Q.2 a. Write about radio propagation in Mobile environment and highlight why 800 MHz is the choice for Cellular communications? (8)

Answer:
For Line of sight communication, the sites for base station have to be chosen properly. For mobile communication, motion is an additional variable since end user is usually in motion. Shadowing is frequently encountered due to man-made structures, mountains, trees etc., Multipath propagation and a delay of the order of 10ms is observed. Doppler shift is also expected due to motion. The UHF band from 800-900MHz and 1200-1700MHz is used for mobile communication.

FM Broadcasts starts in the vicinity of 100MHz, TV broadcasts starts @41MHz and extends up to 960MHz. Air to ground communication uses to 118 to 136 MHz, military uses 225 to 400MHz, maritime , mobile service uses 160MHz. Hence there is over crowding between 30 to 400MHz band. Radio transmission @ 10GHz or above is affected by rain or pathloss, multipath fading etc., Therefore, the choice was 800MHz

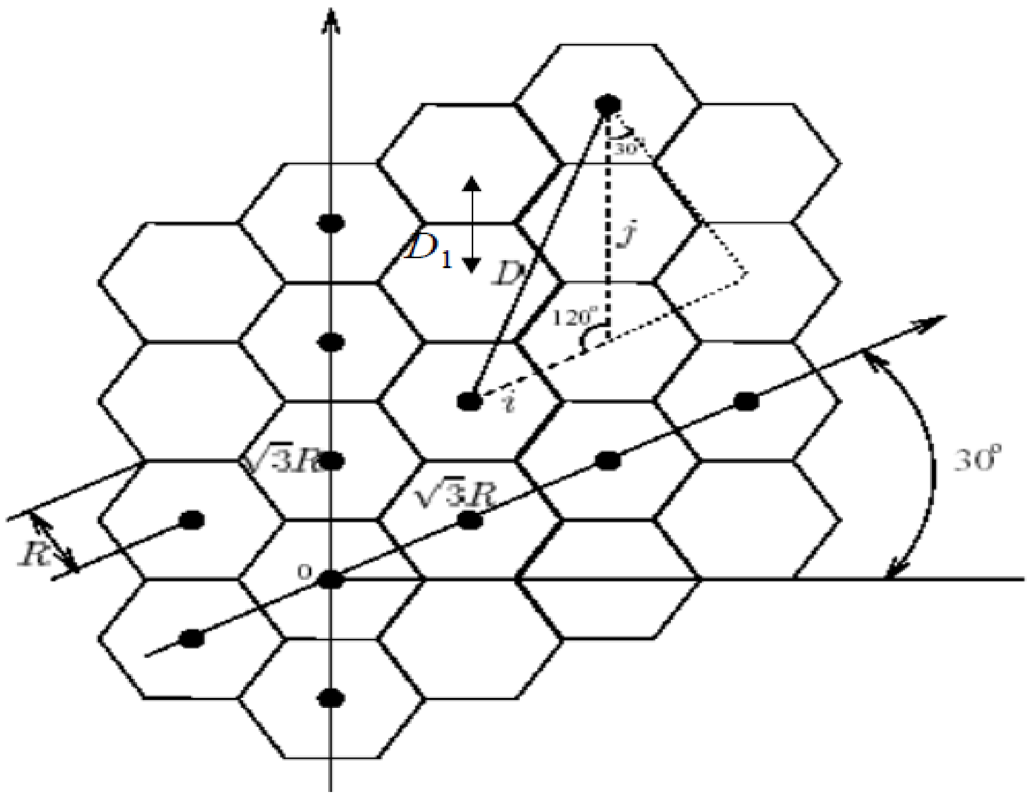
b. Assume a 1 Amp-hour battery is used on a cellular telephone (often called as cellular subscriber unit). Also assume that the cellular telephone draws 35mA in idle mode and 250mA during a call. How long would the phone work (i.e. what is the battery life) if the user leaves the phone ON continually and has one three minute call every day? Every six hours? Every hour? What is the maximum talk time available on the cellular phone in this example? (8)

Answer:

1) 3 minutes at 250ma and 23 hr 57 min at 35 ma. converting to hours and amps, ie, amp hours 0.05 x 0.25 + 23.95 x .035 0.0125 + 0.83825 0.85075 amp hour used in one day so the battery will last a bit longer than a day, for the second day there is 1 – 0.85075 = 0.14925 amp hours. Depends on when in the second day the 3 minute call occurs. without it, you have 0.14925 amp hours / .035 = 4.26 hours bottom line, 24 hours with 1 call, and an extra 4.26 hours with no calls
2) same as above, different numbers idle time is 24 hours – 12 min = 23.8 hrs 0.05 x 0.25 x 4 + 23.8 x .035 0.05 + 0.833 0.883 amp hour used in one day so the battery will last a bit longer than a day, for the second day there is 1 – 0.883 = 0.117 amp hours. Again, Depends on when in the second day the 3 minute call occurs. without it, you have 0.117 amp hours / .035 = 3.34 hours bottom line, 24 hours with 4 calls, and an extra 3.34 hours with no calls
3) same as above, different numbers idle time is 24 hours – 72 min = 24h – 1h12min = 22 hr 48min = 22.8 0.05 x 0.25 x 24 + 22.8 x .035 0.3 + 0.798 1.098 amp hour used in one day start this one over, different approach "after every hour", so in one hour, you use 0.05 x 0.25 + 1 x .035 amp-hour 0.0125 + 0.035 0.0475 amp-hour how many of these are in 1 amp-hr? 1/.0475 = 21.04 so it will last 21 hours plus a bit of idle time. the time used is: 21 x 0.0475 = 0.9975 amp-hr 1 – 0.9975 amp-hr = .0025 amp hour left over 0025 amp hour / 0.035 amp = 0.0714 hour or 4.3 minutes so you have enough power for 21 hours and 21 calls, plus an extra 4.3 minutes with no calls.
4) what does this mean? with no off time? 1 amp hour /0.25 amps = 4 hours.

Q.3 a. Write notes on the geometry of a hexagonal cell. Obtain all relations. Discuss co-channel interference ratio. Show that N=7 is required if S/I ratio is to be 18 dB. (8)

Answer :



Consider hexagonal cells

I. A hexagonal cell has exactly 6 equidistant "nearest" co-channel neighbours.
II. The lines joining the centers of any cell and each of its neighbours are separated by multiples of 60 degrees.

To find the nearest co –channel neighbours follow two steps:

- Move over *i* cells along any chain of hexagons.
- Turn 60 degress counter clockwise and more over j cells where i and j system parameters for determining cluster size.
  $N= i^2+ij=j^2$

R: Radius of the cell (from center to vertex).

D_1 : Distance between the centers of two "adjacent" neighbour cells.

