SYLLABUS
[Academic Session: 2016–17]

WIRELESS COMMUNICATION [ETEC-405]

Instructions to Paper Setters:

1. *Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.*
2. *Apart from Question. No. 1 rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be of 12.5 marks.*

Objective: The objective of the course is to introduce various wireless networks, mobile networks and their basic architecture starting from 2G through to 3G and 4G.

UNIT I

Introduction To Wireless Communication Systems: Evolution of mobile radio communications; examples of wireless comm. systems; paging systems; Cordless telephone systems; overview of generations of cellular systems, comparison of various wireless systems.

Introduction to Personal Communication Services (PCS): PCS architecture, Mobility management, Networks signaling. A basic cellular system, multiple access techniques: FDMA, TDMA, CDMA.

Introduction to Wireless Channels and Diversity: Fast Fading Wireless Channel Modeling, Rayleigh/Ricean Fading Channels, BER Performance in Fading Channels, Introduction to Diversity modeling for Wireless Communications

[T1,T2][No. of Hrs. 11]

UNIT II

2G Networks: Second generation, digital, wireless systems: GSM, IS_136 (D-AMPS), IS-95 CDMA. Global system for Mobile Communication (GSM) system overview: GSM Architecture, Mobility Management, Network signaling, mobile management, voice signal processing and coding. **Spread Spectrum Systems-**Cellular code Division Access Systems-Principle, Power Control, effects of multipath propagation on code division multiple access.

[T1,T2][No. of Hrs. 11]

UNIT III

2.5G Mobile Data Networks: Introduction to Mobile Data Networks, General Packet Radio Services (GPRS): GPRS architecture, GPRS Network nodes, EDGE, Wireless LANs, (IEEE 802.11), Mobile IP.

Third Generation (3G) Mobile Services: Introduction to International Mobile Telecommunications 2000 (IMT 2000) vision, Wideband Code Division Multiple Access (W-CDMA), and CDMA 2000, Quality of services in 3G, Introduction to 4G.

[T1,T2][No. of Hrs. 11]

UNIT IV

Wireless Local Loop (WLL): Introduction to WLL architecture, WLL technologies. Wireless personal area networks (WPAN): Blue tooth, IEEE 802.15, architecture, protocol stack. Wi-Max, introduction to Mobile Adhoc Networks.

Global Mobile Satellite Systems, Case studies of IRIDIUM and GLOBALSTAR systems.

[T1,T2][No. of Hrs. 11]

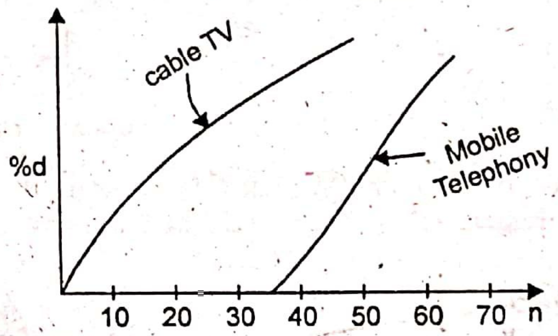
MODEL PAPER–I
FIRST TERM EXAMINATION
SEVENTH SEMESTER [B.TECH]
WIRELESS COMMUNICATION [ETEC-405]

Time : 1½ hrs. **M.M. :30**

Note: *Ques no.1 is compulsory and attempt any two from the rest. In all attempt 3 ques.*

Q.1. Graphically indicate the growth of mobile telephony.

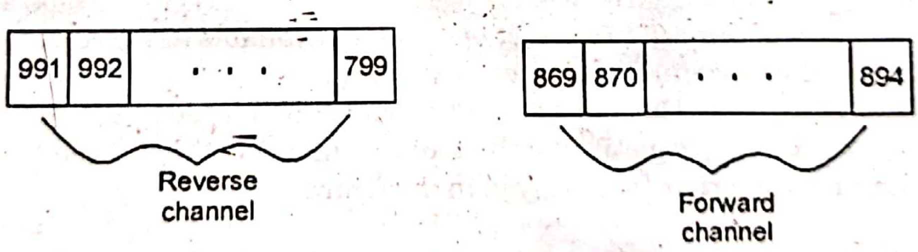
Ans. Mobile telephony have grown in a fastest way & the following graph indicate it.



n: No. of years after the first deployment %d: percent market penetration.

Q.1. (*b*) Indicate the band frequencies of Forward channel & Reverse channel.

Ans. In the band of 800 to 990 MHz the channels are allocated as shown below



Q.1. (*c*) Briefly explain CDMA development.

Ans. CDMA system was developed by Qual Comm. It was standardized by Telecommunication Industry Association (TIA) as an interim standard (IS-95). This system supports a variable no. of users in 1.25 MHz wide channel using direct sequence spread spectrum.

CDMA can operate with a much smaller signal to noise ratio (SNR) than conventional narrow band FM

Q.1. (*d*) Explain the paging system briefly.

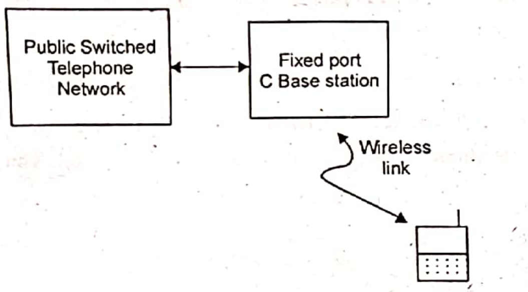
Ans. This is a type of communication system that send brief messages to a subscriber. Depending on the type of service, the message may be of Numeric or alfa-numeric type, or a voice message.

A page is sent to the subscriber which may be in a form to call at some number.

Scanned by CamScanner

Q.2. (a) Explain the cordless telephone system.

Ans. These are of full duplex type of communication system that use radio to connect a portable handset to a dedicated base station which is then connected to a dedicated telephone line with a specific telephone number on the public switched telephone network (PSTN)



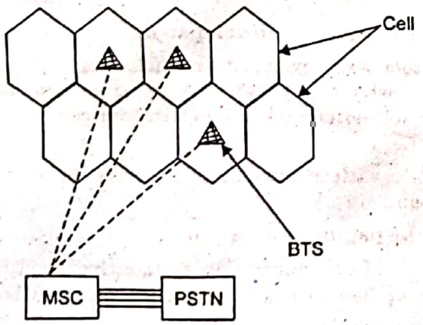
In the first generation telephone system (manufactured in 1980) portable unit used to communicate only to the dedicated base unit & only over a distance of upto few hundred of meters.

Early cordless telephone operates solely as extension telephones to a tranceiver connected to a subscriber line to the PSTN and are used primarily for in home use.

Q.2. (b) Explain the basics of cellular telephone systems.

Ans. Here in this system the telephony services & other value added services are provided on the basic of a cellular structure.

Here the geographic region of interest is divided in small regions (cells) and a BTS is used at the centre of this cell to connect to the users available in the region. Height of the antennas used determines the range of communication. It provides flexibility & mobility to the users when the users are not moving a high speed, then the quality of service (voice or data) is comparable to those of landline networks. Basic schematic of cellular Communication is as follow, given in the figure.



BTS are used to communicate with MSC & users, then the call is routed to PSTN.

MSC stands for mobile switching centre or Mobile services switching centre more precisely.

Q.3. (a) Compare the different wireless Communication systems.

Ans. On the different parameters available we can do comparison as follow:

Service	Coverage Range	Infra-structure	Carrier frequency	Functionality
TV Remote Control	Low	Low	Infrared	Transmitter
Paging System	High	High	< 1 GHz	Receiver
Cordless phone Cellular Phone	Low	Low	1-3 GHz	Transceiver

Q.3. (b) Explain the radio propagation mechanism.

Ans. Radio Propagation depends on the frequency being used & the type of atmospheric conditions prevailing. This can be divided among the following categories:

(1) Free Space Propagation: Here the radio signal travels through the open space. The distance coming in between the transmitter and receiver acts as the major loss for the strength of radio signal satellite communication is a major application for this type of communication

(2) Ground wave Propagation: This mechanism of propagation occurs for the frequencies below 2MHZ. During the propagation, the signal follows the curvature of earth. The signals heard during the day time on the medium waveband are using this way of propagation.

(3) Ionospheric Propagation: This is also known as sky wave propagation. This is used for a range of 2 to 30 MHz. Here the radio signal is reflected from the ionosphere towards the earth surface.

(4) Troposphere Propagation: Here the signal travels through the troposphere where there is a significant change in refractive index of the air medium]

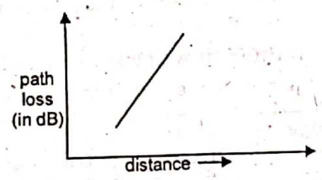
Q.4. (a) Explain the path loss law.

Ans. This law says that the power radiated from the surface of the antenna, falls as an inverse function of the distance, and follows the inverse square law (d^{-2}), received power is expressed in dB as

$$P_r = P_t - 20\log\left(\frac{d}{\lambda/4\pi}\right)$$

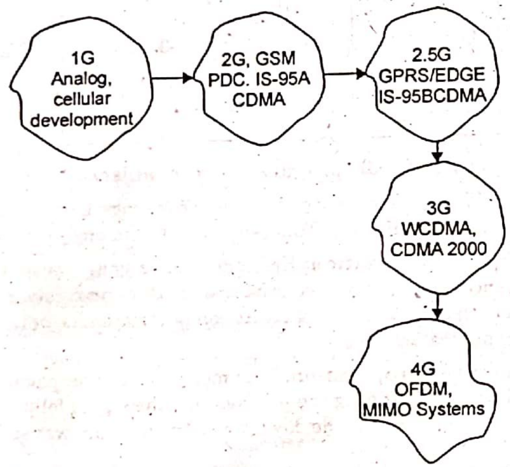
because of this reason, this is also called as the 20 log(d) path loss law. The received power at any distance d_o and the power received at any other distance (d) is related as follows:

$$P_r(d) = P_r(d_o)\left(\frac{d_o}{d}\right)^2 \quad d \geq d_o \geq d_f$$



Q.4. (*b*) Explain the evolution of wireless Communication systems.

Ans. Initially the wireless system used to be of analog nature, where telephony was meant for voice only then other value added services were introduced as shown below:



As the new generations come the data rate kept on increasing.

Higher generation were used for the multimedia applications which required higher data rate. Data rate is also a close function of the Modulation techniques used and the bandwidth provided. In 2G and 2.5G the data rate ranges upto 100Kb while in the case of 3G the data rate can range upto 20 Mbps.

In 4G data rate is sufficiently high of the order of 100 Mbps.

MODEL PAPER–I
SECOND TERM EXAMINATION
FIFTH SEMESTER [B.TECH.]
WIRELESS COMMUNICATION [ETEC-405]

Time : 1½ hrs. **M.M. :30**

Note: *Ques no.1 is compulsory and attempt any two from the rest. In all attempt 3 ques.*

Q.1. (*a*) Explain Pilot Channel.

Ans. Pilot channel is a reference channel using the mobile station to acquire the time and as a phase reference for coherent demodulation. It is continuously transmitted by each base station on each active CDMA frequency. Each mobile station tracks this signal continuously.

Q.1.(*b*) Explain Paging Channel.

Ans. Paging Channels' main objective is to send out pages, that is, notifications of incoming calls, to the mobile stations. The base station uses these pages to transmit system overhead information and mobile station specific messages.

Q.1. (*c*) What is the Function of IMSI?

Ans. The mobile stations are identified by the identity of the international mobile station (IMSI). The IMSI consists of up to 15 numerical characters (0- 9). The first three digits of the IMSI is the country code of the mobile (MCC), the remaining digits are the National NMSI mobile station identity.

The NMSI consists of the mobile network code (MNC) and the mobile station identification number (SIDS). An IMSI is 15 digits in length is called a class 0 IMSI (NMSI is the 12 digits in length). IMSI, which is less than 15 digits in length, is a class called IMSI (NMSI the length is less than 12 counts).

For CDMA operation, the same IMSI may be registered in multiple mobile stations. Individual systems may or may not allow these capabilities. The management of these functions is a function of the base station and the system operator.

Q.1.(*d*) What is TDD and what are the Frequencies it uses?

Ans. TDD is Time Division Duplex. A duplex method by which the Uplink and the Downlink transmissions are carried over the same frequency using synchronized time intervals. The carrier uses a 5 MHz band, although there is a low chip rate solution under study by the 3GPP (1.28 Mcps). The available frequency bands for TDD will be 1900-1920 MHz and 2010-2025 MHz.

Q.2. (*a*) What are the key features of GPRS?

Ans.

1. The always online feature - Removes the dial-up process, making applications only one click away.

2. An upgrade to existing systems - Operators do not have to replace their equipment; rather, GPRS is added on top of the existing infrastructure. An integral part of future 3G systems - GPRS is the packet data core network for 3G systems EDGE and WCDMA.

Q.2. (b) Explain the advantage of GPRS.

Ans. 1. Higher Data rate: GPRS benefits the users in many ways, one of which is higher data rates in turn of shorter access times. In the typical GSM mobile, setup alone is a lengthy process and equally, rates for data permission are restrained to 9.6 kbit/s. The session establishment time offered while GPRS is in practice is lower than one second and ISDN-line data rates are up to many 10 kbit/s.

2. Easy Billing: GPRS packet transmission offers a more user-friendly billing than that offered by circuit switched services. In circuit switched services, billing is based on the duration of the connection. This is unsuitable for applications with bursty traffic. The user must pay for the entire airtime, even for idle periods when no packets are sent (e.g., when the user reads a Web page).

In contrast to this, with packet switched services, billing can be based on the amount of transmitted data. The advantage for the user is that he or she can be "online" over a long period of time but will be billed based on the transmitted data volume.

Q.3. (a) Explain the third generation standards.

Ans. Third Generation Standards: CDMA2000 uses Frequency Division Duplexing-Multicarrier (FDD-MC) mode. Here, multicarrier implies N × 1.25 MHz channels overlaid on N existing IS-95 carriers or deployed on unoccupied spectrum. CDMA2000 includes +

- 1x — uses a spreading rate of 1.2288 Mcps.
- 3x — uses a spreading rate of 3 × 1.2288 Mcps or 3.6864 Mcps.
- 1xEV-DO (1x Evolution – Data Optimized) — uses a spreading rate of 1.2288 Mcps, optimized for the data.

WCDMA/FDD-DS — Wideband CDMA (WCDMA) Frequency Division Duplexing-Direct Sequence spreading (FDD-DS) mode. This has a single 5 MHz channel. WCDMA uses a single carrier per channel and employs a spreading rate of 3.84 Mcps

Q.3. (b) Explain the features of forward and reverse channels used in wireless communication.

Ans. Features of forward and reverse channels are given as follow:

1. Forward Channel: The Forward channel is the direction of the communication or mobile-to-cell downlink path. It includes the following channels –

- **Pilot Channel** – Pilot channel is a reference channel. It uses the mobile station to acquire the time and as a phase reference for coherent demodulation. It is continuously transmitted by each base station on each active CDMA frequency. And, each mobile station tracks this signal continuously.
- **Sync Channel** – Synchronization channel carries a single, repeating message, which gives the information about the time and system configuration to the mobile station. Likewise, the mobile station can have the exact system time by the means of synchronizing to the short code.
- **Paging Channel** – Paging Channel's main objective is to send out pages, that is, notifications of incoming calls, to the mobile stations. The base station uses these pages to transmit system overhead information and mobile station specific messages.
- **Forward Traffic Channel** – Forward Traffic Channels are code channels. It is used to assign calls, usually voice and signaling traffic to the individual users.

2. Reverse Channel: The Reverse channel is the mobile-to-cell direction of communication or the uplink path. It consists of the following channels –

- **Access Channel** – Access channel is used by mobile stations to establish a communication with the base station or to answer Paging Channel messages. The access channel is used for short signaling message exchanges such as call-ups, responses to pages and registrations.
- **Reverse Traffic Channel** – Reverse traffic channel is used by the individual users in their actual calls to transmit traffic from a single mobile station to one or more base stations.

The possibility to operate in either FDD or TDD mode is allowed for efficient use of available spectrum according to frequency allocation in different regions.

Q.4. (a) Explain Processing Gain in CDMA.

Ans. P (gain) = 10log (W/R)

W is Spread Rate

R is Data Rate

For CDMA P (gain) = 10log (1228800/9600)

= 21dB

Actual processing gain = P (gain) - SNR

= 21 – 7 = 14dB

CDMA uses variable rate coder

The Voice Activity Factor of 0.4 is considered = -4dB.

CDMA has 100% frequency reuse. Use of same frequency in surrounding cells causes some additional interference.

In CDMA, frequency reuse efficiency is 0.67 (70% eff.) = -1.73dB

Q.4. (b) What are the Differences between CDMA and FDMA?

Ans. CDMA works on code basis and operation is totally on digital basis while FDMA works on getting channels from the allocated band. Main difference between CDMA and FDMA are ven in the following table:

CDMA	FDMA
1. The same frequency is used by each user	1. When the channel is not used, it is the channel bandwidth while rest simply is relatively narrow (30 KHz), known as **System narrowband.**
2. Simultaneous transmission occurs and each narrowband signal is multiplied by spreading the broadband signal, usually called code word.	2. Little or no equalization is needed.
3. Each user has a separate code pseudo-word that is orthogonal to the other. Only the desired code word is detected by receivers and the other code appears as noise.	3. For broadcasting, time symbols are suitable analogue links.
4. It is mandatory for the receivers to know about the issuer code word.	4. Framing for FDMA or synchronization bits are not needed for the tight filter streaming. It is required to minimize the combined interference of FDD.

MODEL PAPER–I
END TERM EXAMINATION
SEVENTH SEMESTER [B.TECH]
WIRELESS COMMUNICATION [ETEC-405]

Time : 3 hrs. M.M. 75

Note: *Attempt any five questions including Q. No. 1, which is compulsory.*

Q.1. (*a*) What is Hard Handover? Explain.

Ans. In FDMA or TDMA cellular system, new communication establishes after breaking current communication at the moment doing handoff. Communication between MS and BS breaks at the moment switching frequency or timeslot which is known as hard handover.

Q.1.(*b*) What is Power Control?

Ans. Power control is the intelligent selection of transmit power in a communication system for achieving best performance within the system. The performance depends on context and there are chances to include optimizing metrics like link data rate, network capacity, geographic coverage, and range. A higher transmit power translates into a higher signal power at the receiver.

Q.1. (*c*) What is Reverse Link Power Control? Explain.

Ans. The power of closed loop control is used to compensate for the rapid Rayleigh discoloration. This time, the mobile transmitted power is controlled by the base station. For this purpose, the base station continuously monitors the reverse link signal quality. If the quality of the connection is poor then the base station increases the power. Similarly, if the quality of the link is very high then the mobile base station controller reduces the power. This is called as reverse link power control.

Q.1.(*d*) What is Forward Link Power Control? Explain.

Ans. Similar to reverse link power control, forward link power control is also necessary to maintain the forward link quality to a specified level. This time, the mobile monitors the forward link quality and indicates to the base station to turn on or off, this power control has no effect on the near-far problem because all the signals are blurred together the same level of power when they get to the mobile. In short, there is no near-far problem in the forward link.

Q.1.(*e*) Explain the Effects of Power Control.

Ans. There are following effects of power control:

- Power control is capable of compensating the fading fluctuation.
- Received power from all MS are controlled to be equal.
- Near-Far problem is mitigated by the power control.

Q.1.(*f*) How many Channels are there in CDMA Forward Channels?

Ans. Forward channel consists of four channels which includes –

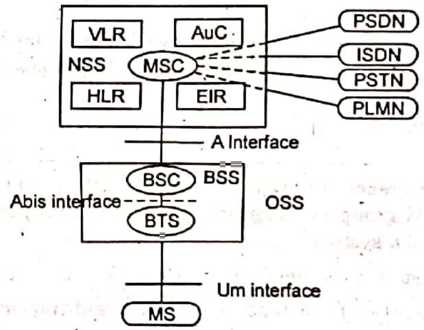
- Pilot Channel,
- Sync Channel,
- Paging Channel, and Forward Traffic Channels.

Q.2. (*a*) Explain the different features of GSM architecture?

Ans. A GSM network comprises of many functional units. These functions and interfaces are explained in this chapter. The GSM network can be broadly divided into:

- The Mobile Station (MS)
- The Base Station Subsystem (BSS)
- The Network Switching Subsystem (NSS)
- The Operation Support Subsystem (OSS)

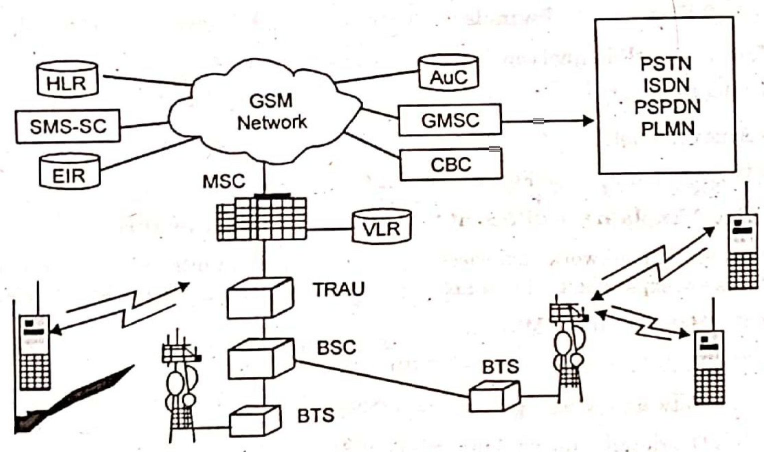
Given below is a simple pictorial view of the GSM architecture.



The additional components of the GSM architecture comprise of databases and messaging systems functions:

- Home Location Register (HLR)
- Visitor Location Register (VLR)
- Equipment Identity Register (EIR)
- Authentication Center (AuC)
- SMS Serving Center (SMS SC)
- Gateway MSC (GMSC)
- Chargeback Center (CBC)
- Transcoder and Adaptation Unit (TRAU)

The following diagram shows the GSM network along with the added elements:



The MS and the BSS communicate across the Um interface. It is also known as the *air interface* or the *radio link*. The BSS communicates with the Network Service Switching (NSS) center across the *A* interface

Q.2. (*b*) Enlist the historical events for the development of GSM.

Ans. The following table shows some of the important events in the rollout of the GSM system.

Years	Events
1982	Conference of European Posts and Telegraph (CEPT) establishes a GSM group to widen the standards for a pan-European cellular mobile system.
	A list of recommendations to be generated by the group is accepted.
1985	
1986	Executed field tests to check the different radio techniques recommended for the air interface.
1987	Time Division Multiple Access (TDMA) is chosen as the access method (with Frequency Division Multiple Access [FDMA]). The initial Memorandum of Understanding (MoU) is signed by telecommunication operators representing 12 countries.
1988	GSM system is validated.
1989	The European Telecommunications Standards Institute (ETSI) was given the responsibility of the GSM specifications.
1990	Phase 1 of the GSM specifications is delivered.
1991	Commercial launch of the GSM service occurs. The DCS1800 specifications are finalized.
1992	The addition of the countries that signed the GSM MoU takes place. Coverage spreads to larger cities and airports.
1993	Coverage of main roads GSM services starts outside Europe.
1994	Data transmission capabilities launched. The number of networks rises to 69 in 43 countries by the end of 1994.
1995	Phase 2 of the GSM specifications occurs. Coverage is extended to rural areas.
1996	June: 133 network in 81 countries operational.
1997	July: 200 network in 109 countries operational, around 44 million subscribers worldwide.
1999	Wireless Application Protocol (WAP) came into existence and became operational in 130 countries with 260 million subscribers.
2000	General Packet Radio Service(GPRS) came into existence.
2001	As of May 2001, over 550 million people were subscribers to mobile telecommunications.

Q.3. (*a*) Explain the working of High-Speed Circuit Switched Data in GSM Technology.

Ans. HSCSD (High-Speed Circuit Switched Data) is a natural evolution of the existing circuit-switched data capability of traditional 2G GSM networks. With today's GSM network standards, it is already possible to transmit narrowband data and digital fax over the TDMA air interface. The methodology is akin to setting up a GSM voice call or perhaps to making a connection over a fixed line PSTN with the use of a modem. The user establishes a connection (or circuit) for the whole duration of that communication session. To set up the circuit, a call set-up process is involved when dialling the called party; network resources are allocated along the path to the end destination.

Within the existing GSM encoding techniques, the maximum circuit-switched data (CSD) speed is 9.6 Kbit/s or with improved encoding, up to 14.4 Kbit/s. The GSM TDMA interfaces can assign up to 8 time division slots per user frequency, not all of which are always used. Typically one is allocated for voice, while other slots may be allocated for fax and data. The availability of these time slots makes it possible to expand the existing CSD into HSCSD. The transition to HSCSD is not a difficult one for an existing 2G operator, and typically only necessitates a software upgrade of the Base Stations Systems (BSS) and Network and Switching System (NSS) systems.

A potential technical difficulty with HSCSD arises because in a multi-timeslot environment, dynamic call transfer between different cells on a mobile network (called 'handover') is complicated, unless the same slots are available end-to-end throughout the duration of the circuit switched data call. The second issue is that circuit switching in general is not efficient for bursty data/Internet traffic. The allocation of more circuits for data calls, with typically longer 'hold' times than for voice calls, creates the same problems that fixed line PSTN operators have experienced with the tremendous growth of Internet traffic – i.e., too few resources in their circuit switched networks

Q.3. (*b*) Indicate the radio spectrum band usage in GSM.

Ans. The ITU, which manages the international allocation of radio spectrum, allocated the 890-915 MHz bands for the uplink (mobile station to base station) and 935-960 MHz bands for the downlink (base station to mobile station) for mobile networks in Europe. "..Since this range was already being used in the early 1980s by the analog systems of the day, the CEPT had the foresight to reserve the top 10 MHz of each band for the GSM network that was still being developed."[1] It should be noted that the World Radio-Communications Conference (WRC) in 1992 identified frequency bands for FPLMTS (Future Public Land Mobile Telecommunications Systems), which is in fact the original name of IMT-2000 (UMTS).[2] The existing second-generation bands for second-generation GSM services consist of spectrum between 862 and 960 MHz and the totality of the GSM1800 band 1710 - 1880 MHz.

Q.4. Explain the EDGE Technology?

Ans. EDGE(Enhanced Data for GSM Evolution): Enhanced Data rates for Global Evolution (EDGE) is a radio based high-speed mobile data standard that allows data transmission speeds of 384 Kbit/s to be achieved when all eight timeslots are used. EDGE was formerly called GSM384, and is also recognized as 'UWC-136' under the ITU's specifications for IMT-2000. It was initially developed for mobile network operators who failed to win spectrum for third generation networks, and is a cost-efficient way of migrating to full-blown 3G services. It gives incumbent GSM operators the opportunity to offer data services at speeds that are near to those available on UMTS networks.

EDGE does not change much of the core network, however, which still uses GPRS/GSM. Rather, it concentrates on improving the capacity and efficiency over the air interface by introducing a more advanced coding scheme where every time slot can transport more data. In addition, it adapts this coding to the current conditions, which means that the speed will be higher when the radio reception is good. Implementation of EDGE by network operators has been designed to be simple, with only the addition of one extra EDGE transceiver unit to each cell. With most vendors, it is envisaged that software upgrades to the BSCs and Base Stations can be carried out remotely. The new EDGE capable transceiver can also handle standard GSM traffic and automatically switches to EDGE mode when needed. 'EDGE-capable' terminals are also needed, since existing GSM terminals do not support new modulation techniques, and need to be upgraded to use EDGE network functionality.

EDGE can provide an evolutionary migration path from GPRS to UMTS by more expeditiously implementing the changes in modulation that are necessary for implementing UMTS later. The main idea behind EDGE is to squeeze out even higher data rates on the current 200 kHz GSM radio carrier, by changing the type of modulation used, whilst still working with current circuit (and packet) switches.

In addition, the TDMA industry association, the "Universal Wireless Communications Corporation", has introduced what it calls EDGE Compact. This is an even more spectrum-efficient version of EDGE that will support the 384 Kbit/s mandated packet data rates, whilst requiring only minimum spectral clearing. In fact, as a result of this, EDGE has been renamed Enhanced Data Rates for GSM and TDMA Evolution. EDGE is planned to be commercially available end of year 2001.

When describing the services to which 3G technologies aspire, it is crucial to bear in mind that there is a difference between what is possible in reality and what is 'hype' vis-à-vis data speeds. That said, however any reference to 'hype', is by definition a reference to the expectations of 3G created largely from the press and other sources less likely to have significant technical mastery of the respective systems. The ITU from the early

phases of IMT-2000 development, has given unambiguous recommendations for the exact testing conditions under which various technical specifications for systems have been developed. How these recommendations have been commonly translated for the mass market, however, has resulted in somewhat 'less-than-scientific' evaluations, which in turn has contributed to the afore-mentioned 'hype'

Q.5.(*a*) What is Spread Spectrum Technique?

Ans. Spread spectrum is a form of wireless communications in which the frequency of the transmitted signal is deliberately varied. This results in a much greater bandwidth than the signal would have, if its frequency were not varied. In other words, the transmitted signal bandwidth is greater than the minimal information bandwidth needed to successfully transmit the signal. Some function other than the information itself is being employed to determine the resultant transmitted bandwidth.

Q.5. (*b*) Enlist the important features of GSM Technology.

Ans. If you are in Europe or Asia and using a mobile phone, then most probably you are using GSM technology in your mobile phone.

• GSM stands for Global System for Mobile Communication. It is a digital cellular technology used for transmitting mobile voice and data services.

• The concept of GSM emerged from a cell-based mobile radio system at Bell Laboratories in the early 1970s.

• GSM is the name of a standardization group established in 1982 to create a common European mobile telephone standard.

• GSM is the most widely accepted standard in telecommunications and it is implemented globally.

• GSM is a circuit-switched system that divides each 200 kHz channel into eight 25 kHz time-slots. GSM operates on the mobile communication bands 900 MHz and 1800 MHz in most parts of the world. In the US, GSM operates in the bands 850 MHz and 1900 MHz.

• GSM owns a market share of more than 70 percent of the world's digital cellular subscribers.

• GSM makes use of narrowband Time Division Multiple Access (TDMA) technique for transmitting signals.

• GSM was developed using digital technology. It has an ability to carry 64 kbps to 120 Mbps of data rates.

• Presently GSM supports more than one billion mobile subscribers in more than 210 countries throughout the world.

• GSM provides basic to advanced voice and data services including roaming service. Roaming is the ability to use your GSM phone number in another GSM network.

GSM digitizes and compresses data, then sends it down through a channel with two other streams of user data, each in its own timeslot.

Q.6. (*a*) What is Walsh Code? Explain.

Ans. Walsh Codes are most commonly used in CDMA applications orthogonal codes. These codes correspond to lines of a special square matrix called the Hadamard matrix. For a set of Walsh codes of length N, it consists of n lines to form a square matrix of $n \times n$ Walsh code. The IS-95 system uses 64 Walsh function matrix 64. The first line of this matrix contains a string of all zeros with each of the following lines containing different combinations of bit 0 and 1. Each line is orthogonal and equal representation for binary bits. When implemented with the CDMA system, each mobile user uses one of the 64 sequences of rows in the matrix as a spreading code, providing zero cross-correlation among all the other users.

Q.6. (*b*) What are the Advantages of CDMA?

Ans. CDMA is having the following advantages:

- CDMA has a soft capacity. The greater the number of codes, the more number of users. However, when many codes are used S/I drops and the BER (Bit Error Rate) will increase for all users.
- CDMA requires a tight power control as it suffers from near-far effect. In other words, a user near the base station transmits the same power as a user later will drown the latter signal. All signals must have more or less equal power at the receiver.
- Rake receivers can be used to improve signal reception. Delayed versions of time (a chip or later) of the signal (multipath signals) can be collected and used to make decisions at the bit level.
- Flexible transfer may be used. Mobile base stations can switch without changing operator. Two base stations receive mobile signal and the mobile receives from two base stations.

Transmission Burst - reduces interference

Q.7.(*a*) What are the Advantages of Spread Spectrum?

Ans. There are following advantages of spread spectrum systems:

- Since the signal is spread over a wide frequency band, the power spectral density becomes very low, so other communication systems do not suffer from this kind of communication. However, the Gaussian noise increases.
- Multipath can be agreed with, as a large number of codes can be generated, allowing a large number of users.
- The maximum number of users have not limited spectrum or resource, as other access systems such as FDMA, here they have only limited interference.
- **Security** – without knowing the spreading code, it is almost impossible to recover the transmitted data.
- **Descending rejection** – as large bandwidth is used the system, it is less susceptible to deformation.

Q.7. (*b*) What is Reverse Link Power Control? Explain.

Ans. The power of closed loop control is used to compensate for the rapid Rayleigh discoloration. This time, the mobile transmitted power is controlled by the base station. For this purpose, the base station continuously monitors the reverse link signal quality. If the quality of the connection is poor then the base station increases the power. Similarly, if the quality of the link is very high then the mobile base station controller reduces the power. This is called as reverse link power control.

Q.8. Explain the working of WLL systems in detail.

Ans. WLL, which stands for Wireless Local Loop is of course a technology that connects subscribers to the PSTN using radio signals as a substitute for copper for all or part of the connection between the subscriber and the switch. This includes cordless access systems, proprietary fixed radio access, and fixed cellular systems. WLL phones in homes, offices or even boats connect with a wireless system in a manner similar to that of CDMA cell phones.

The difference is that WLL phones usually stay in a relatively fixed location. WLL phones often connect to AC current rather than using batteries. They are used to provide voice, fax, and data connections. The diagram below shows how the subscriber unit conveys digital signal through RF to the base station (RBS or BTS), which has a landline to the BSC and then back to the main switch office. This has in turn its own connection to the PSTN and hence to other subscribers.

