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Internal Assesment Test - II

Sub:	WIRELESS COMMUNICATION							Code:	10TE73
Date:	03 / 11/ 2016	Duration:	90 mins	Max Marks:	50	Sem:	VII	Branch:	TCE

Answer Any FIVE FULL Questions

		Marks	OBE CO	OBE RBT
1.	List the different GSM call-setup operations and explain any two using relevant diagrams.	[10]	CO1	L1,L2
2.	Explain Inter-MSC Handover in GSM.	[10]	CO2	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?	[06]	CO3	L3
(b)	Write a brief note on (i) Multipath fading (ii) Doppler effect	[04]	CO1	L2
4	With the neat block diagrams, illustrate the basic spreading procedures, pilot channel and synchronization channel in CDMA Forward Logical Channels.	[10]	CO5	L3
5(a)	Differentiate between FHSS and DSSS.	[04]	CO2	L4
(b)	Explain RAKE Receiver with a neat block diagram.	[06]	CO4	L2
6	Discuss the different CDMA Handoff operations.	[10]	CO2	L3
7	Explain: (i) Mobile Terminated Call operation	[05]	CO1	L2
	(ii) Smart Antenna Technology	[05]	CO4	L2

Course Outcomes		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1:	Explain the basics of propagation of radio signals	3	-	-	-	-	-	-	-	-	2	-	-
CO2:	Explain how radio signals can be used to carry digital information in a spectrally efficient manner.	3	-	-	-	-	-	-	-	-	2	-	-
CO3:	Explain how radio signals can be used to carry digital information in a power efficient manner.	3	1	-	-	-	-	-	-	-	2	-	-
CO4:	Identify diversity afforded by radio propagation to improve performance	3	-	2	1	1	-	-	-	-	2	-	-
CO5:	Explain the design considerations for effective spectrum sharing through multiple access	3	1	-	-	-	-	-	-	-	2	-	-
CO6:	Illustrate technologies used in Time Division Multiple Access (TDMA), Code Division Multiple Access (CDMA) and WiFi Networks.	3	-	-	-	1	1	-	-	-	2	-	1

Cognitive level	KEYWORDS
L1	List, define, tell, describe, identify, show, label, collect, examine, tabulate, quote, name, who, when, where, etc.
L2	summarize, describe, interpret, contrast, predict, associate, distinguish, estimate, differentiate, discuss, extend
L3	Apply, demonstrate, calculate, complete, illustrate, show, solve, examine, modify, relate, change, classify, experiment, discover.
L4	Analyze, separate, order, explain, connect, classify, arrange, divide, compare, select, explain, infer.
L5	Assess, decide, rank, grade, test, measure, recommend, convince, select, judge, explain, discriminate, support, conclude, compare, summarize.

PO1 - *Engineering knowledge*; PO2 - *Problem analysis*; PO3 - *Design/development of solutions*; PO4 - *Conduct investigations of complex problems*; PO5 - *Modern tool usage*; PO6 - *The Engineer and society*; PO7- *Environment and sustainability*; PO8 – *Ethics*; PO9 - *Individual and team work*; PO10 - *Communication*; PO11 - *Project management and finance*; PO12 - *Life-long learning*

IAT - 2 SOLUTIONS

1. List the different GSM Call-setup operations & explain any two using relevant diagrams. (10M)

1) Interrogation
2) Radio Resource Connection Establishment
3) Service Request
4) Authentication
5) Ciphering Mode Setting
6) IMEI Number check.
7) TMSI Allocation
8) Call Initiation
9) Assignment of a Traffic channel.
10) User alert signaling
11) Call Accepted signalling. (4M)

Explanation can be of any two of the above mentioned operations.

→ Flow Diagram ⟶ (2M)
→ Explanation ⟶ (1 M)

For Two operations → 3x3 = (6 M).

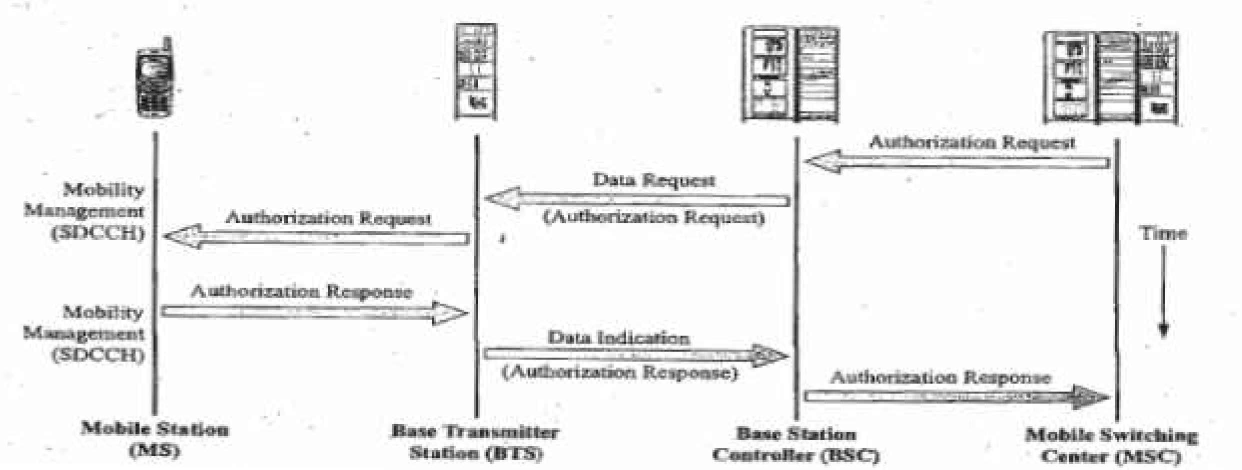
② Explain Inter-MSC Handover in GSM: (10M)

