B.E.
Sixth Semester Examination, Dec-2008
Wireless Communication (EE-402-E)

Note : Attempt any five questions. All questions carry equal marks.

Q. 1. (a) Give evolution history of mobile radio communication.

Ans. Evolution of Mobile Radio Communication : A brief history of evolution of mobile communication throughout the world is useful in order to appreciate the enormous impact that cellular radio and Personal Communication Services (PCS) will have on all of us over the next several decades. It is also useful for a newcomer to the cellular radio field to understand the tremendous impact that government regulatory agencies and services competitors wield in the evolution of new wireless systems, services and technologies.

Wireless communication is enjoying its fastest growth period in history, due to enabling technologies which permit widespread deployment. The ability to provide wireless to an entire population was not even conceived until Bell Laboratories developed the cellular concept in the 1960s and 1970s [No662], [Mac 79], [You 79].

With the phenomenal growth of wireless subscribers in the late 1990s, combined with Nextel's novel business approach of purchasing private mobile radio licenses for bundling as a nation wide commercial cellular service, today's subscriber base for cellular and Personal Communication Services (PCS) for outnumbers all non-cellular licensed users.

By 1934, 194 municipal police radio systems and 58 state police stations had adopted Amplitude Modulation (AM) mobile communication systems for police safety in the US. It was estimated that 5,000 radios were installed in mobiles in the mid 1930s, and vehicle ignition noise was a major problem for these early mobile users [Nob 62]. In 1935, Edwin Armstrong demonstrated Frequency Modulation (FM) for the first time, and since the late 1930s, FM has been the primary modulation technique used for mobile communication systems throughout the world.

The number of U.S. mobile users climbed from several thousand in 1940 to 86000 by 1948, 6,9,5000 by 1958 and about 1.4 million users in 1962 [Nob 62]. The vast majority of mobile users in the 1960s were not connected to the public switched telephone network (PSTN) and thus were not able to directly dial telephone numbers from their vehicles. With the boom in CB radio and cordless appliances such a garage door openers and telephones, the number of users of mobile and portable radio in 1995 was about 100 million, or 371 of the U.S. population.

In the first few years of 21st century, it is clear there will be an equ. number of wireless and conventional wireline customers throughout the world.

Q. 1. (b) Explain one example of wireless communication system.

Ans. Wireless Communication System : Most people are familiar with a number of mobile radio communication systems used in every day life. Garage door opener, remote controller for home entertainment equipment, cordless telephones, hand-held walkie-talkies, pagers and cellular telephones are all examples of mobile radio communication systems. However, the cost, complexity, performance, and types of services offered by each of these mobile systems are vastly different.

The term mobile has historically been used to classify any radio terminal that could be moved during operation. More recently, the term mobile is used to describe a radio terminal that is attached to a high speed mobile-platform whereas the term portable describes a radio terminal that can be hand-held and used by someone at walking speed. The term subscriber is often used to describe a mobile or portable user because in most mobile-communication systems, each user pays a subscription fee to use the system and each user's communication device is called a subscriber unit. The mobile communication to fixed base stations which are connected to a commercial power source and a fixed backbone network.

Mobile radio transmission system may be classified as simplex, half-duplex and full-duplex.

In simplex systems, communication is possible only in one direction. Paging systems, in which messages are received but not acknowledged, are simplex systems. Half-duplex radio systems allow two-way communication, but use the same radio channel for both tansmission and reception. This means that at any given time, a user can only transmit or receive information. Full duplex systems, on the other hand, allow simultaneous radio transmission and reception between a subscriber and a base station, by providing two simultaneous but separate channels (Frequency Division Duplex, or FDD) or adjacent time slots on a single radio channel (Time Division Duplex, or TDD) for communication to and from the user.

Frequency Division Duplexing (FDD) provides simultaneous radio transmission channels for the subscriber and the base station, so that they both may constantly transmit while simultaneously receiving signals from one another. At the base station, separate transmit and receive antennas are used to accomodate the two separate channels. At the subscriber unit, however, a single antenna is used for both transmission to and reception from the base station.

Time Division Duplexing (TDD) uses the fact that it is possible to share a single radio channel in time, so that a portion of the time is used to transmit from the base station to the mobile, and the remaining time is used to transmit from the mobile to the base station.

Q. 2. (a) Give difference between 2G and 3G networks.

Ans. Second Generation Cellular Networks : Second generation standards use digital modulation formats and TDMA/FDD and CDMA/FDD multiple access techniques. The most popular second generation standards include three TDMA standards and one CDMA standard.

