CMR INSTITUTE OF TECHNOLOGY

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Internal Assesment Test - II

Sub:	WIRELESS COMMUNICATION							Code:	10EC81
Date:	8/ 5/ 2017	Duration:	90 mins	Max Marks:	50	Sem:	VIII	Branch:	ECE(A,B)
Answer Any FIVE FULL Questions									

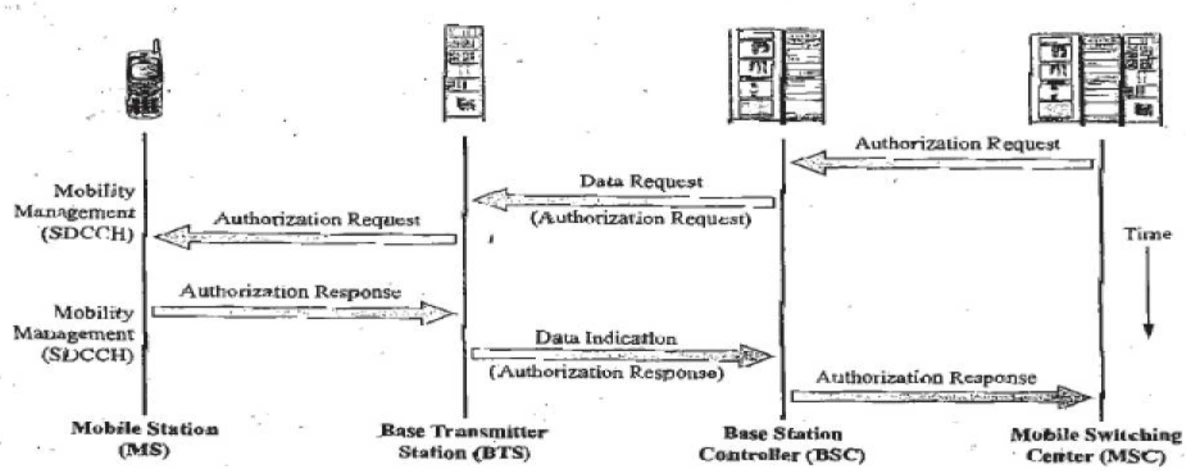
		Marks	OBE	
			CO	RBT
1.	List the different GSM call-setup operations. Explain service request and authentication with relevant diagrams.	[10]	CO1	L4
2.	Explain Inter-MSC Handover in GSM.	[10]	CO1	L2
3.a)	What is the received power in dBm for a signal in free space with a transmitting power of 1W, frequency of 1900 MHz and distance from the receiver of 1000m if the transmitting antenna and receiving antennas both use dipole antennas with gains of approximately 1.6? What is the path loss in db?	[05]	CO3	L3
b)	Discuss (i) Free space propagation model (ii) Two-ray model.	[05]	CO1	L2
4.	With the neat block diagrams, illustrate the basic spreading procedure of CDMA Forward Logical Channels. Explain paging channel in detail.	[10]	CO5	L3
5.	Explain: (i) Mobile Terminated Call operation. (ii) Multipath fading and Doppler effect.	[05] [05]	CO1	L2
6.	Discuss the different CDMA Handoff operations with relevant diagrams.	[10]	CO2	L3

IAT 2 Solutions

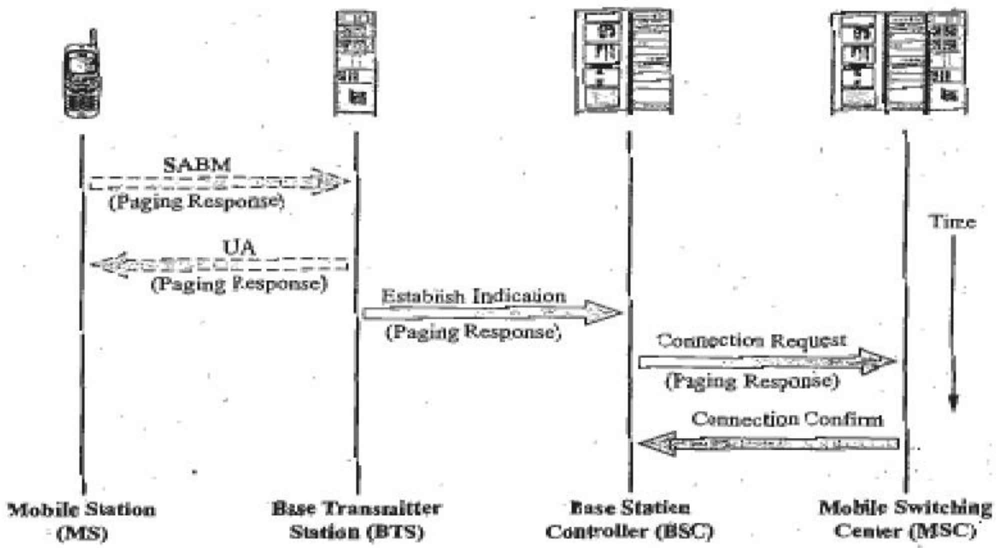
1. **List the different GSM call-setup operations. Explain service request and authentication with relevant diagrams.**

- Interrogation (only for mobile terminating calls)
- Radio Resource Connection Establishment
- Service Request
- Authentication
- Ciphering Mode Setting
- IMEI number check
- TMSI allocation
- Call initiation
- Assignment of a Traffic Channel
- User alerting signaling
- Call Accepted Signaling

Authentication The next step in the call setup procedure is authentication. The authentication process in shown in Figure 5–28. Depending upon the exchange properties stored in the MSC/VLR, as set up by the GSM operator, authentication is either activated or not activated. If authentication is activated, an authentication request message is sent transparently to the MS. The message containing a 128-bit random number (RAND) and the ciphering key sequence number (CKSN) is sent to the MS over the stand-alone dedicated control channel (SDCCH) from the BTS. The MS stores the CKSN and then calculates the value of a signed response (SRES) by using the RAND, the value of k_I (the subscriber authentication key that is stored in the SIM card), and K_C in several authentication algorithms (known as A3 and A8). The value of SRES is returned to the MSC/VLR as a transparent authentication response message. Between the BSC and the BTS a data request frame and a data indication frame are used to pass the Layer 3 message as shown. A timer is set in the MSC/VLR when the first authentication request message is sent. If the timer expires, the request is sent again. If the timer expires a second time, the radio resources (the channel) are released.