Distance D between c1 and c2 is

$D=\{(u2-u1)^2(\cos 30)^2 + [(v2-v1)+(u2-u1)\sin 30]^2\}^{1/2}$.-------------1

$D=\{(u2-u1)^2+ (v2-v1)^2+[(v2-v1)(u2-u1)]\}^{1/2}$.-------------2

If (u1,v1)is (0,0) or origin or center of hexagonal cells and restrict (u2,v2) to integers (I,j) values.

$D= (i^2+ij=j^2)^{1/2}$.

Actual distance between 2 adjacent cells, centre to centre is 2R Cos30 or √3 R where R is the center to vertex distance.

If the cell size and transmitter power are the same then the co-channel interference is independent of the transmitted power and the co – channel interference is a function of q=D/R. and D is a function of S/I.

ConsiderN=6.

From the above figure radius of large cell is given by,

$D^2=3R^2 (i^2+ij=j^2)$----------------------1

Because area of hexagon is proportional to square of distance between centre and vertex.

Alarge= $k[3R^2 (i^2+ij=j^2)]$--------------------------------2

Where k is constant

Asmall=$k(R^2)$-------------------------3

Comparing 2 nd 3 and using 1

Alarge/Asmall=D^2/ R^2 -----------------------4

From symmetry we observe that the large hexagon elcloses the centre cluster of Ncells(7)+1/3rd of Number of cells associated with 6 other peripheral hexagons. Thus, the total no of cells or hexagon =N+6(1/3 N)=3N-------5.

Since the area is proportional to no of cells,

Alarge=3N.

Asmall=1

Alarge/Asmall=3N----------------------6.

Substitute 6 in 4.

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

$D^2/ R^2=3N$

$D/R=q=\sqrt{(3N)}$.

Where q is the re use factor.

Reducing q implies increasing the radius hence a large cells. Therefore less no of cells in a given area[if the BW remains the same and if rearrange the free band then it implies that the traffic capacity per cell increases]. However increasing q means that we are reducing R or cell radius hence smaller cells[if the same BW and rearranging the frequency bands implies a reduction in traffic capacity per cell]

b. In a particular cellular system in a sub-urban environment the average size of a cell is 200 Sq. miles. System has 30 cells designed for 2% GOS. 395 voice channels are divided into 30 freq. groups with freq. reuse factor of 1.52. Calculate
(i) Estimated market penetration.
(ii) Total no of subscribers.
(iii) No of subscribers per Sq. mile.
Note: Traffic generated is 0.025 Erlangs by each subscriber. Erlangs per cell with 2% blocking is = 13.2 (8)

Answer:

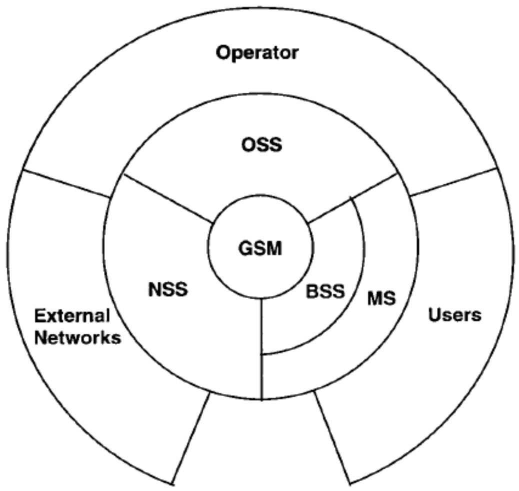
Q.4 a. With the block schematic of GSM architecture explain the Mobile transceiver. (8)

Answer :

A series of functions are required to support the services and facilities in the GSM PLMN. The basic subsystems of the GSM architecture are (Figure 5.2) the Base Station Subsystem (BSS), Network and Switching Subsystem (NSS), and Operational Subsystem (OSS).The BSS provides and manages transmission paths between the MSs and the NSS. This includes management of the radio interface between MSs and the rest of the GSM system. The NSS has the responsibility of managing communications and connecting MSs to the relevant networks or other MSs. The NSS is not in direct contact with the MSs. Neither is the BSS in direct contact with external networks. The MS, BSS, and NSS form the operational part of the GSM system. The OSS provides means for a service provider to control and manage the GSM system. In the GSM, interaction between the subsystems can be grouped in two main parts:

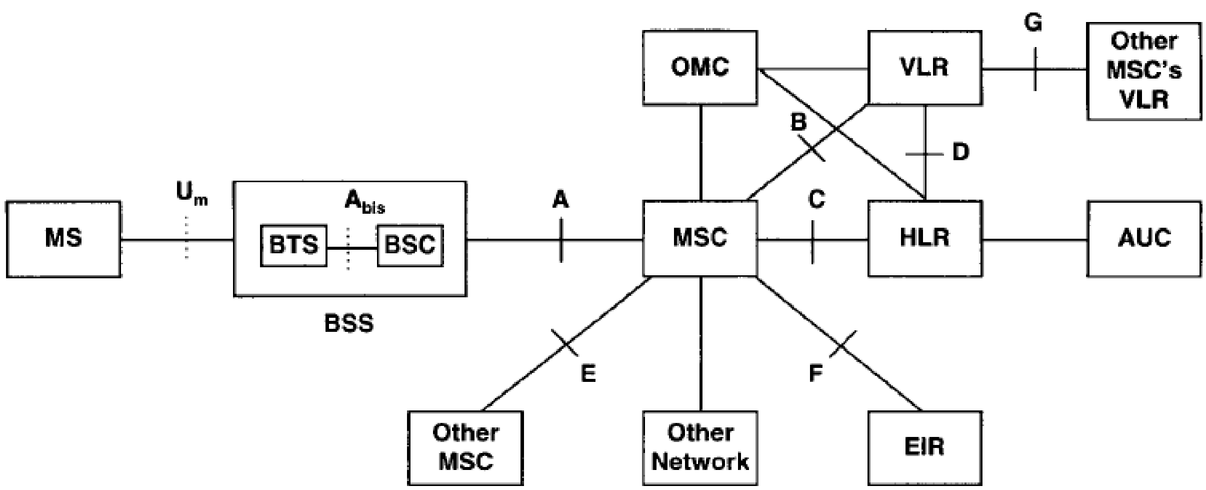
Operational. External networks to/from NSS to/from BSS to/from MS to/from subscriber

Control. OSS to/from service provider. The operational part provides transmission paths and establishes them. The control part interacts with the traffic-handling activity of the operational part by monitoring and modifying it to maintain or improve its functions.



- BSS: Base Station Subsystem
- NSS: Network and Switching Subsystem
- OSS: Operational Subsystem
- MS: Mobile Station

GSM-SUBSYSTEM ENTITY



- MS: Mobile Station
- BSS: Base Station Subsystem
- BTS: Base Transceiver Station
- BSC: Base Station Controller
- MSC: Mobile Service Switching Center
- OMC: Operations and Maintenance Center
- HLR: Home Location Register
- VLR: Visitor Location Register
- EIR: Equipment Identity Register
- AUC: Authentication Center

Figure shows the functional entities of the GSM and their logical interconnection. We will briefly describe these functional entities here.