(i) Global System Mobile (GSM), which supports eight time slotted users for each 200 kHz radio channels and has been deployed widely in the cellular and PCS bands by service providers in Europe, Asia, Australia, South America and some parts of US.

(ii) Interim Standard 136 (IS-136) also known as North American Digital Cellular (NADC) or US Digital Cellular (USDC), which supports three time slotted users for each 30 kHz radio channels.

(iii) Pacific Digital Cellular (PDC), a Japanese TDMA standard that is similar to IS-136 with more than 50 million users.

(iv) The popular 2G CDMA standard-Interim Standard 95 Code Division Multiple Access (IS-95) also known as CDMA one, which supports up to 64 users that are orthogonally coded and simultaneously transmitted on each 1.25 MHz channel.

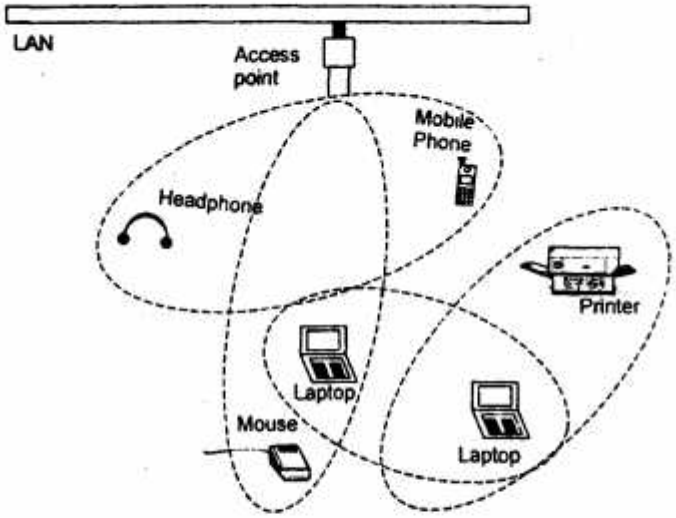
Third Generation (3G) Wireless Networks : 3G systems promise unparalleled wireless access in ways that have never been possible before. Multi-megab He Internet access, communication using voice over Internet protocols (VOIP), voice activated calls, unparalleled network capacity, and ubiquitous "always-on" access are just some of the advantages touted by 3G developers.

The eventual 3G evolution for 2G CDMA systems leads to CDMA 2000. Several variants of CDMA 2000 are currently being developed, but they all are based on the fundamentals of IS-95 and IS-95B technologies. The eventual 3G evolution for GSM, IS-136, and PDC systems leads to Wideband CDMA (W-CDMA), also called Universal Mobile Telecommunications Service (UMTS). W-CDMA is based on the network fundamentals of GSM, as well as the merged versions of GSM and IS-136 through EDGE. It is fair to say that these two major 3G technology camps, CDMA 2000 and W-CDMA, will remain popular throughout the early part of the 21st century.

The 3G W-CDMA air interface standard had been designed for "always-on" packet-based wireless service, so that computers, entertainment devices, and telephone may all share the same wireless network and be connected to the internet, anytime anywhere. W-CDMA will support packet data rates up to 2.048 Mbps per user. CDMA 2000 1x supports an instantaneous data rate of up to 307 kbps for a user in a packet mode and yield typically throughput rates of up to 144 Kbps per user depending on the number of users, the velocity of a user, the propagation condition.

Q. 2. (b) Explain Bluetooth networks.

Ans. Bluetooth Network : Bluetooth is an open standard that has been embraced by over 1,000 manufactures of electronic appliances. It provides an ad-hoc approach for enabling various devices to communicate with one another with in a nominal 10 meter range.



Bluetooth operates in the 2.4 GHz ISM Band (2400-2483.5 MHz) and uses a frequency hopping TDD scheme for each radio channel. Each Bluetooth radio channel has a 1MHz bandwidth and hops at a rate of approximately 1600 hops per second. Transmission, are performed in 625 μs slots with a single packet transmitted over a single slot. For long data transmission particular users may occupy multiple slots using the same transmission frequency thus slowing the instantaneous hopping rate to below 1600 hops/second. The frequency hopping scheme of each Bluetooth user is determined from a cycle code of length $2^{27} - 1$ and each user has a channel symbol rate of 1Mbps using GPSK modulation. The standard has been desinged to support

operation in very high interference levels and relies on a number of Forward Error Control (FEC) coding and automatic repeat request (ARQ) schemes to support a raw channel Bit Error Rate (BER) of about 10^{-3}.