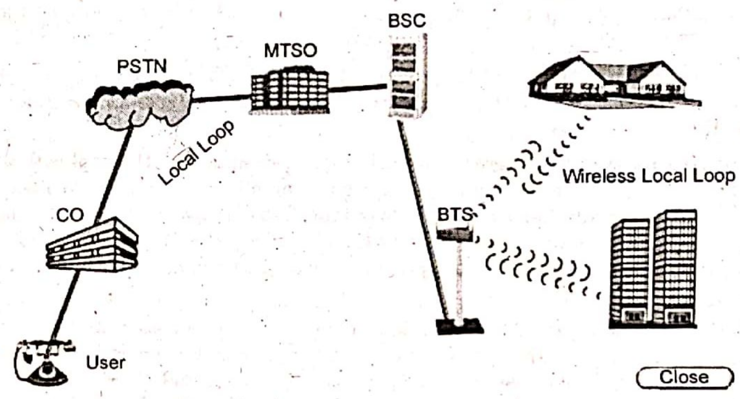


Fig. Basic WLL communication system

Using WLL for data transfer applications rather than using cable or DSL is also becoming a viable option because of the low setup costs of WLL. Below is a diagram of the WLL used in computer data transfers. However price per month for subscribers is another matter. In 2001 a typical contract can run upwards of $100 a month for a 1 Mbps service. This is ontop of the $1500 connection fee. However if the only other choice is no broadband at all, WLL may look much more attractive

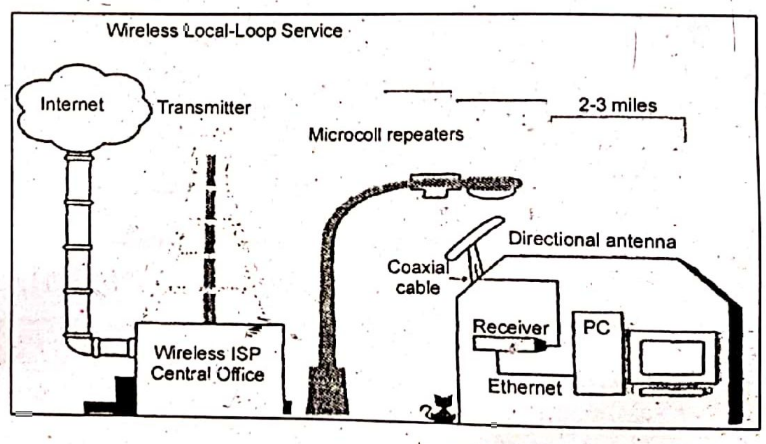


Fig. Wireless local-loop data service

Four different types of WLL systems:

• Cellular-based systems consisting of a network of base stations. The older systems are usually based on analogue technology, which is well proven and low-cost, but provides reduced speech quality, limited data capacity and low security. Examples include NMT 450/900, AMPS, TACS, N-AMPS. The newer digital systems offer better spectrum usage and are cost-effective for voice but are less standardised and still provide only limited fax/data throughput. Examples include GSM, DCS1800/PCS1900, IS-136/D-AMPS, IS-95 800/1900.

• Cordless-based systems. These provide efficient spectrum usage in high densities but with limited range, making high infrastructure costs for smaller cell sizes. Examples include DECT, CT-2, PHS.

• Proprietary systems. These are usually custom-designed for the application and provide high quality voice and data services, and other enhanced services. While many of these systems provide superior service to the cordless and digital cellular standards, they must overcome the inertia created by the high installed base of the older technologies. These include FDMA, TDMA, CDMA systems, such as the products made by Qualcomm and Granger.

• Satellite-based systems, as described above, are also proprietary and are mainly focussed on the mobile market, but fixed line access is also envisaged in a few years. These provide global coverage in virtually all environments, but currently have very high usage costs and there are still unresolved domestic control issues. Examples include Iridium and Globalstar.

MODEL PAPER–II
FIRST TERM EXAMINATION
SEVENTH SEMESTER [B.TECH]
WIRELESS COMMUNICATION [ETEC-405]

Time : 1½ hrs. **M.M. : 80**

Note: *Question no.1 is compulsory and attempt any two from the rest. In all attempt 3 question.*

Q.1. (a) What is space division multiplexing?

Ans. Here the total region is divided in certain sectors and in each sector one antenna is used. These antennas must be directional enough to avoid the interference between each of the sectors as shown below:

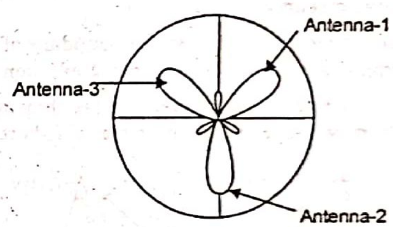
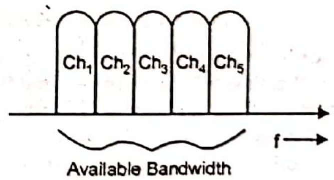


Fig. Radiation Pattern of Directional Antenna.

Q.2. (b) Explain FDMA briefly.

Ans. Here total allocated bandwidth is divided in the slots of pre-defined band. Each channel is allocated to the separate user and is available throughout the time duration. For doing communication in duplex mode the given band is further divided in Forward channel and reverse channel, this is called as frequency division duplexing



Q.1. (c) How many channels can be given in FDMA system?

Ans. Suppose we are using gaurd band in FDMA system to avoid the interference.

let W_g = Gaurd band frequency

W_s = Maximum available signal frequency

W_c = Maximum frequency used to create one channel.

then

$$N_c = \frac{W_c - (N_c - 1)W_g}{W_s}$$

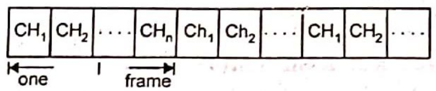
where

$$N_C = \text{No. of channels available}$$

Q.1. (d) Explain the TDMA concept.

Ans. TDMA stands for Time Division Multiple Access, this means that total band is allocated to each user on time division basis and each user accesses the services on time cyclic basis.

Total time is divided in certain slots during which user is allowed to access the services, as shown one frame consist of all the slots

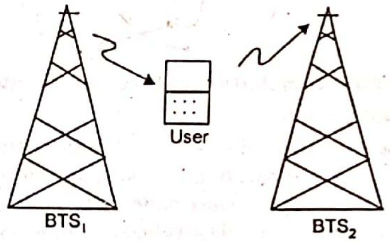


Q.2. (a) Explain the Handover process in CDMA system.

Ans. In the handover process, the called is transferred to that BTS from where user is getting better radio signal strength.

When the CDMA user is moving and is at the boundary of a BTS, the power of originating tower falls rapidly and if call is not transferred, then it will be dropped.

In soft handover user makes the connection with more than one BTS and then user is locked with that BTS from where radio strength signal is better.



Q.2. (b) Compare the different features of GSM & EDGE.

Ans. EDGE is the extended version of GSM technology and stands for Enhanced Data rate for GSM Evolution. This system helps in sending the data at the rate of 34 Kbps over a GSM TDMA system. This may some times be called as E-GPRS. It is anticipated that it can be used to provide the services who do not have licences of 3G. It is highly spectrally efficient and is capable to provided high speed services.

Parameter	GSM	EDGE
Modulation	Gaussion MSK	8psk
Bit rate	270 Kbps	812 Kbps
Channel Bandwidth	200 KHz	200 KHz
Pulse shaping	Gaussian Prefilter	Linearizes GMSK Pulse
Modulation Type	Non Linear	Linear

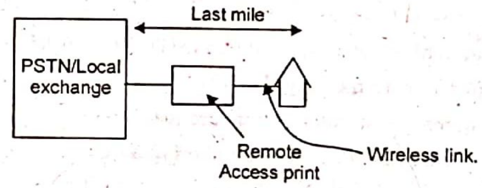
Q.3. (a) Explain the wireless Local Loop (WLL)

Ans. This type of connection is very much suitable for rapid deployment of wireless services. This may be based on some local distance basis or it may be based for remote areas. So it is divided in two categories:

(a) Last Mile WLL

(b) Long-Haul WLL

Last Mile WLL is generally for a distance of less than 35Km and long haul is for more than 35k.m distance.



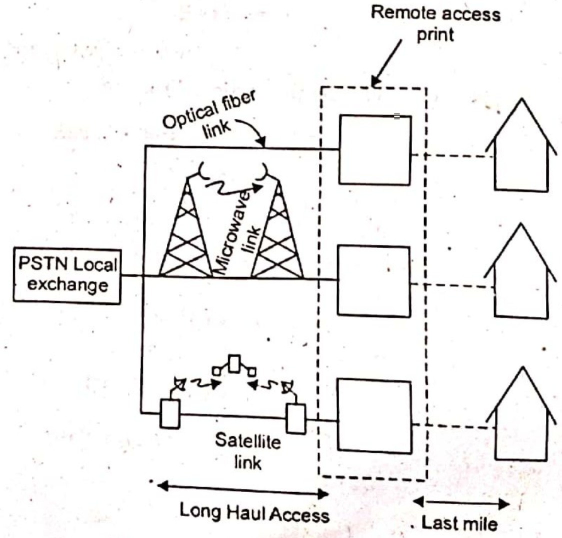
Last mile technology may be based on:

(a) Wireless: PSTN, DSL, Cable Modem

(b) Wireless: LMDS, MMDS, Wireless LAN, PCS

Long Haul WLL System may be based on:

1. Optical fiber links
2. Microwave link
3. VSAT links



Q.3. (b) What is IMT. 2000 Programme?

Ans. Here IMT stands for internation Mobile telecommunication and 2000 indicate the starting year and also the band used e.g. 2000 MHz. IMT is the global standard for 3G (third generation) wireless telecommunication. Main objective of this group is to provide world-wide wireless services and accessing the other networks such as PSTN or optical fiber networks hence provide an interface between the fixed (wired) networks and the digital wireless mobile radio system.

Its functions are govered by ITU (international telecommunication union) like spectrum management traffic and filling operation etc.

The main areas of ITU are as follow:

(a) Telecommunication Development Group (ITU-D)

(b) Radio Communication Group (ITU-R)

(c) Telecommunication standarization group (ITU-T)

IMT-2000 is having the following characteristics:

1. Flexibility
2. Affordability
3. Compatibility with the existing systems
4. Modular Design.

Q.4. (a) Show that D = $\sqrt{3(i^2+ij+j^2)}\times R$

Ans. Since in a hexagon six triangles of equal sides can be formed then Radius of the hexagon (R) can be related as follow:

$$(i/_2)^2 = R^2-(R/_2)^2$$

$$i = \sqrt{3}\times R$$

$$= \text{Centre to centre distance}$$

where i is the distance covered on the vertical direction

$$i_1 = \sqrt{3}R_i \text{ and } j_1 = \sqrt{3}Rj$$

Also
$$\theta = 120^\circ$$

Then
$$D^2 = i_1^{\,2}+j_1^{\,2}-2i_1j_1\cos\theta$$

$$= 3R^2 i^2 + 3R^2 j^2 - 2\times 3R^2 ij\cos(120^\circ)$$

$$= 3R^2 i^2 + 3R^2 j^2 + 2\times 3R^2 ij\left(\frac{1}{2}\right)$$

$$= 3R^2(i^2+ij+j^2)$$

$$D = \sqrt{3R^2(i^2+ij+j^2)}$$

$$= \sqrt{3N}\times R$$

where
$$N = i^2+ij+j^2$$
$$= \text{cluster size.}$$

Q.4. (b) Explain the digital circuit switched cellular system Component.

Ans. On the basis of GSM-900 System there are the following important & integral components:

(a) Mobile Station: It consist of the two parts namely mobile equipment with battery and subscriber identity module (SIM). The SIM contains all the subscriber specific data stored on the MS side.

(b) Base transceiver Station (BTS): Besides having the same function as the analog BS/BTS it has the transcodes/rate adapter unit (TRAU)

(c) Base Station Controller (BSC): This unit controls the radio resources and also manages the allocation of radio channels. It also handles handover, power management time and frequnecy synchronization and frequency re-allocation amount the BTSs.

(d) Switching Sub-Systems: It is the main element that co-ordinates the set-up of calls between MS and PSTN. Other main parts of this system are:

1. Visitor Location Register
2. Home Location Register
3. Authentication Centre
4. Equipment identity Register.
5. Operation and Maintenance Centre (OMC).

MODEL PAPER–II
SECOND TERM EXAMINATION
SEVENTH SEMESTER [B.TECH]
WIRELESS COMMUNICATION [ETEC-405]

Time : 1½ hrs. **M.M. :30**

Note: *Question no.1 is compulsory and attempt any two from the rest. In all attempt 3 question.*

Q.1. (a) Which Channels are present in the Forward Channels?

Ans. Forward channel consists of four channels which includes –

- Pilot Channel,
- Sync Channel,
- Paging Channel, and Forward Traffic Channels

Q.1. (b) Explain Sync Channel.

Ans. Synchronization channel carries a single repeating message and transmits the synchronization configuration information and the system of the mobile station in the CDMA system

Q.1. (c) Enlist the reasons for popularity of GSM

Ans. Listed below are the features of GSM that account for its popularity and wide acceptance.

- Improved spectrum efficiency
- International roaming
- Low-cost mobile sets and base stations (BSs)
- High-quality speech
- Compatibility with Integrated Services Digital Network (ISDN) and other telephone company services
- Support for new services

Q.1. (d) Which modulation technique GSM uses?

Ans. Modulation is the process of transforming the input data into a suitable format for the transmission medium. The transmitted data is demodulated back to its original form at the receiving end. The GSM uses Gaussian Minimum Shift Keying (GMSK) modulation method.

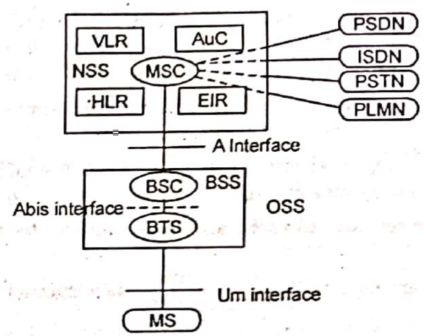
Q.2. (a) Explain the different features of GSM architecture?

Ans. A GSM network comprises of many functional units. These functions and interfaces are explained in this chapter. The GSM network can be broadly divided into:

- The Mobile Station (MS)
- The Base Station Subsystem (BSS)

- The Network Switching Subsystem (NSS)
- The Operation Support Subsystem (OSS)

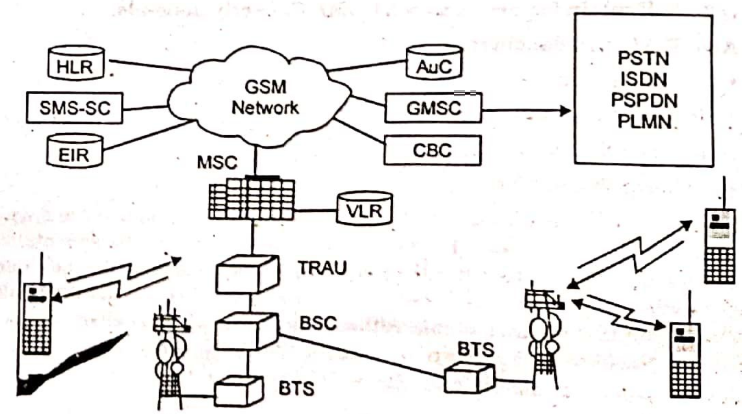
Given below is a simple pictorial view of the GSM architecture



The additional components of the GSM architecture comprise of databases and messaging systems functions:

- Home Location Register (HLR)
- Visitor Location Register (VLR)
- Equipment Identity Register (EIR)
- Authentication Center (AuC)
- SMS Serving Center (SMS SC)
- Gateway MSC (GMSC)
- Chargeback Center (CBC)
- Transcoder and Adaptation Unit (TRAU)

The following diagram shows the GSM network along with the added elements:



The MS and the BSS communicate across the Um interface. It is also known as the *air interface* or the *radio link*. The BSS communicates with the Network Service Switching (NSS) center across the *A* interface

Q.2. (*b*) What is Soft Handover/Handoff?

Ans. Cellular system tracks mobile stations in order to maintain their communication links. The mobile station goes to neighbor cell and communication link switches from current cell to the neighbor cell which is called as soft handover.

- Soft handoff is a feature in which a cellular phone is simultaneously connected to two or more cellular phones during a single call.
- It is the overlapping of repeater coverage ones, which enables every cell phone set is always well within the range of a specific repeater.
- More than one repeater can send and receive signals to transmit signals to and from mobiles.
- All repeaters are used with the same frequency channel for each mobile phone set.
- Practically no dead zones and as result, the connections seldom interrupted or dropped.

Q.3. (*a*) Define the areas of GSM network.

Ans. In a GSM network, the following **areas are** defined:

- **Cell** : Cell is the basic **service area; one BTS covers** one **cell. Each** cell is given a Cell Global Identity (CGI), **a number that uniquely identifies the cell.**
- **Location Area** : A group of cells form **a** Location Area (LA). This is the area that is paged when a subscriber **gets an** incoming **call.** Each LA is **assigned** a Location Area Identity (LAI). Each LA is served by one or more BSCs.
- **MSC/VLR Service Area** : The area covered by one MSC is called the MSC/VLR service area.
- **PLMN**: The area covered by one network operator is called the Public Land Mobile Network (PLMN). A PLMN can contain one or more MSCs.

Q.3. (*b*) Explain factors on which CDMA Capacity depends.

Ans. The factors deciding capacity are –

- Processing Gain,
- Signal to Noise Ratio,
- Voice Activity Factor, and
- Frequency Reuse Efficiency.

Capacity in CDMA is soft, CDMA has all users on each frequency and users are separated by code. This means, CDMA operates in the presence of noise and interference. In addition, neighboring cells use the same frequencies, which means no re-use. So, CDMA capacity calculations should be very simple. No code channels in a cell, multiplied by no cells. But it is not that simple. Although not available code channels are 64, it may not be possible to use a single time, since the CDMA frequency is the same. Flexible capability means that all the code channels can be pursued at a time, but at the expense of quality.

Q.4. (a) What are the Disadvantages of TDMA?

Ans. Following are the major disadvantage of TDMA

- The high data rates of broadband systems require complex equalization.
- Due to the burst mode, a large number of additional bits for synchronization and supervision are needed.
- Call time is needed in each slot to accommodate time to inaccuracies due to clock instability.
- Electronics operating at high bit rates increase energy consumption.
- Complex signal processing is required to synchronize within short slot.

Q.4. (*b*) What is Spread Spectrum Technique?

Ans. Spread spectrum is a form of wireless communications in which the frequency of the transmitted signal is deliberately varied. This results in a much greater bandwidth than the signal would have, if its frequency were not varied. In other words, the transmitted signal bandwidth is greater than the minimal information bandwidth needed to successfully transmit the signal. Some function other than the information itself is being employed to determine the resultant transmitted bandwidth.

MODEL PAPER–II
END TERM EXAMINATION
SEVENTH SEMESTER [B.TECH]
WIRELESS COMMUNICATION [ETEC-405]

Time : 3 hrs. **M.M. 75**

Note: *Attempt any five questions including Q. No. 1 which is compulsory.*

Q.1. (a) How cell selection is done? Explain.

Ans. The requirements that a cell must satisfy before a mobile station can receive service from it are:

- It should be a cell of the selected PLMN. The mobile station checks whether the cell is part of the selected PLMN.
- It should not be "barred". The PLMN operator may decide not to allow mobile stations to access certain cells. These cells may, for example only be used for handover traffic. Barred cell information is broadcast on the BCCH to instruct mobile stations not to access these cells.
- The radio path loss between the mobile station and the selected BTS must be above a threshold set by the PLMN operator.
- If no suitable cell is found then the MS enters a "limited service" state in which it can only make emergency calls.

Q.1. (b) What are functions of VLR in mobile communication ?

Ans. A VLR contains a data record for each of the MS that are currently operating in its area. Each record contains a set of subscriber identity codes, related subscription information, and a Location Area Identity (LAI) code. This information is used by the MSC when handling calls to or from an MS in the area. When an MS moves from one area to another, the responsibility for its supervision passes from one VLR to another. A new data record is created by the VLR that has adopted the MS, and the old record is deleted. Provided that an inter-working agreement exists between the network operators concerned, data transaction can cross both network and national boundaries.

Q.1.(c) How many type of identification numbers are used in mobile communication?

Ans. During the performance of the location update procedure and the processing of a mobile call different types of numbers are used:

- Mobile Station ISDN Number(MSISDN)
- Mobile Subscriber Roaming Number(MSRN)
- International Mobile Subscriber Identity(IMSI)
- Temporary Mobile Subscriber Identity(TMSI)
- Local Mobile Station Identity(LMSI)

Each number is stored in the HLR and/or VLR.

Q.1. (d) Indicate the benefits of EDGE.

Ans. There are following benefits of EDGE

- **Short-term benefits:** Capacity and performance,
- Easy implementation on a GSM/GPRS network,
- Cost effective,

- Increases the capacity and triples the data rate of GPRS,
- Enables new multimedia services,
- Long-term benefit: Harmonization with WCDMA.

Q.1. (e) Explain the Effects of Power Control.

Ans. Following points should be noted while upgrading to EDGE systems from GPRS

- **Mobile Station (MS):** MS should be EDGE enabled.
- **BTS:** HW supplied is Edge enabled.
- **BSC:** Definitions for EDGE timeslots needs to be done in BSC.
- **GPRS Support Nodes (GSNs):** Definitions for Edge need to be defined in GSNs.
- **Databases (HLR, VLR, etc.):** No definition is required.

Q.1. (f) Briefly explain WCDMA-3G

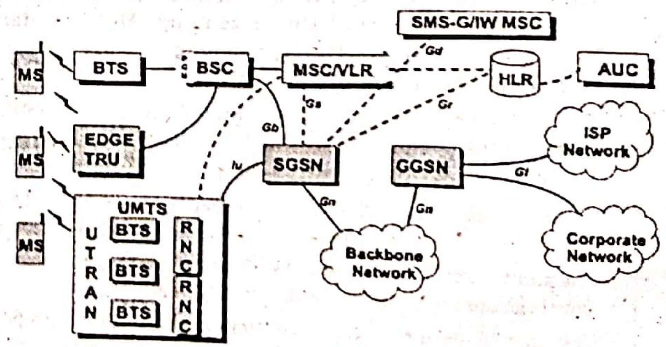
Ans. 3G wireless service has been designed to provide high data speeds, always-on data access, and greater voice capacity. Listed below are a few notable points:

- The high data speeds, measured in Mbps, enable full motion video, high-speed internet access and video-conferencing.
- 3G technology standards include UMTS, based on WCDMA technology (quite often the two terms are used interchangeably) and CDMA2000, which is the outgrowth of the earlier CDMA 2G technology.
- UMTS standard is generally preferred by countries that use GSM network. CDMA2000 has various types, including 1xRTT, 1xEV-DO and 1xEV-DV. The data rates they offer range from 144 kbps to more than 2 mbps.

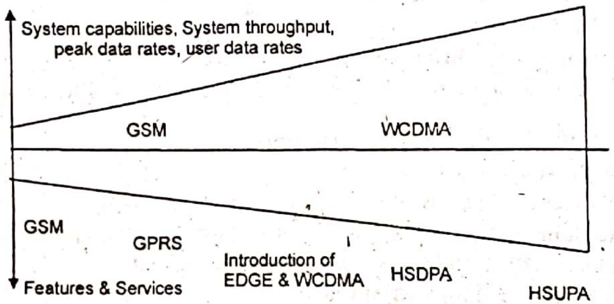
Q.2. (a) Explain UMTS technology and show its network evolution.

Ans. The Universal Mobile Telecommunications System (UMTS) is a third generation mobile cellular system for networks based on the GSM standard. Developed and maintained by the 3GPP (3rd Generation Partnership Project), UMTS is a component of the Standard International Union all IMT-2000 telecommunications and compares it with the standard set for CDMA2000 networks based on competition CDMA-1 technology. UMTS uses wideband code division multiple access (W-CDMA) radio access technology to provide greater spectral efficiency and bandwidth mobile network operators.

Network Evolution



An Evolution that Makes Sense



HSUPA : High Speed Uplink Packet Access

HSDPA : High speed downlink packet access

The main idea behind 3G is to prepare a universal infrastructure able to carry existing and also future services. The infrastructure should be so designed that technology changes and evolution can be adapted to the network without causing uncertainties to the existing services using the existing network structure.

Q.2. (b) Enlist the historical events for the development of GSM.

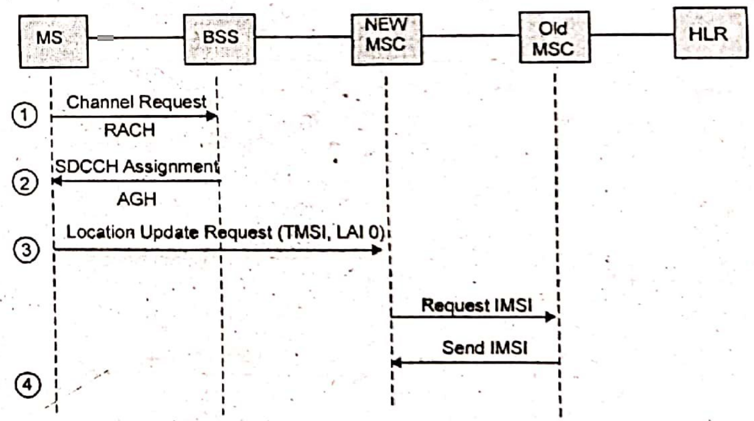
Ans. The following table shows some of the important events in the rollout of the GSM system.

Years	Events
1982	Conference of European Posts and Telegraph (CEPT) establishes a GSM group to widen the standards for a pan-European cellular mobile system.
1985	A list of recommendations to be generated by the group is accepted.
1986	Executed field tests to check the different radio techniques recommended for the air interface.
1987	Time Division Multiple Access (TDMA) is chosen as the access method (with Frequency Division Multiple Access [FDMA]). The initial Memorandum of Understanding (MoU) is signed by telecommunication operators representing 12 countries.
1988	GSM system is validated.
1989	The European Telecommunications Standards Institute (ETSI) was given the responsibility of the GSM specifications.
1990	Phase 1 of the GSM specifications is delivered.
1991	Commercial launch of the GSM service occurs. The DCS1800 specifications are finalized.
1992	The addition of the countries that signed the GSM MoU takes place. Coverage spreads to larger cities and airports.
1993	Coverage of main roads GSM services starts outside Europe.

1994	Data transmission capabilities launched. The number of networks rises to 69 in 43 countries by the end of 1994.
1995	Phase 2 of the GSM specifications occurs. Coverage is extended to rural areas.
1996	June: 133 network in 81 countries operational.
1997	July: 200 network in 109 countries operational, around 44 million subscribers worldwide.
1999	Wireless Application Protocol (WAP) came into existence and became operational in 130 countries with 260 million subscribers.
2000	General Packet Radio Service(GPRS) came into existence.
2001	As of May 2001, over 550 million people were subscribers to mobile telecommunications.

Q.3. How location updation is done in mobile communication. Explain in detail.

Ans. In the following location update scenario it is assumed that an MS enters a new location area that is under control of a different VLR (referred to as the "new VLR") than the one where the MS is currently registered (referred to as the "old VLR"). The following diagram shows the steps of the mobile location update scenario.



The MS enters a new cell area, listens to the Location Area Identity (LAI) being transmitted on the broadcast channel (BCCH), and compares this LAI with the last LAI (stored in the SIM) representing the last area where the mobile was registered.

- The MS detects that it has entered a new Location Area and transmits a Channel Request message over the Random Access Channel (RACH).
- Once the BSS receives the Channel Request message, it allocates a Stand-alone Dedicated Control Channel (SDCCH) and forwards this channel assignment information to the MS over the Access Grant Channel (AGCH). It is over the SDCCH that the MS will communicate with the BSS and MSC.

• The MS transmits a location update request message to the BSS over the SDCCH. Included in this message are the MS Temporary Mobile Subscriber Identity (TMSI) and the old Location Area Subscriber (old LAI). The MS can identify itself either with its IMSI or TMSI. In this example, we will assume that the mobile provided a TMSI. The BSS forwards the location update request message to the MSC.

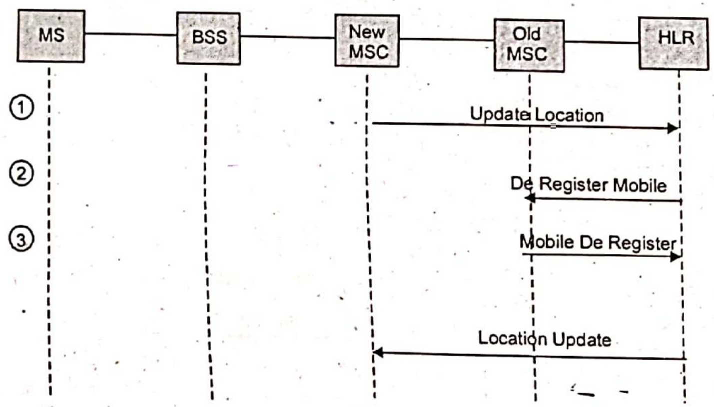
• The VLR analyses the LAI supplied in the message and determines that the TMSI received is associated with a different VLR (old VLR). In order to proceed with the registration the IMSI of the MS must be determined. The new VLR derives the identity of the old VLR by using the received LAI, supplied in the location update request message. It also requests the old VLR to supply the IMSI for a particular TMSI.

• Location Update Scenario-Update HLR/VLR is a point where we are ready to inform the HLR that the MS is under control of a new VLR and that the MS can be de-registered from the old VLR. The steps in update HLR/VLR phase are:

• The new VLR sends a message to the HLR informing it that the given IMSI has changed locations and can be reached by routing all incoming calls to the VLR address included in the message.

• The HLR requests the old VLR to remove the subscriber record associated with the given IMSI. The request is acknowledged.

•The HLR updates the new VLR with the subscriber data (mobiles subscribers' customer profile).



Steps in TMSI Reallocation Phase

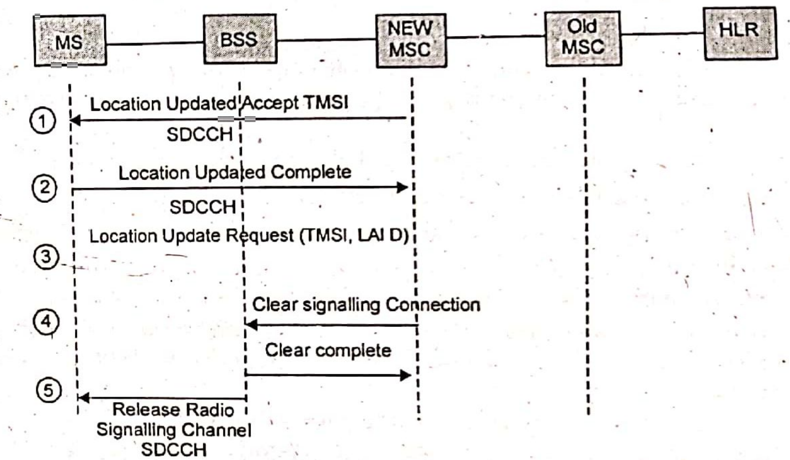
• The MSC forwards the location update accept message to the MS. This message includes the new TMSI.

• The MS retrieves the new TMSI value from the message and updates its SIM with this new value. The mobile then sends an update complete message back to the MSC.

• The MSC requests from the BSS, that the signaling connection be released between the MSC and the MS.

• The MSC releases its portion of the signaling connection when it receives the clear complete message from the BSS.

• The BSS sends a "radio resource" channel release message to the MS and then free up the Stand-alone Dedicated Control Channel (SDCCH) that was allocated previously. The BSS then informs the MSC that the signaling connection has been cleared.



Location Update Periodicity

Location Update automatically takes place when the MS changes its LA. A lot of location updates may be generated if a user crosses LA boundary frequently. If the MS remains in the same LA, Location Update may take place based on time/movement/distance, as defined by the network provider

Q.4. (a) Explain the Rayleigh fading.

Ans. Rayleigh Fading or Macroscopic Variations can be modeled as the addition of two components that make up the path loss between the mobile and the base station. The first component is the deterministic component (L) that adds loss to the signal strength as the distance (R) increases between the base and the mobile. This component can be written as:

$$L = 1/R^n$$

Where n is typically 4. The other macroscopic component is a Log normal random variable which takes into account the effects of shadow fading caused by variations in terrain and other obstructions in the radio path. Local mean value of path loss = deterministic component + log normal random variable.

Microscopic Variations or Rayleigh Fading occurs as the mobile moves over short distances compared to the distance between mobile and base. These short term variations are caused by signal scattering in the vicinity of the mobile unit say by a hill, a building, or traffic. This leads to many different paths that are followed between the transmitter and the receiver (Multipath Propagation). The reflected wave is altered in both phase and amplitude. The signal may effectively disappear if the reflected wave is 180 degree out of phase with the direct path signal. The partial out of phase relationships among multiple received signal produce smaller reduction in received signal strength.

Effects of Rayleigh Fading:

Reflection and multipath propagation can cause positive and negative effects.

Q.4. (b)Indicate the functions of MSC.

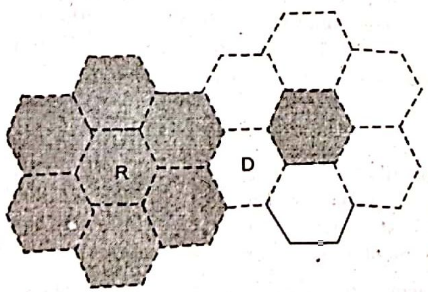
Ans. Functions of MSC:

- Call handling that copes with the mobile ..ature of subscribers considering Location Registration, Authentication of subscribers and equipment, Handover and Prepaid service.
- Management of required logical radio link channel during calls.
- Management of MSC-BSS signaling protocol.
- Handling location registration and ensuring interworking between mobile station and VLR.
- Controls inter-BSS and inter-MSC hand overs.
- Acting as a gateway MSC to interrogate HLR. The MSC which is connected to the PSTN/ISDN network is called as GMSC. This is the only MSC in the network connected to the HLR.
- Standard functions of a switch like charging.

Q.5. (a) What is the cellular approach in mobile communication?

Ans. With limited frequency resource, cellular principle can serve thousands of subscribers at an affordable cost. In a cellular network, total area is subdivided into smaller areas called "cells". Each cell can cover a limited number of mobile subscribers within its boundaries. Each cell can have a base station with a number of RF channels.

Frequencies used in a given cell area will be simultaneously reused at a different cell which is geographically separated. For example, a typical seven-cell pattern can be considered.



Total available frequency resources are divided into seven parts, each part consisting of a number of radio channels and allocated to a cell site. In a group of 7 cells, available frequency spectrum is consumed totally. The same seven sets of frequency can be used after certain distance.

The group of cells where the available frequency spectrum is totally consumed is called a cluster of cells.

Two cells having the same number in the adjacent cluster, use the same set of RF channels and hence are termed as "Co-channel cells". The distance between the cells using the same frequency should be sufficient to keep the co-channel (co-chl) interference to an acceptable level. Hence, the cellular systems are limited by Co-channel interference.

Hence a cellular principle enables the following.

- More efficient usage of available limited RF source.
- Manufacturing of every piece of subscriber's terminal within a region with the same set of channels so that any mobile can be used anywhere within the region.

Q.5. (b) Explain the adjacent channel interference.

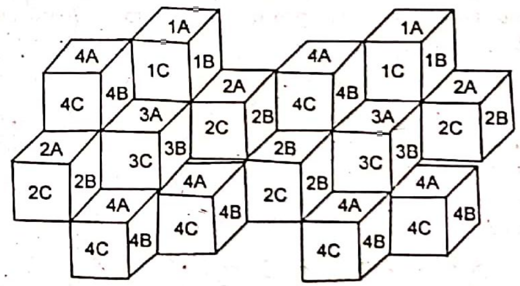
Ans. A given cell/sector uses a number of RF channels. Because of imperfect receiver filters, which allow nearby frequencies to leak into pass band, adjacent channel interference takes place.

It can be reduced by keeping the frequency separations between each RF channel in a given cell as large as possible. When the reuse factor is small, this separation may not be sufficient.

A channel separation, by selecting RF frequencies, which are more than 6 channels apart, is sufficient to keep adjacent channel interferences within limits.

For example, in GSM which follows 4/12 pattern, N=4

Sectors = 3/cell



IA will use RF Carr. 1, 13, 25,........

IB will use RF Carr 5, 17, 29,.........

IC will use RF Carr. 9, 21, 33,........and so on.