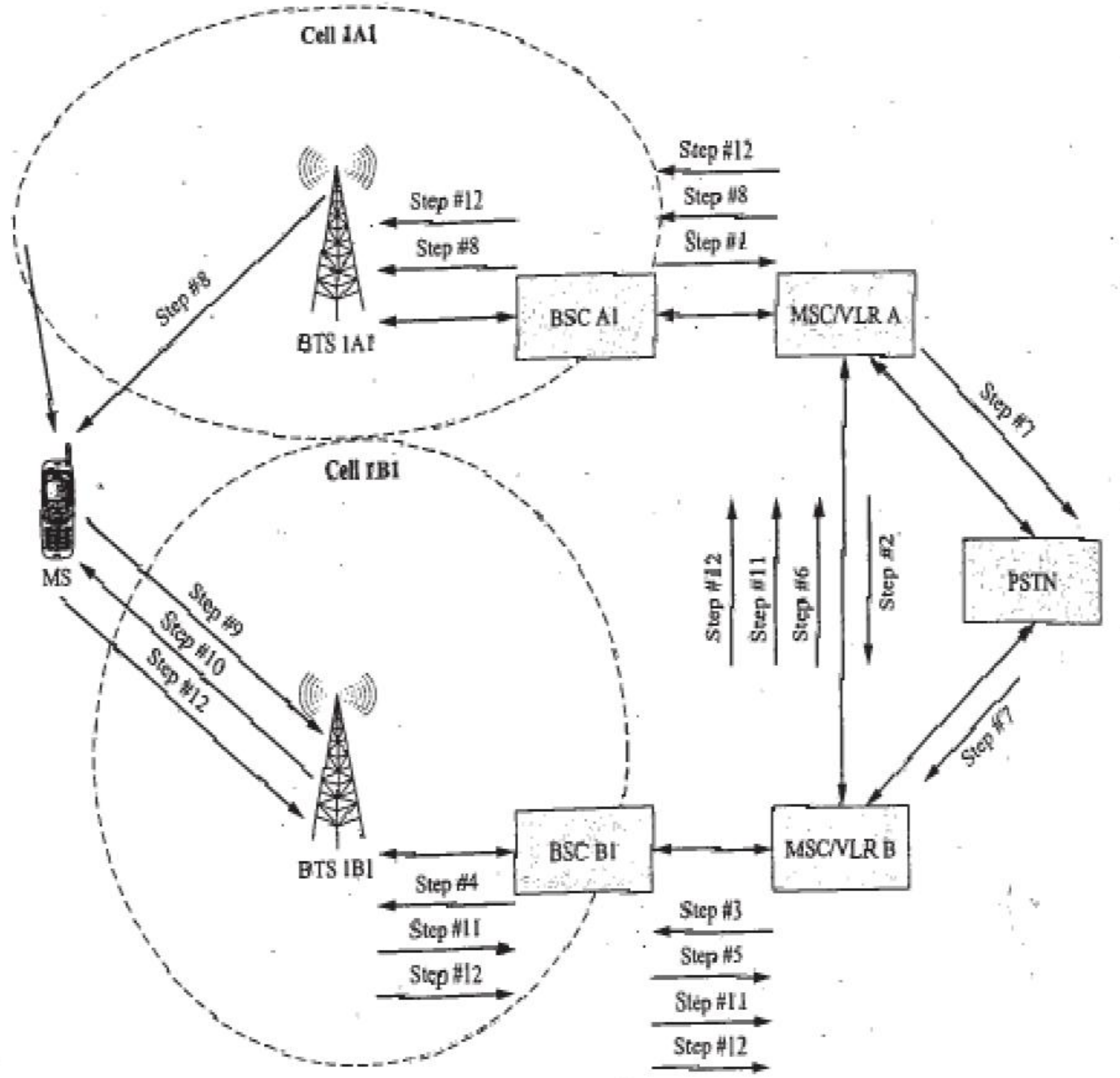
Service Request The service request phase occurs as soon as the MS has tuned to the new channel assigned to it by the immediate assignment message sent during the radio resource connection phase. Figure 5–27



shows these operations. At this time, a Layer 2 message known as set asynchronous balanced mode (SABM) is sent from the MS to the BTS. This Layer 2 message contains a Layer 3 message (i.e., the information field of the Layer 2 message contains the paging response message). Shortly thereafter, the BTS sends back to the MS a Layer 2 message in an unnumbered acknowledgement (UA) frame that contains the original paging response message. This operation prevents the chance occurrence of two MS accessing the same channel simultaneously.

The paging response message from the MS contains information about the MS identity, the ciphering key sequence number, and the MS class mark. When the paging response arrives at the BTS it is forwarded to the BSC in an establish indication message. This message causes the BSC to activate radio connection quality supervision and initiates power control algorithms for the dynamic control of the MS output power level. The paging response message from the MS is to be eventually delivered to the MSC and therefore the BSC sends it on to the MSC as a connection request message after it adds the CGI number to the Layer 3 information contained in the original paging response message. Finally, the MSC sends a connection confirm message back to the BSC. This means that the circuit-switched connection is established on the A interface.