The IEEE 802.15 standards committee has been formed to provide an international forum for developing. Bluetooth and other PANs that interconnect pocket PCs, Personal Digital Assistants (PDAs), cellphones, light projectors and other appliances.

With the rapid proliferation of wearable computers, such as PDAs, cellphones, smart cards, and position location devices, PANs may provide the connection to an entire new era of remote retrieval and monitoring of the world around us.

Example of Personal Area Network (PAN) as provided by the Bluetooth standard.

Q. 3. (a) Explain analog cellular system.

Ans. Analog Cellular System : It is a first generation (1G) cellular system. In early 1980, when cellular system was on evolving stage the 1G system named as Advanced Mobile Phone Service (AMPS) developed by AT and T.

Spectral Allocation of AMPS : There are two frequency band of 25 MHz alloted to the AMPS (869-894 MHz) for base station to the mobile station and (824-849 MHz) for mobile to base station. But to increase the competition between operator for the benefit of customers the above frequency band splited in two parts.

One operator is allocated only 12.5 MHz in each direction for its system. The channels are spaced 30 kHz apart, which allow a total of 416 channels per operator. Out of 416 channels, 21 channels are used for controlling and 395 channels are used for carrying calls. The control channels are data channels operating at 10 Kbps. The modulation technique was also analog frequency modulation.

Operation : Each AMPS include a Numeric Assignment Module (NAM) in read only memory.

The NAM contains the telephone number of the phone, which is assigned by the service provider, and serial number of phone, which is assigned by manufacturer. When the phone is turned ON, it transmits its serial number and phone number to the MTSO. MTSO maintains the data base of user for billing purpose or for blocking the call.

Some terms and their function involved in Analog cellular system :

Home Mobile Station : (Mobile Unit or Mobile Phone)

A mobile unit, that is subscribed in cellular system.

Land Station : A station other than a mobile unit, which links to the mobile station.

Control Channel : A channel used for the tansmission of information from a land station to a mobile station or vice-versa.

Forward Control Channel (FDCC) : Used for land station to mobile station.

Reverse Control Channel (RECC) : Mobile station to land station.

Forward Voice Channel (FVC) : A voice channel used between land station to a mobile unit.

Reverse Voice Channel (RVC) : Voice channel between mobile to land line.

Setup Channels : A number of designated control channel.

Access Channel : Always access from mobile station to cell unit to obtain service.

Paging Channel : When an incoming call from land line has been placed to it.

Signaling Tone : A 10 kHz tone transmitted by the mobile station on a voice channel.

Hand off : The act of transferring a mobile station from one voice channel to another voice channel. There are two kinds of hand offs .

(a) Interhand off : From one cell to another cell.

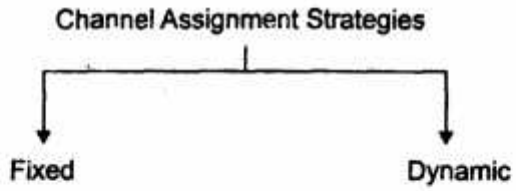
(b) Interhand off : With in a cell.

Q. 3. (b) Give operation of cellular system.

Ans. Cellular System : The cellular concept is a system-level idea which calls for replacing a single, high power transmitter with many low power transmitter (small cells). Each providing coverage to only a small portion of the service area. Each base station is allocated a portion of the total number of channels available to the entire system, and nearby base stations are assigned different groups of channels available to the entire system, and nearby base stations are assigned different groups of channels so that all the available channels are assigned to a relatively small number of neighbouring base stations. Neighbouring base stations are assigned different groups of channels so that the interference between base stations (the mobile users under their control) is minimized. By systematically spacing base stations and their channel groups throughout a market, the available channels are distributed throughout the geographic region and may be reused as many times as necessary so long as the interference between cochannel. Stations is kept below acceptable levels. As the demand for service increases, the number of base stations may be increased thereby providing additional radio capacity with no additional increase in radio spectrum. This fundamental principle is the foundation for all modern wireless communication systems, since it enables a fixed number of channels to serve an arbitrarily larger number of subscribers by reusing the channels throughout the coverage region. Furthermore, the cellular concept allows every piece of subscriber equipment within a country or continent to be manufactured with the same set of channels so that any mobile may be used anywhere within the region.