Q.6. (a)What is Mobile station, explain its functions.

Ans. It refers to the terminal equipment used by the wireless subscribers. It consists of:

- SIM -Subscriber Identity Module
- Mobile Equipment

SIM is removable and with appropriate SIM, the network can be accessed using various mobile equipments.

The equipment identity is not linked to the subscriber. The equipment is validated separately with IMEI and EIR. The SIM contains an integrated circuit chip with a microprocessor, random access memory (RAM) and read only memory (ROM). SIM should be valid and should authenticate the validity of MS while accessing the network.

SIM also stores subscriber related information like IMSI, cell location identity etc.

Functions of Mobile Station

- Radio transmission and reception
- Radio channel management
- Speech encoding/decoding
- Radio link error protection
- Flow control of data
- Rate adaptation of user data to the radio link.
- Mobility management

Performance measurements up to a maximum of six surrounding BTSs and reporting to the BSS, MS can store and display short received alphanumeric messages on the liquid crystal display (LCD) that is used to show call dialing and status information.

There are five different categories of mobile telephone units specified by the European GSM system: 20W, 8W, 5W, 2W, and 0.8W. These correspond to 43-dBm, 39-dBm, 37-dBm, 33-dBm, and 29-dBm power levels. The 20-W and 8-W units (peak power) are either for vehicle-mounted or portable station use. The MS power is adjustable in 2-dB steps from its nominal value down to 20mW (13 dBm). This is done automatically under remote control from the BTS.

Q.6. (*b*) How transcoders help in speech coding and decoding?

Ans. Transcoders are a network entities inserted to interface the MSC side to Mobile side. The voice coding rate on the PSTN side is 64Kbps, and in GSM over the air the voice is coded as 13Kbps. To reduce the data rate over the air interface and to reduce the loading of the terrestrial link (4:1), transcoders are introduced at an appropriate place, mostly with MSC.

The transcoder is the device that takes 13-Kbps speech or 3.6/6/12-Kbps data multiplexes and four of them to convert into standard 64-Kbps data. First, the 13 Kbps or the data at 3.6/6/12 Kbps are brought up to the level of 16 Kbps by inserting additional synchronizing data to make up the difference between a 13-Kbps speech or lower rate data and then four of them are combined in the transponder to provide 64 Kbps channel within the BSS. Four traffic channels can then be multiplexed in one 64-Kpbs circuit. Thus the TRAU output data rate is 64 Kbps

Q.7. (*a*) What are the Advantages and Disadvantages of FDMA?

Ans. Advantages of FDMA: As FDMA systems use low bit rates (large symbol time) compared to average delay spread, it offers the following advantages.

- Reduces the bit rate information and the use of efficient numerical codes increases the capacity.
- It reduces the cost and lowers the inter symbol interference (ISI)

- Equalization is not necessary.
- An FDMA system can be easily implemented. A system can be configured so that the improvements in terms of speech encoder and bit rate reduction may be easily incorporated.
- Since the transmission is continuous, less number of bits are required for synchronization and framing.

Disadvantages of FDMA: Although FDMA offers several advantages, it has a few drawbacks as well, which are listed below.

- It does not differ significantly from analog systems; improving the capacity depends on the signal-to-interference reduction, or a signal-to-noise ratio (SNR).
- The maximum flow rate per channel is fixed and small.
- Guard bands lead to a waste of capacity.
- Hardware implies narrowband filters, which cannot be realized in VLSI and therefore increases the cost

Q.7. (*b*) What are advantages and disadvantages of TDMA? Explain.

Ans. Advantages of TDMA.

Here is a list of few notable advantages of TDMA "

- Permits flexible rates (i.e. several slots can be assigned to a user, for example, each time interval translates 32Kbps, a user is assigned two 64 Kbps slots per frame).
- Can withstand gusty or variable bit rate traffic. Number of slots allocated to a user can be changed frame by frame (for example, two slots in the frame 1, three slots in the frame 2, one slot in the frame 3, frame 0 of the notches 4, etc.).
- No guard band required for the wideband system.
- No narrowband filter required for the wideband system.

Disadvantages of TDMA

The disadvantages of TDMA are as follow:

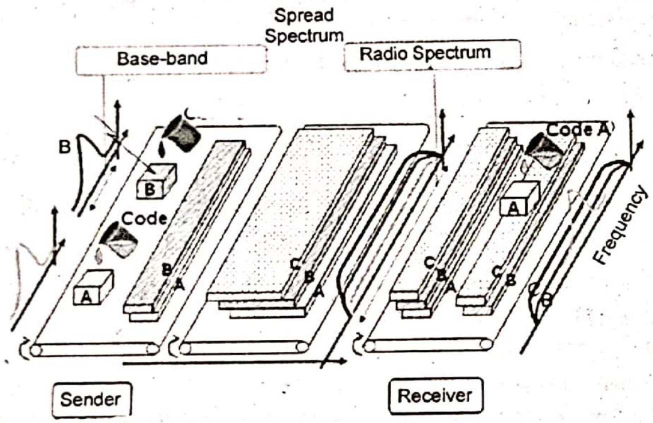
- High data rates of broadband systems require complex equalization.
- Due to the burst mode, a large number of additional bits are required for synchronization and supervision.
- Call time is needed in each slot to accommodate time to inaccuracies (due to clock instability).
- Electronics operating at high bit rates increase energy consumption.
- Complex signal processing is required to synchronize within short slots.

Q.8. Explain the working of CDMA systems in detail.

Ans. CDMA allows up to 61 concurrent users in a 1.2288 MHz channel by processing each voice packet with two PN codes. There are 64 Walsh codes available to differentiate between calls and theoretical limits. Operational limits and quality issues will reduce the maximum number of calls somewhat-lower than this value.

In fact, many different "signals" baseband with different spreading codes can be modulated on the same carrier to allow many different users to be supported. Using different orthogonal codes, interference between the signals is minimal. Conversely, when signals are received from several mobile stations, the base station is capable of isolating each as they have different orthogonal spreading codes.

The following figure shows the technicality of the CDMA system. During the propagation, we mixed the signals of all users, but by that you use the same code as the code that was used at the time of sending the receiving side. You can take out only the signal of each user.



CDMA Capacity

The factors deciding the CDMA capacity are:

- Processing Gain
- Signal to Noise Ratio
- Voice Activity Factor
- Frequency Reuse Efficiency

Capacity in CDMA is soft, CDMA has all users on each frequency and users are separated by code. This means, CDMA operates in the presence of noise and interference.

In addition, neighboring cells use the same frequencies, which means no re-use. So, CDMA capacity calculations should be very simple. No code channel in a cell, multiplied by no cell. But it is not that simple. Although not available code channels are 64, it may not be possible to use a single time, since the CDMA frequency is the same.

Centralized Methods

- The band used in CDMA is 824 MHz to 894 MHz (50 MHz + 20 MHz separation).
- Frequency channel is divided into code channels.
- 1.25 MHz of FDMA channel is divided into 64 code channels.

Processing Gain

CDMA is a spread spectrum technique. Each data bit is spread by a code sequence. This means, energy per bit is also increased. This means that we get a gain of this.

P (gain) = 10log (W/R)

W is Spread Rate

R is Data Rate

For CDMA P (gain) = 10 log (1228800/9600) = 21dB

This is a gain factor and the actual data propagation rate. On an average, a typical transmission condition requires a signal to the noise ratio of 7 dB for the adequate quality of voice.

Translated into a ratio, signal must be five times stronger than noise.

Actual processing gain = P (gain) - SNR

= 21 – 7 = 14dB

CDMA uses variable rate coder

The Voice Activity Factor of 0.4 is considered = -4dB.

Hence, CDMA has 100% frequency reuse. Use of same frequency in surrounding cells causes some additional interference.

In CDMA frequency, reuse efficiency is 0.67 (70% eff.) = -1.73dB

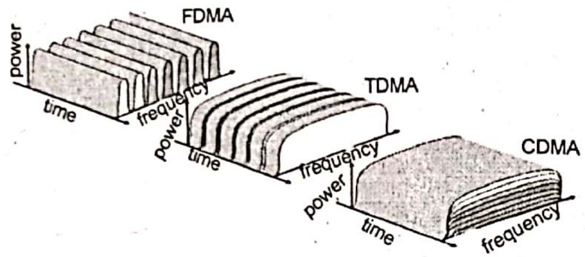
Advantages of CDMA: CDMA has a soft capacity. The greater the number of codes, the more the number of users. It has the following advantages:

- CDMA requires a tight power control, as it suffers from near-far effect. In other words, a user near the base station transmitting with the same power will drown the signal latter. All signals must have more or less equal power at the receiver
- Rake receivers can be used to improve signal reception. Delayed versions of time (a chip or later) of the signal (multipath signals) can be collected and used to make decisions at the bit level.
- Flexible transfer may be used. Mobile base stations can switch without changing operator. Two base stations receive mobile signal and the mobile receives signals from the two base stations.
- Transmission Burst " reduces interference".

Disadvantages of CDMA

The disadvantages of using CDMA are as follows:

- The code length must be carefully selected. A large code length can induce delay or may cause interference.
- Time synchronization is required.
- Gradual transfer increases the use of radio resources and may reduce capacity.
- As the sum of the power received and transmitted from a base station needs constant tight power control. This can result in several handovers.



CDMA Network is the system meant to regulate CDMA technology. It includes all aspects and functionality starting from the base station, transmitting antenna, receiving antenna, to mobile switching centers.

FIRST TERM EXAMINATION [SEPT. 2016]
SEVENTH SEMESTER [B.TECH.]
WIRELESS COMMUNICATION (ETEC–405)

Time : 1.5 hrs. **M.M. : 30**

Note: ***Attempt any three questions including Q. no. 1 which is compulsory.***

Q.1. (*a*) Explain the term frequency reuse. What is the significance of this factor in mobile communications?

Ans. The design process of selecting and allocating channel groups for all of the cellular base station with in a system is called the frequency reuse.

Each BTS is allocated different band of frequency or different channels.

Each BTS antenna is designed in such a way that it covers cell area in which it is placed with frequency allocated without interferring other cell signals.

Generally 3 to 4 frequencies are assigned to each cell depending on the traffic expected. When engineers design or try to use this concept one question arises that after how many cells two cells assigned the same frequency.

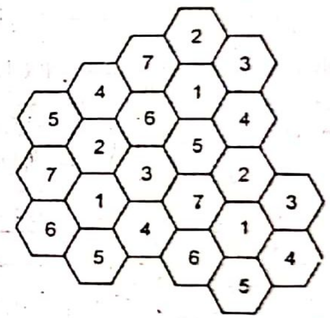


Fig. Frequency Reuse scheme

Q.1. (*b*) Define the term. Soft handoff and where it is employed?

Ans. A soft handoff occurs when a CDMA phone adds a new sufficiently-strong sector to its active set. It is so called because the radio link with the previous sector is not broken before a link is established with a new sector: this type of handoff is described as "make before break"

It is employed in CDMA systems where the phone can be connected to several cell sites simultaneously.

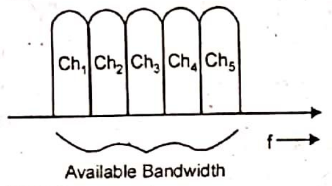
Q.1. (*c*) Briefly explain CDMA development.

Ans. CDMA system was developed by Qual Comm. It was standardized by Telecommunication Industry Association (TIA) as an interim standard (IS-95). This system supports a variable no. of users in 1.25 MHz wide channel using direct sequence spread spectrum.

CDMA can operate with a much smaller signal to noise ratio (SNR) than conventional narrow band FM

Q.2. (*b*) Explain FDMA briefly.

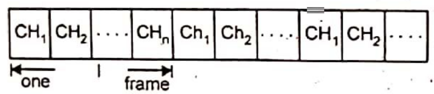
Ans. Here total allocated bandwidth is divided in the slots of pre-defined band. Each channel is allocated to the separate user and is available throughout the time duration. For doing communication in duplex mode the given band is further divided in Forward channel and reverse channel, this is called as frequency division duplexing



Q.1. (e) Explain the TDMA concept.

Ans. TDMA stands for Time Division Multiple Access, this means that total band is allocated to each user on time division basis and each user accesses the services on time cyclic basis.

Total time is divided in certain slots during which user is allowed to access the services, as shown one frame consist of all the slots



Q.2. (*a*) Compare the different features of GSM & EDGE.

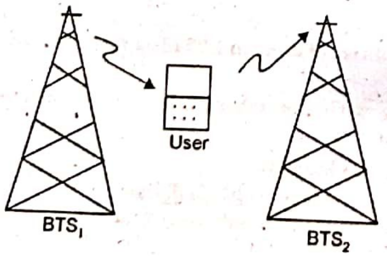
Ans. EDGE is the extended version of GSM technology and stands for Enhanced Data rate for GSM Evolution. This system helps in sending the data at the rate of 34 Kbps over a GSM TDMA system. This may some times be called as E-GPRS. It is anticipated that it can be used to provide the services who do not have licences of 3G. It is highly spectrally efficient and is capable to provided high speed services.

Parameter	GSM	EDGE
Modulation	Gaussion MSK	8psk
Bit rate	270 Kbps	812 Kbps
Channel Bandwidth	200 KHz	200 KHz
Pulse shaping	Gaussian Prefilter	Linearizes GMSK Pulse
Modulation Type	Non Linear	Linear

Q.2. (*b*) Explain the Handover process in CDMA system.

Ans. In the handover process, the called is transferred to that BTS from where user is getting better radio signal strength.

When the CDMA user is moving and is at the boundary of a BTS, the power of originating tower falls rapidly and if call is not transferred, then it will be dropped.



In soft handover user makes the connection with more than one BTS and then user is locked with that BTS from where radio strength signal is better.

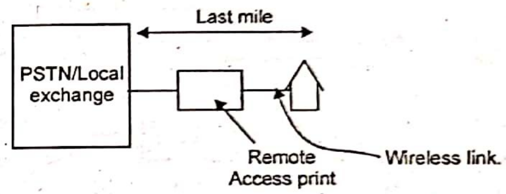
Q.3. (*a*) Explain the wireless Local Loop (WLL)

Ans. This type of connection is very much suitable for rapid deployment of wireless services. This may be based on some local distance basis or it may be based for remote areas. So it is divided in two categories:

(*a*) Last Mile WLL

(*b*) Long-Haul WLL

Last Mile WLL is generally for a distance of less than 35Km and long haul is for more than 35 km distance.



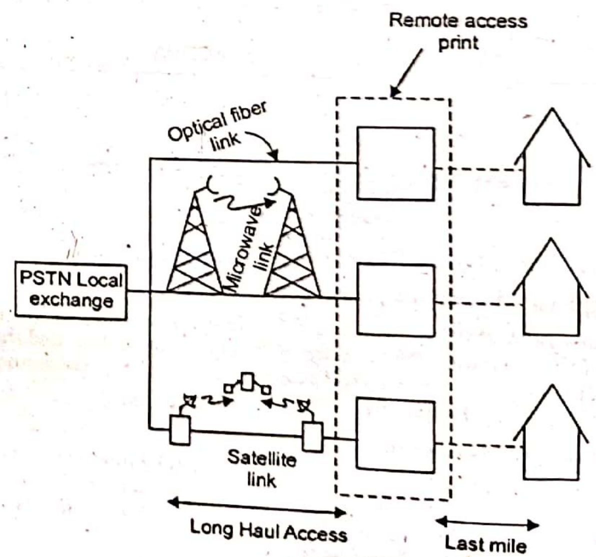
Last mile technology may be based on:

(*a*) Wireless: PSTN, DSL, Cable Modem

(*b*) Wireless: LMDS, MMDS, Wireless LAN, PCS

Long Haul WLL System may be based on:

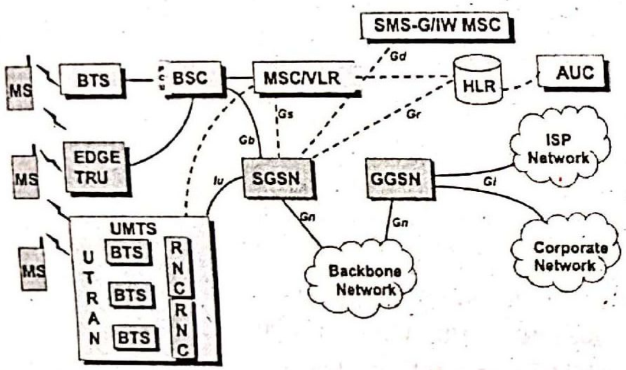
1. Optical fiber links
2. Microwave link
3. VSAT links



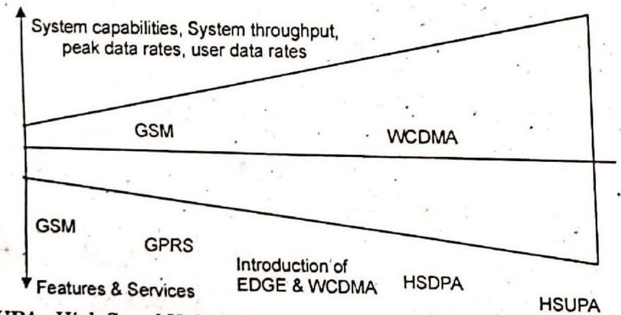
Q.3. (b) Explain UMTS technology and show its network evolution.

Ans. The Universal Mobile Telecommunications System (UMTS) is a third generation mobile cellular system for networks based on the GSM standard. Developed and maintained by the 3GPP (3rd Generation Partnership Project), UMTS is a component of the Standard International Union all IMT-2000 telecommunications and compares it with the standard set for CDMA2000 networks based on competition CDMA-1 technology. UMTS uses wideband code division multiple access (W-CDMA) radio access technology to provide greater spectral efficiency and bandwidth mobile network operators.

Network Evolution



An Evolution that Makes Sense



HSUPA : High Speed Uplink Packet Access

HSDPA : High speed downlink packet access

The main idea behind 3G is to prepare a universal infrastructure able to carry existing and also future services. The infrastructure should be so designed that technology changes and evolution can be adapted to the network without causing uncertainties to the existing services using the existing network structure.

Q.4. (a) Explain the Rayleigh fading.

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strength as the distance (R) increases between the base and the mobile. This component can be written as:

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Effects of Rayleigh Fading:

Reflection and multipath propagation can cause positive and negative effects.

Q.4. (b) Indicate the functions of MSC.

Ans. Functions of MSC:

• Call handling that copes with the mobile nature of subscribers considering Location Registration, Authentication of subscribers and equipment, Handover and Prepaid service.

• Management of required logical radio link channel during calls.

• Management of MSC-BSS signaling protocol.

• Handling location registration and ensuring interworking between mobile station and VLR.

• Controls inter-BSS and inter-MSC hand overs.

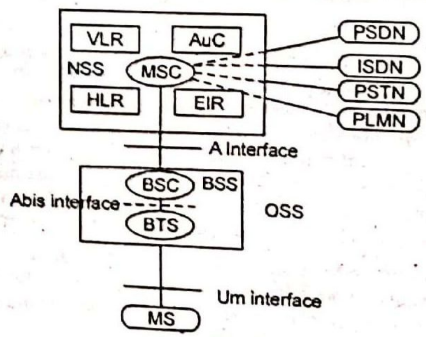
• Acting as a gateway MSC to interrogate HLR. The MSC which is connected to the PSTN/ISDN network is called as GMSC. This is the only MSC in the network connected to the HLR.

• Standard functions of a switch like charging.

Q.5. (a) Explain the different features of GSM architecture?

Ans. A GSM network comprises of many functional units. The GSM network can be broadly divided into:

Given below is a simple pictorial view of the GSM architecture.

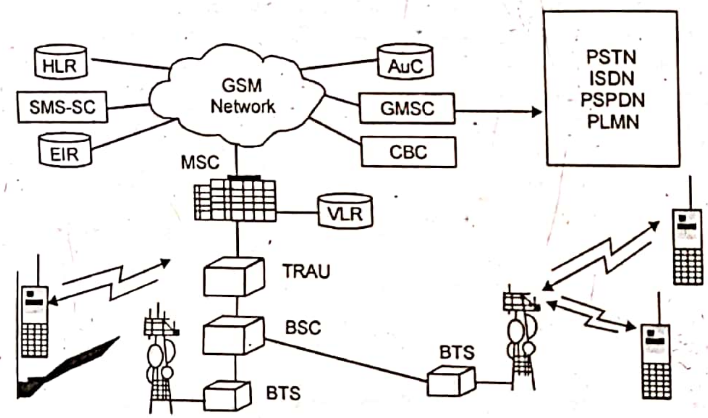


- The Mobile Station (MS)
- The Base Station Subsystem (BSS)
- The Network Switching Subsystem (NSS)
- The Operation Support Subsystem (OSS)

The additional components of the GSM architecture comprise of databases and messaging systems functions:

- Home Location Register (HLR)
- Visitor Location Register (VLR)
- Equipment Identity Register (EIR)
- Authentication Center (AuC)
- SMS Serving Center (SMS SC)
- Gateway MSC (GMSC)
- Chargeback Center (CBC)
- Transcoder and Adaptation Unit (TRAU)

The following diagram shows the GSM network along with the added elements:



The MS and the BSS communicate across the Um interface. It is also known as the *air interface* or the *radio link*. The BSS communicates with the Network Service Switching (NSS) center across the *A* interface

Q.5. (*b*) Explain the working of High-Speed Circuit Switched Data in GSM Technology.

Ans. HSCSD (High-Speed Circuit Switched Data) is a natural evolution of the existing circuit-switched data capability of traditional 2G GSM networks. With today's GSM network standards, it is already possible to transmit narrowband data and digital fax over the TDMA air interface. The methodology is akin to setting up a GSM voice call or perhaps to making a connection over a fixed line PSTN with the use of a modem. The user establishes a connection (or circuit) for the whole duration of that communication session. To set up the circuit, a call set-up process is involved when dialling the called party; network resources are allocated along the path to the end destination.

Within the existing GSM encoding techniques, the maximum circuit-switched data (CSD) speed is 9.6 Kbit/s or with improved encoding, up to 14.4 Kbit/s. The GSM TDMA interfaces can assign up to 8 time division slots per user frequency, not all of which are always used. Typically one is allocated for voice, while other slots may be allocated for fax and data. The availability of these time slots makes it possible to expand the existing CSD into HSCSD. The transition to HSCSD is not a difficult one for an existing 2G operator, and typically only necessitates a software upgrade of the Base Stations Systems (BSS) and Network and Switching System (NSS) systems.

A potential technical difficulty with HSCSD arises because in a multi-timeslot environment, dynamic call transfer between different cells on a mobile network (called 'handover') is complicated, unless the same slots are available end-to-end throughout the duration of the circuit switched data call. The second issue is that circuit switching in general is not efficient for bursty data/Internet traffic. The allocation of more circuits for data calls, with typically longer 'hold' times than for voice calls, creates the same problems that fixed line PSTN operators have experienced with the tremendous growth of Internet traffic – i.e., too few resources in their circuit switched networks

END TERM EXAMINATION [DEC. 2016]
SEVENTH SEMESTER [B.TECH.]
WIRELESS COMMUNICATION (ETEC-405)

Time : 3 hrs. **M.M. : 75**

Note: *Attempt any five questions including Q. no. 1 which is compulsory.*

Q.1. (*a*) What are the two major parts of a typical PCS network architecture? (3)

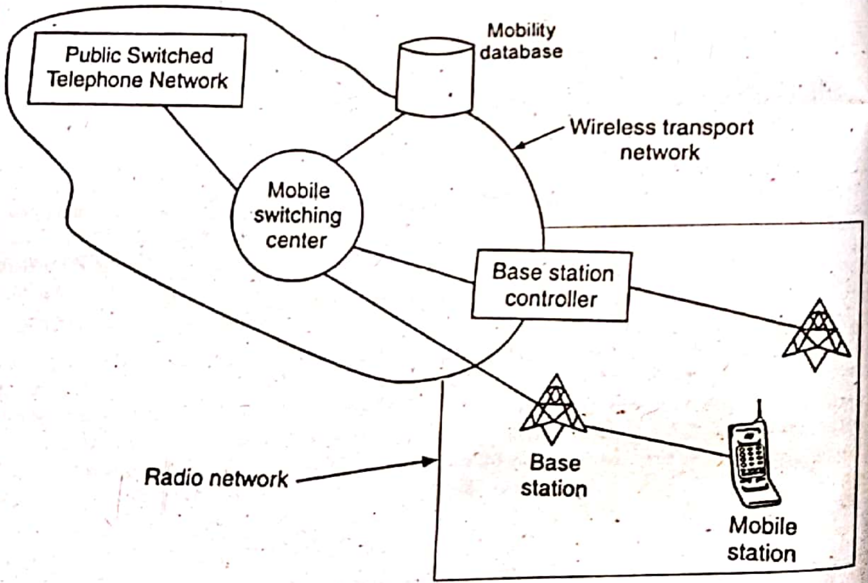
Ans. The PCS architecture consist of two part

i. Radio network

ii. Wireless transport network

Radio Network: PCS users carry mobile stations (MS) to communicate with a BS in a PCS network. MS is also referred to as handset or mobile phone. The radio coverage of a base station is called cell. In GSM network, each cell is controlled by BSC which are connected to MS through BS. The BSC are connected to MSC by landlines.

Wireline Transport Network: An MSC is a telephone exchange configured specially for mobile applications. It interfaces the MS (via BS) with PSTN. MSCs are also connected with mobility database to track the location of MS and roaming management. The databases are HLR and VLR. HLR contains the authentication information like IMSI (International Mobile Subscriber Identity), identification information like name, address of the subscriber, billing information like prepaid or postpaid, operator selection, denial of service to a susbscriber etc. VLR gives information about the location area of the subscriber while on roaming and power off status of the handset.



Q.1. (*b*) What are the differences between the second generation mobile technology and third generation mobile technology? (3)

Ans. Difference between 2G and 3G Technology

• **Cost:** The license fee to be paid for 3G network is much higher as compared to 2G networks. The network construction and maintenance of 3G is much costlier than 2G networks. Also from the customers point of view the expenditure for 3G network will be excessively high if they make use of the various applications of 3G.

• **Data Transmission:** The main **difference between 2G and 3G** networks is seen by the mobile users who download data and browse the Internet on the mobile phones. They find much faster download speeds, faster access to the data and applications in 3G networks as compared to 2G networks. 2G networks are less compatible with the functions of smart phone. The speed of data transmission in 2G network is less than 50,000 bits per sec while in 3G it can be more than 4 million bits per sec.

• **Function:** The main function of 2G technology is the transmission of information via voice signals while that of 3G technologies is data transfer via video conferencing, MMS etc.

• **Features:** The features like mobile TV, video transfers and GPS systems are the additional features of 3G technology that are not available with 2G technologies.

• **Frequencies:** 2G technology uses a broad range of frequencies in both upper and lower bands, under which the transmission depends on conditions such as weather. A drawback of 3G is that it is simply not available in certain regions.

• **Implication:** 3G technology offers a high level of security as compared to 2G technology because 3G networks permit validation measures when communicating with other devices.

• **Making Calls:** Calls can be made easily on both 2G and 3G networks with no real noticeable differences except that in 3G network video calls can also be made. The transmission of text messages and photos is available in both the networks but 2G networks have data limit and the speed of the data transmission is also very slow as compared to 3G.

•**Speed:** The downloading and uploading speeds available in 2G technologies are up to 236 Kbps. While in 3G technology the downloading and uploading speeds are up to 21 Mbps and 5.7 Mbps respectively

Q.1. (*c*) What are the main parts of the GSM SMS protocol stock? (3)

Ans. The CM layer is the topmost layer of the GSM protocol stack. This layer is responsible for Call Control, Supplementary Service Management, and Short Message Service Management. Each of these services are treated as individual layer within the CM layer.

Q.1. (*d*) What is EDGE? Explain. (3)

Ans. EDGE (enhanced data for global evolution) EDGE (also known as Enhanced GPRS or EGPRS) is a data system used on top of GSM networks. It provides nearly three times faster speeds than the outdated GPRS system. The theoretical maximum speed is 473 kbps for 8 timeslots but it is typically limited to 135 kbps in order to conserve spectrum resources. Both phone and network must support EDGE, otherwise the phone will revert automatically GPRS.EEDGE meets the requirements for a 3G network but is usually classified as 2.75G.

1. Q. (*e*) What is Wi-Max Technology? Explain (3)

Ans. WiMAX (Worldwide Interoperability for Microwave Access) is a family of wireless communication standards based on the IEEE 802.16 set of standards, which provide multiple physical layer (PHY) and Media Access Control (MAC) options. WiMAX was initially designed to provide 30 to 40 megabit-per-second data rates, with the 2011 update providing up to 1 Gbit/s for fixed stations.

The bandwidth and range of WiMAX make it suitable for the following potential applications:

- Providing portable mobile broadband connectivity across cities and countries through various devices.
- Providing a wireless alternative to cable and digital subscriber line (DSL) for "last mile" broadband access.
- Providing data, telecommunications (VoIP) and IPTV services (triple play).
- Providing Internet connectivity as part of a business continuity plan.
- Smart grids and metering

Q.2. (*a*) How do TDMA, FDMA and CDMA works? Complete these three technologies **(8)**

Ans. TDMA : TDMA is a digital technique that divides a single channel or band into time slots. Each time slot is used to transmit one byte or another digital segment of each signal in sequential serial data format. This technique works well with slow voice data signals, but it's also useful for compressed video and other high-speed data.

FDMA: FDMA is the process of dividing one channel or bandwidth into multiple individual bands, each for use by a single user *(Fig. 1)*. Each individual band or channel is wide enough to accommodate the signal spectra of the transmissions to be propagated. The data to be transmitted is modulated on to each subcarrier, and all of them are linearly mixed together.

CDMA: CDMA is another pure digital technique. It is also known as spread spectrum because it takes the digitized version of an analog signal and spreads it out over a wider bandwidth at a lower power level. This method is called direct sequence spread spectrum (DSSS) as well .

Frequency division multiple access (FDMA):

It is a technology by which the total bandwidth available to the system is divided into frequencies. This division is done between non overlapping frequencies that are then assigned to each communicating pair (2 phones)

FDMA is used mainly for analog transmission. Its not that this technology is not capable of carrying digital information, but just that it is not considered to be an efficient method for digital transmission. Because just imagine if the frequencies to handle the customers gets over? What if more capacity is required? The only option would be to drill down the existing frequencies to a much narrower amount which will not be very competent. In FDMA all users share the satellite simultaneously but each user transmits at single frequency.

To understand this technology better, just imagine how FM radio works. All the radios have their own frequency bands and they send their signals at the carefully allocated unique frequencies within the available bands.

Code division multiple access (CDMA):

Unlike FDMA, CDMA separates calls by code. Every bit of a conversation is been tagged with a specific and unique code. The system gets a call, it allocates a unique code to that particular conversation, now the data is split into small parts and is tagged with the unique code given to the conversation of which they are part of. Now, this data in small pieces is sent over a number of the discrete frequencies available for use at any time in the specified range. The system then at the endreassembles the conversation from the coded bits and deliver itJ Does it make sense?

Just think about how you recollect your luggage at the end of the flight journey. When you check in, a tag with a code is given to you which is also given to your luggageJ And at the destination, you collects your luggage on the basis of thatJ I know you will say that you recognize your bag, but then I have a habit of always matching the codes of my bag and the one on the tag given to me and that is how I become sure of not picking up the wrong lunguageJ

Time division multiple access (TDMA):

Unlike FDMA and CDMA, In TDMA the division of calls happens on time basis. The system first digitizes the calls, and then combines those conversations into a unified digital stream on a single radio channel. Now it divides each cellular channel into three time slots that means three calls get put on a single frequency and then, a time slot is assigned to each call during the conversation, a regular space in a digital stream. The users transmit in rapid succession, one after the other, each using its own time slot. This allows multiple stations to share the same transmission medium (e.g. radio frequency channel) while using only a part of its channel capacity.

This technology enables three different users to use one frequency at the same time.

Here there is no need for three separate frequencies like in FDMA. As in FDMA, instead of monopolizing a single radio channel for a single call, TDMA efficiently carries three calls at the same timeJ

BTW, this technology is the one used in our GSM system

Q.2. (*b*) What is mobility management? Explain. **(7)**

Ans. Mobility management is one of the major functions of a GSM or a UMTS network that allows mobile phones to work. The aim of mobility management is to track where the subscribers are, allowing calls, SMS and other mobile phone services to be delivered to them.

Location update procedure

The location update procedure allows a mobile device to inform the cellular network, whenever it moves from one location area to the next. Mobiles are responsible for detecting location area codes (LAC). When a mobile finds that the location area code is different from its last update, it performs another update by sending to the network, a location update request, together with its previous location, and its Temporary Mobile Subscriber Identity (TMSI).

The mobile station also stores the current LAC in the SIM card, concatenating it to a list of recently used LACs. This is done to avoid unnecessary IMSI attachment procedures in case the mobile station has been forced to switch off (by removing the battery, for example) without having a chance to notify the network with an IMSI detach and then switched on right after it has been turned off. Considering the fact that the mobile station is still associated with the Mobile Switching Center/Visitor Location Register (MSC/VLR) of the current location area, there is no need for any kind of IMSI attachment procedures to be done. There are several reasons why a mobile may provide updated location information to the network. Whenever a mobile is switched on or off, the network may require it to perform an IMSI attach or IMSI detach location update procedure. Also, each mobile is required to regularly report its location at a set time interval using a *periodic location update* procedure. Whenever a mobile moves from one location area to the next while not on a call, a *random location* update is required. This is also required of a stationary mobile that reselects coverage from a cell in a different location area, because of signal fade. Thus, a subscriber has reliable access to the network and may be reached with a call, while enjoying the freedom of mobility within the whole coverage area.

When a subscriber is paged in an attempt to deliver a call or SMS and the subscriber does not reply to that page then the subscriber is marked as absent in both the MSC/

VLR and the Home Location Register (HLR) (Mobile not reachable flag MNRF is set). The next time the mobile performs a location update, the HLR is updated and the mobile not reachable flag is cleared.

Q.3. (*a*) What is hand off? What is roaming? How do you perform hand off during roaming?

Ans. Roaming is one of the fundamental mobility management procedures of all cellular networks. Roaming is defined as the ability for a cellular customer to automatically make and receive voice calls, send and receive data, or access other services, including home data services, when travelling outside the geographical coverage area of the home network, by means of using a visited network. This can be done by using a communication terminal or else just by using the subscriber identity in the visited network. Roaming is technically supported by a mobility management, authentication, authorization and billing procedures.

Handoff : In cellular telecommunications, the terms **handover** or **handoff** refer to the process of transferring an ongoing call or data session from one channel connected to the core network to another channel. In satellite communications it is the process of transferring satellite control responsibility from one earth station to another without loss or interruption of service.

The most basic form of handover is when a phone call in progress is redirected from its current cell (called *source*) to a new cell (called *target*).[1] In terrestrial networks the source and the target cells may be served from two different cell sites or from one and the same cell site (in the latter case the two cells are usually referred to as two *sectors* on that cell site). Such a handover, in which the source and the target are different cells (even if they are on the same cell site) is called *inter-cell*handover. The purpose of inter-cell handover is to maintain the call as the subscriber is moving out of the area covered by the source cell and entering the area of the target cell.

