due to high buildings and the low elevation further away from the equator limit transmission quality.

The transmit power needed is relatively high which causes problems for battery powered devices. These satellites cannot be used for small mobile phones. The biggest problem for voice and also data communication is the high latency as without having any handovers, the signal has to at least travel 72,000 kms.

Due to the large footprint, either frequencies cannot be reused or the GEO satellite needs special antennas focusing on a smaller footprint. Transferring a GEO into orbit is very expensive.

Low Earth Orbit (LEO) satellites:

These satellites are placed 500-1500 kms above the surface of the earth. As LEOs 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. The delay for packets delivered via a LEO is relatively low (approx 10 ms).

The delay is comparable to long-distance wired connections (about 5–10 ms). Smaller footprints of LEOs allow for better frequency reuse, similar to the concepts used for cellular networks. LEOs can provide a much higher elevation in Polar Regions and so better global coverage.

These satellites are mainly used in remote sensing an providing mobile communication services (due to lower latency).

Disadvantages:

The biggest problem of the LEO concept is the need for many satellites if global coverage is to be reached. Several concepts involve 50–200 or even more satellites in orbit.

The short time of visibility with a high elevation requires additional mechanisms for connection handover between different satellites.

The high number of satellites combined with the fast movements resulting in a high complexity of the whole satellite system.

One general problem of LEOs is the short lifetime of about five to eight years due to atmospheric drag and radiation from the inner Van Allen belt1. Assuming 48 satellites and a lifetime of eight years, a new satellite would be needed every two months.

The low latency via a single LEO is only half of the story. Other factors are the need for routing of data packets from satellite to if a user wants to communicate around the world.

Due to the large footprint, a GEO typically does not need this type of routing, as senders and receivers are most likely in the same footprint.

Medium Earth Orbit (MEO) satellites:

MEOs 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. These satellites move more slowly relative to the earth‟s rotation allowing a simpler system design (satellite periods are about six hours).

Depending on the inclination, a MEO can cover larger populations, so requiring fewer handovers.

Links in satellite communication

1. Uplink , 2. Downlink & 3. Crosslink.

Disadvantages:

Again, due to the larger distance to the earth, delay increases to about 70 – 80 ms. the satellites need higher transmit power and special antennas for smaller footprints

The three orbits of satellite. Low Earth orbit : Medium Earth orbit & Geosynchronous Earth orbit

Visitor location register (VLR)—The VLR is a database that contains temporary information about subscribers that is needed bythe MSC in order to service visiting subscribers. The VLR is always integrated with the MSC. When a mobile station roams into a new MSC area, the VLR connected to that MSC will request data about the mobile station from the HLR. Later, if the mobile station makes a call, the VLR will have the information needed for call setup without having to interrogate the HLR each time.

Mobile services switching center (MSC)—The MSC performs the telephony switching functions of the system. It controls calls to and from other telephone and data systems. It also performs such functions as toll ticketing, network interfacing, common channel signaling, and others.

Home location register (HLR)—The HLR is a database used for storage and management of subscriptions. The HLR is considered the most important database, as it stores permanent data about subscribers, including a subscriber's service profile, location information, and activity status. When an individual buys a subscription from one of the PCS operators, he or she is registered in the HLR of that operator.

Kepler’s laws of planetary motion

1. A satellite will orbit a primary body following an elliptical path

2. For equal intervals of time a satellite will sweep out equal areas in orbital plane
3. The square of the periodic time of orbit is proportional to the cube of the mean distance between the primary and the satellite.

The links in satellite communication?

i) Uplink
ii) Downlink iii) Crosslink

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 They are responsible for providing these services to an assigned region (area) on the earth. The power and bandwidth of these satellites depend upon the preferred size of the footprint, complexity of the traffic control protocol schemes and the cost of ground stations.

A satellite works most efficiently when the transmissions are focused with a desired area. When the area is focused, then the emissions don"t go outside that designated area and thus minimizing the interference to the other systems. This leads more efficient spectrum usage.

Satellite's antenna patterns play an important role and must be designed to best cover the designated geographical area (which is generally irregular in shape). Satellites should be designed by keeping in mind its usability for short and long term effects throughout its life time.

The earth station should be in a position to control the satellite if it drifts from its orbit it is subjected to any kind of drag from the external forces.

Kepler's laws:

Kepler's first law

A satellite will orbit a primary body following an elliptical path

Kepler's second law

For equal intervals of time a satellite will sweep out equal areas in orbital plane

Kepler's third law

The square of the periodic time of orbit is proportional to the cube of the mean distance between the primary and the satellite

Bluetooth

Bluetooth is a standard developed by a group of electronics manufacturers that allows any sort of electronic equipment from computers and cell phones to keyboards and headphones to make its own connections, without wires, cables or any direct action from a user. Bluetooth is intended to be a standard that works at two levels.

