B.E.

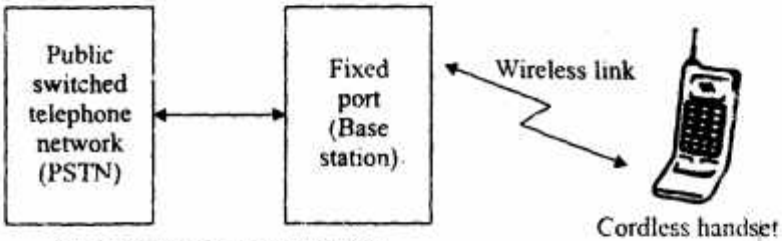
Sixth Semester Examination, May-2009

Wireless Communication (EE-402-E)

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

Q. 1. (a) Explain cordless and cellular telephone system.

Ans. Cordless Telephone Systems : Cordless telephone systems are full duplex communication system that use radio to connect a portable handset to a dedicated base station, which is then connected to a dedicated telephone line to a specific telephone number on the public switched telephone network (PSTN). In first generation, cordless telephone systems, the portable unit communicates only to the dedicated base unit & only over distances of a few meters. Early cordless telephones operate solely as extension techniques to a transceiver connected to a subscriber line on the PSTN and are primarily for-in-home use.



(A cordless telephone system)

Second generation cordless allow subscribers to use their handsets at many outdoor locations. Modern cordless telephones are sometimes combined with paging receivers so that a first be paged and then respond to the pose using the cordless telephone. Cordless telephone systems provide the user with limited range and mobility, as it is usually not possible to maintain a call if the user travels outside the range of base station.

Cellular Telephone System : A cellular telephone system provides a wireless connection to the PSTN for any user location within the radio range of the system. Cellular system accommodate a large number of users over a large geographic area, within a limited frequency spectrum. Cellular radio systems provide high

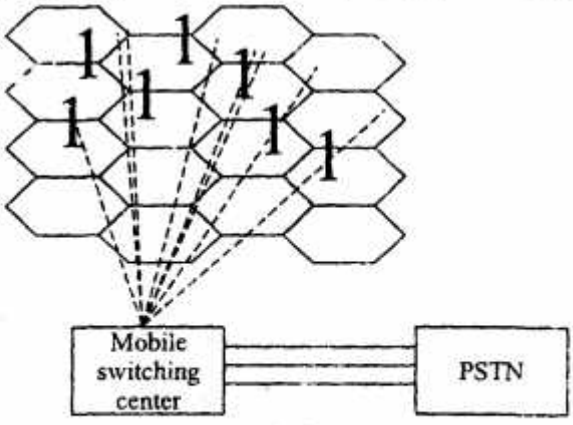


Fig. A cellular system

quality service that is often comparable to that of the landline telephone systems. High capacity is achieved by limiting the coverage of each base station transmitter to a small geographic area called a cell so that the same radio channels may be reused by another base station.

The mobile switching center is sometimes called a mobile telephone switching office (MTSO), since it is responsible for connecting all mobiles to the PSTN in a cellular system. Each mobile communicates via radio with one of the base stations and may be handed-off to any number of base stations throughout the duration of a call.

Q. 1. (b) Compare various wireless systems.

Ans. Comparison of Common Wireless Communication System :

Paging System : Paging systems are communication systems that send brief messages to a subscriber. Paging system vary widely in their complexity and coverage capacity. If the pager is working as a receiver (i.e., mobile station), its coverage range is high, and same is case for pager working as base station. It requires high infrastructure to work as a receiver or a transmitter. While the complexity is low if the pager acts as mobile station and the same is high, if it acts as base station. The carrier frequency is less than 1 GHz for both the cases. The hardware cost of paging system (as receiver) is low, so high for paging system working as transmitter.