Q. 4. (a) Give various channel assignment strategies.

Ans. Channel Assignment Strategies : For efficient utilization of the radio spectrum, a frequency reuse scheme that is consistent with the objectives of increasing capacity and minimizing interference is required. A variety of channel assignment strategies have been developed to achieve these objectives.



(i) Fixed Channel Assignment Strategy : Here, each cell is allocated a predetermined set of voice channels. Any call attempt within the cell can only be served by the unused channels in that particular cell. If all the channels in that cell are occupied, the call is blocked and the subscriber does not receive service. Several variations of the fixed assignment strategy exist. In one approach, called the borrowing strategy, a cell is allowed to borrow channels from a neighbouring cell if all of its own channels are already occupied.

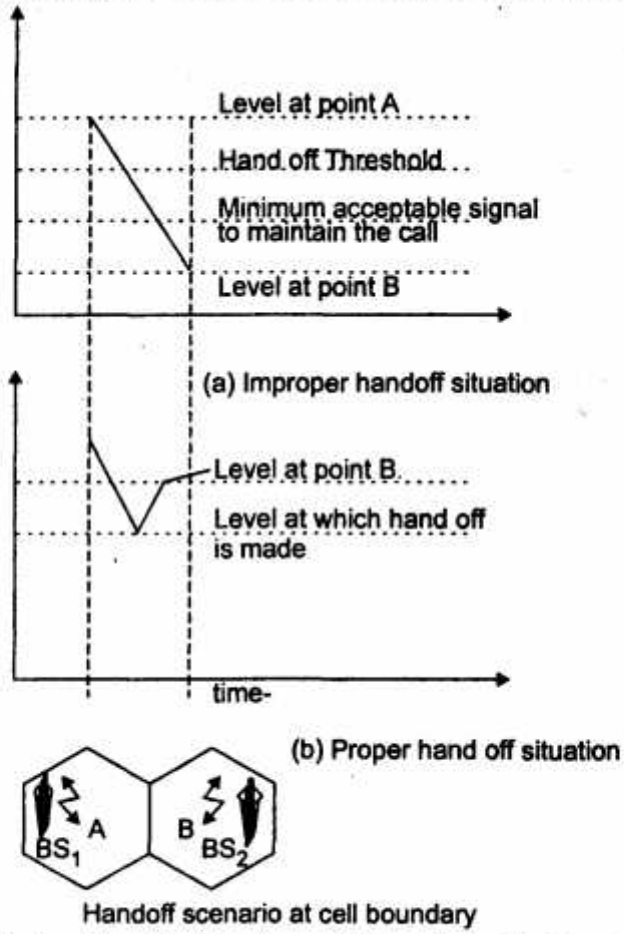
(ii) Dynamic Channel Assignment : In this strategy, voice channels are not allocated to different cells permanently. Instead, each time a call request is made, the serving base station requests a channel from the MSC. The switch then allocates a channel to the request cell following an algorithm that takes into account the likelihood of future blocking within the cell, the frequency of use of the candidate channel, the reuse distance

of the channel, and other cost functions. Dynamic channel assignment reduce the likelihood of blocking, which increases the trunking capacity of the system.

Dynamic channel assignment strategies require the MSC to collect real-time data on channel occupancy, traffic distribution and radio signal strength indications of all channels on a continuous basis.

Q. 4. (b) What are the parameters for cellular system design ?

Ans. Parameters for Cellular System Design : In practical cellular systems, several problems arise when attempting to design for a wide range of mobile vebcities. When a mobile moves in to a different cell while conversation is in progress, the MSC automatically transfers the call to a new channel belonging to the new base station. This hand off operation not only involves identifying a new base station, but also requires that the voice and control signals be allocated to channels associated with the new base station. In order to meet this requirement, system designers must specify an optimum signal level at which to initiate a hand off. Once a particular signal level is specified the minimum usable signal for acceptable voice quality at the base station receiver, a slightly stronger signal level is used as a threshold at which a hand off is made.



Handoff scenario at cell boundary

(ii) Interference and System Capacity : Interference is the major limiting factor in the performance of cellular radio systems. Interference on voice channels causes cross talk, where the subscriber hears

interference in the background due to an undesired transmission on control channel, interference leads to missed and blocked call due to errors in the digital signaling. It is a major bottleneck in increasing capacity and is responsible for dropped calls. The two major system-generated cellular interference are co-channel interference and adjacent channel interference.