2. **Explain Inter-MSC Handover in GSM.**



(1) Handover request is sent by serving BSC (A1) to MSC A.
(2) MSC A requests assistance from MSC B.
(3) MSC B provides MSC A with handover number and sends new BSC (B1) a handover request.
(4) New BSC (B1) sends handover activation order to new BTS (1B1).
(5) BSC sends handover information to new MSC.
(6) Handover information is send to old MSC.
(7) A signaling/traffic link is set up between the two MSCs.
(8) Handover message is sent to MS.
(9) MS sends handover access burst to new BTS.
(10) New BTS sends timing advance information to MS.
(11) Old MSC is sent handover detected message.
(12) MS sends handover complete message to new BSC.
BSC sends handover complete message to the old BSC.
Old BSC sends channel deactivation message to old BTS (1A1).

Inter-MSC Handover

Another possible handover that can occur is when the BSC decides that a handover should occur and the new cell belongs to another MSC. This type of handover is known as an inter-MSC and is shown by Figure 5–44. For this handover to be performed, Step #1, has the BSC sending a handover required message to the serving MSC as was the case for the inter-BSC handover. In Step #2, the serving MSC asks the new MSC for help. In Step #3, the new MSC allocates a "handover number" in order to reroute the call to

the new MSC. Also, a handover request is sent to the new BSC. In Step #4, the new BSC sends a command to the new BTS to activate an idle TCH. In Step #5, the new MSC receives the information about the new TCH and handover reference. In Step #6, the TCH description and the handover reference is passed on to the old MSC with the handover number. In Step #7, a signaling/traffic link is set up from the serving MSC to the new MSC. In Step #8, a handover command message is sent to the MS with the necessary information about channel and timeslot to be used in the new cell and the handover reference to use in the handover access burst. In Step #9, the MS tunes to the new TCH and sends handover access bursts on the FACCH. In Step #10, the new BTS detects the handover access bursts and then sends timing advance information to the

MS on the FACCH. In Step #11, the old MSC is informed about the handover access bursts (this info comes from the new BSC and MSC). In Step #12, a handover complete message is sent from the MS. The new BSC and MSC inform the old MSC. The old MSC informs the old BSC and the old BSC sends a message to the old BTS to release the old TCH. In this procedure the old MSC maintains control of the call until it is cleared. In this process, the old MSC is called the anchor MSC.

Since the call entered a new location area, the MS is required to perform a location updating as soon as the call is released. During this operation, the HLR is updated as to the whereabouts of the MS. Also, the HLR will send a cancel location message to the old VLR telling it to delete all stored information about the MS (again, this operation is known as a VLR purge).

Other Handover Operations

There is the possibility of an intercell handover. This can occur when the channel quality is worse than that expected from the RSS measured values. This would entail a change to a new TCH from an old TCH within the same cell. The handover of SMS occurs on the SDCCH. The procedure is identical to that used for the TCH. Also, there is the possible need to hand over the SDCCH during the call setup operation.

3 (a) What is the received power in dBm for a signal in free space with transmitting power of 1W, freq of 1900 MH and distance from Rxr is 1000 mts if the txting antenna and receiving antennas both use dipole antennas with gains of approximately 1.6 ? What is the path loss in dB.

Solution: $\lambda = c/f = \frac{3\times10^8}{1900\times10^6} = \underline{\underline{0.1579\ m}}$ (1M)

$$P_0 = P_T G_T G_R \left(\frac{\lambda^2}{(4\pi)^2}\right)$$

$$= 1\times1.6\times1.6 \left(\frac{0.1579}{4\times\pi}\right)^2 = 4.04\times10^{-4} \text{ Watts}$$ (1M)

$$P_R = \frac{P_0}{d^2} = \frac{4.04\times10^{-4}}{1000^2 ~~\times 1mW~~} = \frac{4.04\times10^{-4}}{1000^2} = 4.04\times10^{-10} \text{ W}$$

$= -93.9\underline{\underline{3}} \text{ dB}$ (2M)

For dBm → divide by 1mW

$$\therefore P_R = \frac{4.04\times10^{-10}}{10^{-3}} = 4.04\times10^{-7} \text{ W}$$

$= \underline{\underline{-63.93\ dBm}}$ [Received power in dBm] (2

W.K.T. $1\ W = 30\ dBm$. (1M)

Path loss = $P_T - P_R$ (1M)

= ~~30dBm - (-63.93)dBm~~.

= ~~93.93 dBm~~

In dB (1M)

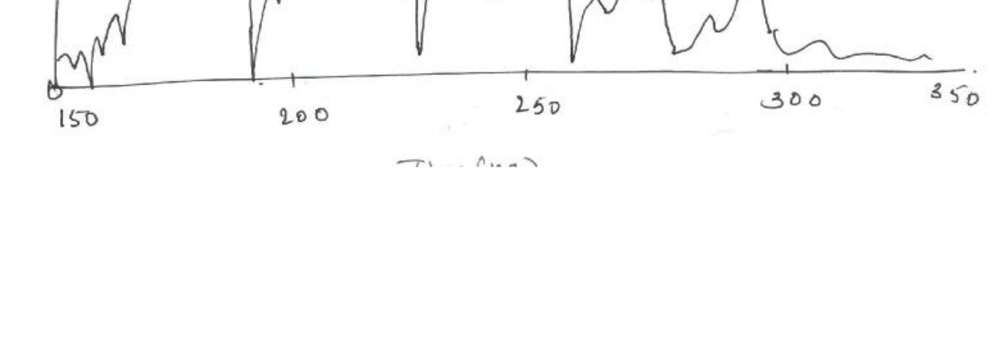
$= 30dB - (-93.93)dB$

Path loss. = $\underline{\underline{113.93\ dB}}$ (1M). [Path loss in dB]

3(b) Write a brief note on (i) multipath fading (5M)
(ii) Doppler Effect (5M)

(i) Multipath fading:

* Multipath is the common term used to describe a propogation sce
* The path loss models have been used to estimate the average received signal strength (RSS) for a given point at some distance from the transmitter.
* Multipath fading leads to both time dispersion of the received signal & frequency selective fading.
* Typically both fading effects are modeled as Rayleigh distributions or, if there is a dominant LOS propogation pat as Rician distributions.
* The major effect of multipath spread is an increase in inter-symbol interference (ISI) if the delay spread is either comparable or larger than the symbol time.
* Channel equalization & directional antennas are the techniques employed to mitigate this effect.