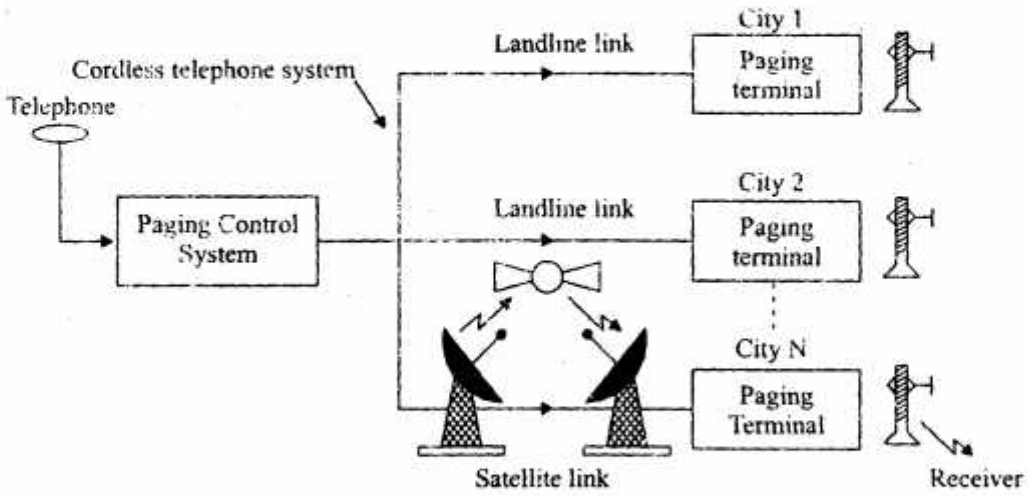


Fig. (a) Wide area paging system

Cordless Telephone System : Block diagram of a cordless telephone system is shown in figure (a). The coverage range of a cordless telephone system is low in comparison to paging system/cellular telephone system. The infrastructue requirement, is again low in comparison to the later systems. The complexity of these systems is moderate, if they acts as mobile station and is low, if they act as base station. The carrier frequency of cordless telephone system is 1-3 GHz. Lastly, the hardware cost is low and moderate for mobile station and base stations respectively.

Cellular Telephone System : The basic functioning of cellular telephone system is shown in figure (b) to compare these with the former two systems, the coverage range of cellular telephone system is high in comparison to cordless telephone system. The infrastructure requirement again is high is comparison to later.

The complexity in these systems is higher and the carrier frequency is less than 2 GHz. The hardware cost of these system is moderate and high when they work as mobile station and base station respectively.

Other Wireless Systems : These are some common household wireless systems, such as TV remote control and Garage door opener. The coverage range of these systems is low in comparison to all the above mentioned wireless systems. As the infrastructure requirement is very low in these systems, hence there is less (low) complexity. The carrier frequency is less then 100 MHz or lies in infrared. Hardwae cost is low as well, for both mobile and base stations.

Q. 2. (a) Explain WLL.

Ans. Wireless Local Loop (WLL) : Fixed wireless equipment is extremely well suited for rapidly deploying a broad band connection in many instances, and this approach is steadily becoming more popular for providing "last mile" broad band local loop access, as well as for emergency or redundant point-point or point-multipoint private networks.

Microwave wireless links can be used to creak a wireless local loop. The local loop can be thought of as the "last mile" of the telecommunication network that resides between the central office and the individual homes and business in close proximity to the central office.

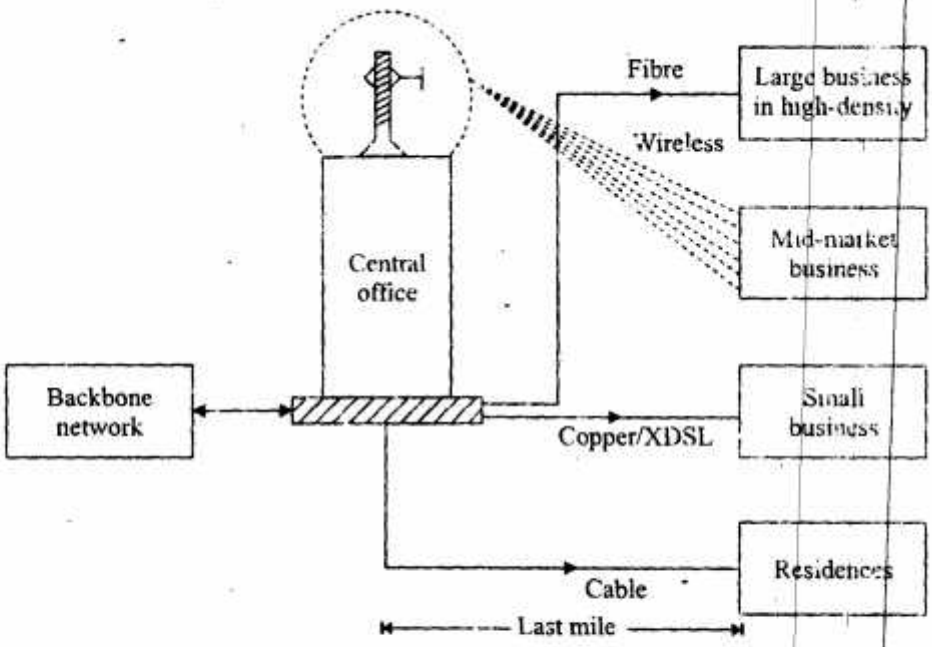


Fig. An example of WLL network

The above shows how WLL can be set up. Copper or fibre optic cable already has been installed to residence and business. However, in many developing nations, cable is too expensive or can take months or years to install. Wireless equipment, on the other hand, can usually be deployed in just a couple of hours. An additional benefit of WLL technology is that once the wireless equipment is paid for, there are no additional costs for transport between the central office and the customer premises equipment, whereas the buried cables often must be leased from a service provider or utility company on a monthly basis. It is possible that WLL

systems could compete with copper-wire base digital subscriber loop technologies that are rapidly proliferating. WLL could greatly improve the efficiency of their citizens while stimulating competition that could lead to improved telecommunication services.