MS: The MS consists of the physical equipment used by the subscriber to access a PLMN for offered telecommunication services. Functionally, the MS includes a Mobile Termination (MT) and, depending on the services it can support, various

Terminal Equipment (TE), and combinations of TE and Terminal Adaptor (TA) functions (the TA acts as a gateway between the TE and the MT) (see Figure 5.4). Various types of MS, such as the vehicle- mounted station, portable station, or handheld station, are used. The MSs come in five power classes which define the maximum RF power level that the unit can transmit. Tables 5.1 and 5.2 provide the details of maximum RF power for various classes in GSM and DCS-1800. Vehicular and portable units can be either class I or class II, whereas handheld units can be class III, IV, and V. The typical classes are II and V. Table 5.3 provides the details of maximum RF power for GSM and DCS-1800 micro-BSs. Basically, an MS can be divided into two parts. The first part contains the hardware and software to support radio and human interface functions. The second part contains terminal/user-specific data in the form of a smart card, which can effectively be considered a sort of logical terminal. The SIM card plugs into the first part of the MS and remains in for the duration of use. Without the SIM card, the MS is not associated with any user and cannot make or receive calls (except possibly an emergency call if the network allows). The SIM card is issued by the mobile service provider after subscription, while the first part of the MS would be available at retail shops to buy or rent. This type of SIM card mobility is analogous to terminal mobility, but provides a personal-mobility-like service within the GSM mobile network (refer to chapter 11 for more details). An MS has a number of identities including the International Mobile Equipment Identity (IMEI), the International Mobile Subscriber Identity (IMSI), and the ISDN number. The IMSI is stored in the SIM. The SIM card contains all the subscriber-related information stored on the user's side of the radio interface.

IMSI. The IMSI is assigned to an MS at subscription time. It uniquely identifies a given MS. The IMSI will be transmitted over the radio interface only if necessary. The IMSI contains 15 digits and includes

Mobile Country Code (MCC)—3 digits (home country)

Mobile Network Code (MNC)—2 digits (home GSM PLMN)

Mobile Subscriber Identification (MSIN)

National Mobile Subscriber Identity (NMSI)

Temporary Mobile Subscriber Identity (TMSI). The TMSI is assigned to an MS by the VLR. The TMSI uniquely identifies an MS within the area controlled by a given VLR. The maximum number of bits that can be used for the TMSI is 32.

IMEI. The IMEI uniquely identifies the MS equipment. It is assigned by the equipment manufacturer. The IMEI contains 15 digits and carries

The Type Approval Code (TAC)—6 digits

The Final Assembly Code (FAC)—2 digits

The serial number (SN)— 6 digits

A Spare (SP)—1 digit

SIM. The SIM carries the following information (see chapter 11 for more details):

IMSI

Authentication Key (K_i)

Subscriber information

Access control class

Cipher Key (K_c)

TMS

Additional GSM services

Location Area Identity (LAI)

Forbidden PLMN

BSS The BSS is the physical equipment that provides radio coverage to prescribed geographical areas, known as the cells. It contains equipment required to communicate with the MS. Functionally, a BSS consists of a con- trol function carried out by the BSC and a transmitting function performed by the BTS. The BTS is the radio transmission equipment and covers each cell. A BSS can serve several cells because it can have multiple BTSs.

The BTS contains the Transcoder Rate Adapter Unit (TRAU). In TRAU, the GSM-specific speech encoding and decoding is carried out, as well as the rate adaptation function for data. In certain situations the TRAU is located at the MSC to gain an advantage of more compressed transmission between the BTS and the MSC.

NSS The NSS includes the main switching functions of GSM, data- bases required for the subscribers, and mobility management. Its main role is to manage the communications between GSM and other network users. Within the NSS, the switching functions are performed by the MSC. Sub- scriber information relevant to provisioning of services is kept in the HLR. The other database in the NSS is the VLR.

The MSC performs the necessary switching functions required for the MSs located in an associated geographical area, called an MSC area.The MSC monitors the mobility of its subscribers and manages neces- sary resources required to handle and update the location registration proce- dures and to carry out the handover functions. The MSC is involved in the interworking functions to communicate with other networks such as PSTN and ISDN. The interworking functions of the MSC depend upon the type of the network to which it is connected and the type of service to be performed. The call routing and control and echo control functions are also performed by the MSC.

The HLR is the functional unit used for management of mobile subscrib- ers. The number of HLRs in a PLMN varies with the characteristics of the PLMN. Two types of information are stored in the HLR: subscriber informa- tion and part of the mobile information to allow incoming calls to be routed to the MSC for the particular MS. Any administrative action by the service pro- vider on subscriber data is performed in the HLR. The HLR stores IMSI, MS ISDN number, VLR address, and subscriber data (e.g., supplementary ser- vices).

The VLR is linked to one or more MSCs. The VLR is the functional unit that dynamically stores subscriber information when the subscriber is located in the area covered by the VLR. When a roaming MS enters an MSC area, the MSC informs the associated VLR about the MS; the MS goes through a registration procedure. The registration procedure for the MS includes these activities:

The VLR recognizes that the MS is from another PLMN.

If roaming is allowed, the VLR finds the MS's HLR in its home PLMN.

The VLR constructs a Global Title (GT) from the IMSI to allow signaling from the VLR to the MS's HLR via the PSTN/ISDN networks. The VLR generates a Mobile Subscriber Roaming Number (MSRN) that is used to route incoming calls to the MS.

The MSRN is sent to the MS's HLR.The information in the VLR includes MSRN, TMSI, the location area in which the MS has been registered, data related to supplementary service, MS ISDN number, IMSI, HLR address or GT, and local MS identity, if used.The NSS contains more than MSCs, HLRs, and VLRs. In order to deliver an incoming call to a GSM user, the call is first routed to a gateway switch, referred to as the Gateway Mobile Service Switching Center (GMSC). The GMSC is responsible for collecting the location information and routing the call to the MSC through which the subscriber can obtain service at that instant (i.e., the visited MSC). The GMSC first finds the right HLR from the directory number of the GSM subscriber and interrogates it. The GMSC has an interface with external networks for which it provides gateway function, as well as with the SS7 signaling network for interworking with other NSS entities.