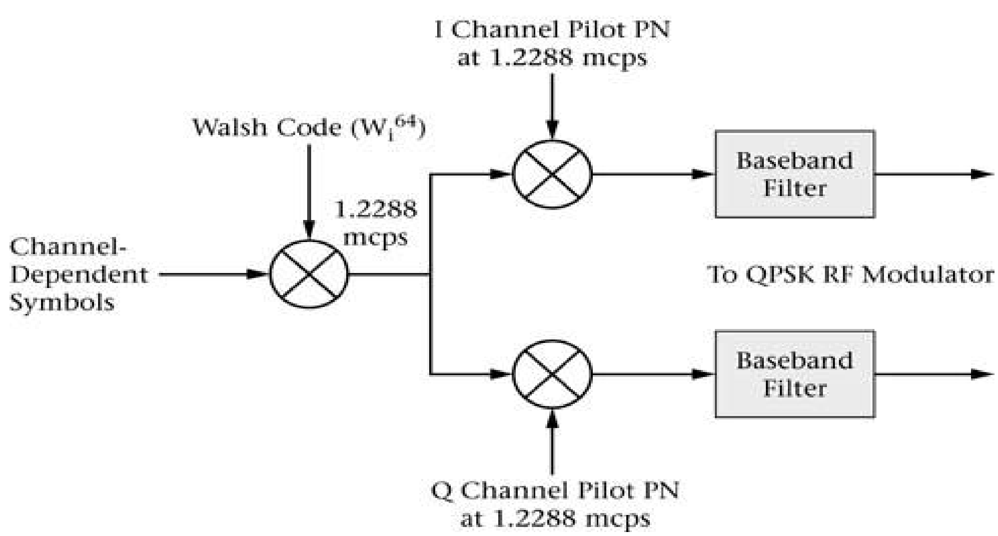


(ii) Doppler Effect:

* Doppler effect occurs due to the motion (rapid) of the mobile itse
* The rapid changes in signal phase due to the equally rapid cha in signal propogation distance cause rapid & deep fluctuatio in RSS.
* The Doppler Effect is the change in frequency or wavelength a wave for an observer moving relative to its source.
* The distance between successive wave fronts is then increased. So the waves spread out.
* The Doppler effect also affects the light emitted by other bodies in space.

4. With the neat block diagrams, illustrate the basic spreading procedure of CDMA Forward Logical Channels. Explain paging channel in detail.

Basic Spreading Procedure



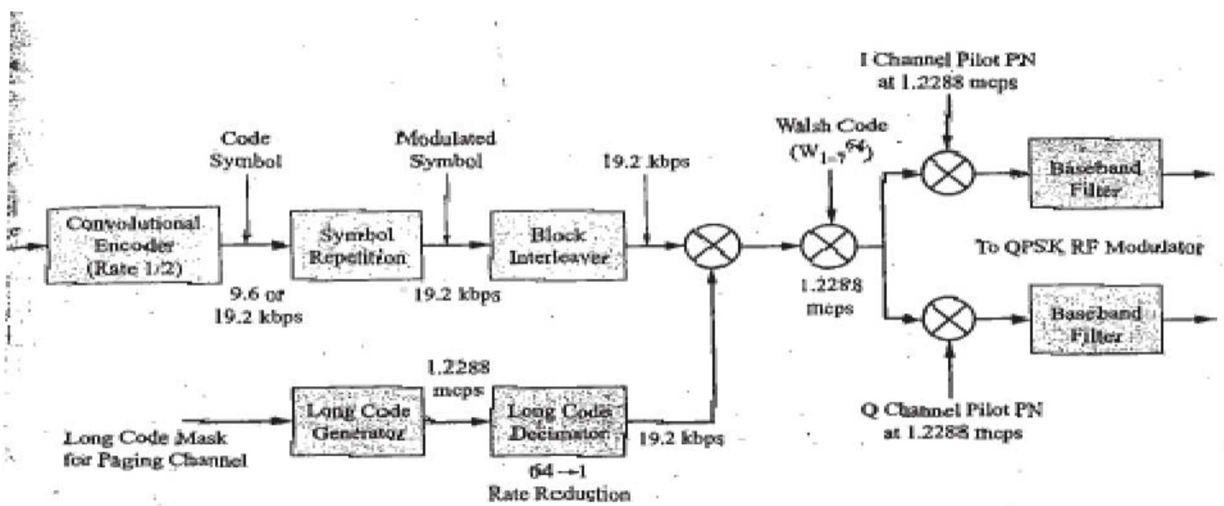
The basic spreading procedure used on the forward CDMA channels is illustrated by Figure 6–11. As shown in Figure 6–11, the digital signal to be transmitted over a particular forward channel is spread by first Exclusive-OR'ing it with a particular Walsh code (W_i^{64}). Then the signal is further scrambled in the in-phase (I) and quadrature phase (Q) lines by two different short PN spreading codes. These short PN spreading codes are not orthogonal codes; however, they have excellent cross-correlation and auto-correlation properties that make them useful for this application. Additionally, it seems that all Walsh codes are not created equal when it comes to the amount of spectrum spreading they produce. Therefore, the use of the short PN spreading code assures that each channel is spread sufficiently over the entire bandwidth of the 1.25-MHz channel. The short in-phase and quadrature PN spreading codes are generated by two linear feedback shift registers (LFSRs) of length 15 with a set polynomial value used to configure the feedback paths of each of the LFSRs (for additional information about this process see the present CDMA standards). The resulting short PN spreading codes are repeating binary sequences that have approximately equal numbers of 0s and 1s and a length of 32,768. The outputs of the in-phase and quadrature phase signals are passed through baseband filters and then applied to an RF quadrature modulator integrated

Paging Channel

Paging Channels

The CDMA paging channels serve the same purpose as the paging channels in a GSM cellular system. These channels are used to page the SDs when there is a mobile-terminated call and to send control messages to the SDs when call setup is taking place. Figure 6–15 depicts the generation of a paging channel message.