Q. 2. (b) Explain key features of wireless local area networks.

Ans. Wireless Local Area Network (WLAN) : The IEEE, wireless LAN working group was founded in 1987 to being standardization of spread spectrum WLANs for use in the ISM bands i.e., industrial scientific and medical bands of 5.150-5.350 GHz. WLANs must operate in the same unlicensed bands that contains cordless phones, baby monitors, bluetooth devices and other WLAN users.

The unique WLAN channels that are specified in the IEEE standard for the 2400-2483.5 MHz band. All WLANs are manufactured to operate on any one of the specified channels and are assigned to a particular channel by the network operator when the WLAN system is first installed. The channelization scheme used by the network installer becomes very important for a high density WLAN installation, since neighbouring access points must be separated from one another in frequency to avoid interference and significantly degraded performance.

Even though WLAN networks are designed to work in an interference-rich environment, and manufacturers may down play the importance of planning, the fact is that the ability to measure or predict the coverage and interference effects caused by specific placements of access points can provide orders of magnitude of improvement in cost and end user data throughputs in a heavily loaded system.

WLAN industry appears to be on the horizon, as standard organizations, to co-ordinate spectrum allocations and end user data rates. In Europe's ETSI established a standardization committee for Broadband Radio Access Networks (BRANs). The goal of BRAN is to develop a family of broadband WLAN-type protocols that allow user interoperability, covering both short range and long range networking.

Q. 3. (a) How are guard spaces realized between users in CDMA?

Ans. In Code-Division Multiple Access systems, the narrowband message signal is multiplied by a very large bandwidth signal called the spreading signal. Many users of a CDMA system share the same frequency.

Unlike TDMA or FDMA, CDMA has a soft capacity limit. Increasing the number of users in a CDMA system raises the noise floor in a linear manner. Thus, there is no absolute limit on the number of users in CDMA. Rather, the system performance gradually degrades for all users as the number of users is increased and improves as the number of users decreases. Since CDMA uses co-channel cells, it can use microscopic spatial diversity to provide soft handoff. Soft handoff is performed by MSC, which can simultaneously monitor a particular user from two or more base stations. The MSC may choose the best version of the signal at any time without switching frequencies.

Self-jamming is a problem in CDMA system. Self-jamming arises from the fact that the spreading sequences of different users are not exactly orthogonal, hence in the despreading of a particular PN code, non-zero contributions to the receiver decision statistic for a desired user arise from the transmissions of other users in the system. The near-far problem occurs at the CDMA receiver if an undesired user has a high detected power as compared to the desired user.

Q. 3. (b) What are the advantages of digital cellular systems over analog cellular systems.

Ans. The first generation of cellular voice systems was based on analog communications from figure, the graph of deployed system types, we observe that the number of users of these systems has declined rapidly with only 3 percent of the subscriber base still using analog phones. Because of the early start in mobile telephony, these legacy analog systems were more widely deployed.

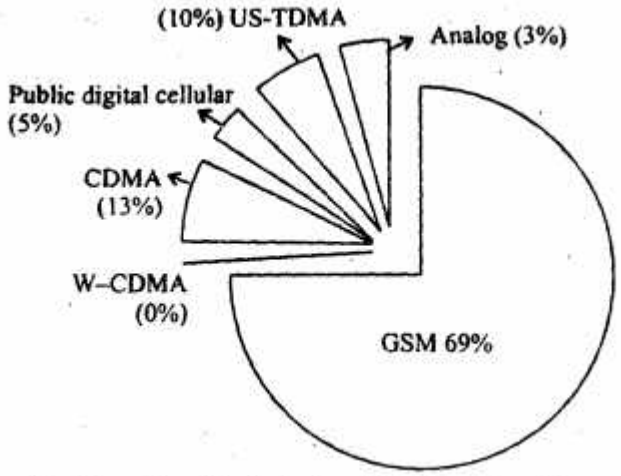


Fig. Recently estimated subscribers by system type

In US. the most widely deployed system was called the Advanced Mobile Phone System (AMPS). There was also an early analog system deployed called Nordic Mobile Telephony (NMT) that is no longer used. The system most deployed in Europe was called the Total Access Communication System (TACS) that still has a small number of subscribers.