Operation and Maintenance Subsystem (OMSS) The OMSS is responsible for handling system security based on validation of identities of various

telecommunications entities. These functions are performed in the Authentication Center (AuC) and EIR.
The AuC is accessed by the HLR to determine whether an MS will be granted service.
The EIR provides MS information used by the MSC. The EIR maintains a list of legitimate, fraudulent, or faulty MSs.
The OMSS is also in charge of remote operation and maintenance func- tions of the PLMN. These functions are monitored and controlled in the OMSS. The OMSS may have one or more Network Management Centers (NMCs) to centralize PLMN control.
The Operational and Maintenance Center (OMC) is the functional entity through which the service provider monitors and controls the system. The OMC provides a single point for the maintenance personnel to maintain the entire system. One OMC can serve multiple MSCs.

b. Why does power control become one of the main issues for the efficient operation of CDMA? (8)

Answer :

Walsh Codes

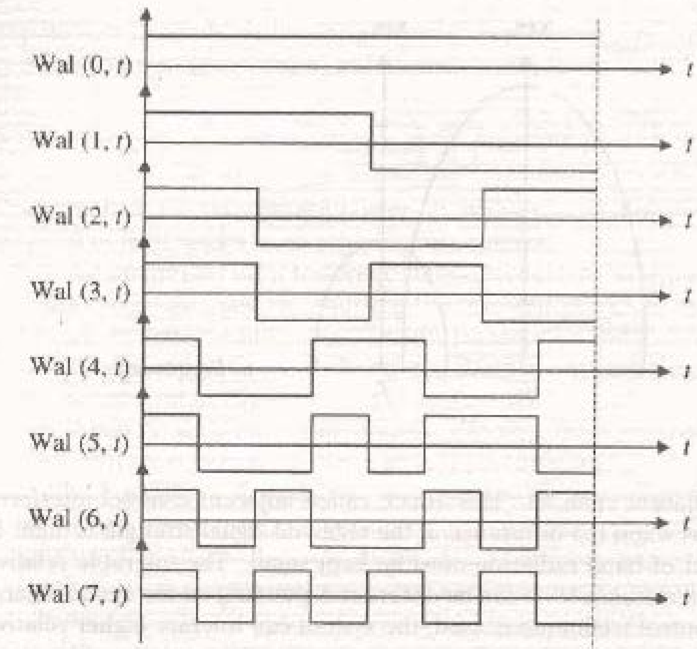
In CDMA, each user is assigned one or many orthogonal waveforms derived fro one orthogonal code. Since the waveforms are orthogonal, users with different co do not interfere with each other. CDMA requires synchronization among the use since the waveforms are orthogonal only if they are aligned in time. An importa set of orthogonal codes is the Walsh set (see Figure 7.16).

Walsh functions are generated using an iterative process of constructing a Hadam matrix starting with $H_0 = [0]$. The Hadamard matrix is built by using the functio

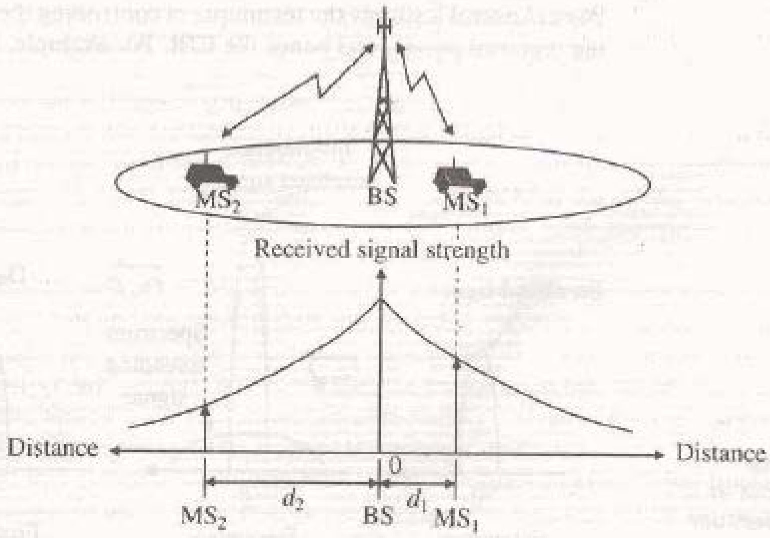
$$H_n = \begin{pmatrix} H_{n-1} & H_{n-1} \\ H_{n-1} & \overline{H_{n-1}} \end{pmatrix}. \quad (7.$$

Near-Far Problem

The near-far problem stems from a wide range of signal levels received in wirele and mobile communication systems. We consider a system in which two MSs ar communicating with a BS, as illustrated in Figure 7.17. If we assume the transmissi power of each MS to be the same, received signal levels at the BS from the MS_1 and MS_2 are quite different due to the difference in the path lengths. Let us assume that the MSs are using adjacent channels, as shown in Figure 7.18. Out-of-band radiation of the signal from the MS_1 interferes with the signal from the MS_2 in the



igure 7.16
Walsh codes.



e 7.17
-far problem.

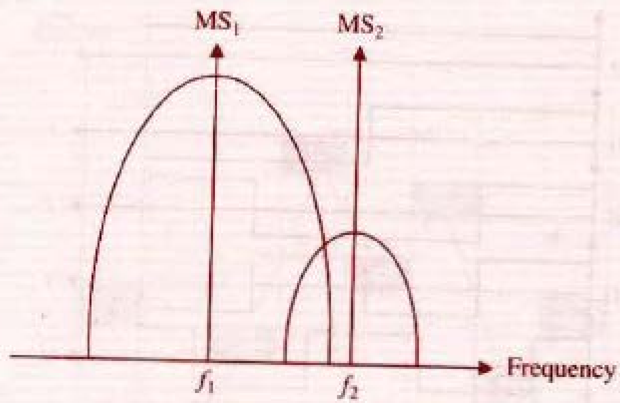


Figure 7.18 Adjacent channel interference.

adjacent channel. This effect, called adjacent channel interference, becomes serious when the difference in the received signal strength is high. For this reason, the out-of-band radiation must be kept small. The tolerable relative adjacent channel interference level can be different depending on the system characteristics. If power control technique is used, the system can tolerate higher relative adjacent channel interference levels. The near-far problem becomes more important for CDMA systems where spread spectrum signals are multiplexed on the same frequency using low crosscorrelation codes, as shown in Figure 7.19. In CDMA, a real question is how to address the near-far problem. One simple solution is power control and is considered next.

