Module-3
CDMA Technology
CDMA System Overview – Introduction, CDMA Network and System Architecture
CDMA Basics – CDMA Channel Concepts, CDMA System (Layer 3) operations, 3G CDMA
(**Text 2-Part 1, Part2 and Part 3 of Chapter 6)** **L1, L2, L3**

PART- 1: CDMA System Overview

3.1 Introduction to CDMA

Cellular services are now being used every day by millions of people worldwide.

The number of customers requiring such services is increasing exponentially, and there is a demand for integration of a variety of multimedia services.

The range of services includes short messaging, voice, data, and video. Consequently, the bit rate required for the services varies widely from just 1.2 kbps for paging up to several Mbps for video transmission.

Supporting such a wide range of data rates with flexible mobility management, increases network complexity dramatically.

The CDMA is a digital modulation and radio access system that employs signature codes (rather than time slots or frequency bands) to arrange simultaneous and continuous accessto a radio network by multiple users.
Contribution to the radio channel interference in mobile communications arises from multiple user access, multipath radio propagation, adjacent channel radiation and radio jamming.

The spread spectrum system's performance is relatively immune to radio interference. Cell sectorization and voice activity used in CDMA radio schemes provide additional capacity compared to FDMA and TDMA. However, CDMA still has a few drawbacks, the main one being that capacity (number of active users at any instant of time) is limited by the access interference.

Furthermore, Near-far effect requires an accurate and fast power controlscheme.
The first cellular CDMA radio system has been constructed in conformity with IS- 95 specifications and is now known commercially as CDMA One.

3.1.1 Evolution of 2G CDMA

- IS-95 has **dual mode of operation in 800-MHz** cellular band for both **AMPS and CDMA.**
- This **standard has features for both mobile station** and **base station ,** compatible with both **AMPS and CDMA.**

- IS-95A is the modified form of **IS-95** with additional features.
- IS-95A describes the structure of wideband 1.25-MHz CDMA channels and operations to provide **power control**, **call processing**, **handoffs,** and **registration procedures for proper system operation**.
- These system provides **circuit switched data service** at **14.4kbps** over the first CDMA system.
- **ANSI J-STD-008** provided for **CDMA operation in CDMA** band.

With few additional standard the system is known as **TIA/EIA-95-B in 1999.**
This was providing the **1.8-to 2.0GHz** CDMA PCS system with IS-95A and **superceded ANSI-J-STD-008.**
This system allows Packet switched data service at rates up to **64kbps** they as known as **2.5G CDMA technology**.

3.1.2 Evolution of 3G

- Cdma2000 is the term used for 3G CDMA system.
- Cdma2000 is the wideband enhanced version of CDMA
- It was compatible with TIA/EIA-95-B.
- It provides the support for data services up to 2mbps, multimedia services, and advanced radio technologies.
- First phase of CDMA is known as 1xRTT (radio transmission technology) happening over a channel of 1.25MHz CDMA channel.
- Next implementation phases is called as 1xEV (evolutionary).

It has two types 1xEV DO (data only-downlink direction data rate 2.4mbps & uplink direction data rate 153 kbps) and 1xEV DV (data and voice-3mbps all over the network)
Note: TIA/EIA Telecommunication Industry Association /Electronic Industries Association

3.1.3 CDMA Basics

- CDMA is a multiple access technology that is based on the use of wideband spread spectrum digital techniques that enable the separation of signals that are concurrent in both time and frequency.
- All signals share the same frequency spectrum simultaneously.
- The signals transmitted by mobile stations and base stations within a cell are spread over the entire bandwidth of a radio channel and encoded, received as a broadband noise signal at the every other mobile or base station receiver.
- The demodulator demodulates the signal intended for the receiver while rejecting all other signals as broadband noise.