Steps and explanation ⟶ (5 M)
Diagram ⟶ (5 M)

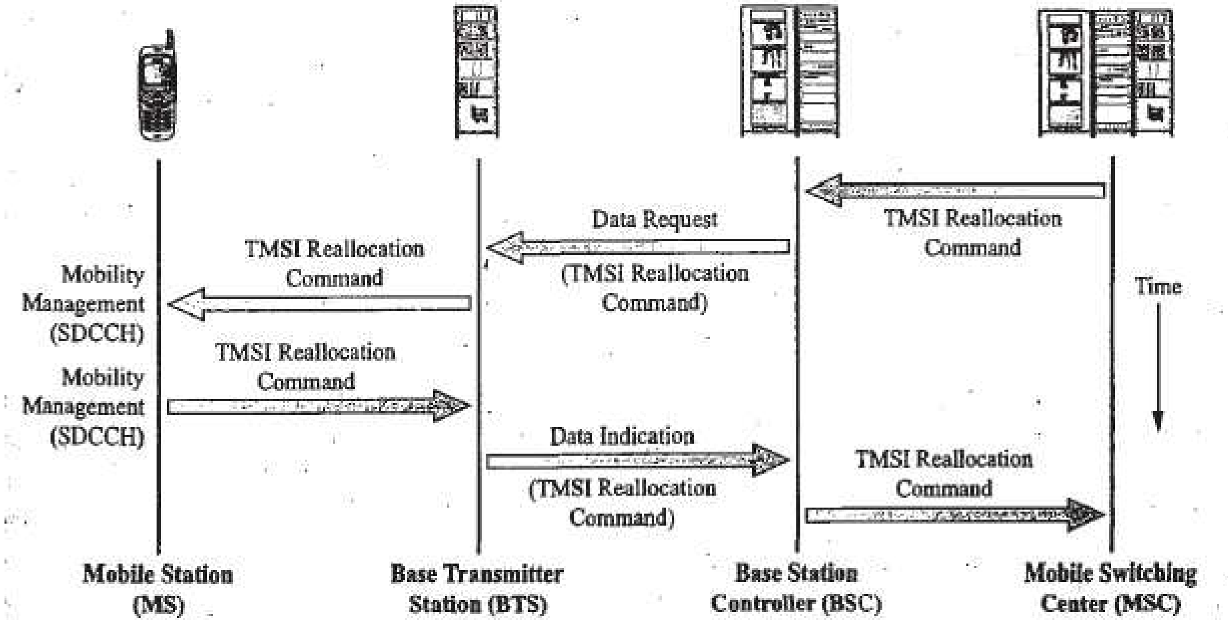
1. **List the different GSM call-setup operations and explain any two using relevant diagrams.**

- 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

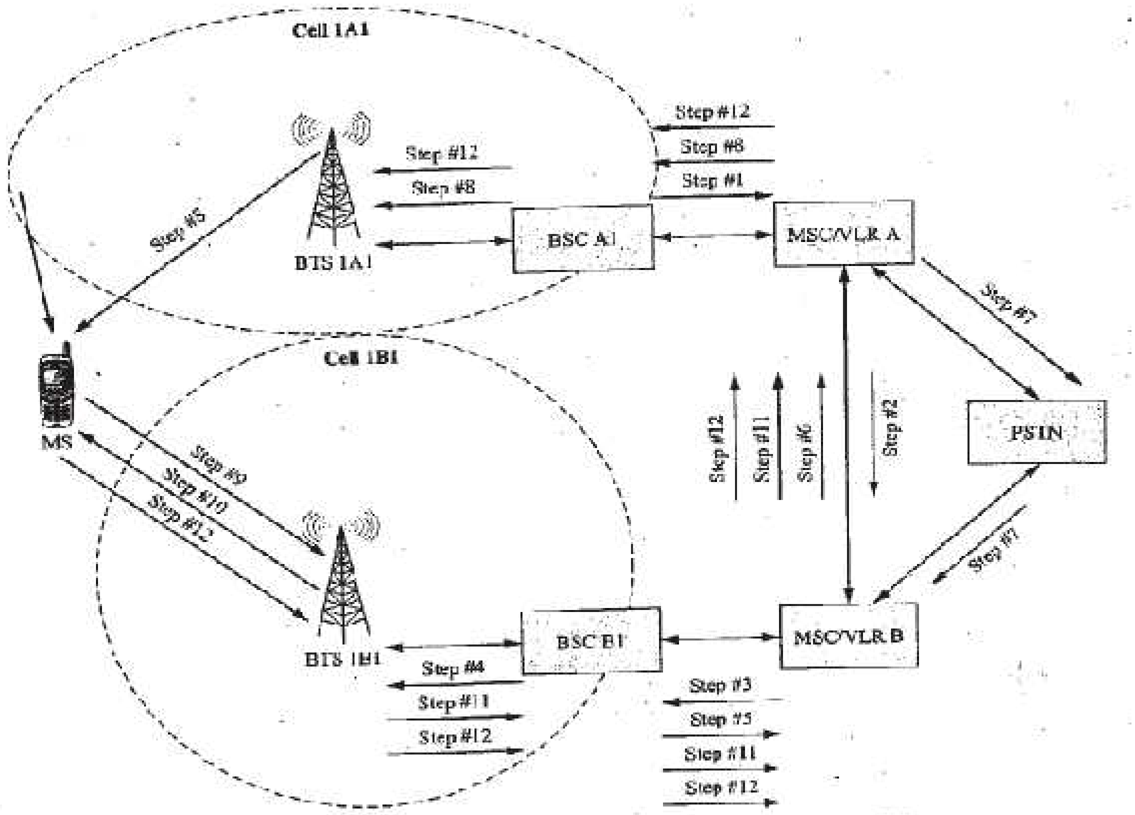
Authentication The next step in the call setup procedure is authentication. The authentication process in shown in Figure 5–28. Depending upon the exchange properties stored in the MSC/VLR, as set up by the GSM operator, authentication is either activated or not activated. If authentication is activated, 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.