Bluetooth is a wireless technology standard for exchanging data over short distances (using short-wavelength UHF radio waves in the ISM band from 2.4 to 2.485 GHz) from fixed and mobile devices, and building personal area networks (PANs). Invented by telecom vendor Ericsson in 1994, it was originally conceived as a wireless alternative to RS-232 data cables. It can connect several devices, overcoming problems of synchronization.

Bluetooth is managed by the Bluetooth Special Interest Group (SIG), which has more than 20,000 member companies in the areas of telecommunication, computing, networking, and consumer electronics. Bluetooth was standardized as **IEEE 802.15.1**, but the standard is no longer maintained. The SIG oversees the development of the specification, manages the qualification program, and protects the trademarks. To be marketed as a Bluetooth device, it must be qualified to standards defined by the SIG. A network of patents is required to implement the technology, which is licensed only for that qualifying device.

Bluetooth operates in the range of 2400–2483.5 MHz (including guard bands). This is in the globally unlicensed (but not unregulated) Industrial, Scientific and Medical (ISM) 2.4 GHz short-range radio frequency band. Bluetooth uses a radio technology called frequency-hopping spread spectrum. The transmitted data are divided into packets and each packet is transmitted on one of the 79 designated Bluetooth channels. Each channel has a bandwidth of 1 MHz. Bluetooth 4.0 uses 2 MHz spacing which allows for 40 channels. The first channel starts at 2402 MHz and continues up to 2480 MHz in 1 MHz steps. It usually performs 1600 hops per second, with Adaptive Frequency-Hopping (AFH) enabled.

Bluetooth profiles

To use Bluetooth wireless technology, a device has to be able to interpret certain Bluetooth profiles, which are definitions of possible applications and specify general behaviours that Bluetooth enabled devices use to communicate with other Bluetooth devices. These profiles include settings to parametrize and to control the communication from start. Adherence to profiles saves the time for transmitting the parameters anew before the bi-directional link becomes effective. There are a wide range of Bluetooth profiles that describe many different types of applications or use cases for devices.[19][20]

List of applications

A typical Bluetooth mobile phone headset.

- Wireless control of and communication between a mobile phone and a handsfree headset. This was one of the earliest applications to become popular.
- Wireless control of and communication between a mobile phone and a Bluetooth compatible car stereo system.
- Wireless control of and communication with tablets and speakers such as iPad and Android devices.
- Wireless Bluetooth headset and Intercom. Idiomatically, a headset is sometimes called "a Bluetooth".
- Wireless networking between PCs in a confined space and where little bandwidth is required.
- Wireless communication with PC input and output devices, the most common being the mouse, keyboard and printer.

- Transfer of files, contact details, calendar appointments, and reminders between devices with OBEX.
- Replacement of previous wired RS-232 serial communications in test equipment, GPS receivers, medical equipment, bar code scanners, and traffic control devices.
- For controls where infrared was often used.
- For low bandwidth applications where higher USB bandwidth is not required and cable-free connection desired.
- Sending small advertisements from Bluetooth-enabled

advertising hoardings to other, discoverable, Bluetooth devices.[21]

- Wireless bridge between two Industrial Ethernet (e.g., PROFINET) networks.
- Three seventh and eighth generation game consoles, Nintendo's Wii.[22] and Sony's PlayStation 3, use Bluetooth for their respective wireless controllers.
- Dial-up internet access on personal computers or PDAs using a data-capable mobile phone as a wireless modem.
- Short range transmission of health sensor data from medical

devices to mobile phone, set-top box or dedicated telehealth devices.[23]

- Allowing a DECT phone to ring and answer calls on behalf of a nearby mobile phone.
- Real-time location systems (RTLS), are used to track and identify the location of objects in real-time using “Nodes” or “tags” attached to, or embedded in the objects tracked, and “Readers” that receive and process the wireless signals from these tags to determine their locations.
- Personal security application on mobile phones for prevention of theft or loss of items. The protected item has a Bluetooth marker (e.g., a tag) that is in constant communication with the phone. If the connection is broken (the marker is out of range of the phone) then an alarm is raised. This can also be used as a man

overboard alarm. A product using this technology has been available since 2009.[25]

- Calgary, Alberta, Canada's Roads Traffic division uses data

collected from travelers' Bluetooth devices to predict travel times and road congestion for motorists.