Second generation systems replaced the analog modulation of the speech signal with digital encoding and compression of the voice signal into a digital bit stream. Digital systems provide much greater utilization of the spectrum. In addition, many users are multiplexed on each carrier channel to squeeze even more phone calls into a given frequency band. Second generation/digital system are characterised by increased use of intelligent networking systems to provide more efficient operations and new services such as caller-ids and SMS. Second generation digital cellular systems are further classified as global system for mobiles (GSM) and the code division multiple access (CDMA) system.

CDMA or time division multiple access includes the spectrum allocation as well as signaling and operations systems used in providing the service.

In USA TDMA runs on both the 800 MHz cellular band and in the 1900 MHz PCS spectrum.

Q. 4. (a) What do you mean by hard handoff & soft handoff?

Ans. Hard Handoff : A hard handoff 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 the connection to the target is made-for this reason such handoffs are also known as break-before-make. Hard handoffs are intended to be instantaneous in order to minimize the disruption to the call. A hard handoff is percieved by network engineers as an event during the call.

An advantage of the hard handoff is that at any moment in time one call uses only one channel. The hard handoff event is ended very short and usually is not perceptible by the user. In the old analog systems it could be heard as a click or a very short beep, in digital systems it is unnoticable. Another advantage of hard handoff is that the phone's hardware does not need the capability of receiving two or more channels in parallel, which makes it cheaper and simpler. A disadvantage is that if a handoff fails the call may be temporarily disrupted or even terminated abnormally. Technologies, which utilise hard handoffs, usually have procedures which can

re-establish the connection to the source cell if the connection to the target cell cannot be made. However re-establishing this connection may not always be possible.

Soft Handoffs : A soft handoff 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 cell is broken, hence this handoff 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 handoff is perceived by network engineers as a state of the call, rather than a brief event. A soft handoff may involve using connections to more than two cells. When a call is in the state of soft handoff the signal of the best of all used channels can be utilised for the call at a given moment or all the signal can be combined to produce a clearer copy of the signal. The later is more advantageous, and when such combining is performed both in the downlink and the uplink the handoff is termed as softer. Softer handoffs are possible when the cells involved in the handoff have a single cell site.

One advantage of the soft handoffs is that the connection to the source cell is broken only when a reliable connection to the target cell has been established and therefore the chances that the call will be terminated abnormally due to a failed handoff are lower. However, by far a bigger advantage comes from the mere fact that simultaneously channels in multiple cells are maintained the call could only fail if all the channels are faded at the same time.

Q. 4. (b) What are the different techniques used for improving coverage and capacity?

Ans. As the demand for wireless services increase, the number of channels assigned to a cell eventually becomes insufficient to support the required number of users. At this point, cellular design techniques are needed to provide more channels per unit coverage area. Techniques such as cell splitting, sectoring and coverage zone approaches are used to expand the capacity of cellular systems.

(i) Cell Splitting : Cell splitting is the process of subdividing a congested all 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. By defining new cells which have a smaller radius than the original cells and by installing these smaller cells between the existing cells, capacity increase due to additional number of channels per unit area.

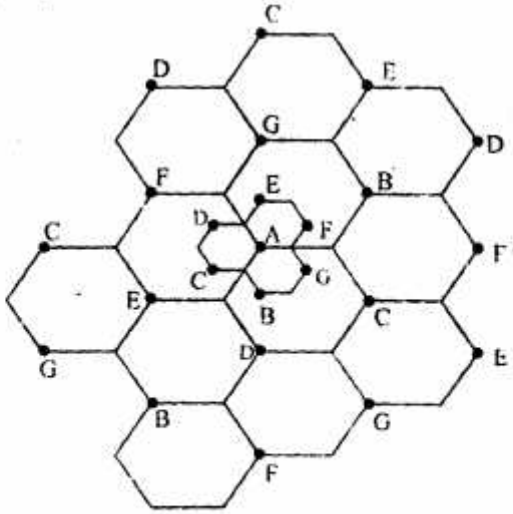
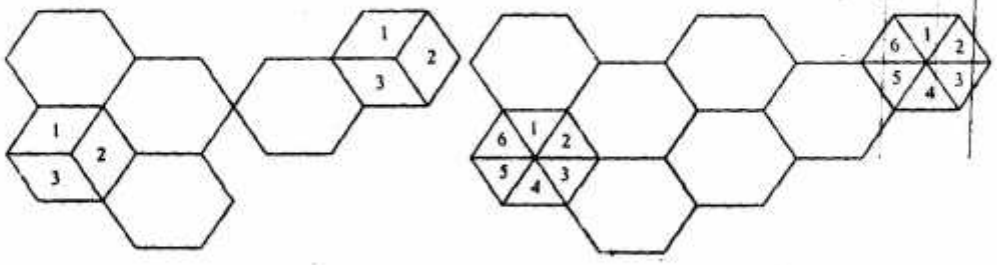