TMSI Reallocation The value of the TMSI number to be used for a particular traffic case or if one will be used at all is determined by the MSC/VLR software program. If a TMSI number is to be used, it is sent transparently to the MS from the MSC/VLR via the TMSI reallocation command as shown in Figure 5–31. This mobility management message is transmitted over the SDCCH from the BTS to the MS. The value of the TMSI number is stored in the SIM card and a TMSI reallocation complete message is sent transparently from the MS to the MSC/VLR over an uplink SDCCH.



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).

3 (a) What is the received power in dBm for a signal in free space with transmitting power of 1 W, freq of 1900 MHz 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: $\lambda = c/f = \frac{3 \times 10^8}{1900 \times 10^6} = \underline{0.1549\ m}$ (1M)

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

$$= 1 \times 1.6 \times 1.6 \left(\frac{0.1549}{4 \times \pi} \right)^2 = 4.04 \times 10^{-4} \text{ Watts}$$ (1M)

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

$$= -93.93 \text{ dB}$$ (2M)

For dBm → divide by 1 mW

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

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

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

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

= ~~30 dB − (63.93) dBm~~

= ~~93.93 dBm~~

In dB (1M)

= 30 dB − (−93.93) dB

Path loss = $\underline{113.93 \text{ dB}}$ (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

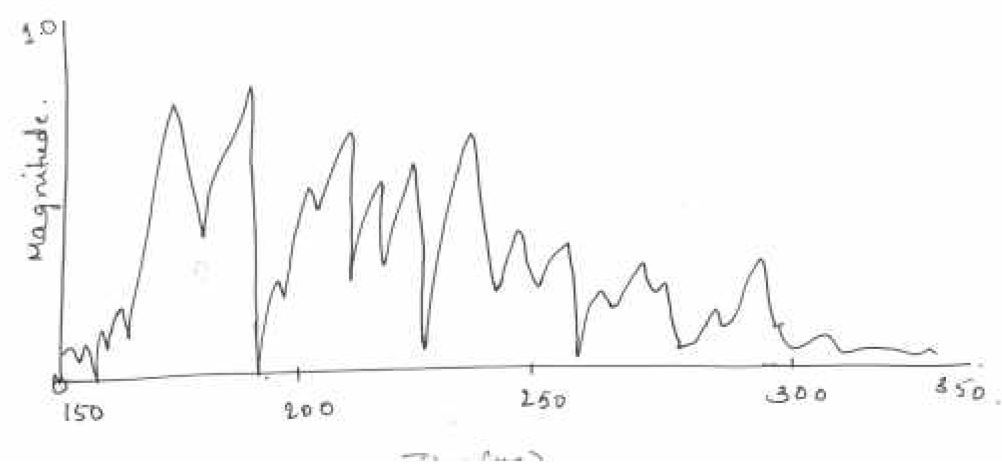
* The path loss models have been used to estimate the average received signal strength (RSS) for a given point at some distance from the transmitter.

* 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 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 wavefronts 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 procedures, pilot channel and synchronization channel in CDMA Forward Logical Channels.