A special case is possible, in which the source and the target are one and the same cell and only the used channel is changed during the handover. Such a handover, in which the cell is not changed, is called *intra-cell* handover. The purpose of intra-cell handover is to change one channel, which may be interfered or fading with a new clearer or less fading channel.

In addition to the above classification of *inter-cell* and *intra-cell* classification of handovers, they also can be divided into hard and soft handovers

Hard handover: Is one in which the channel in the source cell is released and only then the channel in the target cell is engaged. Thus the connection to the source is broken before or 'as' the connection to the target is made—for this reason such handovers are also known as *break-before-make*. Hard handovers are intended to be instantaneous in order to minimize the disruption to the call. A hard handover is perceived by network engineers as an event during the call. It requires the least processing by the network providing service. When the mobile is between base stations, then the mobile can switch with any of the base stations, so the base stations bounce the link with the mobile back and forth. This is called 'ping-ponging'.

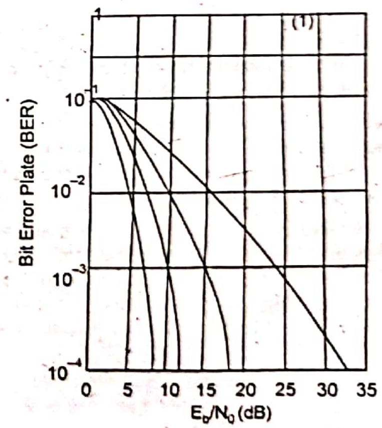
Soft handover: Is one in which the channel in the source cell is retained and used for a while in parallel with the channel in the target cell. In this case the connection to the target is established before the connection to the source is broken, hence this handover is called *make-before-break*. The interval, during which the two connections are used in parallel, may be brief or substantial. For this reason the soft handover is perceived by network engineers as a state of the call, rather than a brief event. Soft handovers may involve using connections to more than two cells: connections to three, four or more cells can be maintained by one phone at the same time. When a call is in a state of soft handover, the signal of the best of all used channels can be used for the call at a given moment or all the signals can be combined to produce a clearer copy of the signal. The latter is more advantageous, and when such combining is performed both in the downlink (forward link) and the uplink (reverse link) the handover is termed as *softer*. Softer handovers are possible when the cells involved in the handovers have a single cell site.

Handover can also be classified on the basis of handover techniques used. Broadly they can be classified into three types:

1. Network controlled handover
2. Mobile phone assisted handover
3. Mobile controlled handover

Q.3. (*b*) Discuss about BER performance in fading channels. **(7)**

Ans. One of the major distinctions between the wire -line and wireless communication lies in the physical properties of wireless channels which include propagation losses, multipath, fading, and so on. Different transmission media have different properties and are modeled differently. Different channel models ; flat and frequency selective fading fast and slow fading ,AWGN, Rayleigh and Rician fading channels. In the performance analysis of a wireless communication system. defining bit error rate (BER; no of bit errors per bit transfered) is very important. Rician fading. wireless channel can be characterized by a parameter K (Rician factor) which is defined as the ratio of the dominant (line of-light) path to the scattered path (multipath). When k = 0, the channel is Raylight channel (the power in dominant path is zero). When K = ∞; the channel is AWGN channel (the power in scattered path is zero). For any finite value of K, the channel is Rician channel.



k = 16; (5)

The theoretical BER vs E_b/N_0 Ratio curve for various Fading conditions (1) Frequency selective fading of fast fading distortion; (2) Flat fading and slow fading rayleigh limit K = 0; (3) Rician fading k = 4; (4) Rician fading (5) Additive white gaussian noise k = ∞.

BER performance as a function of $\frac{E_b}{N_0}$ is plotted in Fig. for various fading channel models. It can be observed that as $\frac{E_b}{N_0}$ ratio increases, the bit-error rate drops. Following conclusions can be obtained from the graph about different fading channel models.

With a reasonably high $\frac{E_b}{N_0}$ ratio, an AWGN wireless channel exhibits fairly good performance.

• A Rician fading channel model exhibit provides good performance with larger values of K.

• The Rayleigh fading channel model provides relatively poor performance.The situation is same for slow as well as flat fading.

• Finally, in aces fast fading and frequency selective fading channel in an urban environment, fading effects worse than the so-called worst case of Rayleigh fading. In such cases, BER performance remains poor even if we increase $\frac{E_b}{N_0}$ ratio.

Q.4. (a) What is distance dependent fading? What is rayleight fading? What is shadow fading?

Ans. Distance dependent fading: The strength of received signal varies with distances is known as distance dependent fading. There are two type of distance dependent fading:

(1) long distance

(2) short distance

Rayleigh fading is a statistical model for the effect cf a propagation environment on a radio signal, such as that used by wireless devices.

Rayleigh fading models assume that the magnitude of a signal that has passed through such a transmission medium (also called a communications channel) will vary randomly, or fade, according to a Rayleigh distribution — the radial component of the sum of two uncorrelated Gaussian random variables.

Rayleigh fading is viewed as a reasonable model for tropospheric and ionospheric signal propagation as well as the effect of heavily built-up urban environments on radio signals. Rayleigh fading is most applicable when there is no dominant propagation along a line of sight between the transmitter and receiver. If there is a dominant line of sight, Rician fading may be more applicable. Rayleigh fading is a special case of two-wave with diffuse power (TWDP) fading.

Rayleigh fading is a reasonable model when there are many objects in the environment that scatter the radio signal before it arrives at the receiver. The central limit theorem holds that, if there is sufficiently much scatter, the channel impulse responsewill be well-modelled as a Gaussian process irrespective of the distribution of the individual components. If there is no dominant component to the scatter, then such a process will have zero mean and phase evenly distributed between 0 and 2π radians. The envelope of the channel response will therefore be Rayleigh distributed colling this random variable.

R, it will have a probability density function

Shadow fading :Shadowing from obstacles affecting the wave propagation, sometimes referred to as **shadow fading**.

Q.4. (b) How does IS-95 CDMA works? Explain **(7)**

Ans. The IS-95 standard describes a Code Division Multiple Access (CDMA) system in which the audio band data signal is multiplied by a high rate spreading signal. This spreading signal is formed from a pseudo-noise code sequence, which is then multiplied by a Walsh code for maximum orthogonality to (ie. to have low cross-correlation with) the other codes in use in that cell. Typically, CDMA pseudo-noise sequences are very long, thereby giving excellent crosscorrelation characteristics. (IS-95 uses a 242-1 chip period, derived from a 42 bit mask.) The IS-95 system can be thought of as having many layers of protection against interference. It allows many users to co-exist, with minimal mutual interference. They can be described by the signal conditioning sequence that occurs on forward and reverse channels (**Figure 1 and Figure 2, respectively**). The forward channel carries information from the base station to the mobile unit; the reverse channel carries information from the mobile unit to the base station. The transmission channels are shown; the reception of each channel follows the reverse sequence. The forward channels are between 869 and 894 MHz, while the reverse channels are between 824 and 849 Mhz. Within these bands, four sub-bands are available for CDMA, of widths 1, 0.1, 9 and 10 MHz;

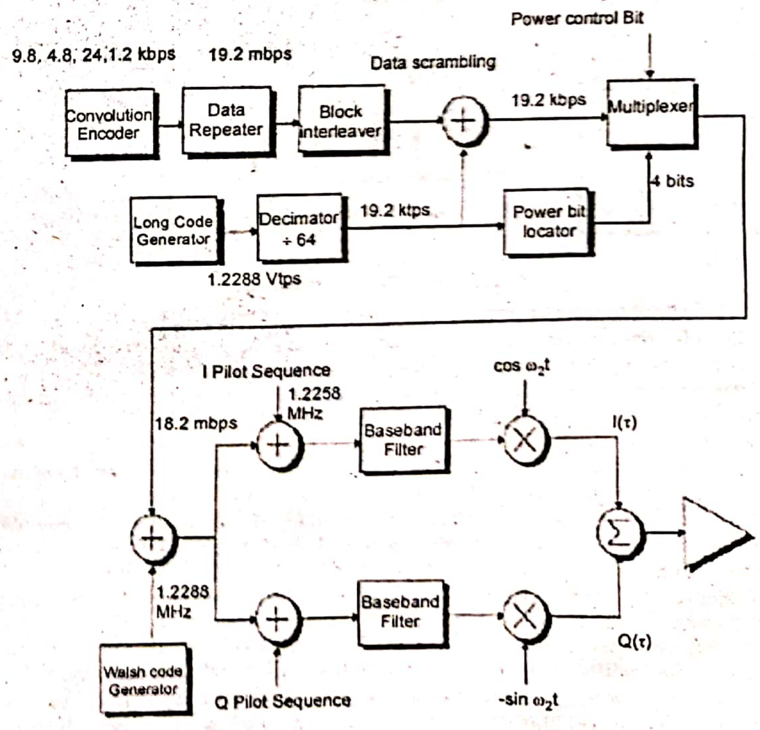


Figure: Forward CDMA channel

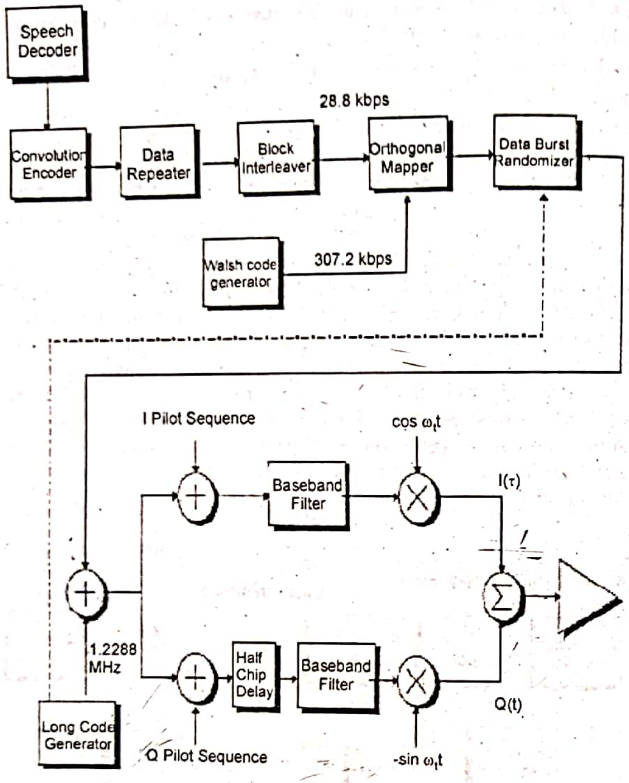


Fig.2. Reverse CDMA Channel

Forward channel transmission sequence:

1. Convolution encoder Encodes the data from one stream to two, doubling the nominal rate from 9.6 kpbs to 19.2 kbps, 4.8 kbps data to 9.6 kbps, etc.

2. Repetition circuit Repeats coded symbols, so lower rate encoded data is increased from 9.6, 4.8 or 2.4 kbps to 19.2 kbps.

3. Block Interleaver Reads data into the rows of a 24 x 16 array, and out of the columns; introduces a 20 msec delay, but spreads important bits (as produced by modern speech encoders) over time as proof against deep fades or noise bursts.

4. Data scrambling The data are Modulo 2 added to every 64th bit of a pseudo-noise (PN) sequence created from a 42 bit shift register. (The resulting 242-1 bits repeat once per century after initiation.) The data rate at this point is still 19.2 kbps.

5. Power control Every 1.25 msec, or 24 data symbols, a power control bit is inserted, in order to instruct the mobile unit to raise or lower its power (to equalize the power received from every mobile unit in the cell.) The location of the power control bit is determined from the PN sequence.

6. Orthogonal covering The 19.2 kbps data are spread with a 1.2288 Mbps Walsh function, so that each one bit data symbol is spread by 64 Walsh chips. The Walsh function provides 64 mutually orthogonal binary sequences, each of length 64.

7. Quadrature spreading The data are split into two bit streams, which are Modulo 2 added to two different but well defined "Pilot" pseudo-noise sequences generated from 15 bit shift registers. The code repeats 75 times every 2 seconds, or at 26.7 msec intervals.

8. Quadrature modulation The binary I and Q outputs are mapped onto four phases of a quadrature modulator, at $\pm\pi/4$ and $\pm 3\pi/4$, using quadrature phase shift keying (QPSK).

9. RF modulation The baseband quadrature data are raised to the forward cellular radio band, 869 to 894 MHz.

The IS-95 channel occupies 1.25 MHz within this band, the rest of which is occupied by other cellular services such as AMPS.

Reverse channel transmission sequence:

1. Speech encoder Produces nominal 9600 bps data stream, dynamically reduced to 4800, 2400, or 1200 bps during pauses and gaps in speech; quiet periods correspond to 1200 bps data.

2. Convolution encoder Encodes the data from one stream to three, tripling the data rate from 9.6 kpbs to 28.8 kbps,4.8 kbps data to 14.4 kbps, etc.

3. Repetition circuit Repeats coded symbols, so lower rate encoded data is increased from 9.6, 4.8 or 2.4 kbps to 19.2 kbps.

4. Block Interleaver Reads data into the columns of a 32 x 18 array, and out of the rows; introduces a 20 msec delay, but spreads important bits over time as proof against deep fades or noise bursts.

5. Orthogonal mapping The 28.8 kbps data are split into sequential sets of six bits each, which are mapped to one of 64 Walsh functions. The data rate is therefore raised to 28.8 k x 64 chips/ 6 bits = 307.2 kpbs.

6. Burst Randomizing The Walsh symbols are broken into groups of six, each group being 1.25 msec in duration.

These are collected into frames of 16 power groups, or 1.25 msec x 16 = 20 msec. At 9600 bps, all 16 groups are transmitted; at 4800 bps, 8 randomly selected groups are transmitted; at 2400 bps, 4 groups; at 1200 bps, 2 groups. The transmitted groups are chosen randomly, according to a formula based on 14 bits of the PN sequence of the second last group in the previous frame.

7. Direct sequence spreading The data are Modulo 2 added to every bit of a pseudo-noise (PN) sequence created from a 42 bit shift register. The PN sequence is generated at 1.2288 MHz, so each Walsh chip is spread by four long code PN chips.

8. Quadrature spreading The data are split into two bit streams, which are Modulo 2 added to two different but well defined "Pilot" pseudo-noise sequences generated from 15 bit shift registers.

9. Quadrature modulation The binary I and Q outputs are mapped onto four phases of a quadrature modulator, at $\pm\pi/4$ and $\pm 3\pi/4$, using offset quadrature phase shift keying (OQPSK). (The Q channel is shifted by half a chip for improved spectral shaping.)

10. RF modulation The baseband quadrature data are raised to the reverse cellular radio band, 824 to 849 MHz.

The IS-95 channel occupies 1.25 MHz within this band, the rest of which is occupied by other cellular services such as AMPS.

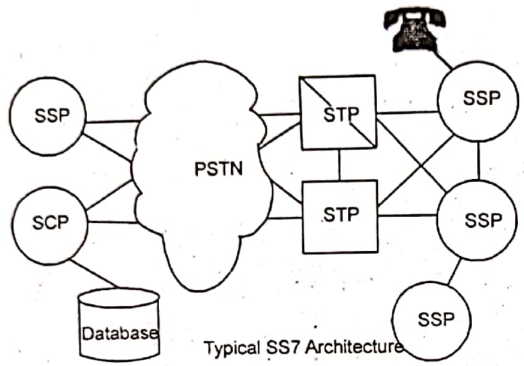
Q.5. (a) Why is SS7 classified as a common channel signaling protocol? What are the main elements in the SS7 architecture. Describe them. (8)

Ans. SS7 Architecture consists of three different entities:

1. SSP (Service Switching Point)

2. STP (Signal Transfer Point)

3. SCP (Service Control Point)



Typical SS7 Architecture

1. Service Switching Point (SSP)

- SSPs are switches in SS7 network.
- SSPs convert a dialed number from a subscriber line to SS7 signaling messages.
- SSPs setup, manage and release voice circuits required to make a call.
- SSPs send messages using the ISDN User Part (ISUP) and Transaction Capabilities Application Part (TCAP) protocols
- SSP's function is to use a global title to determine how to connect a call using its routing table

2. Signal Transfer Point (STP)

- An STP is a router and/or a gateway in the SS7 network.
- Messages are not originated by an STP..
- If an originating SSP does not know the address of a destination SSP, the STP must provide it using Global Title Translation.
- Gateway STPs serve as the interface into another network and they can provide protocol conversion.
- STPs also provide traffic and usage measurements.

3. SCP (Service Control Point)

An SCP is usually a computer used as a front end to a database system. It is an interface to application-specific databases. The address of an SCP is a *point code*, and the address of the database it interfaces with is a *subsystem number*. The database is an application entity which is accessed via the TCAP protocol. It accepts a query for information from a subsystem at another node. SCP is used by STP to perform a function called global title translation

Q.5. (*b*) Show how to integrate the registration and the authentication procedures in GSM. **(7)**

Ans. Home Location Register (HLR): This database contains all the administrative information about each subscriber along with their last known location. In this way, the GSM network is able to route calls to the relevant base station for the MS. When a user switches on their phone, the phone registers with the network and from this it is possible to determine which BTS it communicates with so that incoming calls can be routed appropriately. Even when the phone is not active (but switched on) it re-registers periodically to ensure that the network (HLR) is aware of its latest position.

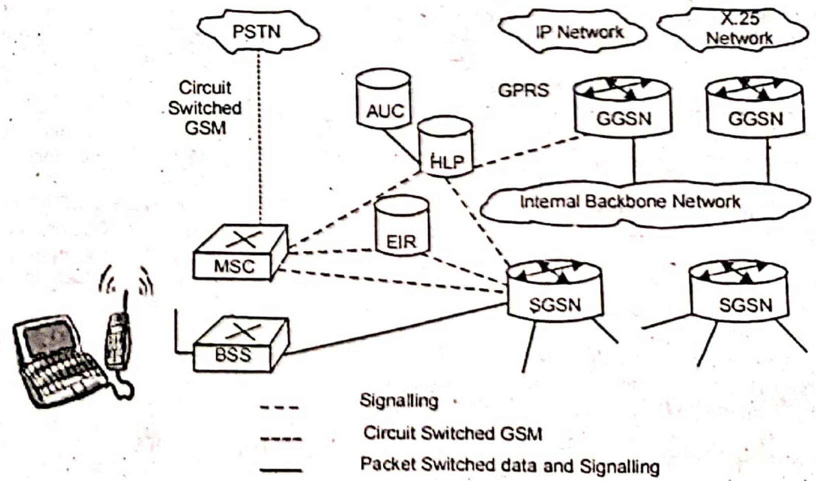
There is one HLR per network, although it may be distributed across various sub-centres to for operational reasons.

- **Visitor Location Register (VLR):** This contains selected information from the HLR that enables the selected services for the individual subscriber to be provided. The VLR can be implemented as a separate entity, but it is commonly realised as an integral part of the MSC, rather than a separate entity. In this way access is made faster and more convenient.
- **Equipment Identity Register (EIR):** The EIR is the entity that decides whether a given mobile equipment may be allowed onto the network. Each mobile equipment has a number known as the International Mobile Equipment Identity. This number, as mentioned above, is installed in the equipment and is checked by the network during registration. Dependent upon the information held in the EIR, the mobile may be allocated one of three states - allowed onto the network, barred access, or monitored in case its problems.
- **Authentication Centre (AuC):** The AuC is a protected database that contains the secret key also contained in the user's SIM card. It is used for authentication and for ciphering on the radio channel.

Q.6. (*a*) Describe the GPRS architecture and protocols. How many of them already exist in GSM? **(8)**

Ans. GPRS architecture works on the same procedure like GSM network, but, has additional entities that allow packet data transmission. This data network overlaps a second-generation GSM network providing packet data transport at the rates from 9.6 to 171 kbps. Along with the packet data transport the GSM network accommodates multiple users to share the same air interface resources concurrently.

Following is the GPRS Architecture diagram:



GPRS attempts to reuse the existing GSM network elements as much as possible, but to effectively build a packet-based mobile cellular network, some new network elements, interfaces, and protocols for handling packet traffic are required.

Therefore, GPRS requires modifications to numerous GSM network elements as summarized below:

GSM Network Element	Modification or Upgrade Required for GPRS
Mobile Station (MS)	New Mobile Station is required to access GPRS services. These new terminals will be backward compatible with GSM for voice calls.
BTS	A software upgrade is required in the existing Base Transceiver Station(BTS).
BSC	The Base Station Controller (BSC) requires a software upgrade and the installation of new hardware called the packet control unit (PCU). The PCU directs the data traffic to the GPRS network and can be a separate hardware element associated with the BSC.
GPRS Support Nodes (GSNs)	The deployment of GPRS requires the installation of new core network elements called the serving GPRS support node (SGSN) and gateway GPRS support node (GGSN).
Databases (HLR, VLR, etc.)	All the databases involved in the network will require software upgrades to handle the new call models and functions introduced by GPRS.

GPRS Mobile Stations

New Mobile Stations (MS) are required to use GPRS services because existing GSM phones do not handle the enhanced air interface or packet data. A variety of MS can exist, including a high-speed version of current phones to support high-speed data access, a new PDA device with an embedded GSM phone, and PC cards for laptop computers. These mobile stations are backward compatible for making voice calls using GSM.

GPRS Base Station Subsystem

Each BSC requires the installation of one or more Packet Control Units (PCUs) and a software upgrade. The PCU provides a physical and logical data interface to the Base Station Subsystem (BSS) for packet data traffic. The BTS can also require a software upgrade but typically does not require hardware enhancements.

When either voice or data traffic is originated at the subscriber mobile, it is transported over the air interface to the BTS, and from the BTS to the BSC in the same way as a standard GSM call. However, at the output of the BSC, the traffic is separated voice is sent to the Mobile Switching Center (MSC) per standard GSM, and data is sent to a new device called the SGSN via the PCU over a Frame Relay interface.

GPRS Support Nodes

Following two new components, called Gateway GPRS Support Nodes (GSNs) and Serving GPRS Support Node (SGSN) are added:

Gateway GPRS Support Node (GGSN)

The Gateway GPRS Support Node acts as an interface and a router to external networks. It contains routing information for GPRS mobiles, which is used to tunnel packets through the IP based internal backbone to the correct Serving GPRS Support Node. The GGSN also collects charging information connected to the use of the external data networks and can act as a packet filter for incoming traffic.

Serving GPRS Support Node (SGSN)

The Serving GPRS Support Node is responsible for authentication of GPRS mobiles registration of mobiles in the network, mobility management, and collecting information on charging for the use of the air interface.

Internal Backbone

The internal backbone is an IP based network used to carry packets between different GSNs. Tunnelling is used between SGSNs and GGSNs, so the internal backbone does not need any information about domains outside the GPRS network. Signalling from a GSN to a MSC, HLR or EIR is done using SS7.

Routing Area

GPRS introduces the concept of a Routing Area. This concept is similar to Location Area in GSM, except that it generally contains fewer cells. Because routing areas are smaller than location areas, less radio resources are used While broadcasting a page message.

Q.6. (*b*) Compare W.CDMA and CDMA 2000.

Ans.

Parameter	WCDMA	CMDA2000
Carrier Spacing : spacing between CDMA operators to obtain channel protection	5 MHz	3.75 MHz
Chip Rate : number of DSSS pulses per second; a chip is a pulse of DSSS code	4.096 MHz	3.68 MHz
Spreading Factor : SF=(Chip Rate)/(Data Rate)	Higher	Lower
Power Control Frequency : the output power of the transmitter is controlled by itself at this frequency	1500 Hz	800 Hz
Frame Duration : the time duration of a frame;between beginning and end of the frame.	10 ms	20 ms (also uses 5, 30, 40 ms frames)
Base Stations : base stations may or may not need synchronous timings	Asynchronous	Synchronous
Forward Link Pilot : The pilot is a channel modulated only by the PN (Pseudo Noise) spreading codes	TDM, Dedicated pilot	CDM, Common Pilot
Antenna Beam Forming : used for directional signal transmission & reception	DM, Dedicated pilot	Auxiliary pilot

Q.7. (*a*) Write short note on quality of service in 3G.

Ans. The Internet was originally designed for nonreal-time data services such as interactive burst or interactive bulk transfer. In these applications, there are no requirements on the maximum amount of delays that a packet may encounter during its transit to the destination. Similarly, bandwidths required by an end user are never specified. As such, the network accepts all incoming packets without using any admission control mechanism, forwards them using a simple, first-come-first-served algorithm, and delivers them on a best-effort basis. Thus, issues concerning the *quality of service* (QoS) delivered to an end user are rather straightforward. The QoS in present-day mobile IP is also minimal because, once again, data is delivered using the best-effort scheme. With the emergence of real-time multimedia services as envisaged by *third-generation* (3G) wireless systems, new QoS requirements are imposed on the networks. For example, with interactive video conferencing or streaming video and audio, the network must be able to deliver these services to the destination on a timely basis. Because flow control or retransmission is not possible for these applications, the bit error rate or packet loss ratio must be kept below a certain level; otherwise, the QoS may suffer. For instance, if the bit error rate is too high, the video in an MPEG application may never synchronize at a receiver.

Q.7. (b) What is mobile IP? Discuss **(7)**

Ans. Mobile IP (or MIP) is an Internet Engineering Task Force (IETF) standard communications protocol that is designed to allow mobile device users to move from one network to another while maintaining a permanent IP address. Mobile IP for IPv4 is described in IETF RFC 5944, and extensions are defined in IETF RFC 4721. **Mobile IPv6**, the IP mobility implementation for the next generation of the Internet Protocol, IPv6, is described in RFC 6275. The Mobile IP allows for location-independent routing of IP datagrams on the Internet. Each mobile node is identified by its home address disregarding its current location in the Internet. While away from its home network, a mobile node is associated with a *care-of* address which identifies its current location and its home address is associated with the local endpoint of a tunnel to its *home agent*. Mobile IP specifies how a mobile node registers with its home agent and how the home agent routes datagrams to the mobile node through the *tunnel*.

Q.8. Describe four major technologies for WLL System. What are the advantage and disadvantage of these approaches? **(15)**

Ans. 1. Wireless local loop is used for wireless communication links which deliver plain old telephone services or broadband services to customers. This is an ideal application which provides telephone services remotely and is mostly used in developing countries where cable infrastructure is either expensive or speed is not fast. This wireless link can be a part of the connection between the subscribers and switch.

This system is based on radio networks which provide services like telephone in remote areas. Different types of wireless local loop include Broadband Wireless Access, Radio in the Loop, Fixed Radio Access andFixed Wireless Access.

1. HNS Terminal Earth Station Quantum System
2. lucent Wireless Subscriber System
3. HNS E-TDMA
4. The PACS WLL System

In comparison to the alternative of deploying copper lines, WLL technology offers a number of key advantages:

• **Faster deployment:** WLL systems can be deployed in weeks or months as compared to the months or years need for the deployment of aboveground or underground copper wire. Even with higher costs per subscriber that may be associated with the WLL terminal and base station equipment, the faster rate of deployment can permit a higher return on investment.

• **Lower deployment costs:** The deployment of WLL technology involves considerably less heavy construction than does the laying of copper lines. The lower construction costs may be more than offset by the additional equipment costs associated with WLL technology, but, in urban areas especially, the process of routing cable to individual households is also much more time consuming than deploying wireless base stations, which are shared by many subscribers. Wireline networks also take more time to deploy than WLL networks because they require government right of way authorization to dig trenches through public streets.

• **Lower network maintenance, management, and operating costs:** Especially in areas where the deployment of copper lines has the potential to be haphazardly performed, wireless equipment can be less failure prone than copper wire and can be less vulnerable to sabotage, theft, or damage due to the elements or other parties. In some WLL systems, network management, including fault-finding and system reconfiguration, can be conducted from a centralized location to fully administer the WLL network between the telephone network interface and the subscriber terminal. The overall result is reduced lifetime network costs.

• **Lower network extension costs:** Wireless local loop technology intrinsically offers flexibility to meet uncertain levels of penetration and subscriber growth rates. Once the WLL infrastructure is in place, each incremental subscriber can be installed at very little cost. WLL systems that are designed to be modular and scalable can furthermore allow the pace of network deployment to closely match demand, minimizing the costs associated with underutilized plant. Such systems are flexible enough to meet uncertain levels of penetration and rates of growth.

• **High bandwidth is available providing:**

- Video;
- High-speed Internet access; and
- Telephony services.

Disadvantages:

• The technology is more costly due to the need for research and development

Moreover, some network operators fear technological obsolescence , that if a commitment is made to a specific WLL technology today, then within a few years it may be surpassed by technologies currently under development.

• The technology has not been tested over a long term of time for reliability and repair costs

The disadvantages of a wireless local loop solution, lie in the fact that much of the technology particularly on the digital side, is relatively untried.

• Certain technologies are not available in all areas, which leaves people with the unsupported technology disconnected

The capital cost of WLL technology, even when it compares favorably to the deployment of copper lines, remains outside the reach of many government or private network operators.

• Wireless technology requires that data be sent over open space, which makes it susceptible to interception and decreases the security of the transmission

• Customer accessibility is still low in the US

Where traditionally most of the innovations in new technology comes from.

• **Market investment is slow in the US**

Due to the low penetration of American companies in the market.

Q.9. Write short note on:

(a) Bluetooth.

Ans. 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.

Bluetooth operates at frequencies between 2402 and 2480 MHz, or 2400 and 2483.5 MHz including guard bands 2 MHz wide at the bottom end and 3.5 MHz wide at the top. 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. Bluetooth divides transmitted data into packets, and transmits each packet on one of 79 designated Bluetooth channels. Each channel has a bandwidth of 1 MHz. It usually performs 800 hops per second, with Adaptive Frequency-Hopping (AFH) enabled. Bluetooth low energy uses 2 MHz spacing, which accommodates 40 channels. Gaussian frequency-shift keying (GFSK) modulation was the only modulation scheme available. Since the introduction of Bluetooth 2.0+EDR, π/4-DQPSK (differential quadrature phase shift keying) and 8DPSK modulation may also be used between compatible devices. Devices functioning with GFSK are said to be operating in basic rate (BR) mode where an instantaneous bit rate of 1 Mbit/s is possible. The term Enhanced Data Rate (EDR) is used to describe π/4-DPSK and 8DPSK schemes, each giving 2 and 3 Mbit/s respectively. The combination of these (BR and EDR) modes in Bluetooth radio technology is classified as a "BR/EDR radioA master BR/EDR Bluetooth device can communicate with a maximum of seven devices in a piconet (an ad-hoc computer network using Bluetooth technology), though not all devices reach this maximum. The devices can switch roles, by agreement, and the slave can become the master (for example, a headset initiating a connection to a phone necessarily begins as master—as initiator of the connection—but may subsequently operate as slave).

Q.9. (*b*) Mobile adhoc networks

Ans. • A **mobile ad hoc network (MANET)**, also known as wireless ad hoc network or **ad hoc wireless network**, is a continuously self-configuring, infrastructure-less network of mobile devices connected wirelessly.

Each device in a MANET is free to move independently in any direction, and will therefore change its links to other devices frequently. Each must forward traffic unrelated to its own use, and therefore be a router. The primary challenge in building a MANET is equipping each device to continuously maintain the information required to properly route traffic. Such networks may operate by themselves or may be connected to the larger Internet. They may contain one or multiple and different transceivers between nodes. This results in a highly dynamic, autonomous topology.

MANETs are a kind of wireless ad hoc network (WANET) that usually has a routable networking environment on top of a Link Layer ad hoc network. MANETs consist of a peer-to-peer, self-forming, self-healing network. MANETs circa 2000-2015 typically communicate at radio frequencies (30 MHz - 5 GHz)

Types of **mobile ad hoc network (MANET)**

• Vehicular ad hoc networks (VANETs) are used for communication between vehicles and roadside equipment. Intelligent vehicular ad hoc networks (InVANETs) are a kind of artificial intelligence that helps vehicles to behave in intelligent manners during vehicle-to-vehicle collisions, accidents.

• Smart phone ad hoc networks (SPANs) leverage the existing hardware (primarily Bluetooth and Wi-Fi) in commercially available smart phones to create peer-to-peer networks without relying on cellular carrier networks, wireless access points, or traditional network infrastructure. SPANs differ from traditional hub and spoke networks, such as Wi-Fi Direct, in that they support multi-hop relays and there is no notion of a group leader so peers can join and leave at will without destroying the network.

• Internet-based mobile ad-hoc networks (iMANETs) is a type of wireless ad hoc network that supports Internet protocols such as TCP/UDP and IP. The network uses a network-layer routing protocol to link mobile nodes and establish routes distributedly and automatically.

• Hub-Spoke MANET - Multiple sub-MANETs may be connected in a classic Hub-Spoke VPN to create a geographically distributed MANET. In such type of networks normal ad hoc routing algorithms does not apply directly. One implementation of this is Persistent System's CloudRelay.

• Military or tactical MANETs are used by military units with emphasis on data rate, real-time requirement, fast re-routing during mobility, data security, radio range, and integration with existing systems. Common radio waveforms include the US Army's JTRS SRW.

FIRST TERM EXAMINATION [SEPT. 2017]
SEVENTH SEMESTER [B.TECH.]
WIRELESS COMMUNICATION
[ETEC–405]

Time : 1.30 hrs. **M.M. : 30**

Note: *Attempt any three question in all and Q.1 is compulsory.*

Q.1. Attempts all parts of the following:

Q.1. (a) What is the radio propagation mechanism? **(3)**

Ans. Radio propagation depends on the frequency being used & the type of atmospheric conditions prevailing. This can be divided among the following categories:

1. Free Space Propagation: Here the radio signal travels through the open space. The distance coming in between the transmitter and receiver acts as the major loss for the strength of radio signal satellite communication is a major application for this type of communication.

2. Ground Wave Propagation: This mechanism of propagation occurs for the frequencies below 2MHz. During the propagation, the signal follows the curvature of earth.

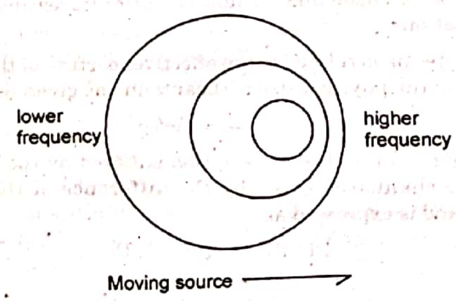
3. Ionospheric Propagation: This is also known as sky wave propagation. This is used for a range of 2 to 30 MHz. here the radio signal is reflected from the ionosphere towards the earth surface.

4. Troposphere Propagation: Here the signal travels through the troposphere where there is a significant change in refractive index of the air medium.

Q.1. (b) What is Doppler effect? Explain. **(3)**

Ans. The Doppler effect can be described as the effect produced by a moving source of waves in which there is an apparent upward shift in frequency for observers towards whom the source is approaching and an apparent downward shift in frequency for observers from whom the source is receding. For example if a pure sinusoidal tone of frequency is transmitted and it is denoted as Fc, then the received signal spectrum is known as Doppler spectrum consisting of components in the range from Fc-Fd to Fc + Fd, in which Fd refers to Doppler shift frequency.

The total amount of the spectral broadening will depend on the Doppler shift Fd.