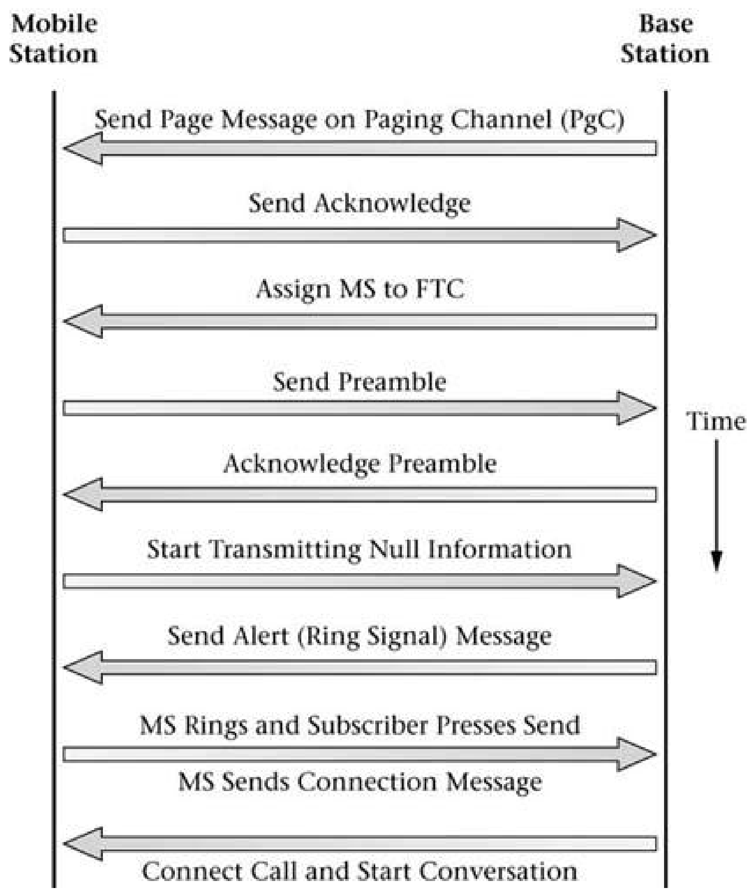
For IS-95 CDMA there can be as many as seven paging channels in operation at any one time. Walsh codes W_1^{64} through W_7^{64} are used for this purpose. As seen in Figure 6–15, the paging channel undergoes an additional scrambling operation using the long PN spreading code sequence. The long PN code is generated by using a 42-bit linear feedback shift register that yields a repeating sequence of length 2^{42}. The paging channel message also goes through a convolutional encoding process, symbol repetition, and block interleaving before being scrambled by a slower version of the long PN code.



5. **Explain: (i) Mobile Terminated Call operation.** [05]

(ii) Multipath fading and Doppler effect. [05]

i) Mobile Terminated Call



Mobile-Terminated Call For a mobile-terminated call, the base station sends a message to the mobi[...] the paging channel. If attached to the system, the mobile sends an acknowledgement response on the acc[...] channel. The base station receives the acknowledgement, configures a forward traffic channel, and assig[...] a receiver to the mobile's reverse traffic channel. The base station begins to send null traffic on the F[...]

and sends a PgC message containing Walsh code and RTC information. The mobile configures itself and begins decoding the null traffic and transmitting a preamble on the RTC. The base station acknowledges the preamble sent on the RTC. The mobile receives the acknowledgement and begins transmitting null traffic on the RTC. The base station sends an alert message for a ring tone and the display of calling number information. The mobile acknowledges the message by ringing the handset and displaying the calling number information. When the subscriber answers the incoming call a connection message is sent on the RTC. The base station acknowledges the connection message and begins to send traffic. See Figure 6–29. Again, the current standards provide much more detail for the interested reader.

ii) Multipath fading and Doppler Effect

Refer to answer 3(b) mentioned earlier

3b) Discuss i) Free space propogation nodel

ii) Two-ray model

Answer: i)

The first **path loss** model to consider is that for free space propagation. It may be shown fairly easily that without any outside influences the propagating signal power of an EM wave decreases by the square of the distance traveled as it spreads out. Therefore, the EM wave undergoes an attenuation of −6 dB every time the distance it travels doubles. The power received from an antenna radiating P_T watts in free space is given by the following equation (known as the Friis equation):

$$P_R = P_T G_T G_R \left(\frac{\lambda}{4\pi d}\right)^2 \tag{8-1}$$

where G_T and G_R are the transmitting and receiving antenna link gains, respectively, λ is the signal wavelength, and d is the distance from the transmitting antenna. A typical technique to simplify the usage of this equation is to rewrite it as:

$$P_R = P_0/d^2 \tag{8-2}$$

where P_0 is the received signal strength at a distance of one meter. Once P_0 has been calculated, it is a simple task to determine the received signal strength at other distances. Also important to note here is that in the free space environment the velocity of propagation for an EM wave translates into an approximately 3.3-ns-per-meter time delay. This means that it takes 3300 ns for a signal to travel a distance of 1000 meters in free space. This fact will be called upon later in our further discussions about multipath propagation. At this point, a free space path loss example is appropriate.

ii)