Solution :

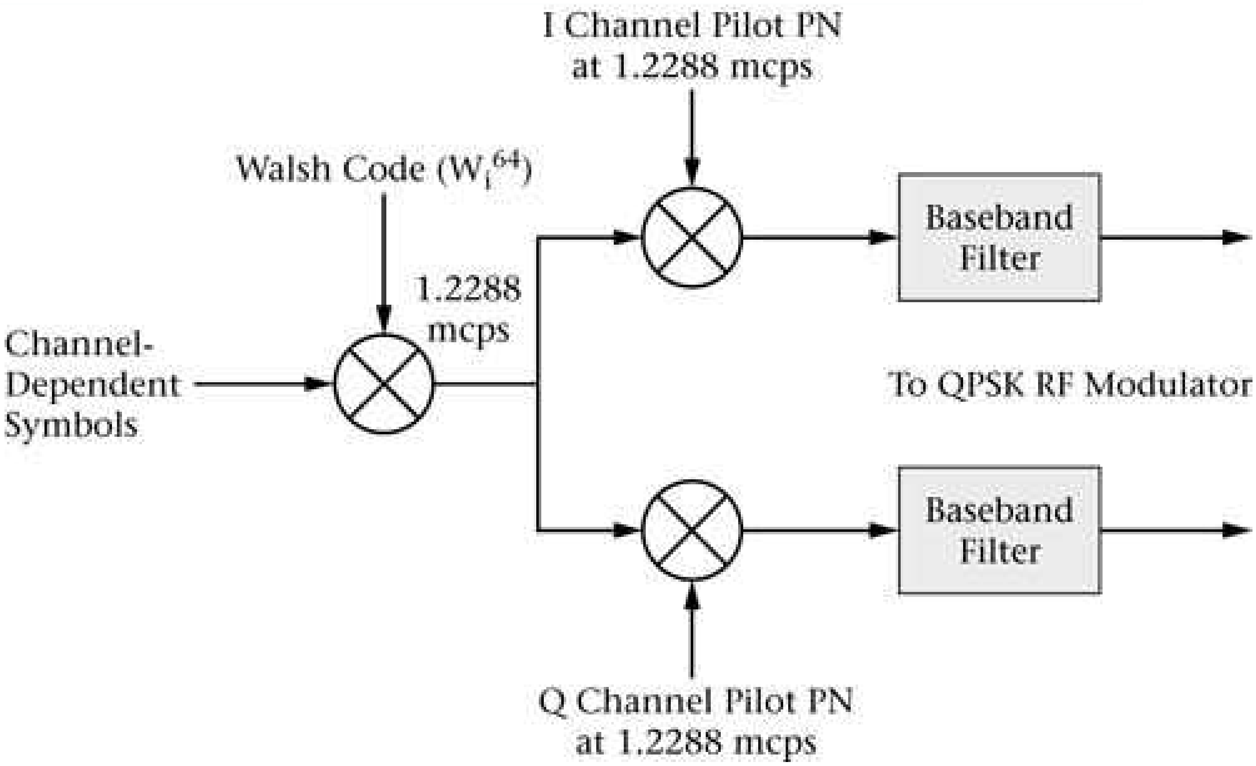
Basic spreading procedure.
- → Block diagram (1M
- → waveforms (1M
- → walsh code & explanat

Pilot channel
- → Block Diagram [2M]
- → Explanation [1M]

Synchronization channel
- → Block Diagram [2M]
- → Explanation [1M].

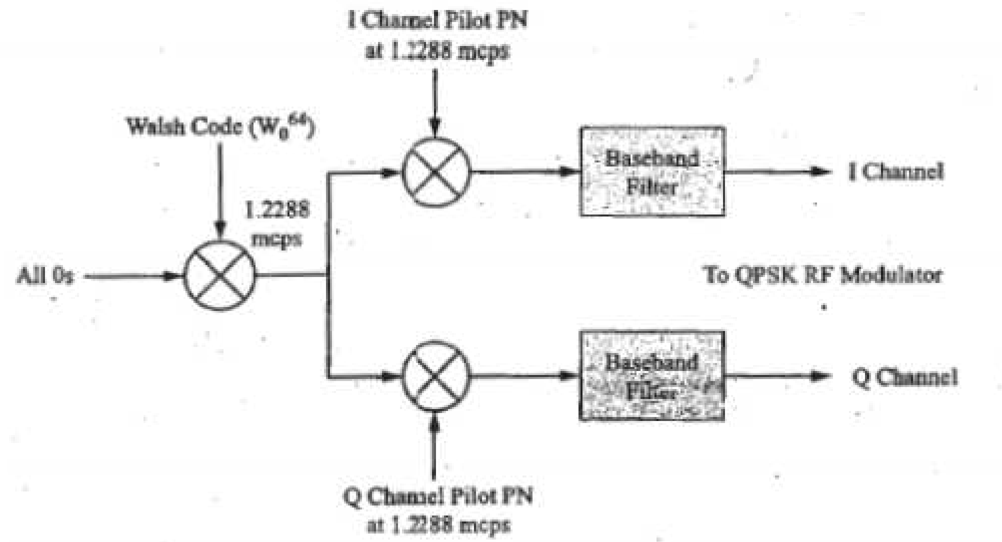
4. With the neat block diagrams, illustrate the basic spreading procedures, pilot channel and synchronization channel in CDMA Forward Logical Channels.