Fig. Illustration of cell splitting

(ii) Sectoring : Another way to increase capacity is to keep the cell radius unchanged and seek methods to decrease the D/R ratio. Sectoring increases SIR so that the cluster size may be reduced. In this approach, first the SIR is improved using directional antennas, then capacity improvement is achieved by reducing the no. of cells in a cluster, thus increasing the frequency reuse. However, it is necessary to reduce the relative interference without decreasing the transmit power. The technique for decreasing, co-channel interference and this increasing system performance by using directional antennas is called sectoring. The factor by which the co-channel interference is reduced depends on the amount of sectoring used, for e.g., 120° sectors or 60° sectors.



(120° sectoring) (60° sectoring)

(iii) Repeaters for Range Extension : Radio transmitters or repeaters are used to provide dedicated coverage for hard-to-reach areas. Repeaters are bi-directional in nature and simultaneously send signal to and receive signals from a serving base station. Repeaters work using over-the-air signals, so that they may be installed anywhere and are capable of repeating entire cellular or PCs band. In practical, directional antennas or distributed antenan systems (DAS) are connected to inputs or outputs of repeaters By modifying the coverage of a serving cell, an operator is able to dedicate a certain amount of the base station's traffic for the areas covered by the repeaters.

(iv) **A Microcell Zone Concept :** The increased number of handoffs required when sectoring is employed results in an increased load on the switching and control link elements of the mobile system. A

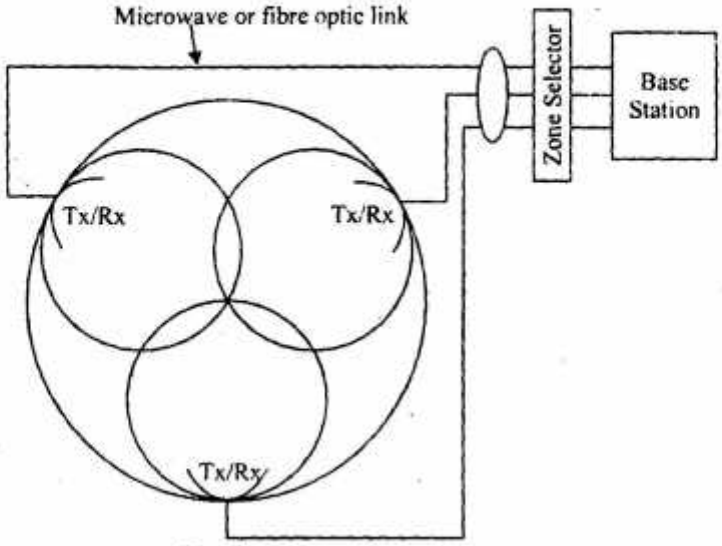


Fig. The microcell concept

solution to this problem is based on the microcell zone concpt for seven cell reuse. In this concept, each of the three zone sites are connected to a single base station and share the same radio equipment. As a mobile travels within the cell, it is served by the zone with the strongest signal. This approach is superior to sectoring as antennas are placed at the outer edges of the cell, and any base station channel may be assigned to any zone by the base station.

Q. 5. (a) Explain the term interference in space, time and frequency domain. What are the countermeasures in SDMA, TDMA & FDMA systems?

Ans. Interference is the major limiting factor in the performance of the cellular radio systems. Sources of interference include another mobile in the same cell, a call in progress in a neighbouring cell, other base stations operating in same frequency band or any non-cellular system which inadvertently leaks energy into cellular frequency band.

In a FDMA system, many channels share the same antenna at the base station. The power amplifier or power combiners are non-linear. The non-linearities cause signal spreading in the frequency domain and generate intermodulation frequencies. Spreading of the spectrum results in adjacent channel interference.

In TDMA, the guard time should be minimized. If the transmitted signal at the edges of a time slots are suppressed sharply in order to shorten the guard-time, the transmitted spectrum will expand and cause interference to adjacent channel.

In SDMA, because of different radio propagation path between each user and base station, the transmitted power from each subscriber unit must be dynamically controlled to prevent any single user from driving up the interference level for all ohter users.

Frequency Division Multiple Access (FDMA) :

(i) The FDMA channel carries only one phone circuit at a time.

(ii) If an FDMA channel is not in use, then it sits idle and cannot be used by other users to increase or share capacity.

(iii) After the assignment of a voice channel, the base station and the mobile transmit simultaneously and continuously.

(iv) The bandwidth of FDMA channels are relatively narrow i.e., 30 kHz in AMPs.