A simple first approximation model for a land mobile outdoor environment is known as the two-ray model. This model assumes a direct LOS signal between the transmitter and the receiver (similar to free space propagation) and another signal path that consists of a reflected signal off of a flat surface of the earth (also known as a ground reflection). For this scenario the two path lengths will vary depending upon the antenna heights, and the reflected and LOS signal can vary in intensity due to the motion of the mobile and other variations in propagation conditions. Therefore, the composite signal received at the mobile station antenna will consist of EM waves that add either constructively or destructively. An equation that approximates this behavior is:

$$P_R = P_T G_T G_R \left(\frac{h_T^2 h_R^2}{d^4} \right) \quad \text{8-4}$$

where, h_T and h_R are the heights of the transmitting and receiving antennas. Several important details that one can discern from this equation are that the higher the antenna heights are above ground the more the received signal power is and that the power falls off by the distance raised to the fourth power for large values of d (i.e., $d \gg \sqrt{h_T h_R}$). This last fact is quite illuminating since it basically doubles the EM wave attenuation rate from −6 dB to −12 dB every time the distance the wave travels doubles. This result is more indicative of the true behavior of a land mobile radio link. Now an approximate equation for path loss using the two-ray model can be written as:

$$Path\ Loss = 40 \log d - (10 \log G_T + 10 \log G_R + 20 \log h_T + 20 \log h_R) \quad \text{8-5}$$

Another popular model for relating the received signal power to the radio link distance is to use the following equation:

$$P_R = P_0 d^{-\alpha} \quad \text{8-6}$$

where α is known as the distance-power gradient. As we have previously discussed, $\alpha = 2$ for free space ... for the two-ray model. It is not unreasonable to assume that for both indoor and

6. **Discuss the different CDMA Handoff operations with relevant diagrams.**

Call Handoff

The specifications for IS-95 CDMA delineate three mobile station states during which a handoff can occur. Referring back to Figure 6–24, these states are the idle state, access state, and traffic state. The procedures used and the type of handoff performed will depend upon the mobile's present state. In all cases, the handoffs are mobile assisted since the mobile station is tasked with reporting signal-strength measurements of various pilot channels to the network. As is typical with any wireless mobile system, handoff occurs when the serving sector/cell is no longer capable of supporting communications between the mobile and itself. CDMA is unique in that it supports soft/softer handoffs. There are several advantages to this type of handoff including improved system performance for the support of voice traffic calls and the support of high-speed data transfers. The details of these handoff operations will be presented next.

Idle/Access Handoff

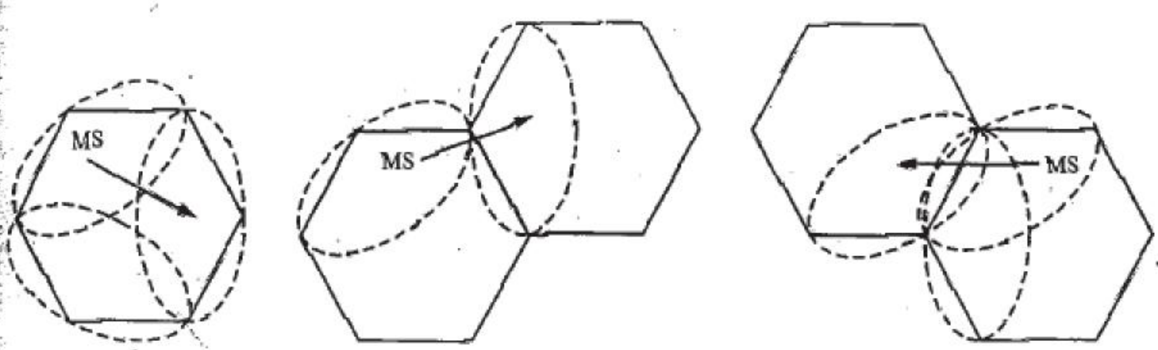
If the mobile is in the idle state and moves from the coverage area of one sector/cell into another sector/cell, an idle handoff can occur. When the received signal strength of a different pilot channel (PC) is determined to be twice as strong (3 dB greater) than the current PC, the mobile will start listening to the paging channel (PgC) associated with the stronger PC. This type of handoff is considered a form of hard handoff since there is a brief interruption of the communication link. But it is certainly different from and less disrupting than a hard handoff that might occur when the mobile is in the traffic mode.

While the mobile is in the access state, it can also perform a handoff. The access handoff may occur before the mobile begins sending access probes, during access probes, and even after it receives an access probe acknowledgement. An access entry handoff allows the mobile to perform a hard idle handoff from one PgC to another in the best signal-strength sector/cell just after the mobile enters the access state. After the mobile has started to send access probes, it can perform an access probe handoff if it detects a stronger pilot signal that may provide it a better chance of receiving service. Even after the mobile has received an access probe acknowledgement, a handoff to a stronger pilot may be possible and necessary to prevent an access failure due to the rapid motion of the mobile away from the current pilot and its base station.

Soft Handoff

A distinct advantage of the CDMA system is that it can support soft handoffs. Basically, a **soft handoff** occurs when the mobile is able to communicate simultaneously with several new cells or a new sector of the current cell over a forward traffic channel (FTC) while still maintaining communications over the FTC of the current cell or sector. The mobile station can only perform a soft handoff while in the traffic state to a new cell or sector that has the same frequency carrier. The use of soft handoffs is associated with the near-far problem and the associated power control mechanism used in CDMA systems. If a mobile moves away from a base station and continually increases its output power to compensate for the signal attenuation encountered at the greater distance, it will cause a great deal of interference to mobiles in neighboring cells and raise the level of background noise in its own cell. To alleviate this problem and to make sure that the mobile is connected to the base station with the greatest RSS, a strategy employing soft handoffs has been designed into CDMA wireless mobile systems. In theory, the optimal CDMA system operation will occur when each mobile is connected to the nearest base station (the base station with the strongest signal) and is transmitting with the lowest output power necessary for proper operation. In fact, the use of soft handoff can actual improve system performance since the procedure used can actually lower reverse link output power because the received signal from several base stations can be combined. A carefully implemented soft handover process can enhance system performance by increasing call quality, improving coverage, and increasing capacity.