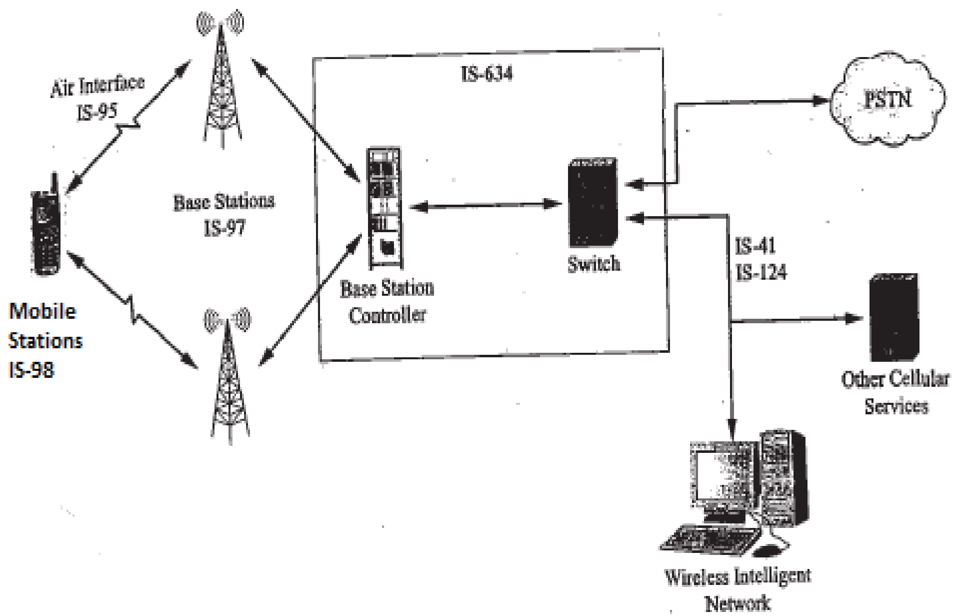

Figure 3.1 Typical Components of a CDMA One network

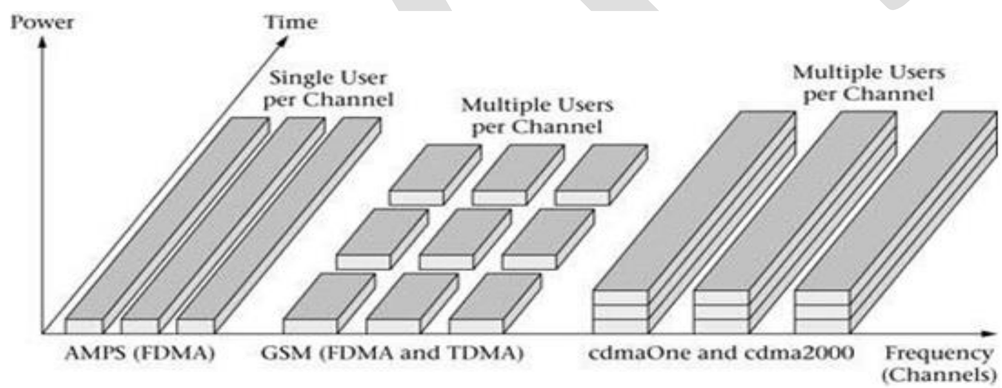

Figure 3.2 Comparison of different techniques such as FDMA, TDMA, AND CDMA air interface

- For FDM made available radio spectrum is divided into narrowband channels and each user is given a particular channel for his for use.
- The user can find transmitted signal power within the channel and selective filters are used at both ends of the radio link to distinguish transmission that are occurring simultaneously on many different channels.
- The frequency allocation can only be reused at a distance far enough away that the resulting interference is negligible.
- In TDMA scheme divide the spectral allocation into time slots. Now each user must confine its transmitted spectral energy within the particular time slot assigned to it, here

are the mobile and base station must employees some type of time synchronisation.