Q.1. (c) What do you mean by mobility management? How is it done? (4)

Ans. Mobility Management: A Mobile station is assigned a home network, commonly known as location area. When an MS migrates out of its current BS into the footprint of another, a procedure is performed to maintain service continuity, known as Handoff management. An agent in the home network, called home agent, keeps track of the current location of the MS. The procedure to keep track of the user's current location is referred to as Location management.

Handoff management and location management together are referred to as Mobility Management.

Handoff: At any instant, each mobile station is logically in a cell and under the control of the cell's base station. When a mobile station moves out of a cell, the base station notices the MS's signal fading away and requests all the neighboring BSs to report the strength they are receiving. The BS then transfers ownership to the cell getting the strongest signal and the MSC changes the channel carrying the call. The process is called handoff. There are two types of handoff; Hard Handoff and Soft Handoff. In a hard handoff, which was used in the early systems, a MS communicates with one BS. As a MS moves from cell A to cell B, the communication between the MS and base station of cell A is first broken before communication is started between the MS and the base station of B. As a consequence, the transition is not smooth. For smooth transition from one cell (say A) to another (say B), an MS continues to talk to both A and B. As the MS moves from cell A to cell B, at some point the communication is broken with the old base station of cell A. This is known as soft handoff.

Roaming: Two fundamental operations are associated with Location Management; location update and paging. When a Mobile Station (MS) enters a new Location Area, it performs a location updating procedure by making an association between the foreign agent and the home agent. One of the BSs, in the newly visited Location Area is informed and the home directory of the MS is updated with its current location. When the home agent receives a message destined for the MS, it forwards the message to the MS via the foreign agent. An authentication process is performed before forwarding the message.

Q. 2. (a) Describe free space propagation model for mobile radio wave propogation. (6)

Ans. Free space model predicts that the received power decays as negative square root of the distance. Friis free space equation is given by

$$Pr(d) = (PtGt\,Gr\,\lambda^{2})/(4\pi)^2d^2L$$

Where Pt is the transmitted power, Pr(d) is the received power, Gt is the transmitter antenna gain, Gr is the receiver antenna gain, d is the Tx-Rx separation and L is the system loss factor depended upon line attenuation, filter losses and antenna lossesand not related to propagation.

The gain of the antenna is related to the effectiveaperture of the antenna which in turn is dependent upon the physical size of theantenna as given below

$$G = 4\pi Ae/\lambda^2$$

The path loss, representing the attenuation suffered by the signal as it travels through the wireless channel is given by the difference of the transmitted and receivedpower in dB and is expressed as:

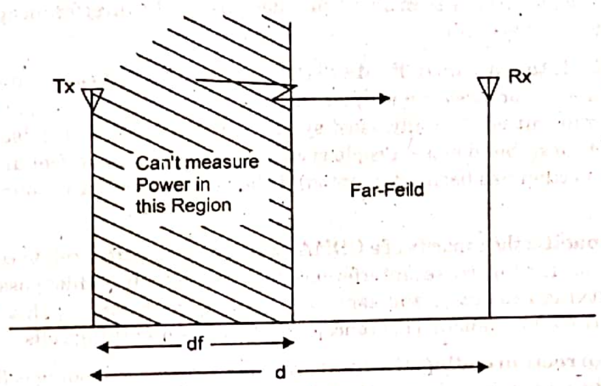
$$PL(dB) = 10\log Pt/Pr$$

The fields of an antenna can broadly be classified in two regions, the far field andthe near field. It is in the far field that the propagating waves act as plane wavesand the power decays inversely with distance. The far field region is also termed as Fraunhofer region and the Friis equation holds in this region. Hence, the Friis equation is used only beyond the far field distance, df, which is dependent upon thelargest dimension of the antenna as

$$df = 2D^2/\lambda$$

Also we can see that the Friis equation is not defined for d=0. For this reason, weuse a close in distance, do, as a reference point. The power received, Pr(d), is then given by:

$$Pr(d) = Pr(do)(do/d)^2$$



Q.2. (b) What do you understand by power control in wireless communication?

Ans. Power control can substantially impact the capacity and perceived quality in cellular wireless systems. Regardless of the mode of multiple access — be it frequency, time or code division — power control is necessary to combat the intercell, or co-channel, interference that arises from frequency reuse.

Additionally, power control is employed to minimize the intra-cell interference in direct sequence code division multiple access (DS-CDMA) systems. On an ideal channel, it is possible to maintain code orthogonality among all users of the same cell. A wireless channel introduces multipath, so this perfect code orthogonality is destroyed and the user experiences intracell interference. Power control is particularly crucial on the DS-CDMA uplink: without it, the signal of a mobile at the cell periphery would be drowned out by an interfering mobile situated close to the base station. Furthermore, on the DS-CDMA uplink the code waveforms of different users arrive at the receiver unsynchronized with one another. Unless the receiver performs code resynchronization, the interference is heightened, exacerbating this "near-far" problem and increasing the need for power control.

Intracell interference can affect TDMA and FDMA systems as well, in the form of adjacent channel interference; for example, practical band pass filters cannot perfectly reject adjacent frequencies, matched filters may not always sample over the correct intervals, and multipath can cause intersymbol interference across different users. This need for power control in cellular systems to combat interference has been recognized and is the subject of much research.

Q.3. (a) What are the various mechanism for capacity increase. Explain in detail. **(5)**

Ans. Methods for Capacity Increases

• **Quiet periods during speech transmission:** for speech transmission, CDMA makes implicit useof the fact that a person does not talk continuously, but rather only about 50% of the time, theremainder of the time (s) he listens to the other participant. In addition, there are pauses betweenwords and even syllables, so that the ratio of "talk time" to "total time of a call" is about 0.4.During quiet periods, no signal, or a signal with a very low data rate, has to be transmitted. In a CDMA system, not transmitting information leads to a decrease in total transmitted power, andthus interference in the system. But we have already seen above that decreasing the interferencepower allows additional users to place calls.

• **Flexible data rate:** in an FDMA (TDMA) system, a user can occupy either one frequency (timeslot), or integer multiples thereof. In a CDMA system, arbitrary data rates can be transmitted. Actually, most systems transmit comfort noise during this time i.e., some background noise. People speakinginto a telephone feel uncomfortable (think the connection has been interrupted) if they cannot hear any soundwhile they talk.

• **Soft capacity:** the capacity of a CDMA system can vary from cell to cell. If a given cell addsmore users, it increases interference to other cells. It is thus possible to have some cells withhigh capacity, and some with lower; furthermore, this can change dynamically, as traffic changes.This concept is known as breathing cells.

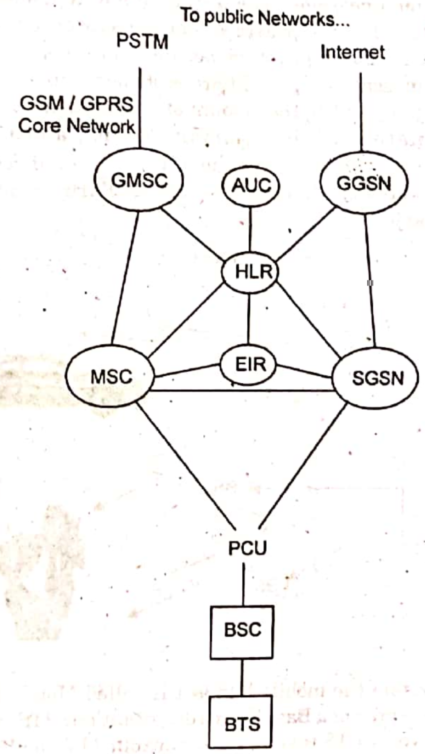
• **Error correction coding:** the drawback of error correction coding is that the data rate that is tobe transmitted is increased, which decreases spectral efficiency. On the other hand, CDMA consciouslyincreases the amount of data to be transmitted. It is thus possible to include errorcorrection coding without decreasing spectral efficiency; in other words, different users aredistinguished by different error correction codes (coding by spreading).

Q.3. (b) Explain the GPRS architecture. **(5)**

Ans. The GPRS is an enhancement over the GSM and adds some nodes in the network to provide the packet switched services. These network nodes are called GSNs (GPRS Support Nodes) and are responsible for the routing and delivery of the data packets to and from the MS and external packet data networks (PDN). The most important network nodes added to the existing GSM networks are:

- SGSN (Serving GPRS Support Node).
- GGSN (Gateway GPRS Support Node).

The serving GPRS support node (SGSN) is responsible for routing the packet switched data to and from the mobile stations (MS) within its area of responsibility. The main functions of SGSN are packet routing and transfer, mobile attach and detach procedure (Mobility Management (MM)), location management, assigning channels and time slots (Logical Link Management (LLM)), authentication and charging for calls. It stores the location information of the user (like the current location, current VLR) and user profile (like IMSI addresses used in packet data networks) of registered users in its location register.



The gateway GPRS support node (GGSN) acts as interface between the GPRS backbone and the external packet data network (PDN). It converts the GPRS packet coming from the SGSN into proper packet data protocol (PDP) format (i.e. X.25 or IP) before sending to the outside data network. Similarly it converts the external PDP addresses to the GSM address of the destination user. It sends these packets to proper SGSN. For this purpose the GGSN stores the current SGSN address of the user and his profile in its location register. The GGSN also performs the authentication and charging functions. In general there may be a many to many relationship between the SGSN and GGSN. However a service provider may have only one GGSN and few SGSNs due to cost constraints. A GGSN proved the interface to several SGSNs to the external PDN.

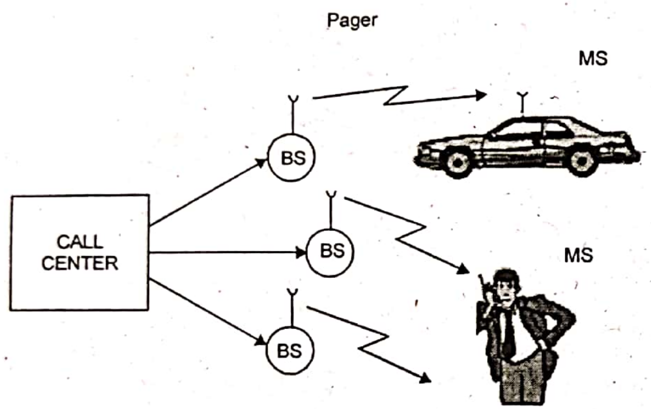
Q. 4. Write a short note on-

(a) Paging systems **(3)**

Ans. Paging systems are unidirectional wireless communications systems. They arecharacterized by the following properties:

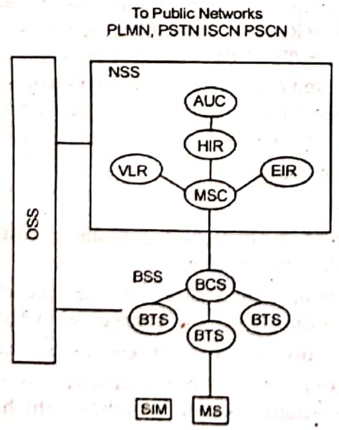
- The user can only receive information, but cannot transmit. Consequently, a "call" (message) can only be initiated by the call center, not by the user.
- The information is intended for, and received by, only a single user.
- The amount of transmitted information is very small. Originally, the received information consistedof a single bit of information, which indicated to the user that

"somebody has sent you amessage." The user then had to make a phone call (usually from a payphone) to the call center,where a human operator repeated the content of the waiting message. Later, paging systemsbecame more sophisticated, allowing the transmission of short messages (e.g., a different phonenumber that should be called, or the nature of an emergency). Still, the amount of informationwas rather limited. Due to the unidirectional nature of the communications, and the small amount of information,the bandwidth required for this service is small. This in turn allows the service to operate at lowercarrier frequencies – e.g., 150MHz – where only small amount of spectrum are available.



Q.4. (b) GSM (4

Ans. In GSM system the mobile handset is called Mobile Station (MS). A cell is formed by the coverage area of a Base Transceiver Station (BTS) which serves the MS in its coverage area. Several BTS together are controlled by one Base Station Controller (BSC). The BTS and BSC together form Base Station Subsystem (BSS). The combined traffic of the mobile stations in their respective cells is routed through a switch called Mobile Switching Center (MSC). Connection originating or terminating from external telephone (PSTN) are handled by a dedicated gateway Gateway Mobile Switching Center (GMSC)



In addition to the above entities several databases are used for the purpose of call control and network management. These databases are Home Location Register (HLR), Visitor Location Register (VLR), the Authentication Center (AUC), and Equipment Identity Register (EIR).

Home Location Register (HLR) stores the permanent (such as user profile) as well as temporary (such as current location) information about all the users registered with the network. A VLR stores the data about the users who are being serviced currently. It includes the data stored in HLR for faster access as well as the temporary data like location of the user. The AUC stores the authentication information of the user such as the keys for encryption. The EIR stores stores data about the equipments and can be used to prevent calls from a stolen equipments.

All the mobile equipments in GSM system are assigned unique id called IMSI (International Mobile Equipment Identity) and is allocated by equipment manufacturer and registered by the service provider. This number is stored in the EIR. The users are identified by the IMSI (International Module Subscriber Identity) which is stored in the Subscriber Identity Module (SIM) of the user. A mobile station can be used only if a valid SIM is inserted into equipment with valid IMSI. The "real" telephone number is different from the above ids and is stored in SIM.

Q.4. (c) IS-95 CDMA (3)

Ans. Interim Standard 95 (IS-95) was the first ever CDMA-based digital cellular technology. It was developed by Qualcomm and later adopted as a standard by the Telecommunications Industry Association in TIA/EIA/IS-95 release published in 1995. The proprietary name for IS-95 is cdma One.

It is a 2G mobile telecommunications standard that uses CDMA, a multiple access scheme for digital radio, to send voice, data and signaling data (such as a dialed telephone number) between mobile telephones and cell sites.

CDMA or "code division multiple access" is a digital radio system that transmits streams of bits (PN codes). CDMA permits several radios to share the same frequencies. Unlike TDMA "time division multiple access", a competing system used in 2G GSM, all radios can be active all the time, because network capacity does not directly limit the number of active radios. Since larger numbers of phones can be served by smaller numbers of cell-sites, CDMA-based standards have a significant economic advantage over TDMA-based standards, or the oldest cellular standards that used frequency-division multiplexing.

In North America, the technology competed with Digital AMPS (IS-136, a TDMA technology). It is now being supplanted by IS-2000 (CDMA2000), a later CDMA-based standard.

- Use of voice activation to reduce interference
- As data rate reduces, the transmitter can reduce the power to achieve the same error rates
- Dual Mode (AMPS/CDMA), Dual Band (900, 1900 MHz bands)
- Low power handsets (sleep mode supported)
- Soft Handoff possible
- Digital Data services (text, fax, circuit switched data)
- Advanced Telephony Features (call waiting, voice mail, etc.)
- Security: CDMA signal + CAVE encryption
- Air Interface Standard Only.

END TERM EXAMINATION [DEC. 2017]
SEVENTH SEMESTER [B.TECH.]
WIRELESS COMMUNICATION
[ETEC–405]

Time : 3 hrs. **M.M. : 75**

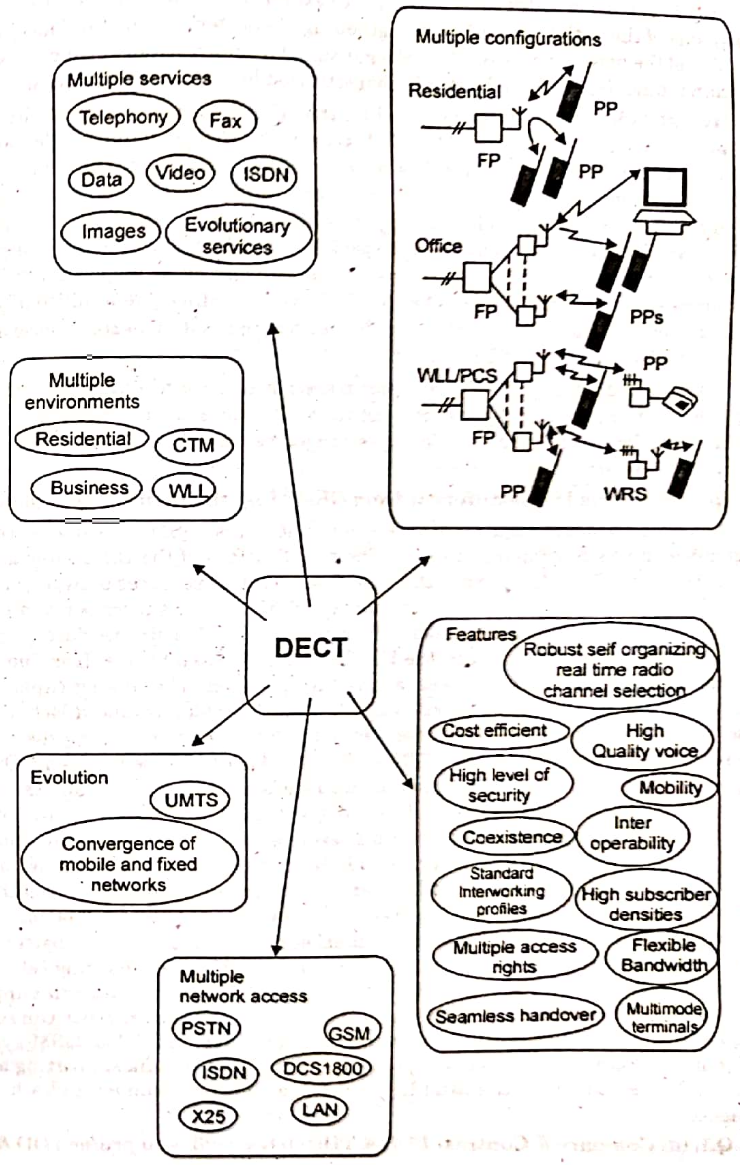
Note: *Attempt any five questions including Q.1 which is compulsory.*

Q.1. (a) What is DCT ? List the PHY interface it operates on along with its radio spectrum. **(3)**

Ans. Digital Enhanced Cordless Telecommunication (DECT), the technology originated as a European initiative is now rapidly conquering the telecommunications world. The benefits offered by this high quality access technology are recognised by more and more users, regulators, standardisation bodies, network operators, and equipment manufacturers. DECT has proven multiple applicability as a network access in residential, business and public environments showing easy mobility, speech quality comparable to wireline telephony, a high level of security through advanced digital technology and encryption, allowing for high subscriber densities, flexible bandwidth allocation, multiple service support, cost competitiveness, flexible deployment and simple installation. The Digital Enhanced Cordless Telecommunications (DECT) standard provides a general radio access technology for wireless telecommunications, operating in the preferred 1880 to 1900 MHz band using GFSK (BT = 0.5) modulation.

DECT has been designed to provide access to any type of telecommunication network thus supporting numerous different applications and services. The range of DECT applications includes residential, PSTN and ISDN access, wireless PABX, GSM access, Wireless Local Loop, Cordless Terminal Mobility CTM, Local Area Network access supporting voice telephony, fax, modem, E-mail, Internet, X.25 and many other services in a cost efficient manner.

The variety of applications supported by DECT finds its origin in the flexibility of the advanced protocol 'toolbox' that allows implementers to assemble virtually any application subset required. Mobility functions in the DECT protocol provide cordlessness to roaming users through a pico-cellular infrastructure of DECT base stations.



Q.1. (b) Compare Rayleigh &Ricean fading and highlight their key differences. **(3)**

Ans. Rician fading or Ricean fading is a stochastic model for radiopropagation anomaly caused by partial cancellation of a radio signal by itself — the signal arrives at the receiver by several different paths (hence exhibiting multipath interference), and at least one of the paths is changing (lengthening or shortening). Rician fading occurs when one of the paths, typically a line of sight signal, is much stronger than the others. In Rician fading, the amplitude gain is characterized by a Rician distribution.

Rayleigh fading is a statistical model for the effect of a propagation environment on a radio signal, such as that used by wireless devices. Rayleigh fading models assume that the magnitude of a signal that has passed through such a transmission medium (also called a communications channel) will vary randomly, or fade, according to a Rayleigh distribution — the radial component of the sum of two uncorrelated Gaussian random variables. Rayleigh fading is the specialised model for stochastic fading when there is no line of sight signal, and is sometimes considered as a special case of the more generalised concept of Rician fading. In Rayleigh fading, the amplitude gain is characterized by a Rayleigh distribution. Rician fading itself is a special case of two-wave with diffuse power (TWDP) fading.

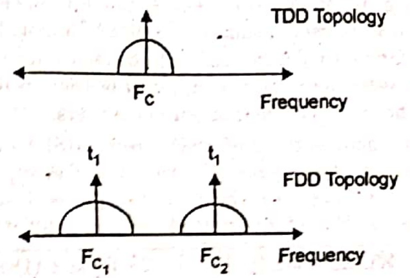
Rayleigh fading is an excellent approximation in a large number of practical scenarios, there are scenarios where it is not valid. The Ricean model can be shown to to exhibit a smaller number of deep fades; the stronger the LOS (Line-of-Sight) component the rarer the occurrence of deep fades.

Q.1. (c) How is IS-136 different from GSM? List the prime differences. (3)

Ans. The Global System for Mobile communications (GSM) is a digital cellular system which was developed in Europe. The specifications of the GSM interfaces are laid down by the ETSI. GSM uses TDMA for sharing radio resources between multiple users. Provision of a Subscriber Identity Module (SIM) to store subscriber related data enables personal mobility independent of terminals. IS-136 is air interface standards for cellular telephony specified by the EIA/TIA of the United States. It is dual mode standard, capable of analog as well as digital operation. The analog capability is supported to make the mobile stations compatible with the older Advanced Mobile Phone System (AMPS) which was widely deployed in the North America during the 80's. IS-136 supports digital operation using TDMA. Both GSM & IS-136 use Frequency Division Duplexing (FDD). In FDD, the base station transmission (forward link) and the mobile station transmission (reverse link) uses a disjoint band of frequencies. In both the systems, the R.F channels used for forward and reverse link transmissions are separated by 45 MHz.In IS-136 each RF channel is 30 KHz wide and can support 3 simultaneous voice links. The transmission on the RF channel is in frames of six time slots each, with each voice link using 2 time slots per frame. RF channels used in a cell is not used in neighbouring cells because of cochannel interference. Frequency reuse patterns are employed to ensure that same RF channels are not used by neighbouring cells. GSM also uses TDMA/FDD. Here each RF channel is 200 KHz wide and can support 8 simultaneous voice links. Each TDMA frame has 8 time slots, each of which can support a voice link. Frequency reuse patterns are employed for GSM also. GSM systems optionally support slow frequency hopping wherein a physical link supporting a voice Cali can be identified by an initial RF channel, a time slot number and a hopping sequence.

Q.1. (d) Compare & Contrast FDD & TDD. Where will you prefer TDD & Why. (3)

Ans. TDD means Time Division Duplex and **FDD** means Frequency Division Duplex These topologies are widely used in advanced wireless communication systems such as WLAN, WiMAX(fixed/mobile), LTE and so on.



As shown in the figure, in TDD system same frequency band FC is used by both Transmit and receive path at different time instants. In FDD system different frequency bands Fc1 and **FDD deployments provide greater coverage than TDD**

Mobile devices in a Frequency Division Duplexing (FDD) system transmit on a continuous basis, which enables devices to achieve cell edge rates farther from the base station. Mobile devices in a Time Division Duplexing (TDD) system transmit periodically (e.g., 1/2 or 1/3 of the time compared to FDD); hence, required rates cannot be achieved at similar distances when compared to FDD. The FDD advantage is consistent regardless of the radio technology being used.

- **FDD needs fewer base stations than TDD:** Since FDD devices achieve desired cell edge rates at farther distances, the number of base stations required to achieve a given area of coverage is reduced. In a coverage-limited system comparison using the same frequency band, the TDD system required 31% more base stations than FDD when using a 1:1 TDD system and 65% more base stations when using a 2:1 TDD system. Higher frequency bands required even more base stations.

- **FDD incurs lower costs:** Capital expenditure (CAPEX) and operating expenditure (OPEX) costs are associated with each base station. These costs are independent of the type of duplexing technique used (FDD or TDD). Since FDD requires fewer base stations for the same coverage, it incurs lower deployment and operating costs.

- **TDD is applicable to unpaired spectrum:** While FDD has clear advantages in coverage and costs, TDD is suitable to be deployed when paired spectrum is not available. FDD systems also benefit from better economies of scale since the implementation of TDD systems is limited.

- **FDD/TDD: Basic difference:** FDD is implemented on a paired spectrum where downlink and uplink transmissions are sent on separate frequencies. This provides simultaneous exchange of information and reduces interference between the uplink and downlink. TDD is implemented on an unpaired spectrum, implying the usage of only one frequency for both downlink and uplink transmissions. It is suitable for asymmetric transmission demands and in cases where paired frequency is not available.

Q.1. (e) List the data rate for HSPA, HSPAT & WiFi. Compare these to transmission speed of Wi-max. (3)

Ans. High-Speed Packet Access is a standard for wireless network communication in the 3G family. The HSPA family of network protocols includes HSDPA and HSUPA. An enhanced version of HSPA called HSPA+ further evolved this standard.

HSDPA: HSPA utilizes the High-Speed Downlink Packet Access protocol for download traffic. HSDPA supports theoretical maximum data rates between 1.8 Mbps and 14.4 Mbps (compared to the 384 Kbps maximum rate of original 3G).

HSUPA: High-Speed Uplink Packet Access provides speed increases for mobile device data uploads on 3G networks similar to HSDPA for downloads. HSUPA supports data rates up to 5.7 Mbps. By design, HSUPA does not offer the same data rates as HSPDA, because providers provision a majority of their cell network capacity for downlinks to match the usage patterns of cellphone users.

HSPA +: An enhanced version of HSPA called HSPA+ or Evolved HSPA was developed and has been deployed by many carriers to better support the huge growth of mobile broadband services. HSPA+ is the fastest 3G protocol, supporting data rates of 42, 84 and sometimes 168 Mbps for downloads and up to 22 Mbps for uploads

Feature	WiMax (802.16a)	Wi-Fi(802.11b)	Wi-Fi(802.11a/g)
Primary Application	Broadband Wireless Access	Wireless LAN	Wireless LAN
Frequency Band	Licensed/Unlicensed 2 G to 11 GHz	2.4 GHz ISM	2.4 GHz ISM (g) 5 GHz U-NII (a)
Channel Bandwidth	Adjustable 1.25 M to 20 MHz	25 MHz	20 MHz
Half/Full Duplex	Full	Half	Half
Radio Technology	OFDM(256-channels)	Direct Sequence Spread Spectrum	OFDM(64-channels)
Bandwidth Efficiency	<=5 bps/Hz	<=0.44 bps/Hz	<=2.7 bps/Hz

Q. 2.What is meant by different generations of wireless networks? When do we conclude that the Generation has changed?

Compare the various generations of wireless networks & their types wrt mobility, range, speed of transmission & radio spectrum used. (15)

Ans. First Generation (1G) 1G cellular networks were invented in the 1980s.

The key idea behind 1G was that the geographical area is divided into cells, each served by a "base station." Cells are small so that frequency reuse can be exploited in nearby (but not adjacent) cells. This allows many more users to be supported in a given area. All 1G systems were analog systems popularly known as early cellular phone technology working in the frequency band of 150 MHz.1G comprised of the following Mobile technologies: Mobile Telephone Systems (MTS), Advance Mobile Telephone Systems (AMTS), Push To Talk (PTT) and Improved Mobile Telephone Service (IMTS).

2G cellular telecom networks were commercially launched on the GSM standard. 2G used digital signals for voice transmission and had a speed up to 64 kbps. It also provided the facility of Short Message Service and used the bandwidth range of 30 - 200 KHz.

Technologies under 2G: 2G comprised of the following Mobile technologies: General Packet Radio Service (GPRS), Code Division Multiple Access (CDMA), Global System for Mobile Communication (GSM) and Enhanced Data Rates for GSM Evolution (EDGE).Some key benefits of 2G Network over its predecessors was that, Digital Encryption was supported by 2G systems which had higher penetration efficiency thereby being more efficient on network spectrum. Moreover, 2G introduced several data services for mobile, the most prominent one being the famous SMS text messages.

International Mobile Telecommunications-2000 (IMT— 2000), better known as 3G or 3rd Generation, is a generation of standards for mobile phones and mobile telecommunications services fulfilling the International Telecommunication Union. It uses Wide Brand Wireless Network with which clarity is increased. The data are sent through the technology called Packet Switching. Voice calls are interpreted through Circuit Switching. Along with verbal communication it includes data services, access to television/video, new services like Global Roaming. It operates at a range of 2100MHz and has a bandwidth of 15-20MHz used for High-speed internet service, video chatting.3G uses Wide Band Voice Channel that is by this the world has been contracted to a little village because a person can contact with other person located in any part of the world and can even send messages too. Technologies under 3G: 2G comprised of the following Mobile technologies: 3G Technology comprises of Wideband CDMA, WLAN, Bluetooth, Universal Mobile telecommunication Systems (UMTS), High Speed Downlink Packet Access (HSDPA). Data are sent through packet switching. Voice calls are interpreted using circuit switching. It also provides facilities such as Global Roaming Clarity in voice calls, Fast Communication, Internet, Mobile T.V, Video Conferencing, Video Calls, Multi Media Messaging Service (MMS), 3D gaming and Multiplayer Gaming.

A 4G system not only provides voice and other 3G services but also provides ultrabroadband network access to mobile devices. Applications vary from IP telephony, HD Mobile Television, video conferencing to gaming services and cloud computing. One of the initial devices to access 4G network was USB wireless modem which was later followed by cellular phones with WiMax and LTE technology. Technologies under 4G: 4G comprised of the following Mobile technologies: Long Term Evolution (LTE) Standard based on the GSM/EDGE and UMTS/HSPA, 3rd Generation Partnership Project (3GPP), Multiple In Multiple Output (MIMO) smart antenna technology, Orthogonal Frequency Digital Multiplexing (OFDM), 802.16e - Worldwide Interoperability for Microwave Access (WiMAX), 802.20 - Mobile Broadband Wireless Access (MBWA).

5G Network Model is an All-IP based model for mobile and wireless network interoperability. The All-IP Network (AIPN) has the capacity to satisfy the ever increasing mammoth demands of the burgeoning cellular market. It also is a general platform for all radio access technologies and standards. All-IP Network uses packet switching as compared to circuit switching used its predecessors, and its continual evolution provides performance and cost optimization. In 5G, Network Architecture consists of a user terminal (which has a crucial role in the new architecture) and a number of independent, autonomous radio access technologies (RAT) . AIPN based mobile applications and services such as Mobile Portals, Mobile Commerce, Mobile Health-Care, Mobile Government, Mobile Banking and several others are offered via Cloud Computing Resources (CCR). The best feature about cloud computing is that a user can access any data uploaded on the cloud ubiquitously from anywhere, from any terminal with an internet connection or a secure connection to the storage cloud without the need to install any third party application or softwares.

Name	1st Generation Mobile Network	2nd Generation Mobile Network	3rd Generation Mobile Network	4th Generation Mobile Network
Introduced in year	1980s	1993	2001	2009
Location of first commercialization	USA	Finland	Japan	South Korea

	(Advanced Mobile Phone System), NMT, TACS			
Multiple Address/ Access system	FDMA	TDMA, CDMA	CDMA	CDMA
Switching type	Circuit switching	Circuit switching for Voice and Packet switching for Data	Packet switching except for Air Interface	Packet switching
Speed (data rates)	2.4 Kbps to 14.4 kbps	14.4 Kbps	3.1 Mbps	100 Mbps
Special Charac-teristic	First wireless communication	Digital version of 1G technology	Digital broadband, speed increments	Very high speeds, All IP
Features	Voice only	Multiple users on single channel	Multimedia features, Video Call	High Speed, real time streaming
Supports Internet service	Voice only No Internet	Voice and Data Narrowband	Voice and Data Broadband	Voice and Data Ultra Broadband
Bandwidth	Analog	25 MHz	25 MHz	100 MHz
Operating frequencies	800 MHz	GSM: 900MHZ, 1800MHz CDMA: 800MHz	2100 MHz	850 MHz, 1800 MHz
Band (Frequency) type	Narrow band	Narrow band	Wide band	Ultra Wide Band
Carrier frequency	30 KHZ	200 KHz	5 MHz	15 MHz
Advantage	Simpler (less complex) network elements	Multimedia features (SMS, MMS), Internet access and SIM introduced	High security, international roaming	Speed, High speed handoffs, MIMO technology, Global mobility
Disadva-ntages	Limited capacity, not secure, poor battery life, large phone size, background interference	Low network range, slow data rates	High power consumption, Low network coverage, High cost of spectrum licence	Hard to implement, complicated hardware required
Applications	Voice Calls	Voice calls, Short messages, browsing (partial)	Video conferencing, mobile TV, GPS	High speed applications, mobile TV, Wearable devices

Approach	TDMA	FDMA	CDMA
Idea	Segments sending time into disjoint time slots demand driven or fixed patterns.	Segment the frequency band into disjoint subbands	Spread the spectrum using orthogonal codes.
Terminals	All terminals are active for short periods of time on same frequency.	Every terminal has its own frequency uninterrupted	All terminals can be active at the same place at the same moment uninterrupted.
Signal separation	Synchronization in time domain	Filtering in the frequency domain.	Code plus special receivers.
Transmission scheme	Discontinuous	Continuous	Continuous
Cell capacity	Limited	Limited	No absolute limit on channel capacity but it is an interference limited system
Advantages	Established fully digital, flexible	Simple, established, robust	Flexible, less frequency planning needed, soft handover
Disadvan-tages	Guard space needed (multipath propagation), synchronization difficult	Inflexible, frequencies are scarce resource	Complex receivers, needs more complicated power control for senders

Soft capacity in CDMA systems describes the fact that CDMA systems can add more and more users to a cell, i.e., there is no hard limit. For TDMA/FDMA systems, a hard upper limit exists – if no more free time/frequency slots are available, the system rejects new users. If a new user is added to a CDMA cell, the noise level rises and the cell shrinks, but the user can still communicate. However, the shrinking of a cell can cause problems, as other users could now drop out of it. Cell planning is more difficult in CDMA systems compared to the more fixed TDMA/FDMA schemes.

Q. 3.(b) What are Soft Handoffs. (5)

Ans. In mobile phone systems, a handoff is the process of transferring a phone call in progress from one base station (tower) to another base station, without interruption of the call. "Soft" handoffs are unique to systems based on CDMA technology. During a soft handoff, a phone may be actively connected to multiple base stations simultaneously, possibly for a considerable length of time.

This contrasts with non-CDMA systems, (such as GSM,) where a phone may only be actively connected to one tower at a time. On such systems, handoffs are "hard", meaning they happen at a specific moment when the call is shifted completely from one base station to another.