Power Control

Power control is simply the technique of controlling the transmit power so as to affect the received power, and hence the CIR. For example, in free space, the propagation

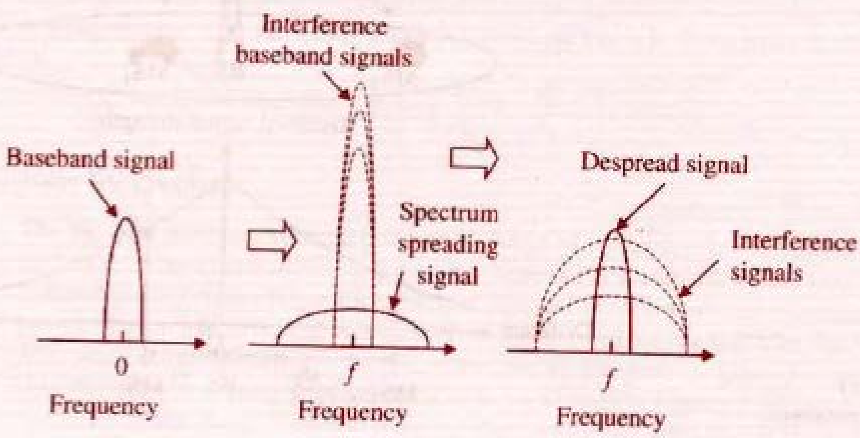


Figure 7.19 Interference in spread spectrum system.

path loss depends on the frequency of transmission, f, and the distance between transmitter and receiver, d, as follows:

$$\frac{P_r}{P_t} = \frac{1}{\left(\frac{4\pi d f}{c}\right)^{\alpha}}, \tag{7.8}$$

where P_t is the transmitted power, P_r is the received power in free space, c is the speed of light, and α is an attenuation constant.

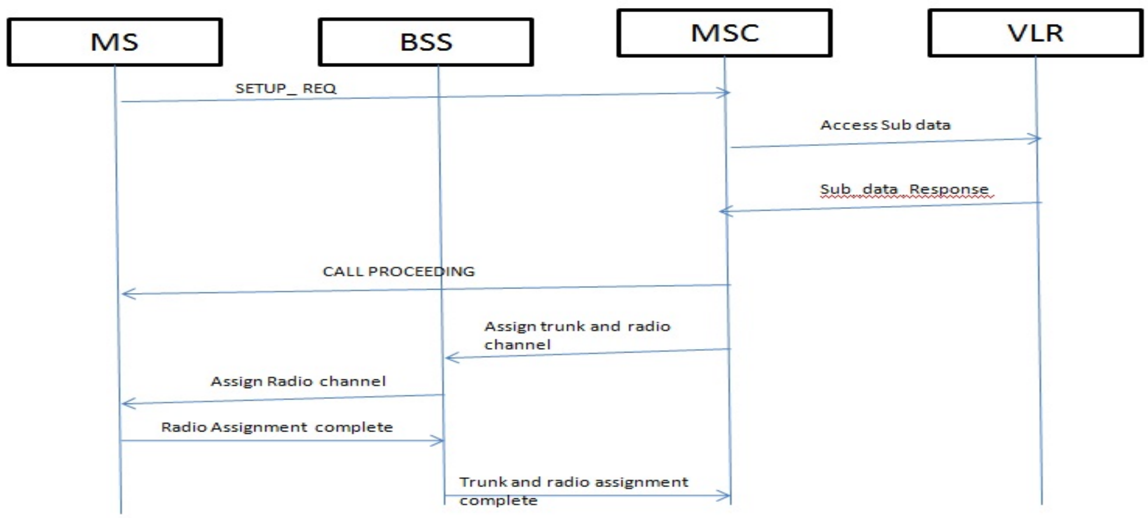
Assuming that the interference remains constant, a desired P_r (and thus a desired CIR) can be attained by adjusting the transmit power P_t appropriately. Note that this can be done by observing currently transmitted and received power, if we assume that the distance d does not change significantly between the time of observation and the adjustment of P_t.

While power control can often be effective, there are some disadvantages. First, since battery power at a MS is a limited resource that needs to be conserved, it may not be possible or desirable to set transmission powers to higher values. Second, increasing the transmitted power on one channel, irrespective of the power levels used on other channels, can cause inequality of transmission over other channels. As a result, there is also the possibility that a set of connections using a pure power control scheme can suffer from unstable behavior, requiring increasingly higher transmission powers. Finally, power control techniques are restricted by the physical limitations on the transmitter power levels.

Q.5 a. Explain call set up with mobile and call release mobile initiated. (8)

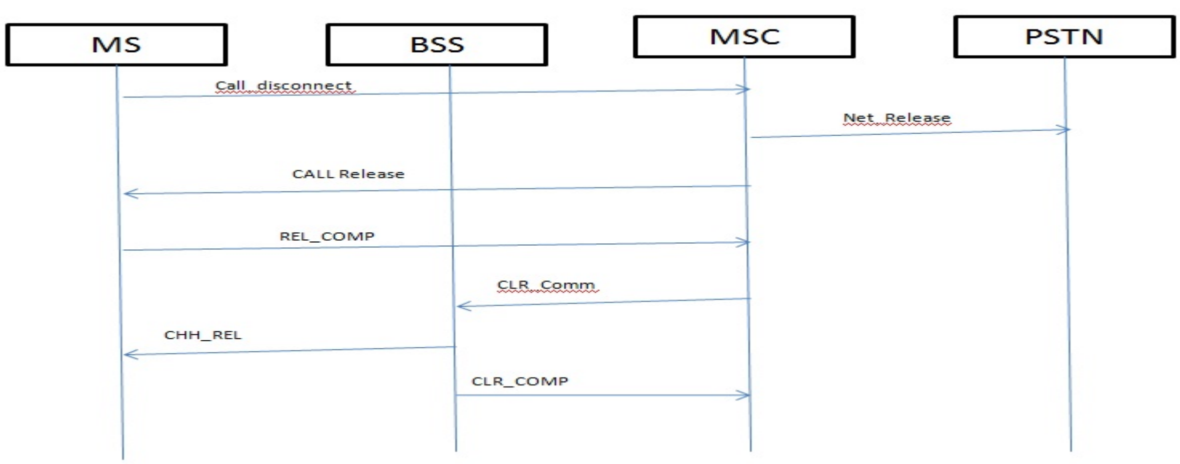
Answer: CALL SET UP WITH A MOBILE:

1) Mobile station sends a SET_UP_REQUEST to the MSC which includes the dialed digits.
2) Upon receiving the requests, the MSC asks the VLR to supply subscriber parameters. The message contains the called number and service time.
3) VLR checks for called barring condition, if call not barred, VLR returns a message SUB_DATA_RESPONSE to MSC.
4) MSC sends a message to MS via BSS informing that the call is proceed.
5) MSC allocates the available trunk to BSS and asks to assign radio traffic channel to MS
6) BSS allocates radio channel and informs MS over the standalone dedicated control channel [SDCCH].
7) MS tunes to assigned radio channel and sends ACK to BSS.
8) BSS connects radio traffic channel to assigned trunk in the MS.