- This technique increases the **spectral efficiency** at the expense of each users total data rate.
- In CDMA each mobile has continuous use of the entire spectrum allocation and spreads its transmitted energy out over the entire bandwidth of the allocation.
- Using a unique code for each transmitted signal the mobile in the base stations are able to distinguish between the signal transmitted simultaneously over the same frequency allocation.
- CDMA can also be combined with FDM TDM Technologies to increase the system capacity.

CDMA Frequency Bands

- The CDMA bands are cellular frequency band (band class 0) personal communication service (PCS Band) Band class 1.
- 3G CDMA systems released 1710- 1755 MHz and 2110 - 2155 MHz advanced wireless service (AWS Band) available for CDMA used including a lower frequency band at 450 MHz
- When used in cellular band frequency separation of 45 MHz between the forward and reverse channel is employed.
- The MS transmit frequency band is 824-849 MHz and the BS transmit frequency band is 869-894 MHz.
- This dual use of frequency bands gives rise to dual mode CDMA phones.

Table 3.1 CDMA channel numbers and frequency assignments for the PCS band.

Transmitter	*CDMA PCS Channel Number (N)*	*Center Frequency for CDMA Channel (MHz)*	*TDMA PCS Channel Number (N)*	*TDMA PCS Channel Frequency (MHz)*
Mobile Station	$0 \le N \le 1199$	$1850.000 + 0.050\,N$	$1 \le N \le 1999$	$1849.980 + 0.030 \times N$
Base Station	$0 \le N \le 1199$	$1930 + 0.050\,N$	$1 \le N \le 1999$	$1930.020 + 0.030 \times N$

Table 3.2 Useable CDMA Channel number and assigned frequencies for Band Class 1

Block Designator	CDMA Channel Validity	CDMA Channel Number	Transmit Frequency Band (MHz)	
			Mobile Station	Base Station
A (15 MHz)	Not Valid Valid Cond. Valid	0–24 25–275 276–299	1850.000–1851.200 1851.250–1863.750 1863.800–1864.950	1930.000–1931.200 1931.250–1943.750 1943.800–1944.950
D (5 MHz)	Cond. Valid Valid Cond. Valid	300–324 325–375 376–399	1865.000–1866.200 1866.250–1868.750 1868.800–1869.950	1945.000–1946.200 1946.250–1948.750 1948.800–1949.950
B (15 MHz)	Cond. Valid Valid Cond. Valid	400–424 425–675 676–699	1870.000–1871.200 1871.250–1883.750 1883.800–1884.950	1950.000–1951.200 1951.250–1963.750 1963.800–1964.950
E (5 MHz)	Cond. Valid Valid Cond. Valid	700–724 725–775 776–799	1885.000–1886.200 1886.250–1888.750 1888.800–1889.950	1965.000–1966.200 1966.250–1968.750 1968.800–1969.950
F (5 MHz)	Cond. Valid Valid Cond. Valid	800–824 825–875 876–899	1890.000–1891.200 1891.250–1893.750 1893.800–1894.950	1970.000–1971.200 1971.250–1973.750 1973.800–1974.950
C (15 MHz)	Cond. Valid Valid Not Valid	900–924 925–1175 1176–1199	1895.000–1896.200 1896.250–1908.750 1908.800–1909.950	1975.000–1976.200 1976.250–1988.750 1988.800–1989.950

3.1.5 Frequency Planning Issues

- Because of a frequency reuse factor N= 1, CDMA frequency planning is relatively simple compared to analog cellular systems.
- System that only requires one carrier per base station, that carrier must be chosen from the list of preferred CDMA channels.
- The same channel should be used by all the base station throughout the system to take advantage of soft and softer handoff capabilities that are possible with CDMA Technology.
- Capacity can be increased by increasing the number of base station carriers.
- Table 3.2 shows the useable CDMA Channel number and assigned frequencies for Band Class 1