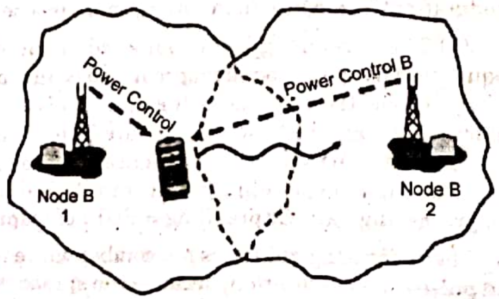


Fig. Soft handoffs

Q.3. (c) Discuss the Near far effect in CDMA & Ways to alleviate it. (5)

Ans. The CDMA near far problem arises because handsets may be anywhere within the particular cell boundaries. Some handsets will be close to the base station, whereas others will be much further away. In a free space scenario signals decay according a an inverse square law - in other words double the distance and the strength falls away to a quarter.

$$\text{Signal} = k \times 1/d2$$

Where: k = a constant

d = distance

In cellular applications this situation may be worse. The effects of objects and other obstructions in the signal propagation path mean that in reality a signal decays at a greater rate than the simple inverse square law. The CDMA near far problem is a serious problem, and requires an effective means of overcoming the problem for CDMA to operate correctly. The schemes used to overcome the CDMA near far problem utilise fast and accurate power control systems.While the power control schemes that are adopted by the different cellular telecommunications technologies work very well and allow the CDMA systems to operate over a wide area, there are penalties for using them:

Reduced data capacity: The power control mechanism requires data to be sent in both directions across the radio interface. This utilises data capacity that could be otherwise used for carrying revenue earning data.

High power handset power consumption at cell edges: In order to be able to maintain the required signal level at the base station when the handset is close to the edge of the cell, it will be required to transmit at a high power level. This will reduce battery life

Q.4. (a) Show that the processing gain (PG) achieved by the spreading-Dispreading action in spread spectrum equals the chip sequence length. (8)

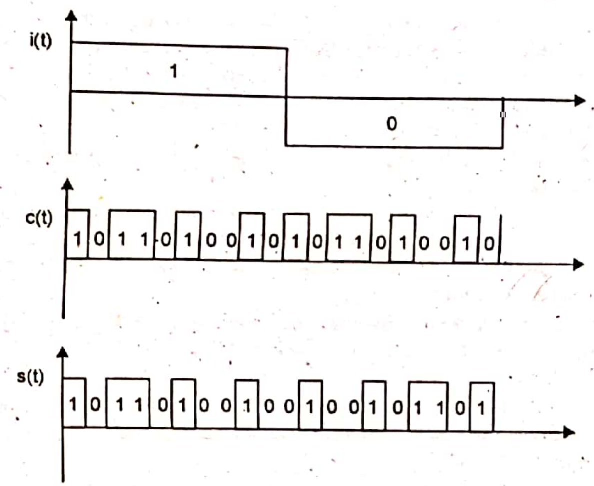
Ans. Spread–spectrum techniques gained their popularity by the needs of military communications. In contrast to narrow-band communication, spread–spectrum techniques were proved to be more resistant against hostile jammers. If a communication system is considered a spread–spectrum system it has to satisfy the following criteria:

(1) The bandwidth of the spread signal has to be greater than the information bandwidth. Since this criteria is satisfied also by frequency modulation, pulse code modulation, and delta modulation, there is a second condition:

(2) The spread signal is composed of the information signal and the spreading sequence. The spreading sequence has to be independent from the information. In Figure a spread spectrum transmitter and receiver are depicted. At the sender side the information signal i(t), with data rate Ri and bandwidth Bi , is spread by a spreading sequence c(t). The spreading sequence has the code symbol rate Rc, also called the chip rate. The ratio of spreading bandwidth Bs and information bandwidth Bi is denoted as the processing gain GSpreading = Bs/Bi of a spread–spectrum system.

The processing gain does not combat white noise as it is with frequency modulation and pulse code modulation, because the spread signal is independent of the information signal.

In a Direct Sequence Spread Spectrum (DSSS) transmitter the information signal is directly modulated by a spreading sequence. The spreading sequence consists of a number of spreading chips with time duration τ chip. The information signal consists of a number of information bits with time duration τ bit. Spreading is achieved if multiple chips represent one bit. If τ bit is a multiple of τ chip the processing gain GDS can be easily calculated by: GDS = τ bit/τ chip



Direct sequence spread spectrum signal generation G_{DS}=10.

Q.4. (b) List the wireless channels types in terms of frequency selectivity and time delay. What are fast fading & flat fading? (7)

Ans. Depending on the channel properties, a channel can be time-invariant / time-variant (fading) channels frequency-flat / frequency-selective (time-dispersive) channels.In wireless communications, fading is variation or the attenuation of a signal with various variables. These variables include time, geographical position, and radio frequency. Fading is often modeled as a random process. A fading channel is a communication channel that experiences fading. In wireless systems, fading may either be due to multipath propagation, referred to as multipath induced fading, weather (particularly rain), or shadowing from obstacles affecting the wave propagation, sometimes referred to as shadow fading.

Slow versus fast fading: The terms slow and fast fading refer to the rate at which the magnitude and phase change imposed by the channel on the signal changes. The coherence time is a measure of the minimum time required for the magnitude change or phase change of the channel to become uncorrelated from its previous value. Slow fading arises when the coherence time of the channel is large relative to the delay requirement of the application.In this regime, the amplitude and phase change imposed by the channel can be considered roughly constant over the period of use. Slow fading can be caused by events such as shadowing, where a large obstruction such as a hill or large building obscures the main signal path between the transmitter and the receiver. The received power change caused by shadowing is often modeled using a log-normal distribution with a standard deviation according to the log-distance path loss model.

Fast fading occurs when the coherence time of the channel is small relative to the delay requirement of the application. In this case, the amplitude and phase change imposed by the channel varies considerably over the period of use. In a fast-fading channel, the transmitter may take advantage of the variations in the channel conditions using time diversity to help increase robustness of the communication to a temporary deep fade. The coherence time of the channel is related to a quantity known as the Doppler spread of the channel. When a user (or reflectors in its environment) is moving, the user's velocity causes a shift in the frequency of the signal transmitted along each signal path. This phenomenon is known as the Doppler shift. Signals traveling along different paths can have different Doppler shifts, corresponding to different rates of change in phase. The difference in Doppler shifts between different signal components contributing to a signal fading channel tap is known as the Doppler spread. In general, coherence time is inversely related to Doppler spread.

Frequency selective fading is a radio propagation anomaly caused by partial cancellation of a radio signal by itself — the signal arrives at the receiver by two different paths, and at least one of the paths is changing (lengthening or shortening).. As the carrier frequency of a signal is varied, the magnitude of the change in amplitude will vary. The coherence bandwidth measures the separation in frequency after which two signals will experience uncorrelated fading.

- In flat fading, the coherence bandwidth of the channel is larger than the bandwidth of the signal. Therefore, all frequency components of the signal will experience the same magnitude of fading.
- In frequency-selective fading, the coherence bandwidth of the channel is smaller than the bandwidth of the signal. Different frequency components of the signal therefore experience uncorrelated fading.

Small-Scale Fading
(Based on multipath time delay spread)

Flat Fading
1. BW of signal < BW of channel
2. Delay spread < Symbol period

Frequency Selective fading
1. BW of signal > BW of channel
2. Delay spread < Symbol period

Small-Scale Fading
(Based on Doppler spread)

Fast Fading
1. High Doppler spread
2. Coherence time < Symbol period
3. Channel variations faster than base-band signal variations

Slow Fading
1. Low Doppler spread
2. Coherence time > Symbol period
3. Channel variations slower than baseband signal variations

Q. 5. Explain with a neat BD the GSM architecture emphasizing on the interfaces, frame structure, logical channel & diversity scheme adopted. (15)

Ans. The GSM standard was developed by the Group Special Mobile, which was an initiative of the Conference of European Post and Telecommunications (CEPT) administrations. The underlying aim was to design a uniform pan-European mobile system to replace the existing incompatible analog systems. Work on the standard was started in 1982, and the first full set of specifications (phase 1) became available in 1990

The characteristics of the initial GSM standard include the following:

- fully digital system utilizing the 900 MHz frequency band
- TDMA over radio carriers (200 kHz carrier spacing)
- 8 full-rate or 16 half-rate TDMA channels per carrier

- user/terminal authentication for fraud control
- encryption of speech and data transmissions over the radio path
- full international roaming capability
- low speed data services (up to 9.6 kb/s)
- compatibility with ISDN for supplementary services
- support of short message service (SMS)

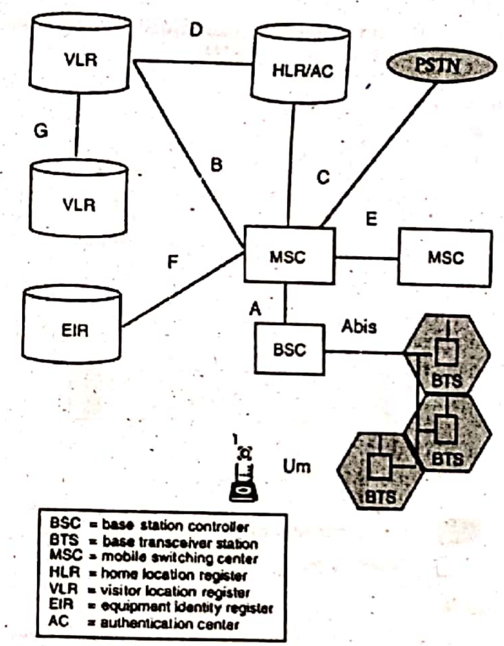


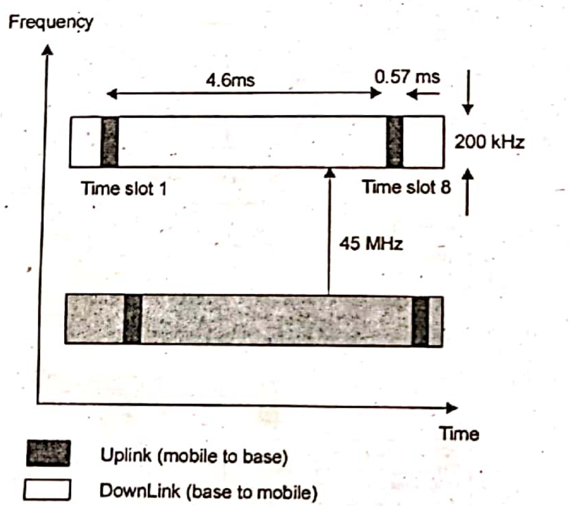
Fig: GSM Architecture

In GSM system the mobile handset is called Mobile Station (MS). A cell is formed by the coverage area of a Base Transceiver Station (BTS) which serves the MS in its coverage area. Several BTS together are controlled by one Base Station Controller (BSC). The BTS and BSC together form Base Station Subsystem (BSS). The combined traffic of the mobile stations in their respective cells is routed through a switch called Mobile. Switching Center (MSC). Connection originating or terminating from external telephone (PSTN) are handled by a dedicated gateway Gateway Mobile Switching Center (GMSC)

In addition to the above entities several databases are used for the purpose of call control and network management. These databases are Home Location Register (HLR), Visitor Location Register (VLR), the Authentication Center (AUC), and Equipment Identity Register (EIR).

Home Location Register (HLR) stores the permanent (such as user profile) as well as temporary (such as current location) information about all the users registered with the network. A VLR stores the data about the users who are being serviced currently. It includes the data stored in HLR for faster access as well as the temporary data like location of the user. The AUC stores the authentication information of the user such as the keys for encryption. The EIR stores stores data about the equipments and can be used to prevent calls from a stolen equipments.

All the mobile equipments in GSM system are assigned unique id called IMSI (International Mobile Equipment Identity) and is allocated by equipment manufacturer and registered by the service provider. This number is stored in the EIR. The users are identified by the IMSI (International Module Subscriber Identity) which is stored in the Subscriber Identity Module (SIM) of the user. A mobile station can be used only if a valid SIM is inserted into an equipment with valid IMSI. The real telephone number is different from the above ids and is stored in SIM.



Logical Channels.

There are two distinct categories of logical channels in GSM: traffic channels (TCH) and control channels (CCH). In the initial GSM specification only the full-rate speech channels (22.8 kb/s) and data channels (9.6, 4.8, and 2.4 kb/s) are defined as TCH. The three types of control channel are broadcast (BCCH), common (CCCH), and dedicated (DCCH), each of which is further subdivided. Figures 3.5 presents the various subcategories of traffic and control channels in GSM. Each traffic channel type shown in Figure is always associated with a control channel (associated control channel). Currently only the full-rate speech channel and the data channels have been fully defined and implemented; the definition of half-rate channel has been completed and is ready for implementation. The broadcast control channel (BCCH) is a unidirectional (base-to mobile) channel that is used to broadcast (continuous transmission) information regarding the mobile's serving cell as well as neighboring cells. It may include a frequency correction channel (FCCH) and a synchronization channel (SCCH) to provide accurate tuning to BS and frame synchronization, respectively. A common control channel (CCCH) may be used either for uplink (mobile-to-base) or downlink (base-to-mobile) communicationing (PCH) and access grant (AGCH) channels operate in the downlink direction—the former for paging a mobile and the latter to assign dedicated resources to the mobile (i.e., SDCCH).

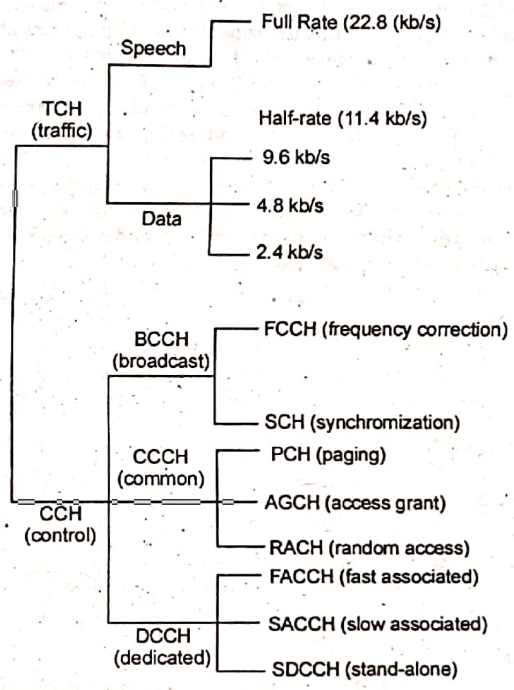


Fig: Logical channel

Q. 6. (a) How RAKE reception enables path diversity in CDMA. Discuss the key principle behind it. **(6)**

Ans. RAKE receiver, used especially in CDMA cellular systems, can combine multipath components, which are time-delayed versions of the original signal transmission. This can be done due to multipath components are practically uncorrelated from another when their relative propagation delay exceeds a chip period. The basic idea of A RAKE receiver was first proposed by Price and Green .Due to reflections from obstacles a radio channel can consist of many copies of originally transmitted signals having different amplitudes, phases, and delays. If the signal components arrive more than duration of one chip apart from each other, a RAKE receiver can be used to resolve and combine them. The RAKE receiver uses a multipath diversity principle. When a signal is received in a matched filter over a multipath channel, the multiple delays appear at the receiver. The RAKE receiver uses several baseband correlators to individually process several signal multipath components. The correlator outputs are combined to achieve improved communications reliability and performance. As it uses multiple correlation peaks so it is called Rake receiver, which collects ("rakes up") the energy from different MPCs. As shown in Figure a Rake receiver consists of a bank of correlators. Each correlator is sampled at a different time (with delay $\hat{o}$), and thus collects energy from the MPC with delay τ. The sample values from the correlators are then weighted and combined. Alternatively, we can interpret the Rake receiver as a tapped delay line, whose outputs are weighted and added up. The tap delays, as well as the tap weights, are adjustable, and matched to the channel. Note that the taps are usually spaced at least one chip duration apart, but there is no requirement for the taps to be spaced at regular intervals. The combination of the receiver filter and the Rake receiver constitutes a filter that is matched to the receive signal. The receive filter is matched to the transmit signal, while the Rake receiver is matched to the channel. Independent of this interpretation, the receiver adds up the (weighted) signal from the different Rake fingers in a coherent way. As these signals correspond to different MPCs, their fading is (approximately) statistically independent – in other words, they provide delay diversity (frequency diversity). A Rake receiver is thus a diversity receiver, and all mathematical methods for the treatment of diversity remain valid.

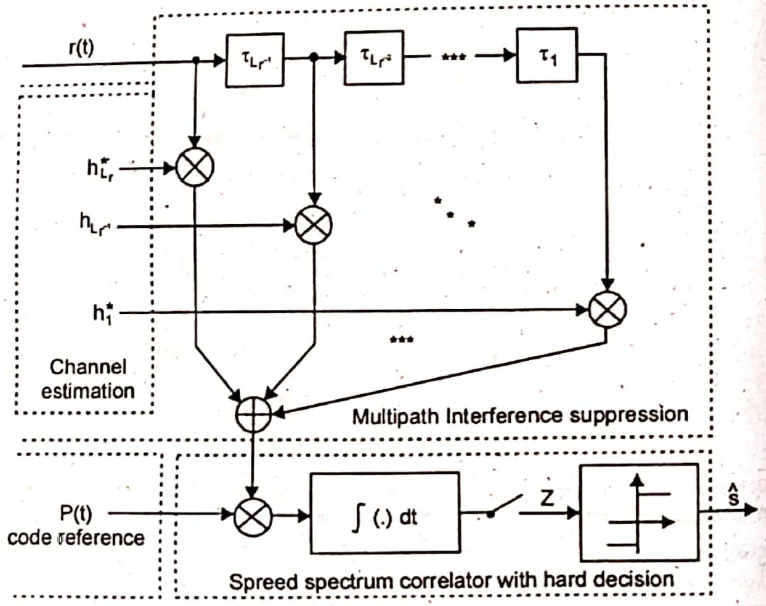


Fig: Rake receiver

Q.6. (b) Explain with a neatly labeled BD the FC & RC structure of IS-95 CDMA & establish the roles of PN & Walsh codes employed therein. (9)

Ans. IS-95 standard describes a Code Division Multiple Access (CDMA) system in which the audio band data signal is multiplied by a high rate spreading signal. This spreading signal is formed from a pseudo-noise code sequence, which is then multiplied by a Walsh code for maximum orthogonality to (i.e. to have low cross-correlation with) the other codes in use in that cell. Typically, CDMA pseudo-noise sequences are very long, thereby giving excellent cross correlation characteristics.IS-95 system can be thought of as having many layers of protection against interference. It allows many users to co-exist, with minimal mutual interference. They can be described by the signal conditioning sequence that occurs on forward and reverse channels. The forward channel carries information from the base station to the mobile unit; the reverse channel carries information from the mobile unit to the base station.

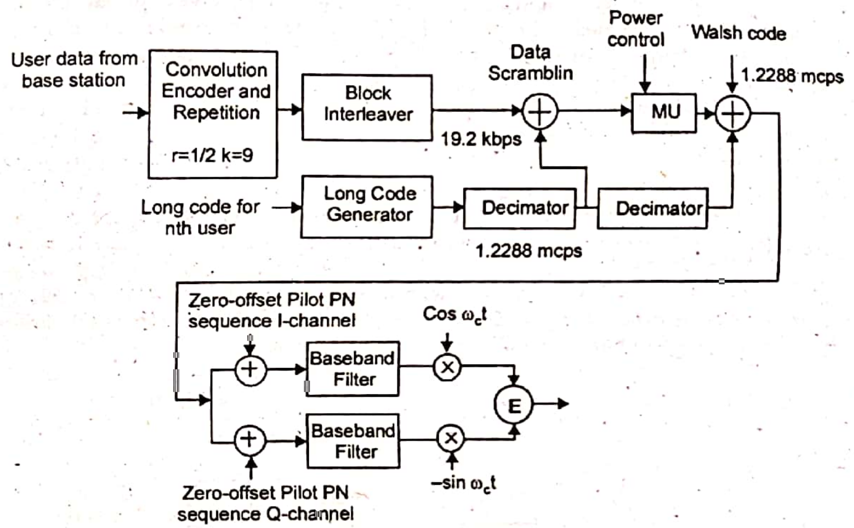


Fig. Forward CDMA channel modulation process

Forward channel transmission sequence:

1. Convolution encoder Encodes the data from one stream to two, doubling the nominal rate from 9.6 kpbs to 19.2 kbps, 4.8 kbps data to 9.6 kbps, etc.

2. Repetition circuit Repeats coded symbols, so lower rate encoded data is increased from 9.6, 4.8 or 2.4 kbps to 19.2 kbps

3. Block Interleaver Reads data into the rows of a 24 x 16 array, and out of the columns; introduces a 20 msec delay, but spreads important bits (as produced by modern speech encoders) over time as proof against deep fades or noise bursts.

4. Data scrambling The data are Modulo 2 added to every 64th bit of a pseudo-noise (PN) sequence created from a 42 bit shift register. (The resulting 242-1 bits repeat once per century after initiation.) The data rate at this point is still 19.2 kbps.

5. Power control Every 1.25 msec, or 24 data symbols, a power control bit is inserted, in order to instruct the mobile unit to raise or lower its power (to equalize the power received from every mobile unit in the cell.) The location of the power control bit is determined from the PN sequence.

6. Orthogonal covering The 19.2 kbps data are spread with a 1.2288 Mbps Walsh function, so that each one bit data symbol is spread by 64 Walsh chips. The Walsh function provides 64 mutually orthogonal binary sequences, each of length 64.

7. Quadrature spreading The data are split into two bit streams, which are Modulo 2 added to two different but well defined "Pilot" pseudo-noise sequences generated from 15 bit shift registers. The code repeats 75 times every 2 seconds, or at 26.7 msec intervals.

8. Quadrature modulation The binary I and Q outputs are mapped onto four phases of a quadrature modulator, at $\pm\delta/4$ and $\pm 3\delta/4$, using quadrature phase shift keying (QPSK).

9. RF modulation The baseband quadrature data are raised to the forward cellular radio band, 869 to 894 MHz. The IS-95 channel occupies 1.25 MHz within this band, the rest of which is occupied by other cellular services such as AMPS.

Of the 64 available orthogonal channels (ie. channels which have minimum mutual interference), one is assigned to the pilot channel and one to the synchronization channel. Several low numbered channels are assigned to paging. The pilot channel corresponds to the all zeros Walsh code (Walsh channel 0), and contains the unmodulated quadrature PN spreading code. It is transmitted at higher power than the user channels, and is provided so that each subscriber within the cell can determine and react to the channel characteristics while employing coherent detection. Walsh channel 32 is assigned to the sync channel, which provides time and frame synchronization to the mobile unit. Time of day and station identification are continuously broadcast on this channel. As users are added to the system, they are assigned user channels from the available Walsh channels. When over 60 users are present, the channels are assigned to multiple users, and protection from mutual interference within the same Walsh channel is provided by the private PN sequences that encode each user link. The number of users can therefore rise to large values, while reasonable quality is maintained.

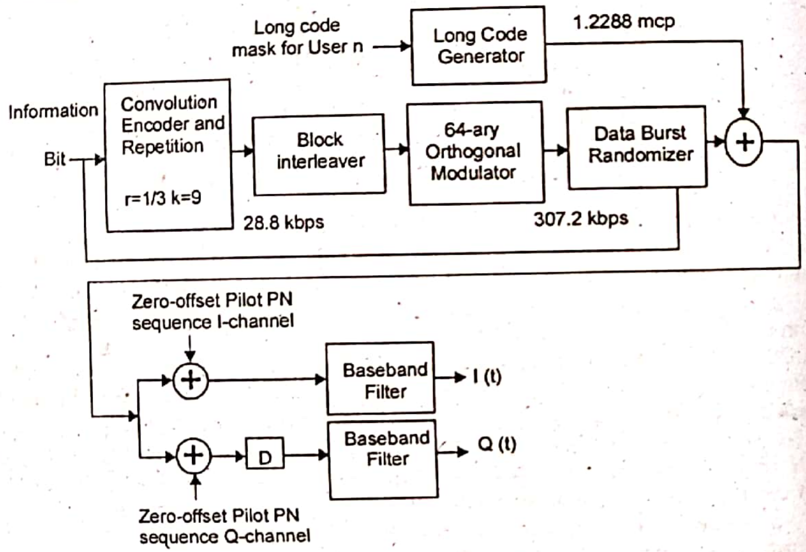


Fig. Reverse CDMA channel modulation process

Reverse channel transmission sequence:

1. Speech encoder Produces nominal 9600 bps data stream, dynamically reduced to 4800, 2400, or 1200 bps during pauses and gaps in speech;

2. Convolution encoder Encodes the data from one stream to three, tripling the data rate from 9.6 kpbs to 28.8 kbps, 4.8 kbps data to 14.4 kbps, etc.

3. Repetition circuit Repeats coded symbols, so lower rate encoded data is increased from 9.6, 4.8 or 2.4 kbps to 19.2 kbps.

4. Block Interleaver Reads data into the columns of a 32 x 18 array, and out of the rows; introduces a 20 msec delay, but spreads important bits over time as proof against deep fades or noise bursts.

5. Orthogonal mapping The 28.8 kbps data are split into sequential sets of six bits each, which are mapped to one of 64 Walsh functions. The data rate is therefore raised to 28.8 k x 64 chips/ 6 bits = 307.2 kpbs.

6. Burst Randomizing The Walsh symbols are broken into groups of six, each group being 1.25 msec in duration. These are collected into frames of 16 power groups, or 1.25 msec x 16 = 20 msec. At 9600 bps, all 16 groups are transmitted; at 4800 bps, 8 randomly selected groups are transmitted; at 2400 bps, 4 groups; at 1200 bps, 2 groups. The transmitted groups are chosen randomly, according to a formula based on 14 bits of the PN sequence of the second last group in the previous frame.

7. Direct sequence spreading The data are Modulo 2 added to every bit of a pseudo-noise (PN) sequence created from a 42 bit shift register. The PN sequence is generated at 1.2288 MHz, so each Walsh chip is spread by four long code PN chips.

8. Quadrature spreading The data are split into two bit streams, which are Modulo 2 added to two different but well defined "Pilot" pseudo-noise sequences generated from 15 bit shift registers.

9. Quadrature modulation The binary I and Q outputs are mapped onto four phases of a quadrature modulator, at $\pm\delta/4$ and $\pm 3\delta/4$, using offset quadrature phase shift keying (OQPSK). (The Q channel is shifted by half a chip for improved spectral shaping.)

10. RF modulation The baseband quadrature data are raised to the reverse cellular radio band, 824 to 849 MHz. The IS-95 channel occupies 1.25 MHz within this band, the rest of which is occupied by other cellular services such as AMPS.

Q. 7. (a) What is EDGE & which generation does it belong. Explain how EDGE achieves greater data rates than allowed in GSM. (9)

Ans. EDGE is an evolution to the GSM mobile cellular phone system. The name EDGE stands for Enhanced Data rates for GSM Evolution and it enables data to be sent over a GSM TDMA system at speeds up to 384 kbps. In some instances GSM EDGE evolution systems may also be known as EGPRS, or Enhanced General Packet Radio Service systems. Although strictly speaking a "2.5G" system, the GSM EDGE cellular technology is capable of providing data rates that are a distinct increase on those that could be supported by GPRS.

EDGE evolution is intended to build on the enhancements provided by the addition of GPRS (General Packet Radio Service) where packet switching is applied to a network. It then enables a three-fold increase in the speed at which data can be transferred by adopting a new form of modulation. GSM uses a form of modulation known as Gaussian Minimum Shift Keying (GMSK), but EDGE evolution changes the modulation to 8PSK and thereby enabling a significant increase in data rate to be achieved.

There are a number of key elements in the upgrade from GSM or GPRS to EDGE. The GSM EDGE technology requires a number of new elements to be added to the system:

Use of 8PSK modulation: In order to achieve the higher data rates within GSM EDGE, the modulation format can be changed from GMSK to 8PSK. This provides a significant advantage in being able to convey 3 bits per symbol, thereby increasing the maximum data rate. This upgrade requires a change to the base station. Sometimes hardware upgrades may be required, although it is often simply a software change.

Base station: Apart from the upgrade to incorporate the 8PSK modulation capability, other small changes are required to the base station. These are normally relatively small and can often be accomplished by software upgrades.

Upgrade to network architecture: GSM EDGE provides the capability for IP based data transfer. As a result, additional network elements are required. These are the same as those needed for GPRS and later for UMTS. In this way the introduction of EDGE technology is part of the overall migration path from GSM to UMTS.

The two main additional nodes required for the network are the Gateway GPRS Service Node (GGSN) and the Serving GPRS Service Node (SGSN). The GGSN connects to packet-switched networks such as the Internet and other GPRS networks. The SGSN provides the packet-switched link to mobile stations.

Mobile stations: It is necessary to have a GSM EDGE handset that is EDGE compatible. As it is not possible to upgrade handsets, this means that the user needs to buy a new GSM EDGE handset.

Q.7. (b) Write down the GPRS architecture & explain its key features. (6)

Ans. Refer Q. 3. (b) of First term 2017.

Q.8. (a) Compare & control WCDMA & CDMA 2000 schemes under IMT-2000. (6)

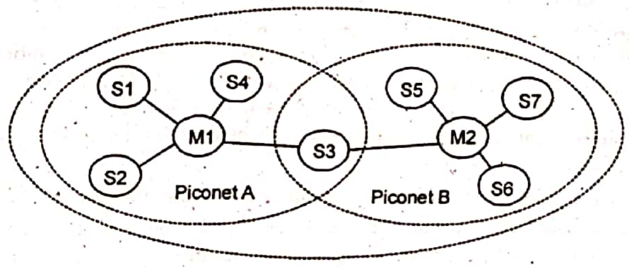
Ans. Major differences between WCDMA (3GPP) & CDMA2000 (3GPP2) standards for CDMA-based 3G implementations:

Parameter	WCDMA	CMDA 2000
Carrier Spacing : spacing between CDMA operators to obtain channel protection	5 MHz	3.75 MHz
Chip Rate : number of DSSS pulses per second; a chip is a pulse of DSSS code	4.096 MHz	3.68 MHz
Spreading Factor : SF=(Chip Rate)/(Data Rate)	Higher	Lower
Power Control Frequency : the output power of the transmitter is controlled by itself at this frequency	1500 Hz	800 Hz
Frame Duration : the time duration of a frame;between beginning and end of the frame.	10 ms	20 ms (also uses 5, 30, 40 ms frames)
Base Stations : base stations may or may not need synchronous timings	Asynchronous	Synchronous
Forward Link Pilot : The pilot is a channel modulated only by the PN (Pseudo Noise) spreading codes	TDM, Dedicated pilot	CDM, Common Pilot
Antenna Beam Forming : used for directional signal transmission & reception	TDM, Dedicated pilot	Auxiliary pilot

Q.8.(b) Explain breifly the Bluetooth Architecture, Radio link & Protocol Stack. (9)

Ans. Like IEEE 802.11b, Bluetooth operates in the 2.4 GHz ISM band. A very important term in the context of Bluetooth is a piconet. A piconet is a collection of Bluetooth devices which are synchronized to the same hopping sequence. Figure shows a collection of devices with different roles. One device in the piconet can act as master (M), all other devices connected to the master must act as slaves (S). The master determines the hopping pattern in the piconet and the slaves have to synchronize to this pattern. Each piconet has a unique hopping pattern. If a device wants to participate it has to synchronize to this. Two additional types of devices are shown: parked devices (P) can not actively participate in the piconet (i.e., they do not have a connection), but are known and can be reactivated within some milliseconds. Devices in stand-by (SB) do not participate in the piconet. Each piconet has exactly one master and up to seven

simultaneous slaves. More than 200 devices can be parked. The reason for the upper limit of eight active devices, is the 3-bit address used in Bluetooth. If a parked device wants to communicate and there are already seven active slaves, one slave has to switch to park mode to allow the parked device to switch to active mode.



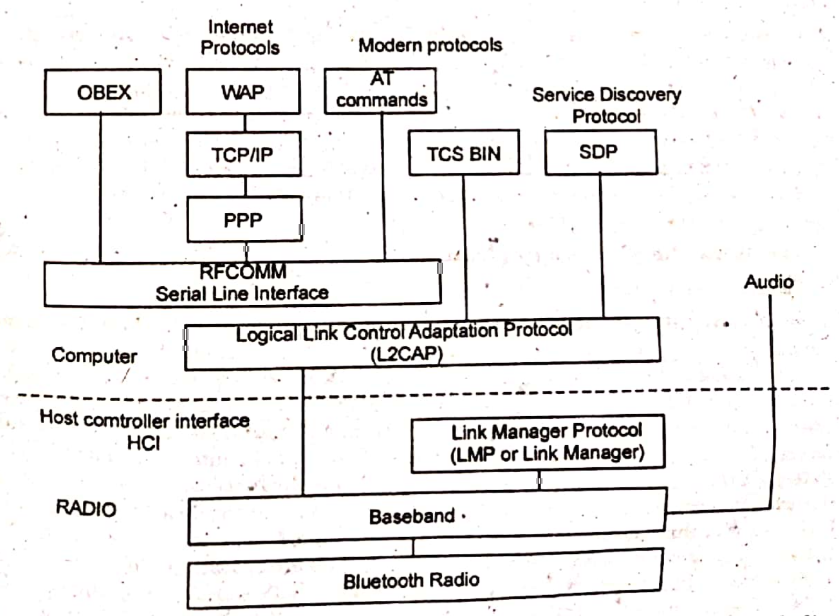
Scatternet

The core protocols of Bluetooth comprise the following elements:

Radio: Specification of the air interface, i.e., frequencies, modulation, and transmit power.

Baseband: Description of basic connection establishment, packet formats, timing, and basic QoS parameters.

Bluetooth Protocol Stack



Link manager protocol: Link set-up and management between devices including security functions and parameter negotiation

• Logical link control and adaptation protocol (L2CAP): Adaptation of higher layers to the baseband (connectionless and connection-oriented services,

• Service discovery protocol: Device discovery in close proximity plus querying of service characteristics

On top of L2CAP is the cable replacement protocol RFCOMM that emulates a serial line interface following the EIA-232 (formerly RS-232) standards. This allows for a simple replacement of serial line cables and enables many legacy applications and protocols to run over Bluetooth. RFCOMM supports multiple serial ports over a single physical channel. The telephony control protocol specification – binary (TCS BIN) describes a bit-oriented protocol that defines call control signaling for the establishment of voice and data calls between

Bluetooth devices. It also describes mobility and group management functions.

The host controller interface (HCI) between the baseband and L2CAP provides a command interface to the baseband controller and link manager, and access to the hardware status and control registers. The HCI can be seen as the hardware/software boundary.