Basic Spreading Procedure



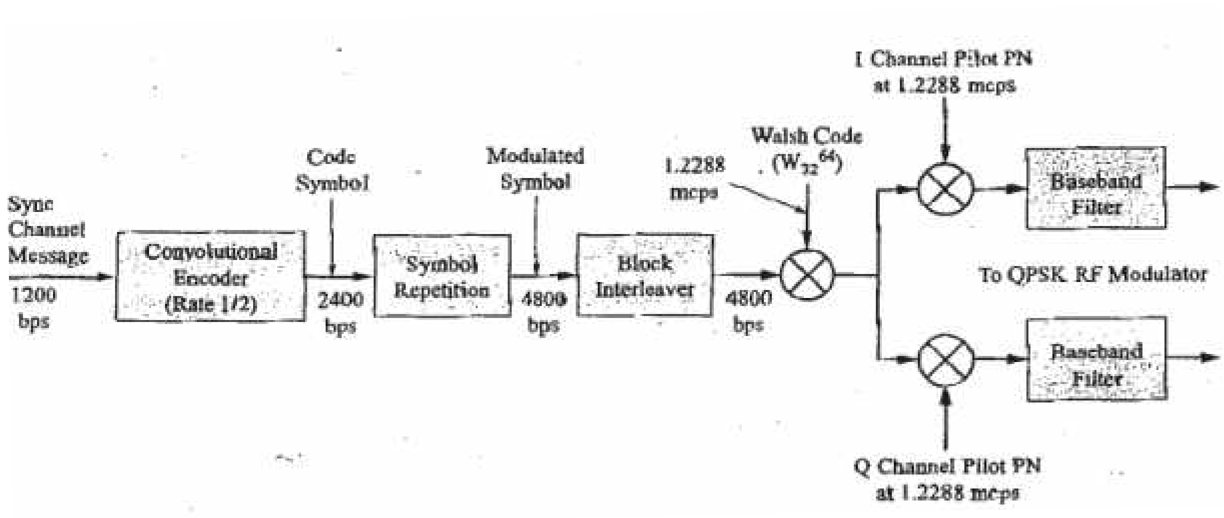
The basic spreading procedure used on the forward CDMA channels is illustrated by Figure 6–11. As shown in Figure 6–11, the digital signal to be transmitted over a particular forward channel is spread by first Exclusive-OR'ing it with a particular Walsh code (W_i^{64}). Then the signal is further scrambled 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

Pilot Channel:



- **Provides a reference signal for all the SDs within a cell.**
- **The all 0s Walsh codes (W_0^{64}) used for initial signal spreading on sequence of all 0's.**
- **Resulting signal is un-modulated spread spectrum signal.**
- **Short PN sequence is used to identify the Base station.**
- **4-6 dB stronger than any other channel (transmitted power)**

Synchronization Channel :