Table 3.3 Preferred set of CDMA frequency assignments for Band Class 1

	Spreading rate	Preferred channel numbers
A	1	25,50,75,100,125,150,175,200,225,250,275
	3	50,75,100,125,150,175,200,225,250
D	1	325,350,375
	3	350,
B	1	425,450,475,500,525,55,575,600,625,650,675
	3	450,475,500,525,550,575,600,625,650
E	1	725,750,775
	3	750
F	1	825,850,875,
	3	850
C	1	925,950,975,1000,1025,1050,1075,1100,1125,1150,1175
	3	950,975,1000,1025,1050,1075,1100,1125,1150

3.2.CDMA Network and System Architecture

- There is **increasing demand** for **data traffic over mobile radio**.
- The mobile **radio industry has to evolve the current radio infrastructures** to accommodate the expected data traffic with the efficient provision of high-speed voice traffic.
- The **General Packet Radio Service (GPRS)** is being introduced to efficiently support high-rate data over GSM.
- **GPRS signalling** and **data do not travel through GSM network**.
- The **GPRS operation** is supported by new protocols and new network nodes: **Serving GPRS support node (SGSN)** and **Gateway GPRS support node (GGSN).**
- One prominent protocol used to tunnel data through IP backbone network is the **GPRS tunnel protocol (GTP**).
- GPRS obtains user profile data **using location register database** of **GSM network.**
- GPRS supports **quality of service** and **peak data rate** of up to **171.2 kbps** with GPRS using all **8 timeslots at the same time**.

- GPRS uses the same modulation as that used in GSM that is Gaussian Minimum Shift Keying (GMSK) with 4 coding schemes. Figure 3.3 shows the Initial CDMA (IS-95) reference architecture

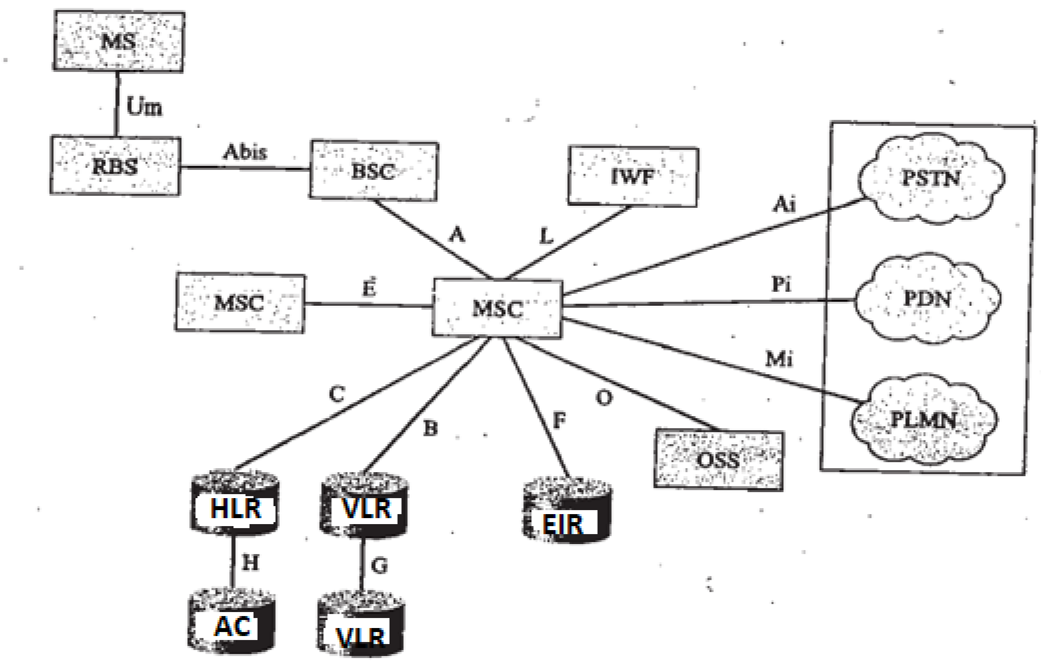

Fig 3.3 Initial CDMA (IS-95) reference architecture

In block diagram Radio base station is connecting interface between BSC and MS (mobile station). PSTN (public switched telephone network), PLMN (public land mobile network) and PDN (public data network) are the main nodes where the mobile switching centre is interacting.