Many protocols have been adopted in the Bluetooth standard. Classical Internet applications can still use the standard TCP/IP stack running over PPP or use the more efficient Bluetooth network encapsulation protocol (BNEP). Telephony applications can use the AT modem commands as if they were using a standard modem. Calendar and business card objects (vCalendar/vCard) can be exchanged using the object exchange protocol (OBEX) as common with IrDA interfaces. A real difference to other protocol stacks is the support of audio. Audio applications may directly use the baseband layer after encoding the audio signals

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Q.9. Write short notes on any three:- **(5)**

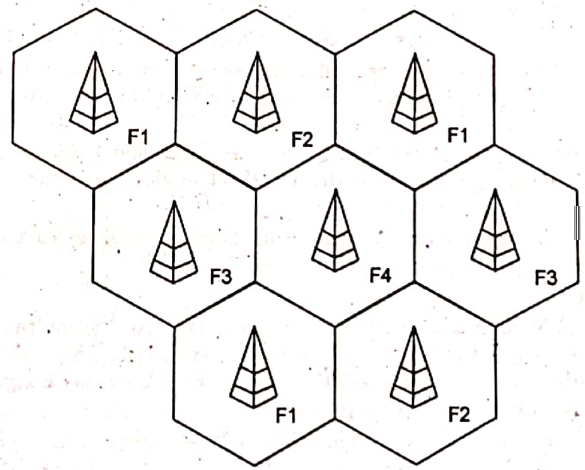
(a) Diversity Gain

Ans. Diversity gain reflects the fact that it is improbable that several antenna elements are in a fading dip simultaneously; the probability for very low signal levels is thus decreased by the use of multiple antenna elements. Beamforming gain reflects the fact that (for combining diversity) the combiner performs an averaging over the noise at different antennas. Thus, even if the signal levels at all antenna elements are identical, the combiner output SNR is larger than the SNR at a single-antenna element.MIMO systems can be used to achieve spatial multiplexing, diversity, and/or beamforming. However, it is not possible to attain all of those goals simultaneously at their full extent. First, we find that there is a tradeoff between beamforming and diversity gain; this tradeoff also depends on the environment in which we are operating. Consider first an LOS scenario. In this case, it is obvious that the achievable beamforming gain is NtNr: we form beams at the TX (with gain Nt) and at the RX (with gain Nr), and point them at each other. The gains thus multiply. On the other hand, there is obviously no diversity

gain, since there is no fading in an LOS scenario – in other words, the slope of the SNR distribution curve does not change.

Q.9. (b) Frequency Reuse & Cellular Topology **(5)**

Ans. A cellular network is a radio network distributed over land areas called cells, each served by at least one fixed-location transceiver, known as a base station. When joined together these cells provide radio coverage over a wide geographic area. This enables a large number of portable transceivers (e.g., mobile phones, pagers, etc.) to communicate with each other and with fixed transceivers and telephones anywhere in the network, via base stations, even if some of the transceivers are moving through more than one cell during transmission. In a cellular radio system, a land area to be supplied with radio service is divided into regular shaped cells, which can be hexagonal, square, circular or some other irregular shapes, although hexagonal cells are conventional. Each of these cells is assigned multiple frequencies (f1 - f6) which have corresponding radio base stations. The group of frequencies can be reused in other cells, provided that the same frequencies are not reused in adjacent neighboring cells as that would cause co-channel interference.The increased capacity in a cellular network, compared with a network with a single transmitter, comes from the fact that the same radio frequency can be reused in a different area for a completely different transmission. If there is a single plain transmitter, only one transmission can be used on any given frequency.



The key characteristic of a cellular network is the ability to re-use frequencies to increase both coverage and capacity. As described above, adjacent cells must use different frequencies, however there is no problem with two cells sufficiently far apart operating on the same frequency. The elements that determine frequency reuse are the reuse distance and the reuse factor.

The reuse distance, D is calculated as

$$D = R\sqrt{3N},$$

where R is the cell radius and N is the number of cells per cluster. Cells may vary in radius in the ranges (1 km to 30 km).

Q.9. (c) WLAN 802.11 PHY Layer **(5)**

Ans. 802.11 Physical Layer (PHY):

At the physical layer, IEEE 802.11 defines three physical characteristics for WLANs:

Diffused infrared (baseband), DSSS, and FHSS. All three support a 1 to 2 Mbps data rate. Both DSSS and FHSS use the 2.4 GHz ISM band (2.4–2.4835 GHz). The physical layer provides three levels of functionality.

These include: (1) frame exchange between the MAC and PHY under the control of the physical layer convergence procedure (PLCP) sublayer; (2) use of signal carrier and spread spectrum (SS) modulation to transmit data frames over the media under the control of the physical medium dependent (PMD) sublayer; and (3) providing a carrier sense indication back to the MAC to verify activity on the media

DSSS PHY:

In the DSSS PHY, data transmission over the media is controlled by the PMD sublayer as directed by the PLCP sublayer. The PMD sublayer takes the binary information bits from the PLCP protocol data unit (PPDU) and converts them into RF signals by using modulation and DSSS techniques.

In the PPDU frame, which consists of a PLCP preamble, PLCP header, and MAC protocol data unit (MPDU). The PLCP preamble and PLCP header are always transmitted at 1 Mbps, and the MPDU can be sent at 1 or 2 Mbps.

The start of frame delimiter (SFD) contains information that marks the start of the PPDU frame. The SFD specified is common for all IEEE 802.11 DSSS radios.

The signal field indicates which modulation scheme should be used to receive the incoming MPDU. The binary value in this field is equal to the data rate multiplied by 100 kbps.

The service field is reserved for future use. The length field indicates the number of microseconds necessary to transmit the MPDU. The MAC layer uses this field to determine the end of a PPDU frame.

The CRC field contains the results of a calculated frame check sequence from the sending station.

FHSS PHY:

In FHSS PHY, data transmission over media is controlled by the FHSS PMD sublayer as directed by the FHSS PLCP sublayer. The FHSS PMD takes the binary information bits from the whitened PSDU and converts them into RF signals by using carrier modulation and FHSS techniques.

The format of the PPDU is shown in Figure 3. It is consists of the PLCP preamble, PLCP header, and PLCP service data unit (PSDU). The PLCP preamble is used to acquire the incoming signal and synchronize the receiver's demodulator.

The PLCP header contains information about PSDU from the sending physical layer. The PLCP preamble and header are transmitted at 1 Mbps.

PLCP-Preamble		PLCP Header			
SYNC 80-bits	SFD 16-bits	PLW 12-bits	PSF 4-bits	Header Error Check 16-bits	Whitened PSDU
PPDU					

Fig. 3. FHSS PHY PPDU frame

The sync field contains a string of alternating 0s and 1s pattern and is used by the receiver to synchronize the receiver's packet timing and correct for frequency offsets.

The SFD field contains information marking the start of a PSDU frame.

FHSS radios use a 0 0 0 0 1 1 0 0 1 0 1 1 1 1 0 1 bit pattern. The leftmost bit is transmitted first.

The PLCP length word (PLW) field specifies the length of the PSDU in octets and is used by the MAC layer to detect the end of a PPDU frame.

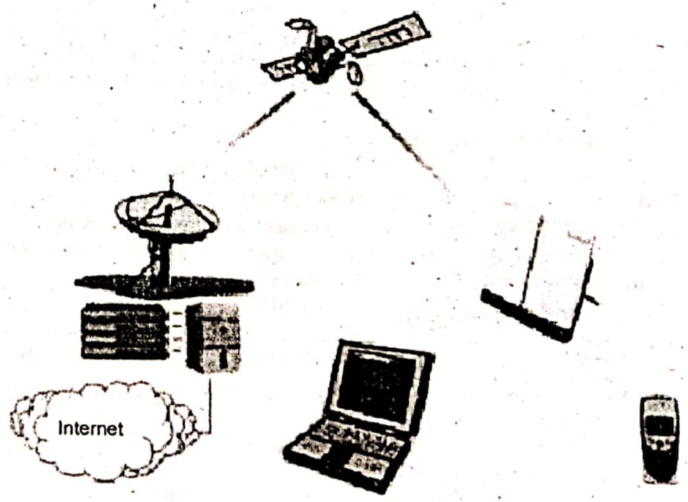
The PLCP signaling field (PSF) identifies the data rate of the whitened PSDU ranging from 1 to 4.5 Mbps in increments of 0.5 Mbps.

The header error check field contains the results of a calculated frame check sequence from the sending station.

Data whitening is used for the PSDU before transmission to minimize DC bias on the data if long strings of 1s or 0s are contained in the PSDU. The PHY stuffs a special symbol every 4 octets of the PDSU in a PPDU frame.

Q.9. (d) Mobile Satellite Systems. **(5)**

Ans. Mobile satellite service system (MSS) is the term used to describe telecommunication services delivered to or from the mobile users by using the satellites. MSS can be used in remote areas lacking wired networks. Limitations of MSS are availability of line of sight requirement and emerging technologies.



Mobile satellite service (MSS) system

The basic MSS System comprises of these three segments:

Space segment

User segment

Control segment

Space segment: Space segment is equipped with satellite pay-load equipment. The Pay load is used to enable the ability of the satellite for users in space communication.

User segment: The user segment consists of an equipment that transmits and receives the signals from the satellite.

Control segment: The control segment controls the satellite and operations of all internet connections to maintain the bandwidth and adjust power supply and antennas. (5)

Q.9. (e) Ad hoc Mobile Networks.

Ans. There may be several situations where users of a network cannot rely on an infrastructure, it is too expensive, or there is none at all. In these situations mobile ad-hoc networks are the only choice.

ad-hoc networks offer a completely new way of setting up mobile communications if no infrastructure is available. In these networks routing is a major topic, because there is no base station that can reach all nodes via broadcast as in cellular networks. Traditional routing algorithms do not work at all well in the highly dynamic environment of ad-hoc networks, so extensions of existing or completely new algorithms have to be applied. For larger groups of nodes only hierarchical approaches solve the routing problem, flat algorithms such as DSR or AODV do not scale well. An important difference in wireless networks is the knowledge required about layer 2 characteristics. Information about interference and acknowledgements can help in finding a good route. Location information can further optimize routing. These networks cannot rely on security mechanisms provided by an infrastructure (e.g., authentication systems of mobile phone systems). There are also critical positions towards mobile multi-hop ad-hoc networks that do not foresee applications outside the military area. For almost all civil applications, such as electronic classrooms, meeting points etc. an infrastructure is available. If ad-hoc communication is needed without an infrastructure this is typically not a multi-hop scenario but, e.g., a spontaneous exchange of data between several devices within broadcast range.

Applications of Adhoc Network

- Instant infrastructure: Unplanned meetings, spontaneous interpersonal communications etc. cannot rely on any infrastructure.
- Disaster relief: Infrastructures typically break down in disaster areas. Hurricanes cut phone and power lines, floods destroy base stations, fires burn servers. Emergency teams can only rely on an infrastructure they can set up themselves.
- Remote areas: Even if infrastructures could be planned ahead, it is sometimes too expensive to set up an infrastructure in sparsely populated areas. Depending on the communication pattern, ad-hoc networks or satellite infrastructures can be a solution.
- Effectiveness: Services provided by existing infrastructures might betoo expensive for certain applications.

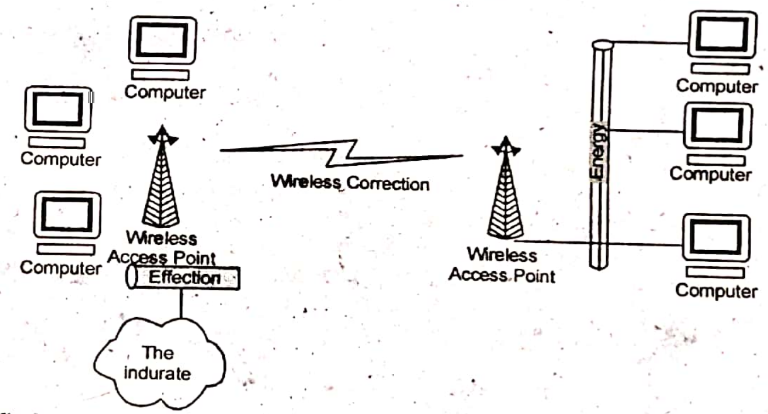
FIRST TERM EXAMINATION [SEPT. 2018]
SEVENTH SEMESTER [B.TECH]
WIRELESS COMMUNICATION [ETEC-405]

Time : 1.5 hrs. **M.M. : 30**

Note: *Attempt any three questions. Question No. 1 is compulsory.*

Q.1. Write the advantages of wireless communication systems. **(10)**

Ans. Advantages of wireless communication system.



Wireless communication involves transfer of information without any physical connection between two or more points. Because of this absence of any 'physical infrastructure', wireless communication has certain advantages. This would often include collapsing distance or space.

Wireless communication has several advantages; the most important ones are discussed below

Cost effectiveness: Wired communication entails the use of connection wires. In wireless networks, communication does not require elaborate physical infrastructure or maintenance practices. Hence the cost is reduced.

Example– Any company providing wireless communication services does not incur a lot of costs, and as a result, it is able to charge cheaply with regard to its customer fees.

Flexibility: Wireless communication enables people to communicate regardless of their location. It is not necessary to be in an office or some telephone booth in order to pass and receive messages.

Miners in the outback can rely on satellite phones to call their loved ones, and thus, help improve their general welfare by keeping them in touch with the people who mean the most to them.

Convenience: Wireless communication devices like mobile phones are quite simple and therefore allow anyone to use them, wherever they may be. There is no need to physically connect anything in order to receive or pass messages.

Example– Wireless communications services can also be seen in Internet technologies such as Wi-Fi. With no network cables hampering movement, we can now connect with almost anyone, anywhere, anytime.

Speed: Improvements can also be seen in speed. The network connectivity or the accessibility were much improved in accuracy and speed.

Example– A wireless remote can operate a system faster than a wired one. The wireless control of a machine can easily stop its working if something goes wrong, whereas direct operation can't act so fast.

Accessibility: The wireless technology helps easy accessibility as the remote areas where ground lines can't be properly laid, are being easily connected to the network.

Example– In rural regions, online education is now possible. Educators no longer need to travel to far-flung areas to teach their lessons. Thanks to live streaming of their educational modules.

Constant connectivity: Constant connectivity also ensures that people can respond to emergencies relatively quickly.

Example– A wireless mobile can ensure you a constant connectivity though you move from place to place or while you travel, whereas a wired land line can't.

Q.2. Define and explain multiple access techniques. (10)

Ans. Multiple access schemes are used to allow many mobile users to share simultaneously a finite amount of radio spectrum.

Multiple Access Techniques: In wireless communication systems, it is often desirable to allow the subscriber to send information simultaneously from the mobile station to the base station while receiving information from the base station to the mobile station.

A cellular system divides any given area into cells where a mobile unit in each cell communicates with a base station. The main aim in the cellular system design is to be able to increase the capacity of the channel, i.e., to handle as many calls as possible in a given bandwidth with a sufficient level of quality of service.

There are several different ways to allow access to the channel. These includes mainly the following –

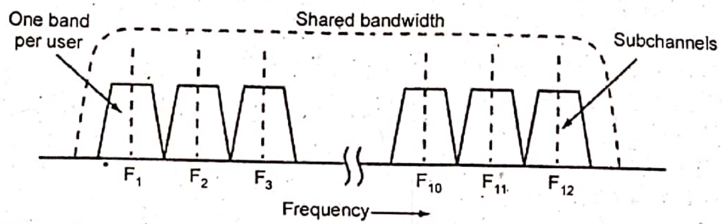
- Frequency division multiple-access (FDMA)
- Time division multiple-access (TDMA)
- Code division multiple-access (CDMA)
- Space division multiple access (SDMA)

Depending on how the available bandwidth is allocated to the users, these techniques can be classified as narrowband and wideband systems.

Narrowband Systems: Systems operating with channels substantially narrower than the coherence bandwidth are called as Narrow band systems. Narrow band TDMA allows users to use the same channel but allocates a unique time slot to each user on the channel, thus separating a small number of users in time on a single channel.

Wideband Systems: In wideband systems, the transmission bandwidth of a single channel is much larger than the coherence bandwidth of the channel. Thus, multipath fading doesn't greatly affect the received signal within a wideband channel, and frequency selective fades occur only in a small fraction of the signal bandwidth.

FDMA: FDMA is the process of dividing one channel or bandwidth into multiple individual bands, each for use by a single user. Each individual band or channel is wide enough to accommodate the signal spectra of the transmissions to be propagated. The data to be transmitted is modulated on to each subcarrier, and all of them are linearly mixed together.



1. FDMA divides the shared medium bandwidth into individual channels. Subcarriers modulated by the information to be transmitted occupy each subchannel.

The best example of this is the cable television system. The medium is a single coax cable that is used to broadcast hundreds of channels of video/audio programming to homes. The coax cable has a useful bandwidth from about 4 MHz to 1 GHz. This bandwidth is divided up into 6-MHz wide channels. Initially, one TV station or channel used a single 6-MHz band. But with digital techniques, multiple TV channels may share a single band today thanks to compression and multiplexing techniques used in each channel.

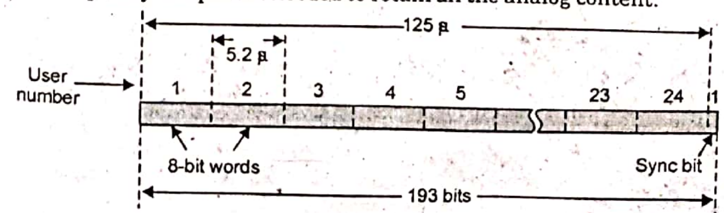
This technique is also used in fiber optic communications systems. A single fiber optic cable has enormous bandwidth that can be subdivided to provide FDMA. Different data or information sources are each assigned a different light frequency for transmission. Light generally isn't referred to by frequency but by its wavelength (λ). As a result, fiber optic FDMA is called wavelength division multiple access (WDMA) or just wavelength division multiplexing (WDM).

One of the older FDMA systems is the original analog telephone system, which used a hierarchy of frequency multiplex techniques to put multiple telephone calls on single line. The analog 300-Hz to 3400-Hz voice signals were used to modulate subcarriers in 12 channels from 60 kHz to 108 kHz. Modulator/mixers created single sideband (SSB) signals, both upper and lower sidebands. These subcarriers were then further frequency multiplexed on subcarriers in the 312-kHz to 552-kHz range using the same modulation methods. At the receiving end of the system, the signals were sorted out and recovered with filters and demodulators.

Original aerospace telemetry systems used an FDMA system to accommodate multiple sensor data on a single radio channel. Early satellite systems shared individual 36-MHz bandwidth transponders in the 4-GHz to 6-GHz range with multiple voice, video, or data signals via FDMA. Today, all of these applications use TDMA digital techniques.

TDMA: TDMA is a digital technique that divides a single channel or band into time slots. Each time slot is used to transmit one byte or another digital segment of each signal in sequential serial data format. This technique works well with slow voice data signals, but it's also useful for compressed video and other high-speed data.

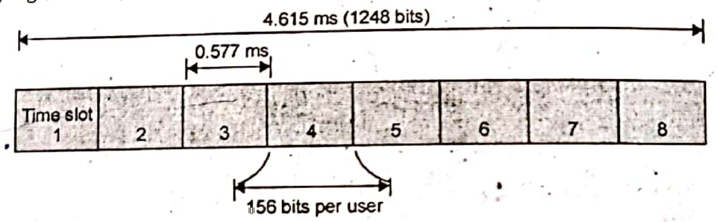
A good example is the widely used T1 transmission system, which has been used for years in the telecom industry. T1 lines carry up to 24 individual voice telephone calls on a single line. Each voice signal usually covers 300 Hz to 3000 Hz and is digitized at an 8-kHz rate, which is just a bit more than the minimal Nyquist rate of two times the highest-frequency component needed to retain all the analog content.



2. This T1 digital telephony frame illustrates TDM and TDMA. Each time slot is allocated to one user. The high data rate makes the user unaware of the lack of simultaneity.

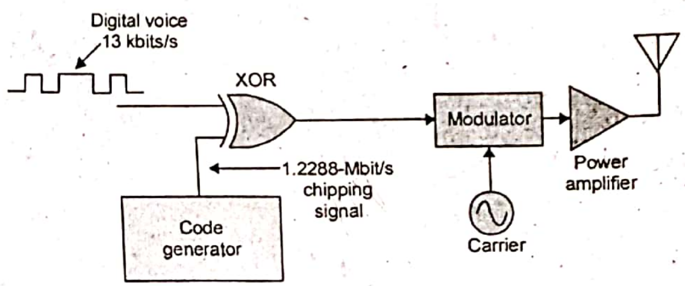
The digitized voice appears as individual serial bytes that occur at a 64-kHz rate, and 24 of these bytes are interleaved, producing one T1 frame of data. The frame occurs at a 1.536-MHz rate (24 by 64 kHz) for a total of 192 bits. A single synchronizing bit is added for timing purposes for an overall data rate of 1.544 Mbits/s. At the receiving end, the individual voice bytes are recovered at the 64-kHz rate and passed through a digital-to-analog converter (DAC) that reproduces the analog voice.

The basic GSM (Global System of Mobile Communications) cellular phone system is TDMA-based. It divides up the radio spectrum into 200-kHz bands and then uses time division techniques to put eight voice calls into one channel. Figure 3 shows one frame of a GSM TDMA signal. The eight time slots can be voice signals or data such as texts or e-mails. The frame is transmitted at a 270-kbit/s rate using Gaussian minimum shift keying (GMSK), which is a form of frequency shift keying (FSK) modulation.



3. This GSM digital cellular method shows how up to eight users can share a 200-kHz channel in different time slots within a frame of 1248 bits.

CDMA: CDMA is another pure digital technique. It is also known as spread spectrum because it takes the digitized version of an analog signal and spreads it out over a wider bandwidth at a lower power level. This method is called direct sequence spread spectrum (DSSS) as well. The digitized and compressed voice signal in serial data form is spread by processing it in an XOR circuit along with a chipping signal at a much higher frequency. In the cdma IS-95 standard, a 1.2288-Mbit/s chipping signal spreads the digitized compressed voice at 13 kbits/s.



4. Spread spectrum is the technique of CDMA. The compressed and digitized voice signal is processed in an XOR logic circuit along with a higher-frequency coded chipping signal. The result is that the digital voice is spread over a much wider bandwidth that can be shared with other users using different codes.

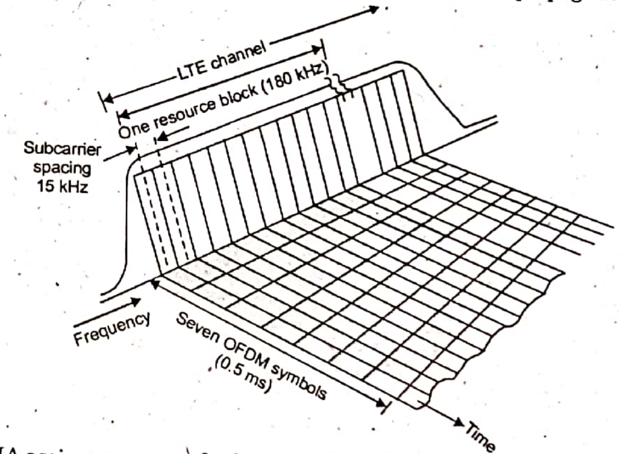
The chipping signal is derived from a pseudorandom code generator that **assigns a unique code to each user of the channel.** This code spreads the voice signal **over a**

bandwidth of 1.25 MHz. The resulting signal is at a low power level and appears more like noise. Many such signals can occupy the same channel simultaneously. For example, using 64 unique chipping codes allows up to 64 users to occupy the same 1.25-MHz channel at the same time. At the receiver, a correlating circuit finds and identifies a specific caller's code and recovers it.

The third generation (3G) cell-phone technology called wideband CDMA (WCDMA) uses a similar method with compressed voice and 3.84-Mbit/s chipping codes in a 5-MHz channel to allow multiple users to share the same band.

OFDMA: OFDMA is the access technique used in Long-Term Evolution (LTE) cellular systems to accommodate multiple users in a given bandwidth. Orthogonal frequency division multiplexing (OFDM) is a modulation method that divides a channel into multiple narrow orthogonal bands that are spaced so they don't interfere with one another. Each band is divided into hundreds or even thousands of 15-kHz wide subcarriers.

The data to be transmitted is divided into many lower-speed bit streams and modulated onto the subcarriers. Time slots within each subchannel data stream are used to package the data to be transmitted. This technique is very spectrally efficient, so it provides very high data rates. It also is less affected by multipath propagation effects.

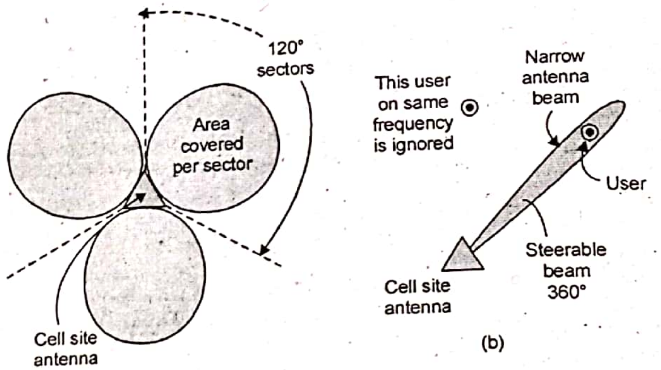


5. OFDMA assigns a group of subcarriers to each user. The subcarriers are part of the large number of subcarriers used to implement OFDM for LTE. The data may be voice, video, or something else, and it's assembled into time segments that are then transmitted over some of the assigned subcarriers.

To implement OFDMA, each user is assigned a group of subchannels and related time slots. The smallest group of subchannels assigned is 12 and called a resource block (RB). The system assigns the number of RBs to each user as needed.

SDMA: SDMA uses physical separation methods that permit the sharing of wireless channels. For instance, a single channel may be used simultaneously if the users are spaced far enough from one another to avoid interference. Known as frequency reuse, the method is widely used in cellular radio systems. Cell sites are spaced from one another to minimize interference.

In addition to spacing, directional antennas are used to avoid interference. Most cell sites use three antennas to create 120° sectors that allow frequency sharing (fig. a). New technologies like smart antennas or adaptive arrays use dynamic beamforming to shrink signals into narrow beams that can be focused on specific users, excluding all others (Fig. b).



(a) (b)

6. SDMA separates users on shared frequencies by isolating them with directional antennas. Most cell sites have three antenna arrays to separate their coverage into isolated 120° sectors (a). Adaptive arrays use beamforming to pinpoint desired users while ignoring any others on the same frequency (b).

One unique variation of SDMA, polarization division multiple access (PDMA), separates signals by using different polarizations of the antennas. Two different signals then can use the same frequency, one transmitting a vertically polarized signal and the other transmitting a horizontally polarized signal.

The signals won't interfere with one another even if they're on the same frequency because they're orthogonal and the antennas won't respond to the oppositely polarized signal. Separate vertical and horizontal receiver antennas are used to recover the two orthogonal signals. This technique is widely used in satellite systems.

Polarization is also used for multiplexing in fiber optic systems. The new 100-Gbit/s systems use dual polarization quadrature phase shift keying (DP-QPSK) to achieve high speeds on a single fiber. The high-speed data is divided into two slower data streams, one using vertical light polarization and the other horizontal light polarization. Polarization filters separate the two signals at the transmitter and receiver and merge them back into the high-speed stream.

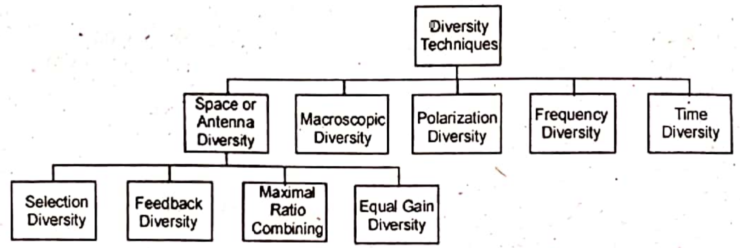
Q.3. Explain diversity technique in detail. **(10)**

Ans. Diversity is a technique, which is used to diminish the channel fading & is often implemented by using two or more receiving antennas. In 3G transmit diversity is used where base-stations may transmit replicas of the signal on spatially alienated antennas or frequencies. With an equalizer, diversity improves the quality of a wireless communication link without alerting the common air interface & devoid of increasing the transmitted power or bandwidth. The difference in equalization & diversity is that equalizer technique is used to reduce ISI, whereas diversity technique is used to diminish the effect of fading on wireless communication. Diversity exploits the random nature of radio propagation by finding independent signal paths for communication. Diversity technique is mainly applied on the receiver, & unknown to the transmitter. By this technique the strongest or the best signal is received at the receiver. According to the types of fading i.e. small & large scale, diversity techniques may be classified as:

(1). Small- scale fading: Small scale fades are characterized by deep & rapid amplitude fluctuations which arise as the mobile moves just few wavelengths. These fades are caused by multiple reflections from the surrounding object. To alleviate this, microscopic diversity technique, space diversity or antenna diversity techniques may be used.

(2). Large-scale fading: Large scale fading is caused by shadowing due to variations in the terrain profile & surrounding also. It occurs at large distance from the base-station. To alleviate this, macroscopic diversity may be used.

Classification of Diversity Techniques: According to way the fading of the incoming signal is mitigate in wireless communication diversity techniques are classification as:



- **Space Diversity or Antenna diversity:** It is one of the most popular diversity technique used in wireless systems. The direct path between the transmitter (BS) and receiver (MS) is not guaranteed and the possibility of a number of scatters in the mobile environment suggests a Rayleigh fading signal (small-scale fading). Multiple signals from spatially separated antenna (BS) is received on the mobile the best signals is picked by the mobile using the diversity technique as shown in fig. It is also used in the base station (BS) design. At each cell site, multiple BS receiving antennas are used to provide diversity reception as shown in Fig. The space or Antenna diversity [6] can be categorize as:

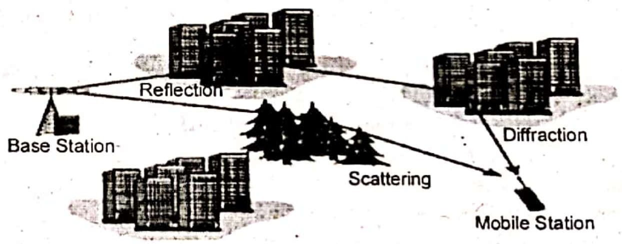


Fig. Multipath Signal Environment and Selection of strongest signal.

(1) Selection Diversity: This is simplest diversity technique where demodulators are used to give diversity branches whose gains are adjusted to provide the same average SNR for each branch. The receiver branch having the highest instantaneous SNR is connected to the demodulator. In practice the branch with the largest (S+N) N is used, as it is difficult to measure SNR above. Fig. shown the block diagram of selection diversity in communication system.

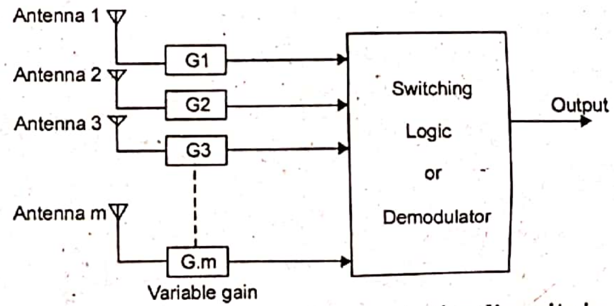


Fig. Shown the block diagram of selection diversity in communications systems.

(2) Feedback or Scanning Diversity: This technique is very similar to selection diversity except that instead of always using the best 'n' signals the 'n' signals are scanned in a fixed sequence until one's found above a predetermined threshold value. Now, this signal is then continuously received until it falls below threshold value and if falls, the scanning process is again inifiate. The flow diagram of feedback or scanning diversity is shown in fig.

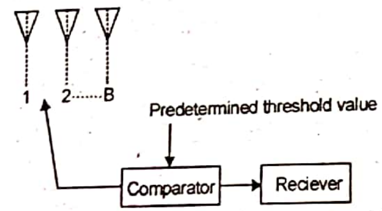


Fig. Block Daigram of Feedback Scanning Diversity.

(3) Maximal Ratio Combining (MRC): In this method, the signal from the all branches are weighted according to their voltage to noise power ratios and then summed (unlike selection diversity, where individual receiver is used). MRC [1] produces an output SNR equal to the sum of the individual SNR.

This technique has a merit of producing an output with an acceptable SNR even when none of the individual signals are themselves good enough. It is used in modern DSP techniques and digital receivers. Here the individual signals must be co-phased before summation.

Maximal Ratio combining (MRC). On the i^{th} receive antenna the received signal is, $y_i = h_i x + n_i$ where

y_i is the received symbol on the i^{th} receive antenna.

h_i is the channel on the i^{th} receive antenna.

x is the transmitted symbol and

n_i is the noise on i^{th} receive antenna.

4. Equal Gain Diversity: In certain cases, it is impossible to provide variable weighting capability like MRC.

In such cases, the branch weights are set to unity, but the signals from each branch are co-phased to provide equal gain combining diversity. This allows the receiver to exploit signals that are simultaneously received on each branch. This is superior than selection diversity but inferior than MRC technique. The block diagram of the Equal Gain Diversity is shown in fig.

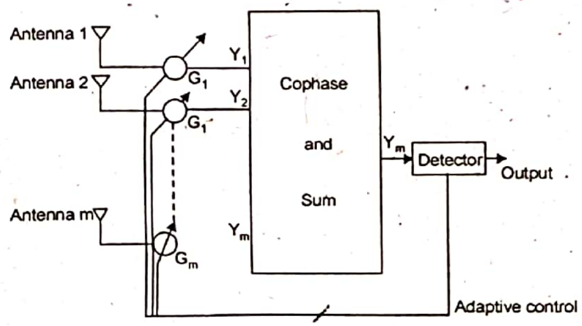


Fig. Block diagram of the Equal Gain Diversity

• **Macroscopic Diversity:** Macroscopic diversity is a technique that can facilitate high quality and ubiquitous communications between low-power portable radiotelephones and data terminals, and radio base stations (ports) that are connected to the local network. It uses radio signals from several base stations to alleviate the effect of shadow fading a variation of signal strength over space created by the presence of buildings, foliage, and terrain variations. With a path loss exponent of four and a shadow fading standard deviation of 10 dB, four-branch macroscopic diversity results in a 13 dB improvement in signal strength and a 15 dB improvement in signal to co-channel interference ratio for high user capacity interference limited operation. (Both figures are for 99 percent statistical coverage of the service area) The improvement in signal to co-phased channel interference ratio is equivalent to a factor-of-five savings of spectrum.

• **Polarization diversity:** It relies on the de-correlation of the two receive ports to achive diversity gain. The two receiver ports must remain cross-polarized. Effective Diversity is obtained with a Correlation Coefficient below 0.7. In order to keep the correlation at this level-space diversity at a base station requires antenna spacing of up to 20 wavelengths for the broadside case, and even more for the inline case.

Polarization diversity at a base station does not require antenna spacing. At the base station, space diversity is considerably less practical than at the mobile because the narrow angle of incident fields requires large antenna spacing. The comparatively high cost of using space diversity at the base station prompts the consideration of using orthogonal polarization. Polarization diversity provides two diversity branches and allows the antenna elements to be considered.

• **Frequency diversity:** The signal is transmitted using several frequency channels or spread over a broad spectrum that is exaggerated by frequency-selective fading. Middle-late 20th century microwave radio relay lines often used numerous regular wideband radio channels, and one protection channel for antomatic use by any faded channel. Later examples include: (1) OFDM (orthogonal frequency division multiplexing) modulation in combination with subcarrier interleaving and forward error correction and (2) Spread spectrum, for example frequency hopping or DS-CDMA.

• **Time diversity:** Multiple versions of the same signal are transmitted at different time instants. Time Diversity repeatedly transmits information at time spacing that exceeds the coherence time of the channel. A modern implementation of time diversity involves the use of RAKE receiver for spread spectrum CDMA, where multipath channel provides redundancy in the transmitted message. Multiple repetitions of the signal will be received with multiple fading conditions, thereby providing for diversity.