Frequency reuse implies that in a given coverage area there are several cells that use the same set of frequencies. These cells are called co-channel cells and the interference between signals from these cells is called co-channel interference. Even though interfering signals are often generated within the cellular system, they are difficult to control in practice.

Q. 5. (a) What are various multiple access techniques ?

Ans. Multiple Access Techniques : Frequency Division Multiple Access (FDMA), Time Division Multiple Access (TDMA) and Code Division Multiple Access (CDMA) are the three major access techniques used to share the available bandwidth in a wireless communication system.

(i) Frequency Division Multiple Access (FDMA) : FDMA assigns individual channels to individual users. Here each user is allocated a unique frequency band or channel. These channels are assigned on demand to users who request service. During the period of the call, no other user can share the same channel.

(ii) Time Division Multiple Access : In TDMA systems divide the radio spectrum into time slots, and in each slot only one user is allowed to either transmit or receive. It can be seen from fig. (b), that each user occupies a cyclically repeating time slot, so a channel may be thought of as a particular time slot that reoccurs every frame, where N time slots comprise a frame. TDMA systems transmit data in a buffer-and-burst method, thus the transmission for any user is non-continuous.

(iii) Code Division Multiple Accees : In CDMA sytemes, the narrowband message signal is multiplied by a very large bandwidth signal called the spreading signal. The spreading signal is a pseudonoise code sequence that has a chip rate which is orders of magnitudes greater than the data rate of the message. All users in a CDMA system, as seen from fig. (i), use the same carrier frequency and may transmit simultaneously.