- PCMD→ Per Call Measurement Data
- CAIT→ CDMA Air Interface Tester
- WINDUMP→ Windows version of TCPDUMP
- PDSN→ Packet Data Serving Node
- **tcpdump** utility is used to capture and analyze network traffic

In the case of MSC to BSC interface provides for the messaging between these two systems elements and now allows the equipment used for these functions to be provided by multiple different vendors.

Figure 3.5 shows the layered architecture of specified TIA/EIA 634B.

As shown in figure, A interface between the MSC-BSC interface supports four functional planes.

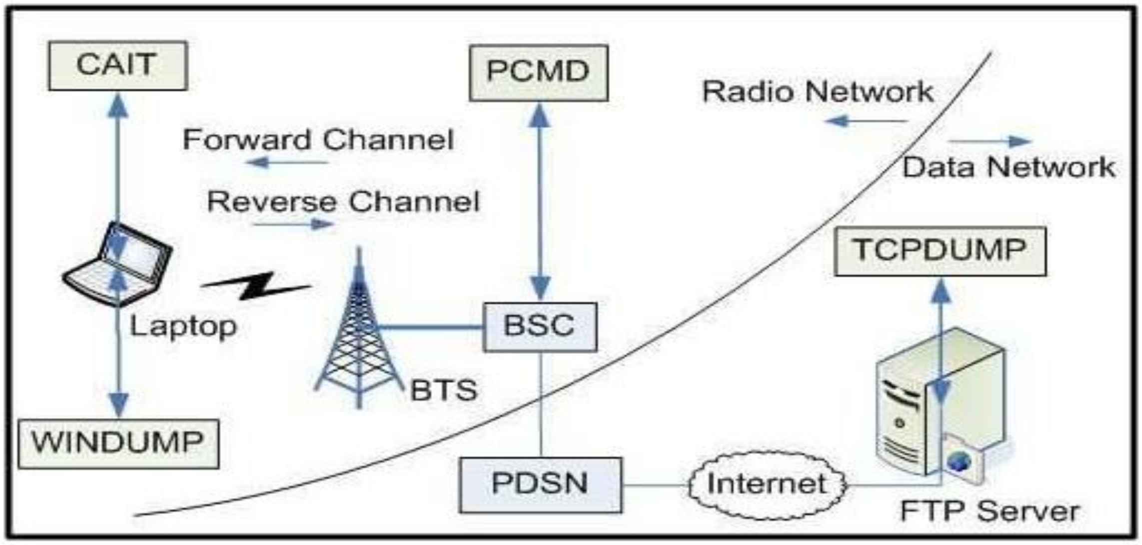

Fig 3.4 cdma2000 reference architecture[REF[https://www.researchgate.net/publication/220850246_TCP_over_CDMA2000_networks_A_cross-layer_measurement_study]