Figure 6–30 depicts the three types of soft handoffs defined in the IS-95 CDMA standard. The first type of handoff is known as a *softer* handoff since the handoff is between two sectors of the same cell. A *soft* handoff occurs between two different cells and a *soft-softer* handoff can occur when the motion of the mobile gives it a handoff choice between two sectors of the same cell and a sector from an adjacent cell.



(a) Softer Handoff (b) Soft Handoff (c) Soft Softer Handoff

Figure 6–30 Three types of soft CDMA handoff.

In all CDMA handoff procedures a number of base stations and their pilot channels are involved. The procedures for soft and softer handoffs control the manner in which a call is maintained as a mobile crosses boundaries between cells or enters a new sector of the same cell. In a soft handoff, more than one cell simultaneously supports the mobile's call. In a softer handoff, more than one sector of a cell simultaneously supports the mobile's call. The CDMA mobile station will continuously scan for pilots and establish communication with any sector or cell (up to a maximum of three) that has a pilot RSS that exceeds a certain threshold value (T_ADD). In a similar fashion, the mobile will drop communications with a sector or cell that has a pilot RSS less than a certain threshold (T_DROP). Recall that each pilot has a different time offset for the same short PN sequence code. This fact is used to differentiate cells and sectors within the system. The mobile's identification of different pilot signals depends upon this property. Since the offsets are integral multiples of a known time delay, the mobile's search for the pilots is made easier. The mobile will categorize pilots that it receives as well as other pilots that the serving sector/cell specifies to it into the following groups: an active set that consists of the pilots that are currently supporting the mobile's call, a candidate set that consists of pilots that based upon their RSS could support the mobile's call, a neighbor set that consists of pilots not in the active or candidate set but that are geographically nearby, and a remaining set of pilots that consists of the rest of the pilots within the system.

The mobile's continuous assessment of pilot RSS and a set of adjustable threshold values will determine the movement of pilot signals within these sets. These measurements, in conjunction with information received from the serving sector/cell and mobile station timers, give rise to dynamically changing sets if the mobile moves about the system. Figure 6–31 depicts a simplified flowchart of this process.

To complete our coverage of this topic, let us compare soft/softer handoff to handoff in other systems. In most other access technologies a mobile station moving from one sector/cell to another must switch to an available channel in the new sector/cell. This process requires a brief interruption of the communications link. Since a CDMA system reuses the same frequency in every sector/cell within the system, soft/softer handoff does not cause an interruption in the communications link. This fact is extremely important when it comes to the ability of the system to transmit high-speed data since there is no potential loss of data due to a hard handover. Furthermore, the use of soft/softer handoff gives rise to improved system performance as previously mentioned. With soft/softer handoff reduced mobile transmit power is

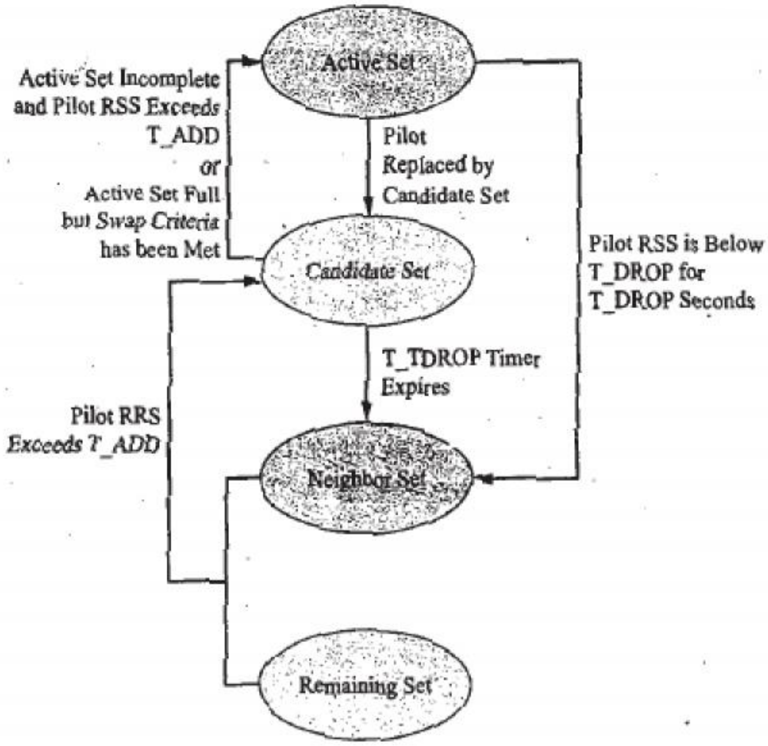


Figure 6–31 Flowchart of the generation of the active and candidate pilot set for CDMA handoff operations.

possible because of the inherent gain involved with the use of multiple receivers. With soft handoff, the MSC selects the best signal on a frame-by-frame basis of those received (this could be up to three different signals). This process tends to mitigate signal impairments that occur during transmission over the air interface. With softer handoff, the increase in performance is realized at the base station by a combining of the signals from multiple sectors.

Hard Handoff

A CDMA mobile in the *traffic state* can also experience a hard handoff. This will occur for the case of an intercarrier handoff. Intercarrier handoff causes the radio link to be *abruptly interrupted* for a short period while the base and mobile station switch from one carrier frequency to another. There are two basic types of intercarrier handoff: a **hand-down** is a hard handover between two different carriers within the same cell, and a handover is a hard handoff between two different carriers in two different cells. The circumstances necessary to cause a hard handoff can be due to the particular coverage area implementation of a service provider or the less frequent case of the existence of two service providers in adjacent areas.