CALL RELEASE -MOBILE INITIATED:

1) At the end of a call, MS sends CALL_disconnect message to MSC.
2) MSC NET_REL requests to PSTN.
3) MSC asks MS to begin the clearing proceed.
4) After MS has performed its clearing, it informs the MSC to a REL_COMP message.
5) MSC sends CLR_COMM message to BSS to release all allocated dedicated resources.
6) BSS sends CHH_REL message to MS to release the traffic channel.
7) BSS sends an ACK to MSC CLR_COMP that all resources are cleared.



b. Given the indoor path loss model of the form PL (d) db = 40 + 20 log d + Σ FAF d ≥ 1 m Where d is in mts. Find the mean received power between three floors of a building if FAF is 15db per floor. Assume the transmitter radiates 20 db and unity gain antenna are used at both the transmitter and receiver, and that the straight line path between the Tx and Rx is 15mt through the floors. (8)

Answer :

Given,

$$PL(d)\,db = 40 + 20 \log d + \Sigma FAF \quad d \geq 1\ m$$

Σ FAF=15+15+15=45dB.
D=15m
PL(d)=108.52dB.
Mean received Power=20-108.52= -88.52dB.

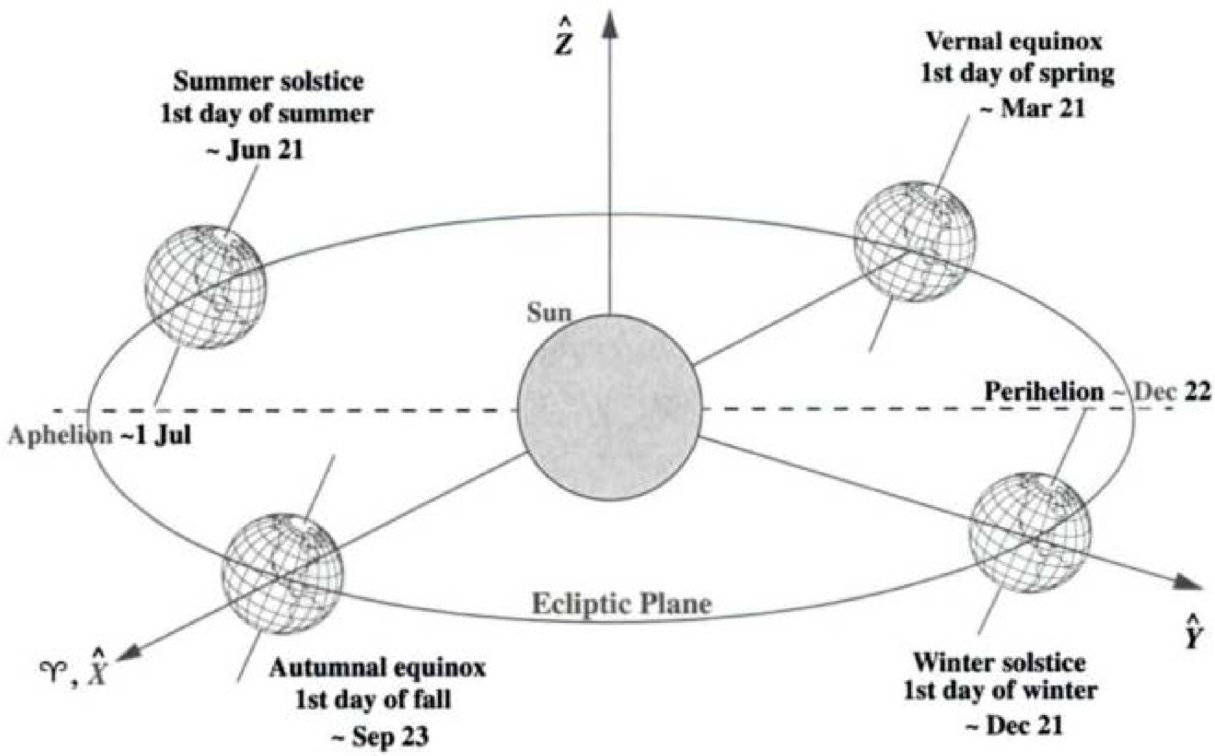
Q.6 a. Explain Heliocentric-ecliptic, geocentric equatorial co-ordinate system and co-ordinates of a point on the earth. (8)

Answer:

The origin of Earth-based systems may be at the Earth's center (geocentric), or at a site on the Earth's surface (topocentric), or off the Earth's surface. These coordinate systems are the basis for most operations in this book. As we do for the heliocentric system, we can define a barycentric system ($I_B J_B K_B$) and a rotating synodic system ($I_S J_S K_S$) that are very useful in the restricted three-body problem. Remember the Earth-Moon barycenter is about 4671 km from the geocenter, in the direction of the Moon.

Geocentric Equatorial* Coordinate System, *IJK

This system originates at the center of the Earth, as the name implies, and is designated with the letters IJK. The fundamental plane is the Earth's equator, as shown in Fig. The *I* axis points towards the vernal equinox; the *J* axis is 90° to the east in the equatorial plane; the *K* axis extends through the North Pole.



b. Explain what is meant by apogee height and perigee height? The Cosmos 1675 satellite has an apogee height of 39342 Kms and perigee height of 613 Kms. Determine the semi major axis and eccentricity of its orbit. Assume a mean earth radius of 6371 Kms. (8)

Answer:

Q.7 a. What are the specific advantages of static channel allocation over dynamic channel allocation strategies? (8)

Answer:

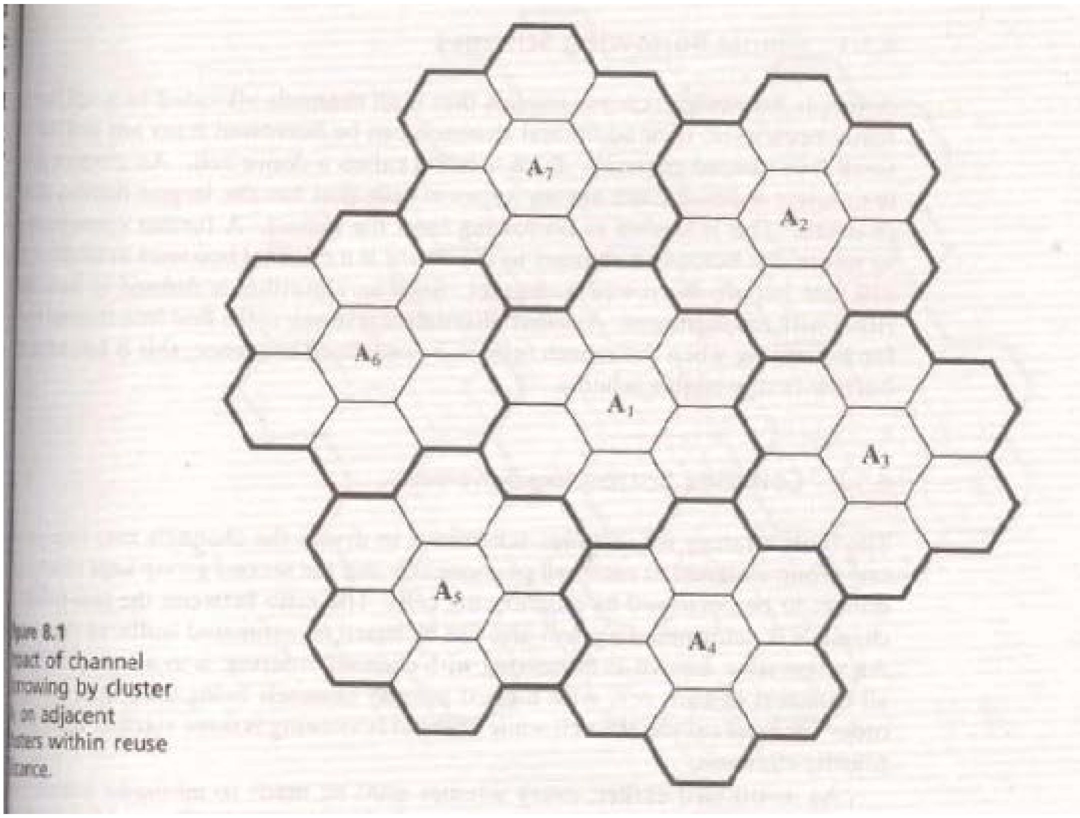
8.2 Static Allocation versus Dynamic Allocation