(v) The complexity of FDMA mobile systems is lower than compared to TDMA systems.

(vi) Since FDMA is a continuous transmission scheme, fewer bits are needed for overhead purposes as compared to TDMA.

(vii) FDMA systems have higher cell site system costs.

(viii) FDMA mobile unit uses duplexers since both the transmitter and receiver operate at the same time.

(ix) FDMA requires tight RF filtering to minimize adjacent channel interference.

Time Division Multiple Access (TDMA) :

(i) TDMA systems divide the radio spectrum into time slots, and in each slot only one user is allowed to either transmit or receive.

(ii) TDMA systems transmit data in a buffer and burst method, thus the transmission is non-continuous.

(iii) In TDMA, half of the time slots in the frame information message would be used for the forward link and half would be used for reverse link channels.

(iv) In general, TDMA systems intentionally induce several time slots of delay between forward and reverse time slots.

(v) Duplexers are not required in the subscriber unit.

(vi) Guard times are utilized to allow synchronization of the receivers between different slots and frames.

(v) TDMA shares common/single carrier frequency with several users.

(vi) Because of non-continuous transmission in TDMA, the handoff process is much simpler for a subscriber unit.

Space Division Multiple Access :

(i) SDMA controls the radiated energy for each user in space.

(ii) SDMA serves different users by using spot beam antennas, these different areas covered by the antenna beam may be served by same or different frequencies.

(iii) Sectorized antennas may be thought of as a primitive application of SDMA.

(iv) If the base station antenna is made to be spatially filter each desired user so that more energy is detected from each subscriber, then the reverse link for each user is improved and less power is required.

Q. 5. (b) Explain capacity of a cellular system.

Ans. Channel capacity for a radio system can be defined as the maximum number of channels or users that can be provided in a fixed frequency band. Radio capacity is a parameter which measures spectrum efficiency of a wireless system. This parameter is determined by the required carrier-to-interference ratio (C/I ratio) and the channel bandwidth B_c.

Considering, the forward channel interference problem, let D be the distance between two co-channel cells and R be the all radius. Then the minimum ratio of D/R that is required to provide a tolerable level of co-channel interference is called co-channel reuse rather, given as

$$Q = \frac{D}{R}$$

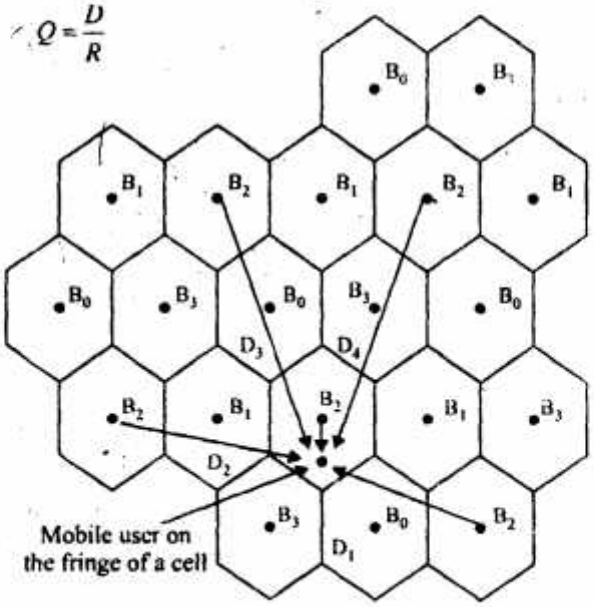


Fig. Illustration of forward channel interference for a cluster size N = 4

The radio propagation characteristics determine the carrier-to-interference ratio (C/I) at a given location. As shown in figure, the M closest co-channel cells may be considered as first order interference, in which case C/I is given by

$$\frac{C}{I} = \frac{D_0^{-n_0}}{\sum_{k=1}^{M} D_k^{-n_k}}$$

Where, n_0 = Path loss exponent in the desired cell

D_0 = Distance from the desired base station to the mobile

D_k = Distance of the k^{th} cell from the mobile

n_k = Path loss exponent to the k^{th} base station.

If only the size closest interfering cells are considered, then

$$\frac{C}{I} = \frac{D_0^{-n}}{6D^{-n}}$$

When mobile is at the cell edge $D_0 = R$, then the following equation must hold for acceptable performance

$$\frac{1}{6}\left(\frac{R}{D}\right)^{-n} \geq \left(\frac{C}{I}\right)_{min}$$

Then, co-channel reuse factor is $$Q = \left[6\left(\frac{C}{I}\right)_{min}\right]^{1/n}$$

The radio capacity of a cellular system is defined as

$$m = \frac{B_t}{B_c N} \text{ radio channels/cell}$$

B_t = Total allocated spectrum for the system

B_c = Channel bandwidth

N = No. of cells in a complete frequency reuse cluster.