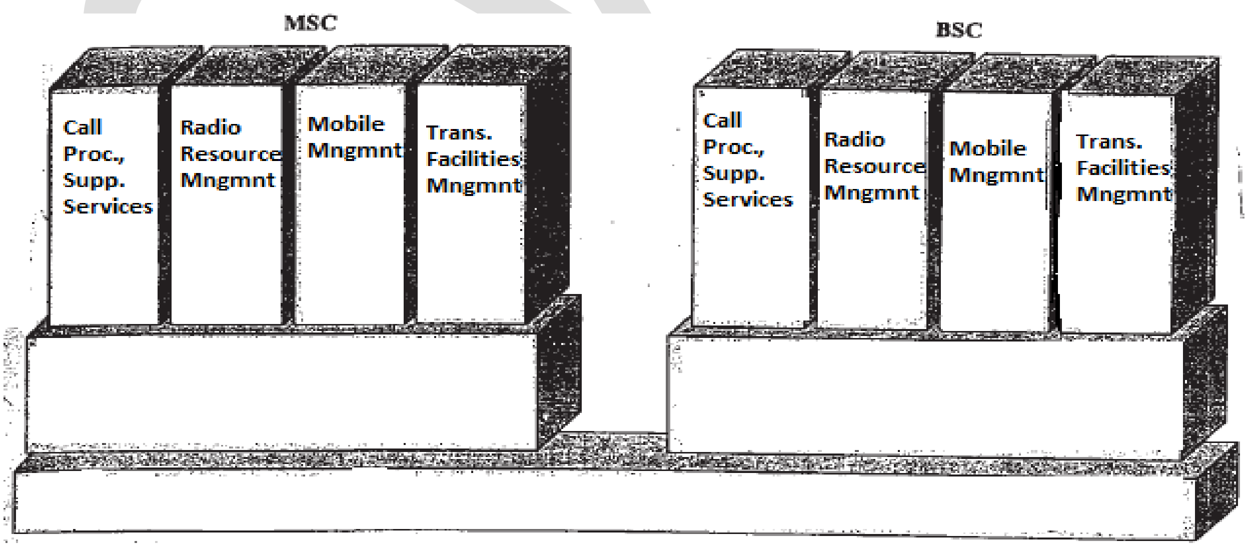

Fig 3.5 cdma2000 MSC-BSC interface functional planes

Call processing and mobility management functions occurs between the mobile station in the MSc the types of call processing and Supplementary Services supported over TIA/EIA 634 B of calls origination and termination by the subscriber call release, call waiting and saw the mobility management function supports the typical operations of registration and the registrations are then taxation voice privacy and etc.

Function of various resources management and transmission Facilities Management occurs between MSc and the base station.

The transmission Facilities Management operations are connected with the facilities that transport the voice data of signalling information between MSC and the base station

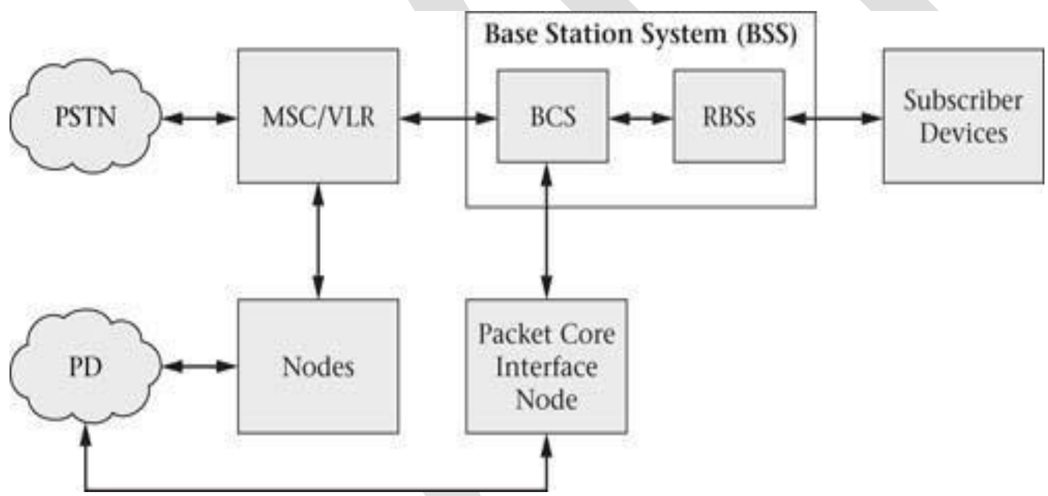

Fig 3.6 Major Network components of a cdma2000 wireless system

RBS→ Radio base Station

Figure 3.6 shows the major network elements of the modern cdma2000 system and figure 3.7 shows the additional details of typical call network not found in cdma2000.