There are two ways by which traffic channels can be allocated to different cells i a FDMA/TDMA cellular system: static and dynamic. In static allocation, a fixe number of channels is allocated to each cell, while dynamic allocation implies th allocation of channels to different cells is done dynamically, as needed, possib from a central pool. There are many possible variations of channel allocation, eac having specific characteristics and offering different advantages. Even within a sta scheme, an equal number of channels can be allocated to each cell, or nonunifor fixed channel allocation (FCA) could be done based on the amount of traffic i different cells (which is based on past statistical information). Another alternativ is to combine some aspects of both FCA and dynamic channel allocation (DCA schemes.

In brief, channel allocation schemes can be classified as follows:

1. Fixed channel allocation (FCA)
2. Dynamic channel allocation (DCA)
3. Hybrid channel allocation (HCA) [8.2]

There are many alternatives within each scheme, and some of the important ones are considered in this chapter.



b. Explain different parameters that influence handoff in mobile communication system. **(8)**

Answer:

9.4 Handoff Parameters and Underlying Support

Handoff basically involves change of radio resources from one cell to another adjacent cell. From a handoff perspective, it is important that a free channel is available in a new cell whenever handoff occurs, so that undisrupted service is available.

9.4.1 Parameters Influencing Handoff

As discussed in Chapter 5, handoff depends on cell size, boundary length, signal strength, fading, reflection and refraction of signals, and man-made noise. If we make a simplistic assumption that the MSs are uniformly distributed in each cell, we can also say that the probability of a channel being available in a new cell depends on the number of channels per unit area. From Table 5.1, it can be easily observed that the number of channels per area increases if the number of channels allocated per cell is increased or if the area of each cell is decreased. The radio resources and hence the number of assigned channels are limited and may not be changed to a great extent. However, the cell coverage area could be decreased for a given number of channels per cell. This leads to a smaller cell size and may be good for the availability of free channel perspectives. However, this would cause more frequent handoffs, especially for MSs with high mobility and speed.

Handoff can be initiated either by the BS or the MS, and it could be due to

1. The radio link
2. Network management
3. Service issues

Radio link–type handoff is primarily due to the mobility of the MS and depends on the relative value of the radio link parameters. Radio link–type handoff depends on

- Number of MSs that are in the cell
- Number of MSs that have left the cell
- Number of calls generated in the cell
- Number of calls transferred to the cell from neighboring cells by the handoff
- Number and duration of calls terminated in the cell
- Number of calls handed off to neighboring cells
- Cell dwell time

Network management may cause handoff if there is a drastic imbalance of tra over adjacent cells, and optimal balance of channels and other resources are requ Service-related handoff is due to degradation of quality of service (QoS), and hand could be invoked when such a situation is detected.

The factors that define the right time for handoff are

- Signal strength
- Signal phase
- Combination of the above two
- Bit error rate (BER)
- Distance

The need for handoff is determined in two different ways:

1. Signal strength
2. Carrier-to-interference ratio (CIR)

An example of handoff based on received power has been covered in Figure 5.5. In addition to the power level of the received signal, another important aspect is the value of CIR in a cell at a given location. A low value of CIR may force the BS to change the channel currently being used between the BS and the MS. Handoff could also occur if directional antennas are employed in a cell and a MS moves from one sector to another sector of the cell (or one beam area to another in a SDMA system). The handoff procedure and associated steps depend on the cellular systems, and the specific units involved in setting up a call are as follows:

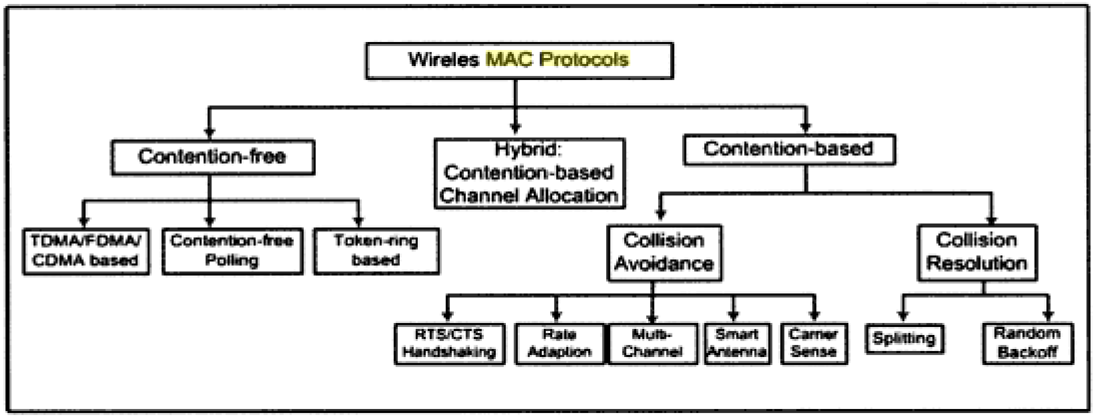
1. Base station controller (BSC)
2. Mobile station (MS)
3. Mobile switching center (MSC)

Q.8 a. What is meant by Hybrid routing protocols? Highlight the major issues that affect the design, deployment and performance of ad-hoc networks. (8)

Answer:

b. Classify the various MAC protocols and explain one example for each of them. (8)

Answer:



Wireless MAC protocols can be broadly categorized as contention-based, contention-free and hybrid, depending on the channel access mechanisms. Contention-free MAC protocols such as TDMA/CDMA/FDMA based protocols allow each station to access the channel by a predetermined time slot, code sequence or frequency band. Since the channel access schedule is fixed, the transmission is guaranteed to be conflict-free. The polling scheme can be used as alternative contention-free algorithm. It requires the centralized controller to poll each station at a time, and the polled station is allowed to transmit data packets within the permitted duration. All these algorithms require the coordination of a central controller, such as a base station or an access point. The token-ring based wireless MAC protocol provides a distributed way to offer contention-free channel access. More specifically, a token is circulated among all stations in the network in a round-robin fashion. A station can only transmit data when it seizes the token. Many contention-free protocols assume full connectivity of the network, and therefore, it is problematic apply them to the multihop wireless networks without incurring excessive overhead.