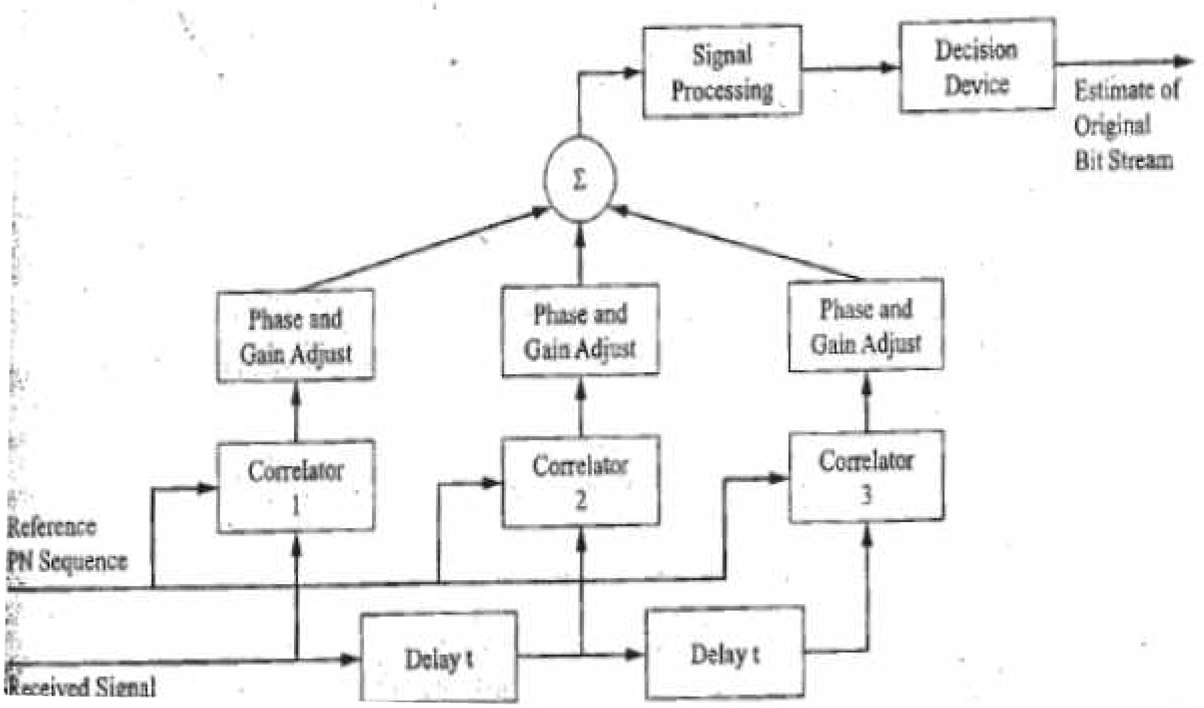


- **Initial time synchronization.**
- **Here Walsh code W_{32}^{64} (32 0’s and 32 1’s) is used to spread the synchronization channel signal.**
- **Even Synchronization channel message is also uses (32 0’s and 32 1’s).**
- **Short PN sequence is with offset and is used for further spreading.**
- **The synchronization message is about 1200 bps.**
- **The sync message undergoing convolution encoding, symbol repetition and Block inter-leaving by raising the rate to 4.6 kbps.**
- **Sync message includes system and Network identification codes, paging channel n data rates, offset values short PN spreading rate. (Fixed o/p power)**

5(a) Differentiate Between FHSS & DHSS

FHSS	DHSS
→ Frequency Hopping Spread Spectrum	→ Direct Sequence Spread Spectrum.
→ FHSS utilizes frequency hopping to spread the data into wider bandwidth	→ DSSS utilizes pseudo noise to modify the phase of the sign
→ Frequency hopping is achieved by dividing large Bandwidth into Smaller channels that would fit the data	→ DSSS spreads information across the band by introducing pseudo noise into the signal to change i phase at the given time.
→ FHSS changes the frequency being used	→ DSSS changes the phase.
→ It is easier to synchronize	→ Synchronization is difficult at receiver.
→ It is not used in positioning Systems	→ It is used in positioning Systems.

5 (b) Explain RAKE receiver with neat block Diagram



- Combat multipath fading effects.
- Exploit by isolating signal paths at the receiver
- If fading of multipath signal is different, the isolation process will yield diverse signals needed to improve receiver performance.
- RAKE receiver was introduced in 1950's for equalization of multipath.
- It posses the ability to dynamically adjust the taps in response to search algorithms and to locate multipath components.
- The smart receiver several signals combined by several standard diversity combining techniques that provide more reliable receiver output therefore improves the system performance.
- In cases where the CDMA systems do not suffer from ISI, these types of receivers can be implemented.

5(b) Explain RAKE Receiver with neat block diagram. (6M)

Block Diagram — (3M)
Explanation — (3M).

6. Discuss different CDMA Handoff operations (10M)

Idle Handoff → (1M)
Access Handoff → (1M)

Soft handoff
Softer Handoff
Soft - softer Handoff
} → Diagram → (1M), Explain → (1M) } Total 2×3 = 6M

Hard Handoff → (2M).

7 Explain: (i) Mobile Terminated Call operation (5M)
(ii) Smart Antenna Technology (5M)

(i) Mobile Terminated Call Operation

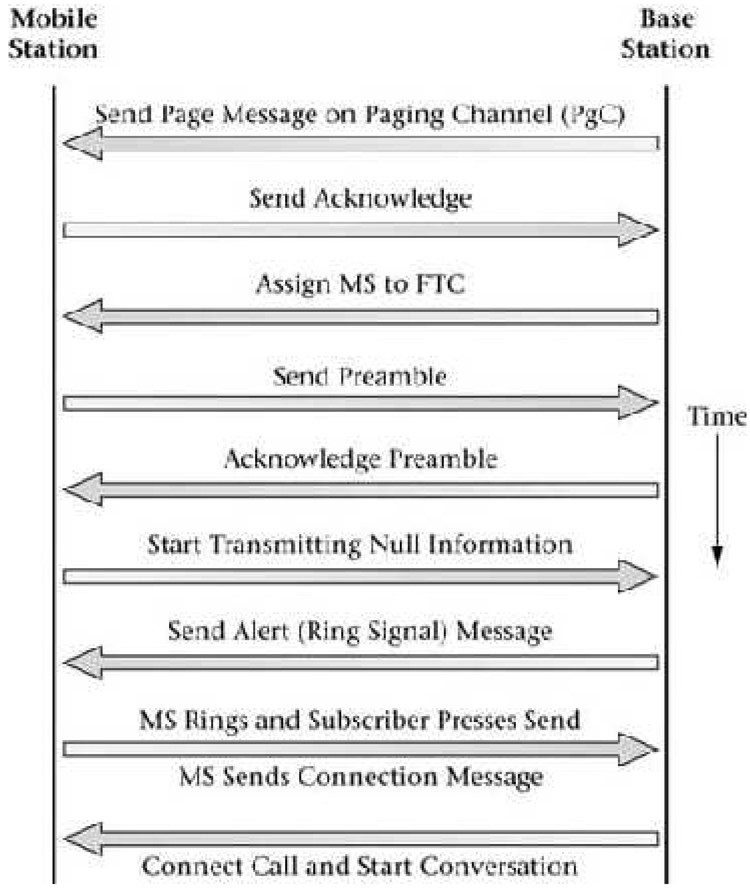
Flow Diagram → (3M)
Explanation → (2M)

(ii) Smart Antenna Technology

Diagram → (2M)
Explanation → (3 M)

7. Explain:

(i) Mobile Terminated Call Operation



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.