In the first case, known as a pocketed implementation, a service provider might use a second CDMA carrier in individual or noncontiguous cells to provide additional capacity during system growth or for local high-traffic hot spots. Figure 6–32 depicts a possible scenario of this situation. A mobile that is using the second carrier and exiting the pocket of second-carrier cells must be handed off to the common carrier to continue the call. The best way to perform this handoff is to first hand down the call to the common carrier before the mobile leaves the pocketed area. Then a soft handoff can be performed as the mobile moves across the border from the pocketed area into the surrounding service area.

Typically, this process of hand-down occurs, if possible, at the border cells (sectors) of the pocketed area. In general, border cells (sectors) must be identified and configured to operate in a slightly different fashion than nonborder cells (sectors). In Figure 6–32 this can be more readily accomplished for the pocket in the middle of the system but is not as easily achieved for the pockets in the lower left and right corners

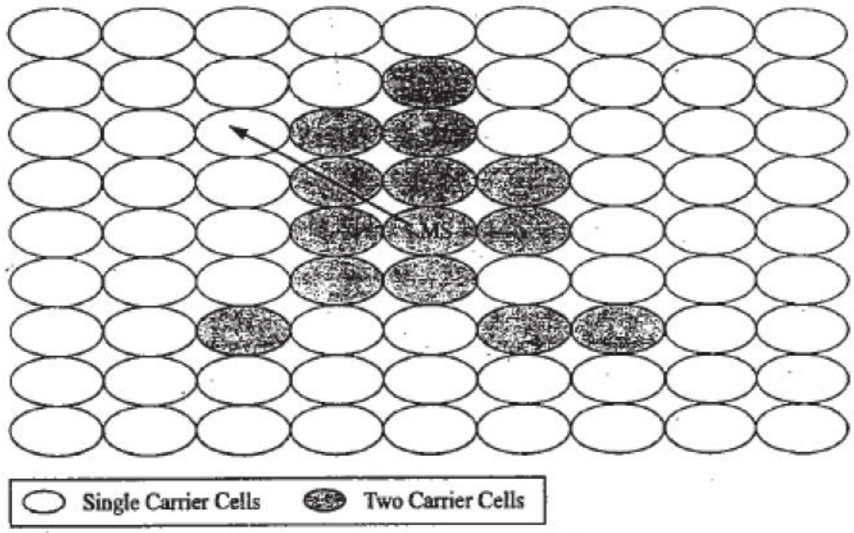


Figure 6–32 Hard CDMA handoffs due to intercarrier handoff.

of the diagram. Usually, careful examination of cell geometry and local traffic routes can aid in the selection of a border cell (sector).

When a mobile enters a border sector, it is instructed by the base station to issue frequent pilot-strength measurement messages. This process allows the sector to more closely monitor the mobile's status instead of waiting for reports triggered by other pilot events. If the pilot report indicates that the sector's pilot has dropped below a certain threshold level, the base station directs the mobile to hand down to the first carrier. The value of threshold used in this process forces this hand-down to occur before the mobile has reached the edge of the sector. This process allows sufficient time for the normal soft handoff to occur as the mobile exists at the border sector. This type of process will work well for a large pocket with well-defined border cells but does not work well where insufficient first-carrier capacity is available to accommodate the required hand-down as might be the case for an isolated cell with a second carrier. In the latter case, the solution is to expand the second-carrier pocket so that it has sufficient first-carrier capacity to handle normal first-carrier traffic and hand-downs. In the case where a second carrier is added to a cell to facilitate hand-downs instead of providing normal traffic relief, the term *transition cell* is used instead of border cell. The area around the original isolated cell is known as the transition zone and hand-down is only allowed in the transition zone providing relief for the heavily loaded original cell.

It is possible to have disjoint systems where distinct CDMA carriers exist in different regions due to issues such as the availability of appropriate spectrum. Figure 6–33 depicts this situation. The most common methods used to provide handoff between the two regions is to implement a border area that supports the use of both carrier frequencies and is configured to provide hand-down as previously described or to simply execute a hard handoff from one carrier to the other as the mobile crosses the border between the two regions.

The first scenario works well for a clearly defined border area with a predictable flow of traffic. However, if a mobile might be expected to turn around within the border area and return to the region it had previously left, a more complex border area must be created to prevent the possibility of thrashing (extremely undesirable) between the two carriers. The last situation requires the identification of border cells that facilitate the handover from one carrier to the other. These border cells are configured to make frequent pilot-strength measurements and use a threshold value that will cause a handover from the host (current) cell to the target (future) cell in the vicinity of the border between the two cells.

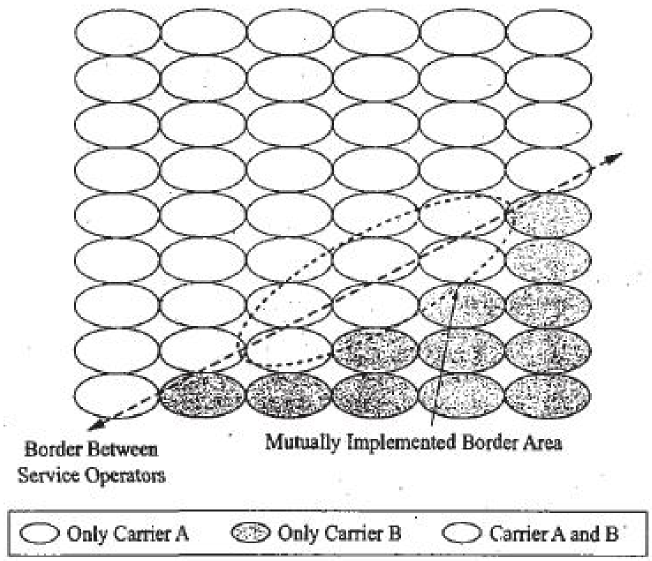


Figure 6–33 Hard CDMA handoffs due to disjointed regions.