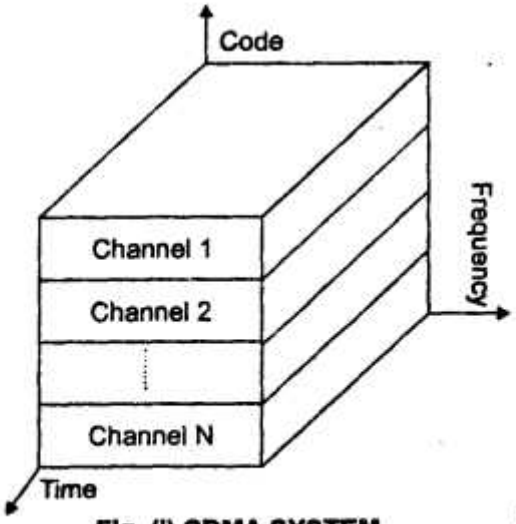


Fig. (i) CDMA SYSTEM

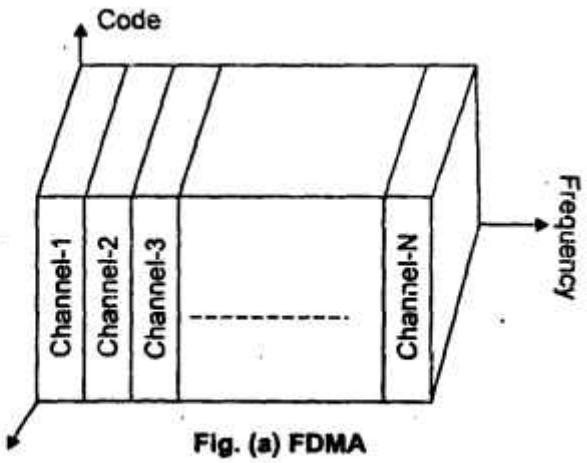


Fig. (a) FDMA

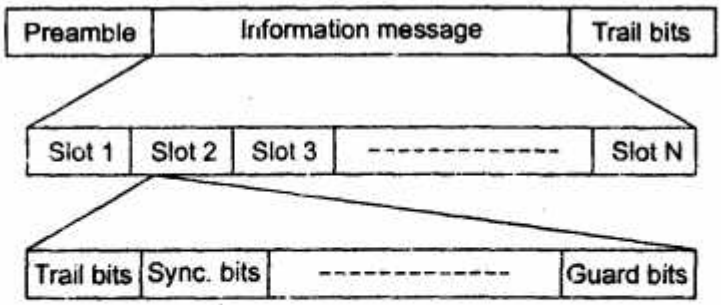


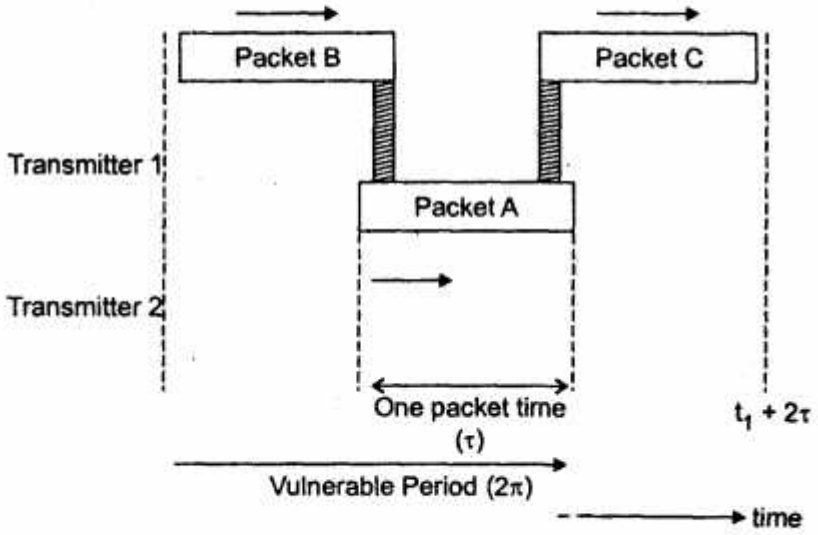
Fig. TDMA Frame Structure

Each user has its own pseudorandom codeword which is orthogonal to all other codewords. The receiver performs a time correlation operation to detect only the specific desired codeward.

Q. 5. (b) What is packet radio system ? Explain.

Ans. Packet Radio System : In packet radio, system many subscribers attempt to access a single channel in an uncoordinated manner. Transmission is done by using bursts of data. Collisions from the simultaneous transmissions of multiple transmitters are detected at the base station receiver, in which case an ACK or NACK signal is broadcast by the base station to alert the desired user of received transmission. The ACK signal indicates an acknowledgement of a received burst from a particular user by the base station, and a NACK indicates that the previous burst was not received correctly by the base station. By using ACK and NACK signals, a PR system employs perfect feedback even though traffic delay due to collisions may be high.

In Packet Radio System, the subscriber use a contention technique to transmit on a common channel ALOHA protocols, developed for early satellite systems, are best examples of contention techniques.



ALOHA allows each subscriber to transmit whenever they have data to send. The transmitting subscribers listen to the acknowledgement feedback to determine if transmission has been successful or not. If a collision occurs, the subscriber waits a random amount of time, and then retransmits the packet. The

advantage of packet contention technique is the ability to serve a large number of subscribers with virtually no overhead. The performance can be and evaluated by the throughput (T), which is defined as the average number of messages successfully transmitted per unit time and the average delay (D), experienced by a message burst.

Q.6. (a) Explain ISDN system.

Ans. ISDN System : Integrated Services Digital Network is a complete Network framework designed around the concept of common channel signaling. ISDN provides two distinct kinds of signaling components to end-users in a telecommunications, network. The first component supports traffic between the end-user and the network, and is called access signaling. It defines how end-users obtain access to the PSTN and the ISDN for communication and is governed by a protocols known as digital subscriber signaling system number.

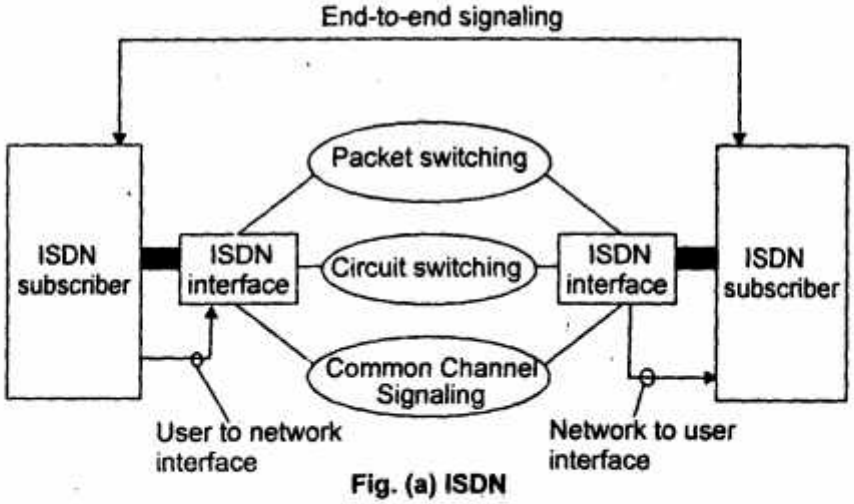


Fig. (a) ISDN

The second signaling component of ISDN is network signaling and is governed by the 557 suite of protocols. ISDN provides a complete digital interface between end-users over twisted pair telephone lines. The ISDN interface is divided into three different types of channels. Information bearing channels called bearer channels (B channels) are used for end-user traffic. Out-of-band signaling channels, called data channels (D Channels) are used to send signaling and control information across the interface to end-users, as shown in figure, ISDN provides Integrated end-user access to both circuit-switched and packet switched networks with digital end-to-end connectivity.