7 (ii) Smart - Antennas

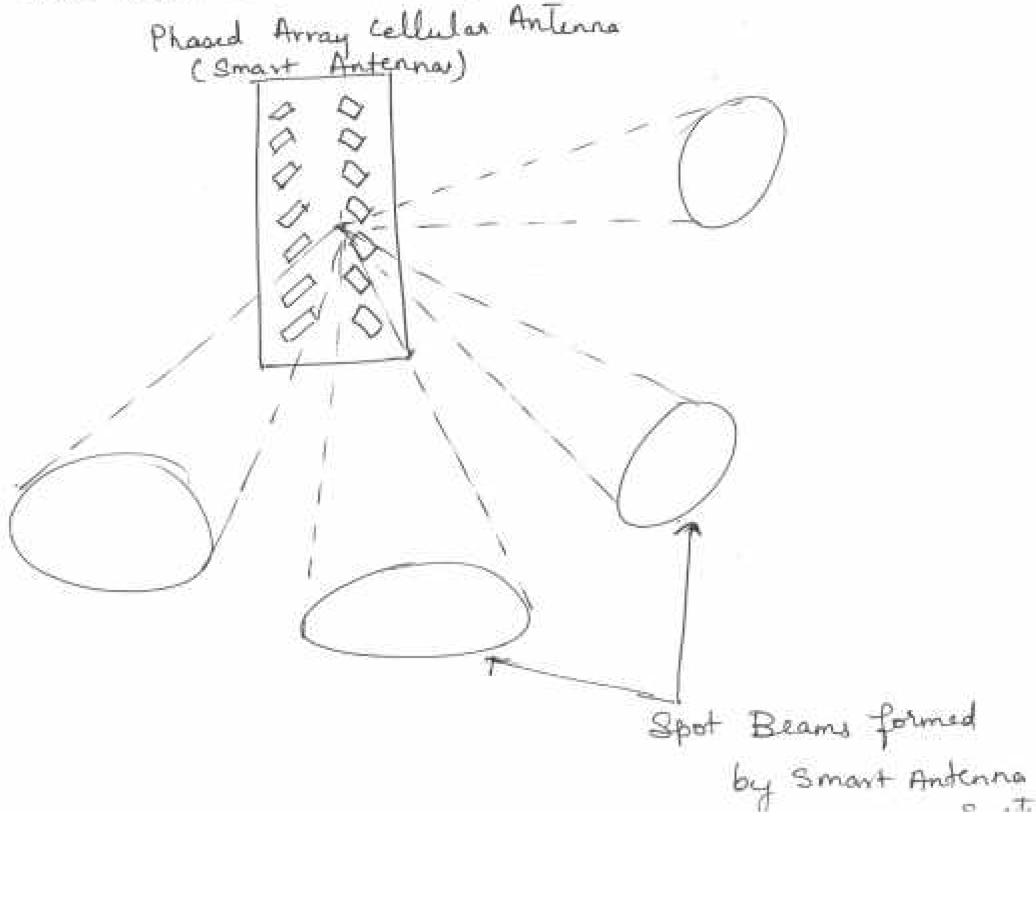
→ Technique to improve system performance makes use of phased array or "beam steering" antenna systems.

→ These types of antennas can use a narrow pencil-beam patterns to communicate with a subset of active users with a cell.

→ The use of radio link that approaches point-to-point characteristics is extremely useful in mobile environment.

→ The amount of interference received will be reduced and system capacity can be increased.

→ As the mobile user moves about the coverage area, the smart antenna will track the mobile's motion.



6. Discuss the different CDMA Handoff operations.

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.

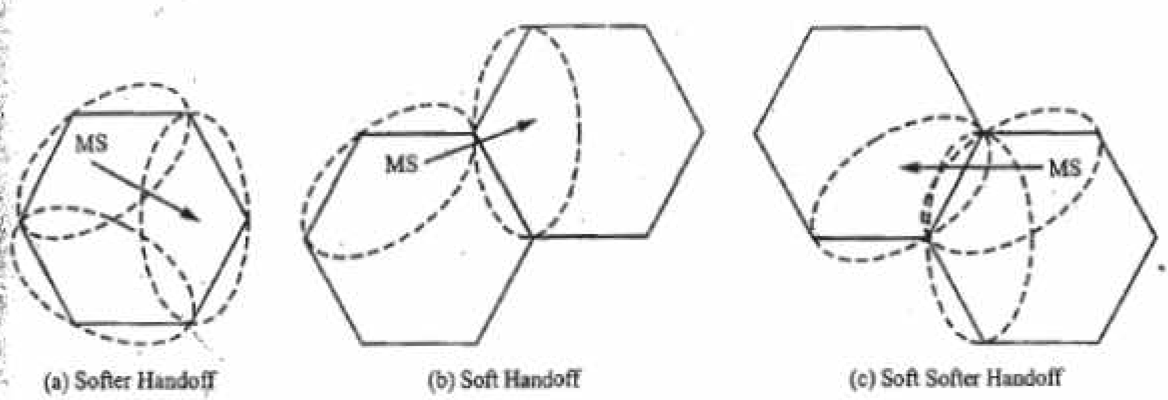


Figure 6–30 Three types of soft CDMA handoff.