Q. 4. Write short notes on:

(a) GSM **(5)**

Ans. Refer to Q. 4. (b) First Term 2017.

Q.4.(b) GPRS **(5)**

Ans. Refer to Q. 3. (b) First Term 2017.

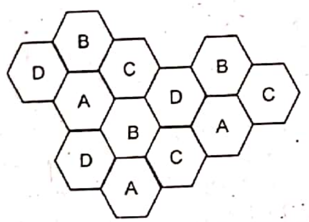
END TERM EXAMINATION [DEC-2018]
SEVENTH SEMESTER [B.TECH]
WIRELESS COMMUNICATION [ETEC-405]

Time : 3 hrs. **M.M. : 75**

***Note:** Attempt any five questions including Q. No. 1 which is compulsory.*

Q.1. (a) What is the necessity of having a large number of cell sites in a cellular system? **(3)**

Ans. Primary goal of the cellular telephone network is to provide wireless communication between two moving devices, called mobile stations or between one mobile unit and a stationary unit, commonly referred to as land-line unit. To accommodate a large number of users over a large geographic area, the cellular telephone system uses a large number of low-power wireless transmitters to create cells. Variable power levels allow cells to be sized according to subscriber density and demand within a particular region. As mobile users travel from cell to cell, their conversations are handed off between cells. Channels (frequencies) used in one cell can be reused in another cell some distance away, which allows communication by a large number stations using a limited number of radio frequencies. To summarize, the basic concept of reuse allows a fixed number of channels to serve an arbitrarily large number of users.



Q. 1. (b)Differentiate between LMDS and MMDS applications of WLL technology. **(3)**

Ans. MMDS: Multichannel multipoint distribution service. It is known as wireless cable or multichannel multipoint distribution service, used for general purpose broadband networking or as an alternative method of cable television programming reception.

- ICC has assigned five bands of frequency in US in range from 2.15 GHz to 2.68 GHz for MMDS

Advantages

- Larger wavelength of signal
- Base station cost is lower

LMDS– Local multi-point distribution system: It is a broadband wireless point to multipoint communication system that provides reliable digital two-way voice, data and Internet services. The term "Local" indicates that the signals range limit. "Multipoint" indicates a broadcast signal from the subscribers, the term "distribution" defines the wide range of data that can be transmitted, data ranging anywhere from voice, or video to Internet and video traffic.

It provides high capacity point to multipoint data access that is less investment intensive.

Advantages:

- Lower entry and deployment cost
- Ease and speed of deployment

- Fast realization of revenue
- Uses low powered high frequency (25-31 GHz) signals over a short distance.

Q.1. (c) Explain different types of spread spectrum techniques. **(3)**

Ans. Spread spectrum multiple access technique uses signals which have a transmission bandwidth of a magnitude greater than the minimum required RF bandwidth. The main advantage of spread spectrum communication technique is to prevent "interference" whether it is intentional or unintentional.

(a) Frequency Hopped Spread Spectrum (FHSS): This is frequency hopping technique, where the users are made to change the frequencies of usage, from one to another in a specified time interval, hence called as frequency hopping. For example, a frequency was allotted to sender 1 for a particular period of time. Now, after a while, sender 1 hops to the other frequency and sender 2 uses the first frequency, which was previously used by sender 1. This is called as frequency reuse.

The frequencies of the data are hopped from one to another in order to provide a secure transmission. The amount of time spent on each frequency hop is called as Dwell time.

(b) Direct Sequence Spread Spectrum (DSSS)

Whenever a user wants to send data using this DSSS technique, each and every bit of the user data is multiplied by a secret code, called as chipping code. This chipping code is nothing but the spreading code which is multiplied with the original message and transmitted. The receiver uses the same code to retrieve the original message.

Q. 1. (d) Compare IS 95, CDMA 2000 and WCDMA in terms of Power Control Mechanism. **(3)**

Ans.

Technology	IS-95	WCDMA	CDMA2000
Channel Bandwidth	1.25 MHz	5MHz	1.25MHz
Chip rate	1.228 Mcps	3.84 Mcps	1x: 1.2288 Mcps,,3x: 3.6864 Mcps
Data rate	14.4 kbps - IS-95A 115 kbps - IS-95B	384 kbps	144 kbps
Frame size	20ms	10ms	5ms, 10ms or 20ms
Power Control is at the rate of	800Hz	1500Hz	800Hz

Q. 1. (e) Define the term: Fade Rate, Average fade duration, Depth of fading? **(3)**

Ans. Fade rate is defined as the number of times that the received signal envelope crosses the threshold value in a positive-going direction per unit time.

Average fade duration is defined as the average period of time for which the received signal is below a specified received signal level.

Depth of fading is defined as the ratio between the mean square value and the minimum value of the fading signal.

Q. 2. (a) List out the features of cordless telephone systems. **(5)**

Ans. Cordless telephone system consists of two units viz. base unit and portable unit(referred as handset). Base unit is wired with standard telephone line, It is powered from AC mains and provide place to place and charge the handset unit on it.

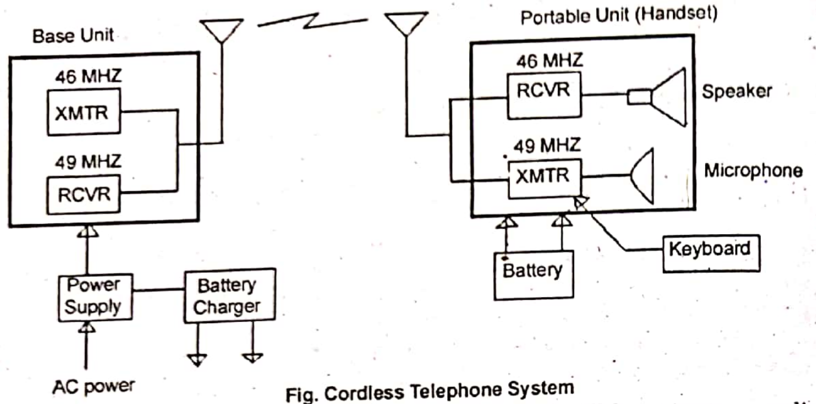


Fig. Cordless Telephone System

As shown in the figure, both base unit and handset will have two way radio transmission and reception. This is possible due to availability of RF transceiver on both the units to enable full duplex operation. To facilitate full duplex communication cordless telephone operates on two different frequencies one for transmit and another for receive. Base Unit transmits in the range from 43-46 MHz and receives in the 49 MHz range. Handset unit transmits in 49MHz range and receives in 43-46 MHz range.

FCC has allocated about 25 duplex channels for cordless telephone system. Here Frequency modulation technique is employed. Crystal control is provided to set these frequencies. This helps one set frequency channel such that interference can be avoided. FCC has limited transmit power to maximum value of 500 mW. Maximum usable range between base unit and portable unit is about 100 ft.

Q. 2. (b) Discuss Forward and Reverse channels in IS 95 CDMA. **(5)**

Ans. Refer Q. 4. (b) End Term 2016.

Q. 2. (c) Consider that geographical service area of a cellular system is 4200 km². A total of 1001 radio channels are available for handling traffic. Suppose the area of a cell is 12 km². How many times would the cluster of size 7 have to be replicated in order to cover the entire service area? Calculate the no. of channels per cell and the system capacity. **(5)**

Ans. Service area of a cellular system, Asys= 4200 km² (given)

Total number of available channels, N- 1001 (given)

Coverage area of a cell, Acell = 12km², (given)

To calculate number of clusters, cell capacity, and system capacity

Cluster size =7 (given)

Step 1. The coverage area of a cluster, Acluster = K * Acell= 7 × 12=84Km²

Step 2. To calculate the number of clusters

The number of times that the cluster has to be replicated to cover the entire service area of cellular system =Asys/Acluster= 4200/84= 50 clusters

Step 3. To calculate cell capacity

Since total number of available channels are allocated to one cluster.

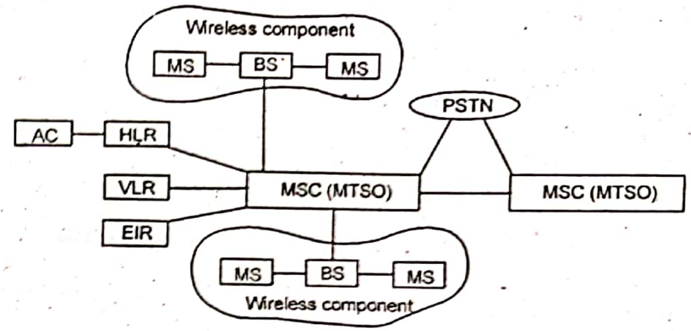
The number of channels per cell, J = N/K =1001/7 = 143 channels/cell

Step 4. To calculate system capacity

The system capacity, C = N * M = 1001 × 50 = 50,050 channels

Q.3. (a) Draw & explain PCS Network Architecture in detail. **(9)**

Ans.



PSTN: Public Switched Network.

MSC: Mobile Switching Center. Also called MTSO (Mobile Telephone Switching Office)

BS: Base Station

MS: Mobile Station Also called MU (Mobile Unit) or Mobile Host (MH)

HLR: Home Location Register

VLR: Visitor Location Register

EIR: Equipment Identify Register

AC: Access Channel

Personal communications service (PCS) is a type of wireless mobile service with advanced coverage and that delivers services at a more personal level. It generally refers to the modern mobile communication that boosts the capabilities of conventional cellular networks and fixed-line telephony networks as well.

PCS is also known as digital cellular.

The network architecture required to support PCS is based on the integration of multiple networks (e.g., PSTN, and Cellular), and the addition of the intelligent network capabilities. The network architecture will not only provide users with access to many telecommunications network resources, such as circuit switched network, private line network or packet data network, but will also provide subscribers with customized communications environments and the freedom to choose any access means. There are three main dimensions to the network architecture: (1) Access, (2) Service, and (3) Interworking. The Access Dimension addresses various wired and wireless accesses for residential, business, and public communications environments. The Service Dimension addresses the service control technique of the intelligent network for PCS provisioning. The Interworking Dimension addresses internetwork mobility and service portability across networks.

Q. 3. (b) What is diversity in wireless communication? Explain different types of diversity techniques. **(6)**

Ans. Diversity is a powerful communication receiver technique that provides wireless link improvement at a relatively low cost. Diversity techniques are used in wireless communications systems to primarily to improve performance over a fading radio channel.

In such a system, the receiver is provided with multiple copies of the same information signal which are transmitted over two or more real or virtual communication channels. Thus the basic idea of diversity is repetition or redundancy of information. In virtually all the applications, the diversity decisions are made by the receiver and are unknown to the transmitter.

Types of Diversity

- **Frequency Diversity:** The same information signal is transmitted on different carriers, the frequency separation between them being at least the coherence bandwidth.
- **Time Diversity:** The information signal is transmitted repeatedly in time at regularly intervals. The separation between the transmit times should be greater than the coherence time, Tc. The time interval depends on the fading rate, and increases with the decrease in the rate of fading.
- **Polarization diversity:** Here, the electric and magnetic fields of the signal carrying the information are modified and many such signals are used to send the same information. Thus orthogonal type of polarization is obtained.
- **Angle Diversity:** Here, directional antennas are used to create independent copies of the transmitted signal over multiple paths.
- **Space Diversity:** In Space diversity, there are multiple receiving antennas placed at different spatial locations, resulting in different (possibly independent) received signals.

Q. 4. (a) Explain GSM Protocol Architecture in detail with the help of diagram. (7)

Ans. Refer Q. 5. End Term 2017.

Q. 4. (b) GSM uses a frame structure where each frame consists of 8 times slot and each time slot contains 156.25 bits and data is transmitted over a channel at 27..833 bps. Find (8)

(i) Time duration of a bit.

(ii) Time duration of a time slot.

(iii) Time duration of a TDMA frame.

(iv) How long must a user wail when occupying a single time slot between two successive transmissions?

Ans. I.Time duration of a bit= 1/27.833= 0.036s

II.Time duration of a time slot = 156.25 × 0.036= 5.62s

III. Time duration of a TDMA frame = 8 × 5.62 =44.96 s

IV. Waiting time = 7 × 5.62 =39.34s

Q.5.(a) Illustrate the step by step procedure for mobile initiated call establishment procedure giving the type of logical channel with sub-layer categories of GSM Layer III. (10)

Ans. Table shows the mobile-initiated call-establishment procedure. The second column identifies the action taken or the message type. The third column identifies the logical channel that is used to carry the message. The fourth column identifies the sublayer of the Layer III in which GSM standard describes the message. Note that Layer III does not bandle the trafbic message and therefore there is no sublayer associated for that part of the procedure

Table 11.5 I Layer III sublayer categories for mobile-initiated call

Step No.	Message type	Logical channel used	Layer III sublayer category
1.	Request for a channel	RACH	RRM
2.	Immediate assignment	AGCH	RRM
3.	Request for call establishment	SDCCH	CM
4.	Request for a channel	SDCCH	MM
5.	Authentication response	SDCCH	MM
6.	Ciphering command	SDCCH	RRM
7.	Ciphering response	SDCCH	RRM
8.	Send called number	SDCCH	CM
9.	Routing response	SDCCH	CM
10.	Traffic channel assigned	SDCCH	RRM
11.	Traffic channel established	FACCH	RRM
12.	Free/busy signal	FACCH	RRM
13.	Acceptance of call	FACCH	CM
14.	Connection established	FACCH	CM
15.	Conversation	TCH	CM

Q.5.(b) An FHSS system employs a total bandwidth of 600 MHz and an individual channel bandwidth of 100 Hz. What is the minimum no. of PN bits required for each frequency gap? (5)

Ans. Total Bandwidth = 600 MHz

Individual channel Bandwidth = 100 Hz

$$\text{No. of Hop possible} = \frac{600 \times 10^6}{100} = 6\text{ MHz} = 6 \times 10^6\text{ Hz}$$

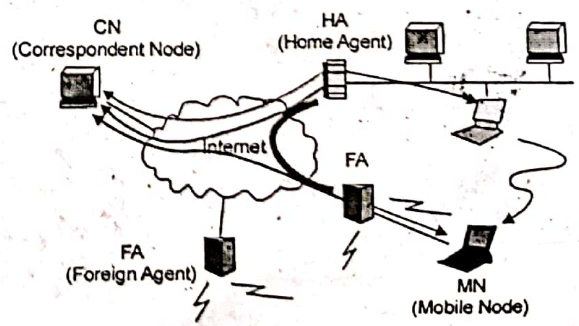
Minimum number of PN bit required

$$= \log_2 6 \times 10^6 = 22.51 = 23\text{ bits}$$

Q. 6. (a) Describe Operation and Encapsulation in Mobile IP. (9)

Ans. • When mobile node on foriegn network registered with home agent

- The Mobile IP datagram forwarding process will be fully a vated
- The home agent will intercept datagrams intended for the mobile node
- and forward them to the mobile node
- This is done by encapsulating the datagrams and then sending them to the node's care-of address.



Mobile IP Data Encapsulation Techniques

- Data exist at each layer contained within a unit called protocol Data unit.
- Date Encapsulation is a process of adding header to wrap the data flows through OSI model.
- The new headers specify how to send the encapsulated datagram to the mobile node's care-of-address.
- The default encapsulation process used in Mobile IP is called IP Encapsulation Within IP, commonly abbreviated IP-in-IP
- In addition to IP-in-IP, two other encapsulation methods may be optionally used.

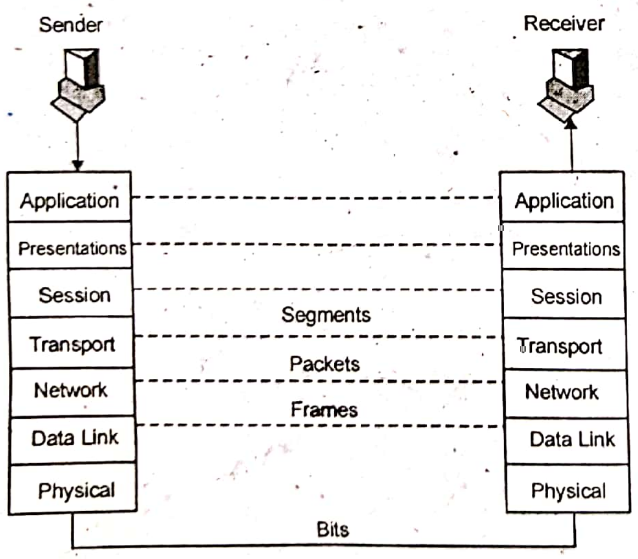
– Minimal Encapsulation Within IP

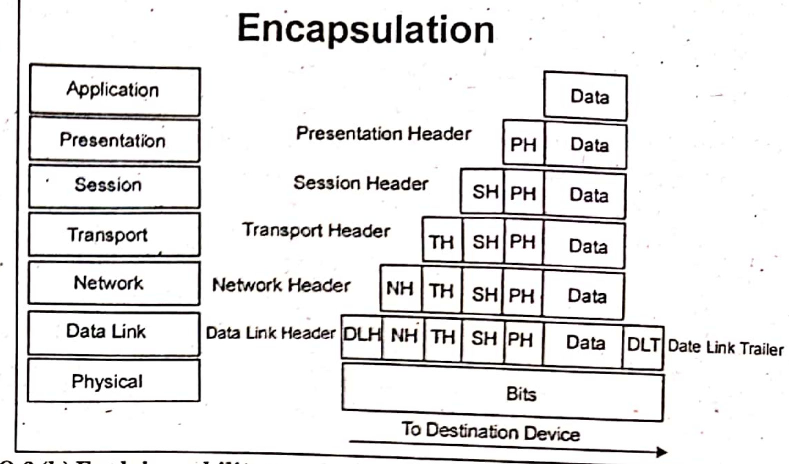
– Genetic Routing Encapsulation (GRE)

- To use either of these, the mobile node must request the appropriate method in its Registration Request
- The home agent must agree to use it, if foreign agent care-of addressing is used.
- The foreign agent also must support the method desired.

– Steps of Data Encapsulation are:

- The Application, Presentation and Session layer creats DATA (Message) from user's input
- The transport layer converts that data into SEGMENTS (User Datagram)
- The network layer converts this Segment into Packet (Datagram).
- The data link converts that Packet into Frames.
- The Physical layer converts that Frames into BITS.





Q.6.(b) Explain mobility management in GPRS. **(6)**

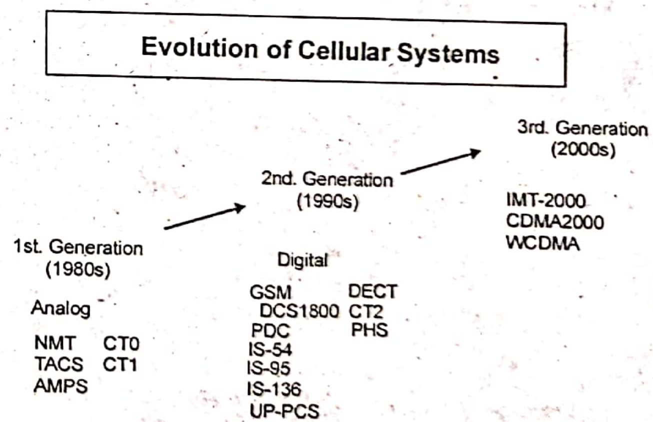
Ans. Refer to Q.1.(c) First Term 2017.

Q.7.(a) Briefly describe UMTS Network Architecture, Identify various interfaces used in its different entities. **(9)**

Ans. Refer to Q.3.(b) of First Term 4-2016.

Q.7.(b) List the comparison of the main technical parameters of third generation WCDMA cellular system and second generation IS-95 CDMA cellular system. **(6)**

Ans.



- WCDMA is a Wideband Direct-Sequence Code Division Multiple Access (DS-CDMA) system.
- Information bits are spread over a wide bandwidth by multiplying the it with pseudo-random bits called chips derived from CDMA spreading codes.
- The chip rate of 3.84 Mcps used in WCDMA leads to a carrier bandwidth of approximately 5 MHz.
- Narrowband CDMA (IS-95) occupies a bandwidth of 1.25 MHz.

IS-95 CDMA

- IS-95 (cdmaone) 2G digital cellular standard
- Motivation
  - Intended as a new system (greenfield) or replacement for AMPS (not an upgrade)
  - Increase system capacity
  - Add new features/services
- History:
  - 1990 Qualcomm proposed a code division multiple access (CDMA) digital cellular system claimed to increase capacity by factor 20 or more
  - Started debate about how CDMA should be implemented and the advantages vs. TDMA (religious tones to debate)
  - 1992 TIA started study of spread spectrum cellular.

Differences between WCDMA and IS-95

Table Main difference between and IS-95 air interfaces

	WCDMA	IS-95
Carrier specing	5 MHz	125 MHz
Chip rate	3.84 Mcps	1.2288 Mcps
Power control frequency	1500 Hz, both uplink and download	Uplink 800 Hz, downlink show power control
Base station synchronisation	Not needed	Yes, typically obtained via GPS
Inter-frequency handovers	Yes, measurement with sloted mode	Possible but measurement method not specfied
Efficient ratio resource management algorithms	Yes, provides required of service	Not needed for speech only networks
Packet data	Load-based packet scheduling	Packet data transmitted as short circuit switched calls
Downlink transmit diversity	Supported for improving downlink (capacity)	Not supported by the standard

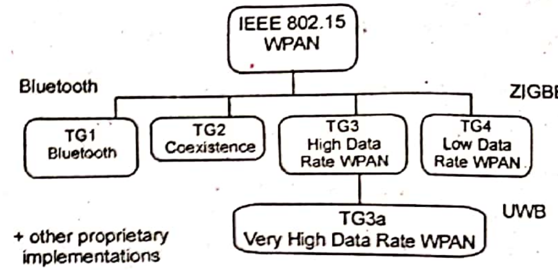
Q. 8. (a) Explain essential requirements and various standards of IEEE 802.11. **(7)**

Ans. Refer to Q.9.(c) of 2017.

Q. 8. (b) What is WPAN technology? Write down its standard and its various applions. **(8)**

Ans. Wireless Personal Area Network: A Wireless Personal Area Network (WPAN) is a wireless ad hoc data communications system that allows a number of independent data devices to communicate. The worldwide 2.4 GHz ISM band is the frequency of interest for WPANs because of its general availability worldwide and its suitability to low cost radio solutions. It is noted that there are efforts at harmonizing the spectrum allocation such that there is a minimum of 83.5 MHz bandwidth worldwide. WPANs are capable of operating over an area up to 10 meters in diameter. To support other uses, for example the home environment, the PAN can extend the range (up to 100m). This is accomplished primarily by choosing 0dBm or +20dBm Modules.

IEEE standards for Wireless Personal Area networking technologies



Emerging WPAN tireless Personal Area Networking) standards (IEEE 802.15 standards) are focused in general to provide cost effective and innovative smart wireless applications such as

- Wireless Sensor Networking
- RFID Applications
- Mobile Ad Hoc Networks (MANETs)

Wireless sensor networking is one of the most exciting technology markets today and market for such smart wireless solutions are growing at an exponential rate. Main advantages of such wireless sensor networking are

- Low Installation
- Easier maintenance with handheld wireless devices
- New markets for wireless applications

RFID applications are catching up fast replacing barcodes and optical scanner based tracking applications and mainly used for

- Asset Tracking
- People Tracking
- Inventory Tracking

Mobile Ad Hoc Networks (MANETs) are of great interest to researches and system integrators to develop cost effective wireless application networks using mix of Wireless PAN Standards and proprietary technologies

- Bluetooth IEEE802.15.1
- Zigbee IEEE 802.15.4
- UWB (Ultra Wide Band) IEEE 802.15.3a
- Proprietary standards based on Embedded Wireless Chips

For larger network and special aplications even IEEE 802.11 WLAN Wifi standard can be used for designing wireless solutions.

This means different smart wireless applications can be designed for both training of students and real life development projects by entrepreneurs by using mix of available WPAN and WLAN standards.

For example.

- Home automation using Bluetooth or Zigbee or Propertary solutions
- Industrial automation using Zigbee or Proprietary or mix of solutions
- RFID applications using properitary solutions or integrating with WiFi
- Smart wireless applications using stadard based or proprietary solutions.

Q.9. Write short notes on:

(a) Comparison of case studies of IRIDIUM with GLOBALSTAR. (8)

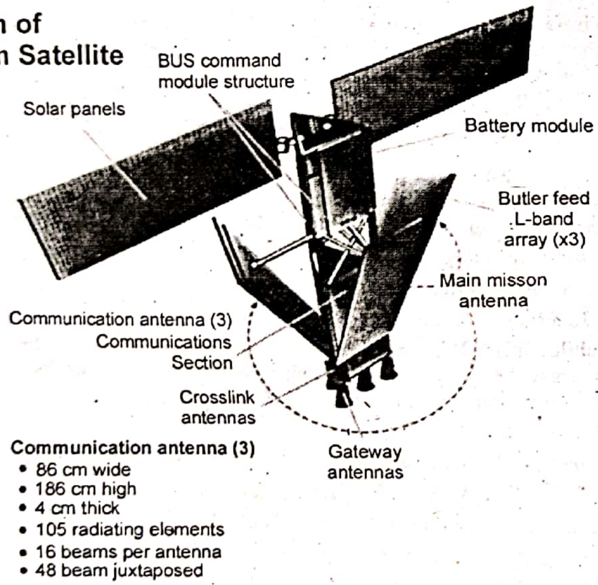
Ans.

• A Satellite is something that goes around and around a large something, like the earth or another planet. • Some satellite are natural, like the moon .which is a natural satellite of the earth. Other satellite are made by scientists and technologists to go around the earth and do certain jobs. • Some satellites send and receive television signals. • The signal is sent from a station on the earth's surface. • The satellite receives the signal and rebroadcasts it to other places on the earth

• To avoid number of repeaters on the earth surface. • Avoiding line of sight propagation . • High coverage area i.e. a single satellite covers 48% earth surface . For this we require 3 satellites to cover the total surface. • To avoid obstacles like building, tree , mountain etc. • Instant communication. • To cover remote areas. • Increase data transfer rates.

• Contains 77 satellites. • Named IRIDIUM after cement Indium with the satellites evoking tie Bohr's Model of electrons orbiting round the Earth as its nucleus. • The constellation of 66 active satellites has 6 orbital planes spaced 30 degrees apart, with 11 satellites in each plane.

Sketch of Iridium Satellite



• Iridium system is a satellite-based, wireless personal communications network providing voice and data features all over the globe.

• It is comprised of three principal components

1. the satellite network
2. the ground network
3. Iridium subscriber products, including phones and data modems

Working of Iridium Network:

• Iridium network allows voice and data messages to be routed anywhere in the world.

• Voice and data calls are relayed from one satellite to another until they reach the satellite above the Iridium handset or terminal and the signal is relayed back to Earth.

• When an Iridium customer places a call from a handset or terminal, it connects to satellite overhead, and the signal is relayed among satellites around the globe to whatever satellite is above the appropriate Earth gateway, which downlinks the call and transfers it to the global public voice network or Internet so that it reaches the recipient.

2nd Generation Globalstar Satellite:

• Heart of a Globalstar satellite is its communications systems.

• There are **C-band** antennas for communications with **Globalstar gateways, and L- and S-band** antennas for communications with **user terminals.**

• The advanced constellation provides Globalstar customers with enhanced future services

1. Increased data speeds of up to 256 kbps in a flexible Internet protocol multimedia subsystem, IMS, configuration.
2. push-to-talk and multicasting.
3. advanced messaging capabilities such as multimedia messaging or MMS.
4. geo-location services.
5. multi-band and multi-mode handsets
6. data devices with GPS integration.

• The satellites were designed to operate in the **920-km** orbit with the **inclination 52 degrees** toward the Equator.

• Uses **sun sensors, Earth sensors, and a magnetic sensor** to help maintain attitude.

• Utilizes thrusters for orbit-raising, station-keeping maneuvers and altitude control.

• Two solar arrays provide the primary source of power, while batteries are used during eclipses and peak traffic periods. The solar panels automatically track the Sun as the satellite orbits the Earth, providing maximum possible exposure to the solar energy.

• New Globalstar second-generation satellite is **three-axis stabilized spacecraft** consisting of a **trapezoidal main body** with **two solar arrays.**

• The second-generation architecture has emphasized on redundancy management and the radiation environment of the Globalstar operational orbit.

• Each second-generation Globalstar satellite

1. weighs approximately 700 kgs.
2. offers power of 2.4 kW .
3. Fitted with 16 transponders from C-to S-band, and 16 receivers from L- to C-band.

• The satellite's body is fabricated from rigid aluminum honeycomb panels.

Difference between Iridium vs Global Star satellite configurations.

Working of Global Star Satellite

GLOBALSTAR SATELLITE:

• Several satellites pick up a call, and "path diversity" helps assure that the call is not dropped even if a phone moves out of sight of one of the satellites.

• a second satellite picks up the signal and is able to contact the same terrestrial gateway, it begins to simultaneously transmit.

If buildings or terrain block your phone signal, this "soft-handoff prevents call interruption. The second satellite now maintains transmission of the original signal to the terrestrial "gateway".

• Gateways process calls, then distribute them. But if there are no gateway stations to cover certain remote areas, service cannot be provided in these remote areas, even if the satellites may fly over them.

Difference between Iridium Vs Global Star satellite configurations

Specification	Iridium	Global Star
Number of satellite	72	52
Altitude in Km	780	1.414
Elevation(min.)	8 degree	20 degree
Uplink Frequency(GHz)	29.2	6.9
Downlink Frequency(GHz)	19.5	5.1
Inter-satellite Frequency(GHz)	23.3	-
Mobile Station Frequency(GHz)	1.6	2.5
Bit Rate	2.4 Kbps	9.6 Kbps
Coverage	global	+/-70 degree latitude
Access Technique	FDMA/TDMA	CDMA
Number of Channels	4000	2700
Lifetime in Years	5.8	7.5

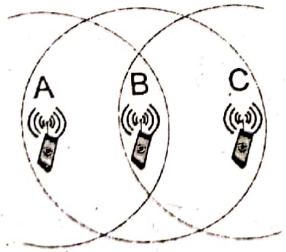
Q.9.(b) Hidden and exposed node problem in MANET. (7)

Ans. HiddenTerminal Problem:

A wireless network with lack of centralized control entity, sharing of wireless bandwidth among network access nodes i.e. medium access control (MAC) nodes must be organized in decentralized manner. The hidden terminal problem occurs when a terminal is visible from a wireless access point (APs), but not from other nodes communicating with that AP. This situation leads the difficulties in medium access control sublayer over wireless networking.

In a formal way hidden terminals are nodes in a wireless network that are out of range of other node or a collection of nodes. Consider a wireless networking, each node at the far edge of the access point's range, which is known as A, can see the access point, but it is unlikely that the same node can see a node on the opposite end of the access point's range, C. These nodes are known as hidden. The problem is when nodes A and C start to send packets simultaneously to the access point B. Because the nodes A and C are out of range of each other and so cannot detect a collision while transmitting, Carrier sense multiple access with collision detection (CSMA/CD) does not work, and collisions occur, which then corrupt the data received by the access point. To overcome the hidden node problem, RTS/CTS handshaking (IEEE 802.11 RTS/CTS) is implemented in conjunction with the Carrier sense multiple accesses with collision avoidance (CSMA/CA) scheme. The same problem exists in a MANET.

Consider the scenario of wireless networking with three wireless devices (e.g. mobile phones) as shown below.



Hidden Terminal Problem: The transmission range of access point A reaches at B, but not at access point C, similarly transmission range of access point C reaches B, but not at A. These nodes are known as hidden terminals. The problem occurs when nodes A and C start to send data packets simultaneously to the access point B. Because the access points A and C are out of range of each other and resultant they cannot detect a collision while transmitting, Carrier sense multiple access with collision detection (CSMA/CD) does not work, and collisions occur, which then corrupt the data received by the access point B due to the hidden terminal problem.

The hidden terminal analogy is described as follows:

- Terminal A sends data to B, terminal C cannot hear A
- Terminal C wants to send data to B, terminal C senses a "free" medium (CS fails) and starts transmitting
- Collision at B occurs, A cannot detect this collision (CD fails) and continues with its transmission to B
- Terminal A is "hidden" from C and vice versa.

IEEE 802.11 uses 802.11 RTS/CTS acknowledgment and handshake techniques over wireless networks to transferring packets that partly overcome the hidden node problem. RTS/CTS is not a proper and permanent solution and may decrease throughput even further, but adaptive acknowledgments from the base station can help too.

Some other technology that can be employed to solve hidden node problem are :

Increase Transmitting Power from the Nodes: With the enhancement of the transmission power of access point can solve the hidden terminal problem by allowing the cell around each node to increase in size, encompassing all of the other nodes.

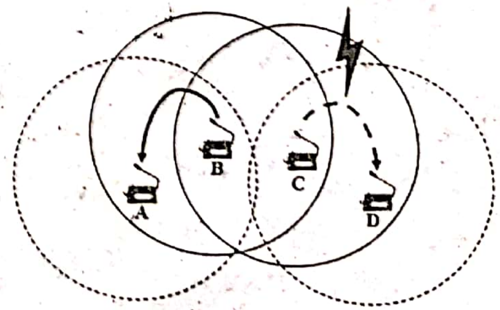
Use Omni directional antennas: Since nodes using directional antennas are nearly invisible to nodes that are not positioned in the direction the antenna is aimed at, directional antennas should be used only for very small networks.

Remove obstacles: Keep away the obstacles that affect the performance of access point accessibility.

Move the node: Provide the mobility features to the nodes.

Use protocol enhancement software: Pooling and token passing strategy should be used before start data transformation.

Exposed Terminal Problem:: In wireless networks, when a node is prevented from sending packets to other nodes because of a neighboring transmitter is known as the exposed node problem.



Exposed Terminal Problem: Consider the below wireless network having four nodes labeled A, B, C, and D, where the two receivers are out of range of each other, yet the two transmitters (B, C) in the middle are in range of each other. Here, if a transmission between A and B is taking place, node C is prevented from transmitting to D as it concludes after carrier sense that it will interfere with the transmission by its neighbor node B. However note that node D could still receive the transmission of C without interference because it is out of range from B. Therefore, implementing directional antenna at a physical layer in each node could reduce the probability of signal interference, because the signal is propagated in a narrow band.

The exposed terminal analogy is described as follows:

- B sends to A, C wants to send to another terminal D not A or B.
- C senses the carrier and detects that the carrier is busy.
- C postpones its transmission until it detects the medium as being idle again
- But A is outside radio range of C, waiting is not necessary
- C is "exposed" to B

Note: Hidden terminals cause collisions, where as Exposed terminals causes' unnecessary delay.s

Hidden vs. Exposed Terminal Problem:

Let us consider the following arguments:

- In the case of hidden terminal problem, unsuccessful transmissions result from collisions between transmissions originated by a node such as node A which cannot hear the ongoing transmissions to its corresponding node B. The probability of such a collision is proportional to the total number of terminals hidden from node A.
- In the case of exposed terminal, unsuccessful transmissions result from nodes such as node A being prevented from transmitting, because their corresponding node is unable to send a CTS. Again such unsuccessful transmissions are proportional to the number of exposed terminals. Both these events lead to degradation of a node's throughput.