The ISDN end-users may select between two different interfaces, the Basic Rate Interface (BRI). It is intended to serve small capacity terminals ISDN circuits may be concatenated into high speed information channels, H channels are used by the ISDN backbone to provide efficient data transport of many users on a single physical connection.

Q. 6. (b) Give difference between wireless and fixed telephone networks.

Ans. Difference Between Wireless and Fixed Telephone Networks : In fixed telephony network PSTN is the main part, from where transfer of information table place to land line phones, as comparable to MSC in wireless networking. Connection between PSTN and landline phone may be with a optical fibre, copper wire, co-axial cable, depending upon capacity. The network configuration in the PSTN are virtually

static, since the network. Connections may only be changed when a subscriber changes residence and requires re-programming at the local central office of the subscriber.

While in wireless network connection being re-arranged every time, where ever a subscriber moves into the coverage region of a different base station or a new market. And also wireless networks must reconfigured for users within small interval of time to provide roaming and imperceptible hand offs between calls as a mobile move about.

The available channel bandwidth for fixed networks can be increased by installing high capacity cables (fibre-optic) whereas wireless networks are constrained by the RF cellular bandwidth provide for each user. Whenever a subscriber demand for a landline phone from the exchanges called PSTN office. After completing the formalities, officer provide a dedicated physical link between subscriber phone and PSTN office.

This dedicated link cannot be given to any other subscriber, until first user demand for termination of his facility. While in wireless there is no dedicated path between mobile unit and cell site.

Q. 7. (a) Give intelligent cell concept.

Ans. Cell Concept : Cellular radio systems rely on an intelligent allocation and reuse of channels throughout a coverage region. Each cellular base stations is allocated a group of radio channels to be used within a small geographic area called a "**cell**". Base stations in adjacent cells are assigned channel groups which contain completely different channels than neighbouring **cells**. The base station antennas are designed to achieve the desired coverage wihtin the particular cells. By limiting the coverage area to within the boundaries of a cell, the same group of channels may be used to cover different cells that are separated from one another by distance large enough to keep interference levels within tolerable limits. **Cell Splitting** is used to expand the capacity of cellular systems. **Cell splitting** allows an orderly growth of the cellular system. The zone microcell concept distributes the coverage of a cell and extends the cell boundary to hard-to-reach places. Cell splitting is the process of subdividing a congested cell into smaller cells, each with its own base station and a corresponding reduction in antenna height and transmitter power. **Cell splitting** increases the capacity of a cellular system since it increases the number of times that channels are reused. Fig.(a) shows cell splitting, the base stations are placed at corners of the cells and the area served by base station A is assumed to be saturated with traffic. Here, the smaller cells were **addead** in such a way as to preserve the frequency reuse plan of the system.

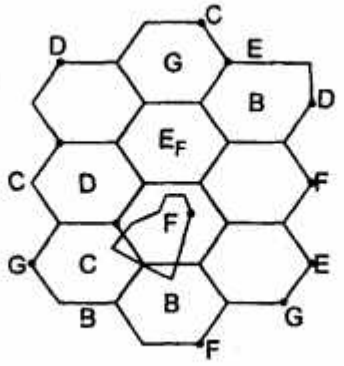
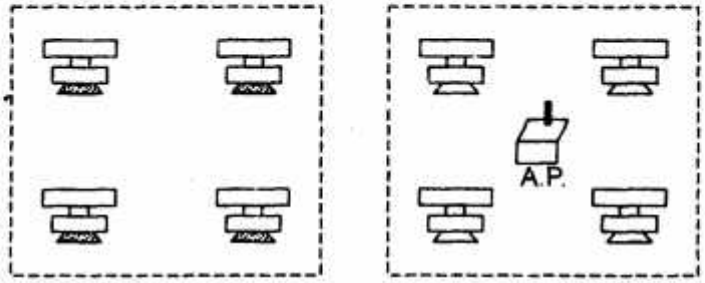


Fig. Illustration of cell splitting

Q. 7. (b) Explain model of In-building communication system.

Ans. Model of In-building Communication System : Wireless LANs can be found on College Campuses, in office buildings and in many public areas IEEE 802.11 defines the basic service set (BSS) as the building block of a wireless LAN. A basic service set is made of stationary or mobile wireless stations and an optional central base station, known as the access point (AP). Fig. (a) shows two sets in this standard.