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

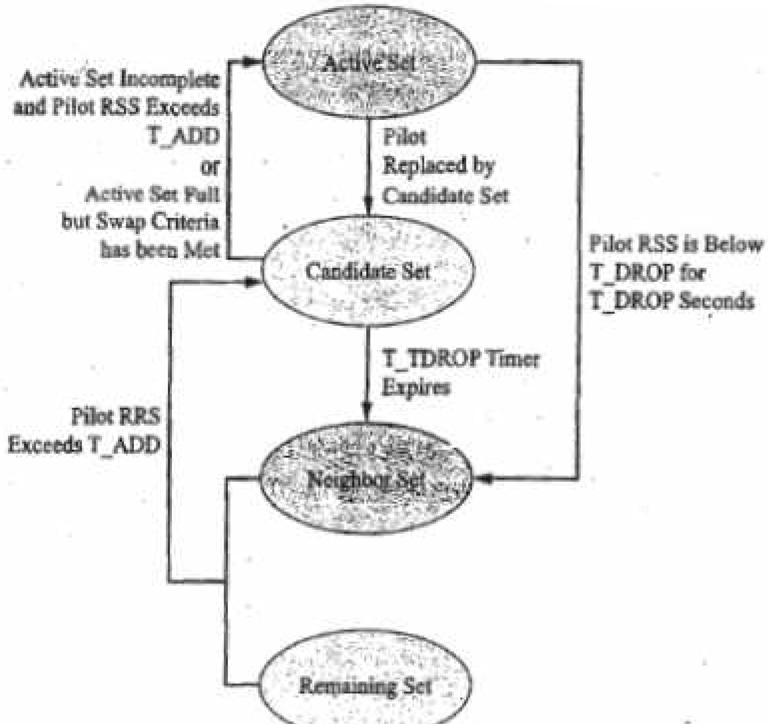


Figure 6–31 Flowchart of the generation of the active and candidate pilot set for CDMA handoff operations.

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

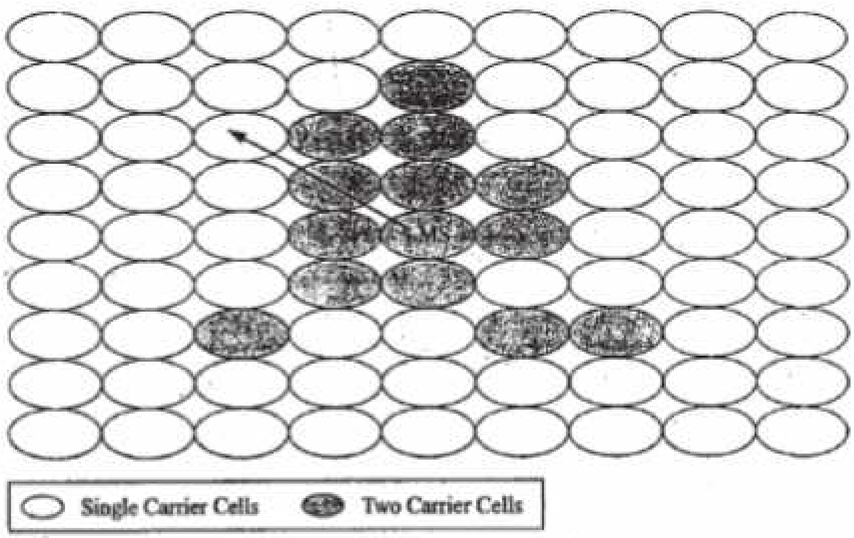


Figure 6–32 Hard CDMA handoffs due to intercarrier handoff.

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.

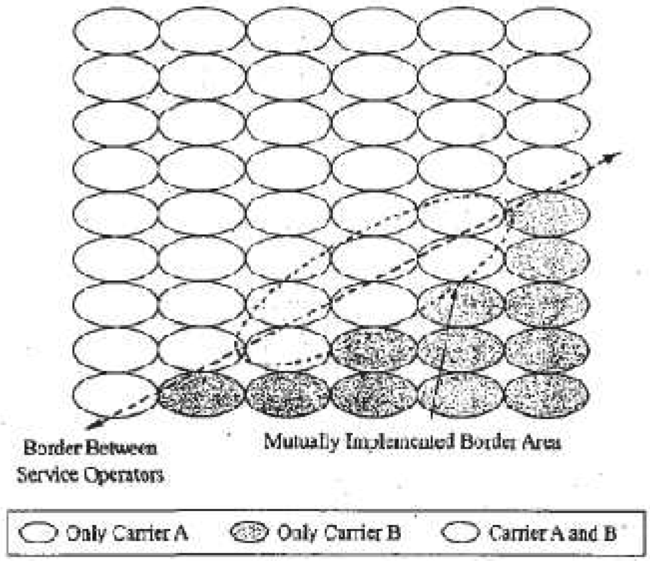


Figure 6–33 Hard CDMA handoffs due to disjointed regions