GPRS packetizes the user data and transports it over 1 to 8 radio channel timeslots using IP backbone network.

The Enhanced Data Rates for GSM Evolution (EDGE) employs an Enhanced GPRS (EGPRS) to support data rate up to 384 kbps through optimised modulation.

EGPRS support 2 modulation schemes, namely GMSK with 4 coding schemes and 8-PSK with 5 coding schemes.

Unlike GPRS where header and data are encoded together, headers are encoded separately in EGPRS.

Mobile-services switching center and visitor location register

CDMA mobile service Coaching Centre serves as the interface between the Public Switched Telephone Network and the base station subsystem (BSS).

That performs the functions necessary for the establishment of the cost to and from the system mobile subscribers.

MVC also provides subscriber registration authentication location updating functions call hands off and call routing for roaming subscribers and also permit subscriber mobility and warming.

Visitor location register function is located with the MSc its function is to provide a database containing temporary information about register subscribers that may be needed by the embassy in the performance of call control operations and provisioning of subscriber services for the mobile currently registered in the MSVC/VLR service area

Interworking function:

- It is the only Gateway between the wireless networks and the packet data network.
- It provides a direct connection to the PDN and packet data calls.
- It supports circuits which data caused by providing internal modem for connections to dial up internet service providers.

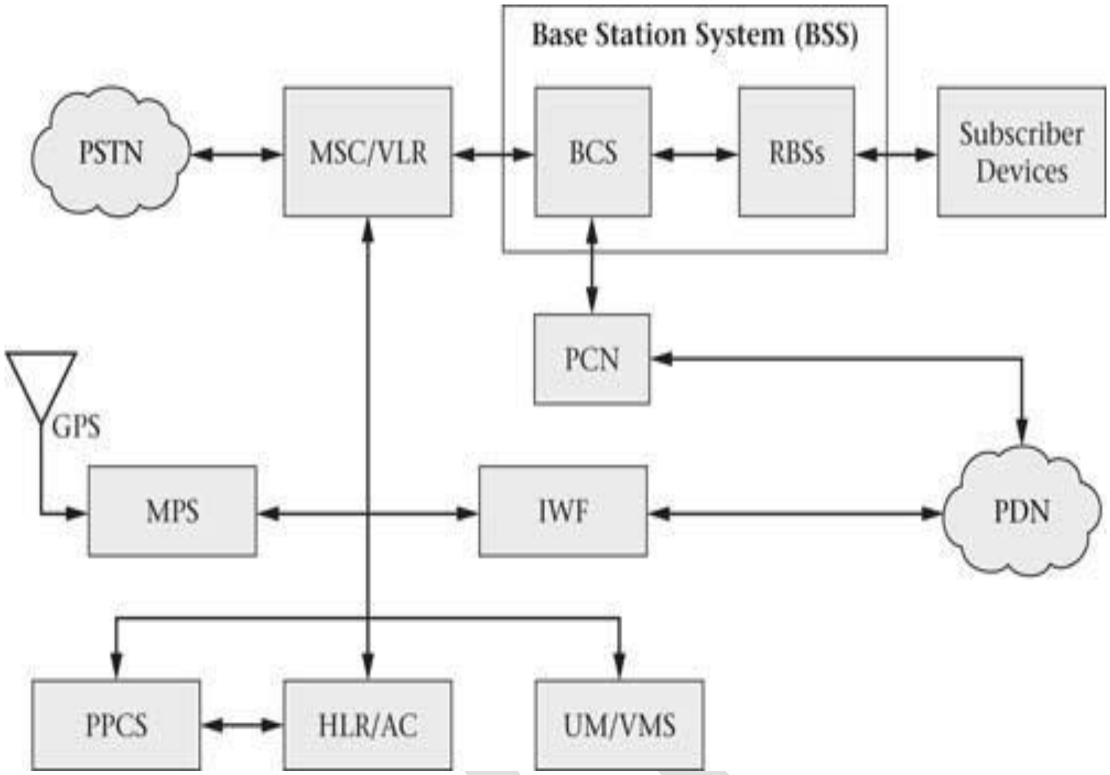

Fig 3.7 Details of the network nodes found in a Cdma 2000 wireless system.