The BSS without an AP is a stand-alone network. and cannot send data to other BSSs. It is called an ad hoc architecture. In this architecture, stations can form a network without the need of a AP; they can locate one another and agree to be part of a BSS. A BSS with an AP is sometimes referred to as an infrastructure network.

An extended service set (ESS) is made up of two or more BSSs with APs. In this case, the BSSs are connected through a distribution system, which is usually a wired LAN. The distribution system connects the APs in the BSSs. IEEE 802.11 doesnot restrict the distribution system; it can be any IEEE LAN such as Ethernet. When BSSs are connected, the stations with in reach of one another can communicate without the use of an AP. However, communication between two stations in two different BSSs usually occurs via two APs.

Q. 8. (a) Write short notes on :

(a) CDMA

(b) Frequency reuse (c)

Wireless data services.

Ans. (a) Code Division Multiple Access : In CDMA, the narrowband message signal is multiplied by a very large bandwidth signal called the spreading signal. It is a pseudonoise code sequence that has a chip rate which is orders of magnitudes greater than the data rate of the message. All users in a **CDMA system,** as shown in fig. use the same carrier frequency and may transmit simultaneously. Each users has its own Pseudorandom codeword which is orthogonal to all other codewords. The receiver performs a time correlation operation to detect only the specific desired codeward. All other codewords appear as noise due to decorrelation. For detection of the message signal, the receiver needs to know the codeword used by the transmitter. Each user operates indpendently with no knowledge of the other users.

In CDMA, the power of multiple users at a receiver determines the noise floor after decorrelation. If the power of each user within a cell is not controlled such that they do not appear equal at the base station receiver, then the near-for problem occurs.

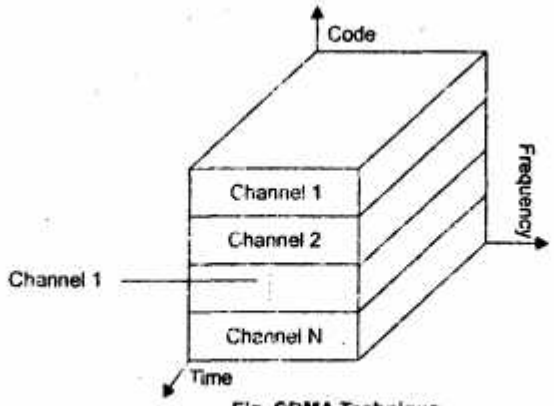


Fig. CDMA Technique

To combat the near far problem, power control is used is most CDMA implementations.

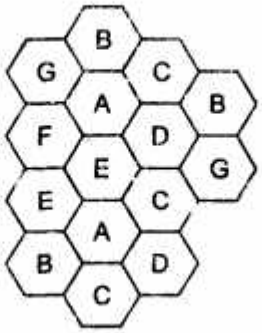
(b) Frequency Reuse : The design process of selecting and allocating channel groups for all of the cellular base stations within a system is called **frequency reuse** or **frequency planning.** Let us a consider a cellular system which has a total of S duplex channels available for use. If each cell is allocated a group of K channels and if the S channels are divided among N cells into unique and disjoint channel groups which each have the same no. of channels, the total no. of available radio channels will be :

$$\therefore \qquad S = KN$$

The N cells which collectively use the complete set of available frequencies is called a cluster. If a cluster is replicated M times within the system, the total no. of duplex channels, C can be used as a measure of capacity and is given by :

$$\therefore \qquad C = MKN = MS$$

The capacity of a cellular system is directly proportional to the no. of times a cluster is replicated in a fixed service area. From a design viewpoint, the smallest possible value of N, is desirable in order to maximize capacity over a given coverage area. The frequency reuse factor of a cellular system is given by 1/N, since each cell within a cluster is only assigned 1/N of the total available channels in the system.



(a) Illustration of Cellular Frequency Reuse