Also co-channel reuse factor is given as $Q = \sqrt{3N}$

$$\therefore \quad \boxed{m = \frac{B_t}{B_c \frac{Q^2}{3}} = \frac{B_t}{B_c\left[\frac{6}{3^{n/2}}\left(\frac{C}{I}\right)_{min}\right]^{2/n}}}$$

Q. 6. (a) Difference between packet switching and circuit switching technique.

Ans. Voice communications through the public switched telephone network and the cellular telephone network use circuit-switching technology to complete phone calls. With circuit switching, a physical connection is set up at the time of the phone call and remains connected until the parties disconnect. In data applications, such as the internet, connections are logical, and the user data is divided into packets that are switched independently through the network. The logical connection uses resources only when one of the parties send data. The problem with circuit switching is that the application or phone call consumes network resources, even when there is no network traffic.

The capacity of circuit-switched networks is fixed, and the network must be carefully designed to meet peak calling loads.

The problem with packet switching is that packets take different paths through the network. Depending on traffic on the network, packets can be delayed or lost. This means that packets arrive at their destination at a rate that can vary quite dynamically.

The variable packet-transmission rate does not cause problem for most data applications, but it can degrade the quality of voice and video. Network operator. would eventually like to have the efficiency, scalability and manageability of an all digital, all packet-switched network for content. To achieve this, networks have different classes of service. For instance, a network that needs low latency, which is end-to-end delay through the network, and low jitter, which is the variation in the arrival rates of individual packets, should be able to request this service from the network.

Q. 6. (b) Explain advanced intelligent networks.

Ans. The advanced intelligent network (AIN) is a telephone network architecture that separates service logic from switching equipment, allowing new services to be added without having to redesign switches to support new services. It encourages competition among service providers since it makes it easier for a provider to add services and it offers customers more services choices.

A telephone caller dials a number that is received by a switch at the telephone company central office. The switch-known as the service switching point (SSP) forwards the call over a signalling system 7 (SS7) network to a service control point (SCP) where the service logic is located. The SCP identifies the service requested from part of the number that was dialed and returns information about how to handle the call to the service switching point.

In some cases, the call can be handled more quickly by an intelligent peripheral (IP) that is attached to the service switching point over a high-speed connection. In addition, an "adjunct" facility can be added directly to the service switching point for high-speed connection to additional, undefined services. On of the services that AIN makes possible is local number portability (LNP).

The AIN Release Table :

Release 0 : Trigger checkpoints at off-hook, digit collection and analysis, and routing points of call code gapping to check for overload conditions at SCP 75 announcements at the switching system.

Release 0.1 : Adds a formal call model that distinguishes the originating half of the call from the terminating half.

Release 0.2 : Adds phase 2-personal communication service (PCS) support, voice activated dialing (VAD).

Release 1 : A full set of capabilities.

Q. 7. (a) Explain CDMA cellular Radio networks.

Ans. The CDMA architecture has allowed a selection of different voice encoding systems. The original qual-comm system gave a bit rate of approximately 9.6 Kbps. This voice signal is combined with a pseudo-noise signal called a chip code of 1-28 Mbps, unique to each mobile station in the cell. The resulting bit stream is then modulated onto a 1.25 MHz carrier channel using binary or quadrature phase shift keying.

Downstream transmissions from the base station to all of the mobiles in the cell are all sent at the same time, and theoretically upto 62 mobiles could use the same channel. Practically, this is often limited to less than 20 mobiles in a cell. The mobiles only listens to the transmission encoded with its chipcode. Like GSM, CDMA makes use of voice activity detection and other scheme to increase capacity and limit interference.

An analogy that is often used to describe this type of coding is a large party where many pairs of people want to talk to each other at once. If each pair of people speaks a different language, despite the fact that everyone is talking at once, each person can listen for their language and filter the other conversations out as noise.

One important advantage that the CDMA multiplexing technique offers results from using the same frequencies in every sector. There is no need for elaborate frequency planning which is required in GSM and TDMA. If more radio capacity is needed, cells can be divided or added almost in an ad hoc manner. Another interesting feature of CDMA, is called a soft-hand off. Since all of the cells adjacent to a cell phone user are operating on the same frequencies, the mobile station can maintain communications with multiple cells at the same time. Only when the new cell determines that it has the best signal, does the hand-off actually occur.