The contention-based MAC protocols allow stations to access the channel randomly when they are ready to transmit. As a result, packet collision is inevitable. There are many proposed algorithms and protocols to utilize the channel more efficiently, as we have discussed in the previous section. The contention-based algorithm provides great flexibility to the network, since there is no predetermined schedule to follow. A contention-based protocol usually works well when the network load is light. When the network load is heavy, many stations attempt to access the channel simultaneously, causing the system performance downgraded. On the contrary, the contention-free algorithm defines rigid channel access rules on how to schedule data transmission. When a network load is light, there is bandwidth waste since some stations that are given the resources have no data to transmit. But a contention-free protocol often is superior in heavily loaded networks, since stations don't need to waste time and bandwidth to contend the channel, and transmission delay is bounded. A hybrid MAC protocol combines both strategies to offer contention-based channel allocation to wireless stations. Such protocols can provide better QoS for multihop delay-sensitive networks.

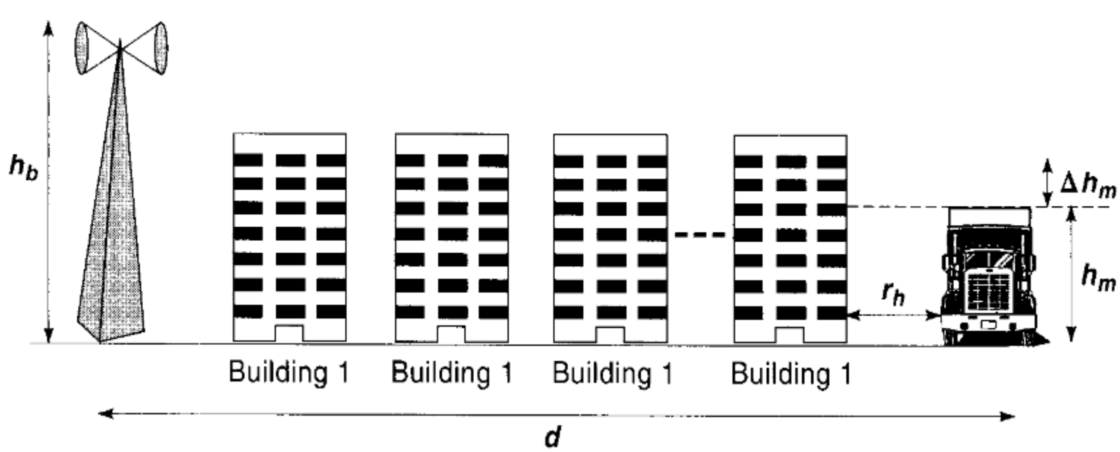
Q.9 a. What is meant by microcell path loss prediction model? Explain with suitable relation. Only one sample relation for various parameters need be given. (8)

Answer:

Microcells are cells that span hundreds of meters to a kilometer or so and are usually supported by below rooftop level base station antennas mounted on lampposts or utility poles. The shapes of microcells are also no longer circular (or close to circular) because they are deployed in streets in urban areas where tall buildings create *urban canyons*. There is little or no propagation of signals through buildings, and the shape of a microcell is more like a cross or a rectangle, depending on the placement of base station antennas at the intersection of streets or in between intersections. The propagation characteristics are quite complex with the propagation of signals affected by reflection from buildings and the ground and scattering from nearby vehicles. For obstructed paths, diffraction around building corners and rooftops become important. Many individual scenarios should be considered, unlike radio propagation in macrocells.

As usual, d is the distance between the mobile terminal and the transmitter in kilometers, h_b is the height of the base station in meters, h_m is the height of the mobile terminal antenna from the ground in meters, and f_c is now the center frequency of the carrier in GHz that can range between 0.9 and 2 GHz.

Environment	Scenario	Path Loss Expression
Low Rise	NLOS	$L_p = [139.01 + 42.59 \log f_c] - [14.97 + 4.99 \log f_c] \operatorname{sgn}(\Delta h)\log(1 + \lvert\Delta h\rvert) + [40.67 - 4.57 \operatorname{sgn}(\Delta h) \log(1 + \lvert\Delta h\rvert) \log d + 20 \log (\Delta h_m/7.8) + 10 \log (20/r_h)$
High Rise $h_m = 1.6$m	Streets perpendicular to the LOS streets	$L_p = 135.41 + 12.49 \log f_c - 4.99 \log h_b + [46.84 - 2.34 \log h_b] \log d$
	Streets parallel to the LOS Streets	$L_p = 143.21 + 29.74 \log f_c - 0.99 \log h_b + [47.23 - 3.72 \log h_b] \log d$
Low Rise + High Rise	LOS	$L_p = 81.14 + 39.40 \log f_c - 0.09 \log h_b + [15.80 - 5.73 \log h_b] \log d$, for $d < d_{bk}$
		$L_p = [48.38 - 32.1 \log d] + 45.7 \log f_c - (25.34 - 13.9 \log d) \log h_b + [32.10 + 13.90 \log h_b] \log d + 20 \log (1.6/h_m)$, for $d > d_{bk}$



b. Mobile terminal is 500 ft from cell site antenna which is 30 ft high. Three buildings in line between mobile terminal and cell site antenna of cross section widths 50, 100

and 150 ft respectively. ERP = + 30 dBm (1Watt). Calculate received power at mobile terminal. (8)

Answer:

$$\alpha_B = 1.2 + 12.5 \log(300 \text{ ft}/25 \text{ ft})$$
$$= 1.2 \text{ dB} + 13.5 \text{ dB}$$
$$= 14.7 \text{ dB}$$

The receive signal level, P_r, is

$$P_r = -53.79 \text{ dBm} - 14.7 \text{ dB}$$
$$= -68.47 \text{ dBm}$$

Of course, we must assume that the sum of the gain of the receive antenna and the transmission line loss equals 0 dB so that P_r is the same as the isotropic receive level.

TEXT BOOK

I. **Introduction to Wireless and Mobile Systems, Second Edition (2007), Dharma Prakash Agrawal and Qing-An Zeng, Thomson India Edition**