Q. 7. (b) What are the applications of intelligent micro-cell systems?

Ans. Improved microcell system for cellular telephone systems has a plurality of contiguous cells wherein the cells are configured in a plurality of clusters with each cell in a cluster having a different assigned set of transmission frequencies. Each of the frequencies in an assigned set for a given cell is assignable to a given mobile telephone within the cell for all locations of the mobile telephone within the cell. Frequency handoff circuitry is provided for maintaining continuous communication with mobile telephones moving from cell to cell. Each of the cells is provided with a plurality of antennas each of which is arranged and configured to limit propagation of signals substantially to one of the plurality of regions within the boundaries of the cell, which regions are substantially less in area than the area of the cell. Transmission at any one frequencies of the set of transmission frequencies assigned to a cell is confined to the zone wherein the strongest signal is received from the mobile telephone to which such one frequency has been assigned. Accordingly, the clusters of cells may be arranged with a frequency reuse pattern of three and a ratio of co-channel separation of cell radius of less than four.

Q. 8. Write short notes on :

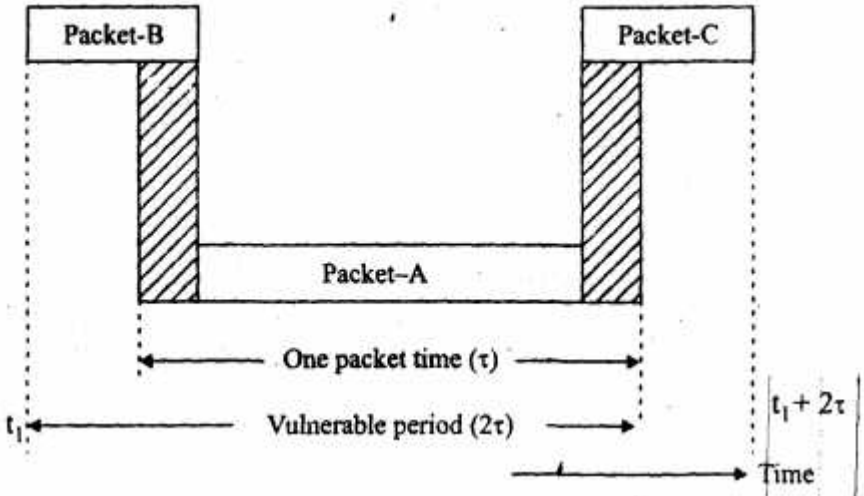
(a) Packet radio

(b) Common channel signalling

(c) Tracking and grade off service

Ans. (a) Packet Ratio : In packet radio access techniques, many subscribers attempt to access a single channel in an unco-ordinaded manner. Transmission is done by using bursts of data. Collisions from the simultaneous transmissions of multiple transmitters are denoted 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 through traffic delay due to collisions may be high.

Packet radio multiple access is very easy to implement, bus has low spectral efficiency and may induce delay. The performance of contention techniques can be evaluated by the throughput (T), which is defined as the average number of messages successfully transmitted per unit, and the average delay (D) experienced by a typical message burst. Packet A will collide with packets B and C because of overlap in transmission line.



(b) Common Channel Signalling : Common digital signalling (CCS) is a digital communications technique that provides simultaneous transmission of user data, signalling data and other related traffic throughout a network. This is accomplished by using out-of-band signalling channels which logically separates the logic data from the user information on the same channel.

CCS is an out-of-band signalling technique which allows much faster communications between two nodes within the PSTN. Instead of being constrained to signalling data rates are on the order of audio frequencies, ECS supports signalling data rates from 56 Kbps to many megabits per second. Thus, network signalling data is carried in a seemingly parallel, out-of-band, signalling channel while only user data is carried on the PSTN. CCS provides a substantial increase in the number of users which are served by trunked PSTN lines but requires that a dedicated portion of the trunk time be used to provide a signalling channel used for network traffic.

(c) Tracking & Grade Off Service : Cellular radio systems rely on trunking to accommodate a large number of users in a limited radio spectrum. The concept of trunking allows a large network of users to share the relatively small number of channels in a cell by providing access to each user, on demand, from a pool of available channels. In a trunked radio system, each user is allocated a channel on a per unit call basis, and upon termination of the call, the previously occupied channel is immediately returned to the pool of available channels. Trunking exploits the statistical behaviour of users so that a fixed number of channels or circuits may accommodate a large, random user community.

The grade of service (GOS) is a measure of the ability of a user to access a trunked system during the bursiest hour. The busy hour is based upon customer demand at the busiest hour during a week, month or year. The busy hours for cellular radio systems typically occur during rush hours, between 4 pm and 6 pm on a Thursday or Friday evening. The grade of service is a benchmark used to define the desired performance of a particular trunked system by specifying a desired likelihood of a user obtaining channel access given a specific number of channels available in the system. It is the wireless designer's job to estimate the maximum required capacity and to allocate the proper number of channels in order to meet the GOS. GOS is typically given as the likelihood that a call is blocked, or the likelihood of a call experiencing a delay greater than a certain queuing time.