Mobile positioning system:

- Ongoing program mandated by the federal Communications commission and design to upgrade the United States cellular systems, a location system is incorporated by CDMA system that can determine the Geographic position of the mobile subscriber.

- This mobile positioning system is based on global positioning system and it is used for emergency services.
- Other proposed uses of the system capability related to what are known as location basic services for location specific marketing tools.

Unified messaging/voice mail service

Unified messaging/voice mail services it integrates email and voice mail access.
Tthis node provide messaging waiting indication using short message services and multiple message retrieval modes including the use of DTMF or either a web or WAP browser.
Shown in figure 3.7 the UM/VMS node connects the period and the MSc in Ericsson system

HLR/AC

The home location register and other indications centres are typically called located in CDMA cdma2000 systems.
The HLR holds the subscriber information in a database format that is used by system to manage subscriber devices activity.
Syndication provides a secure database for the authentication of mobile subscriber when they first register with his demand during call origination and termination.
Authentication Centre uses shared secret data (SSD) for identification calculation both the AC and ST caliphate SSD based on authentication key or a key.

PPCS, and other nodes:

- Prepaid calling services node provides a prepaid calling service using a subscriber home location area MSC.
- This is the snow provides the MSc with the information about the subscriber located minutes and provides a subscriber with account balance information.
- It is associated with the prepaid administration computer system that provide necessary database to store the subscriber information and update it as needed.

PDN→ Public data network,
RBS→ Radio base station,
BCS→B channel Circuit Switched/Base station controller,
IWF→ Interworking functions,
MPS→ Mobile Positioning System,
PPCS→ Prepaid Calling Service
UM/VMS→ Unified Messaging/Voice Mail Service
PCN→ Packet Core network
C-RAN CDMA Radio access Network
PLMN→ Public land mobile network

Base Station Subsystem

It has one Base station controller (BSC) and one Radio base station (RBS) controlled by the BSC.
The BSS provides the mobile subscriber with an interface to the circuit switched core network (PSTN) through the MSc and an interface to the public data network through the packet core network.

Base station controller (BSC)

- Base station controller provides the following functionalities.
- It is the interface between the MSc and the packet core network, other BSS in the same system and all of the radio base stations that it controls.
- It provides routing of data packets between the PC and RBS radio resource allocation system timing and synchronisation system power control all and the procedures and the

processing of both voice and data as needed.

Radio base station (RBS)

- It provides the interface between the BSc and the subscriber devices why are the common air interface
- The functions provided by the RBS includes CDMA encoding and decoding of the subscriber traffic and system overhead channels and the CDMA radio links to and from the subscribers the typical RPS contains an integrated GPS antenna and the receiver that is used to provide system timing and frequency references.

PLMN Subnetwork

- Cdma2000 public land mobile network provides mobile wireless communication services subscribers and typically consists of several functional subnetworks.
- Sab networks are circuit core network (CCN), packet core Network (PCN) and service node network (SNN) the CDMA radio access network (C-RAN)

Circuit core network (CCN),

- It provides the switching functions necessary to complete calls to and from the mobile subscriber to the PSTN the major network element in the CNN is MSc.
- The primary function of this network is completion of voice calls between the subscriber and the PSTN.
- The MSC is basically an extension of PSTN and that services the various cells associated radio base stations within the cell send message provide circuit switching and provides features such as call charging, subscriber roaming support and maintenance of subscriber database.

<u>CDMA radio access network (C-RAN)</u>

- It provides the interface between the wireless cellular subscriber and circuit core network network.
- Decision consists of the MSc and other system components involved with connection to the PSTN for all circuit switched voice and data calls.

<u>Cdma2000 Packet Core Network elements</u>

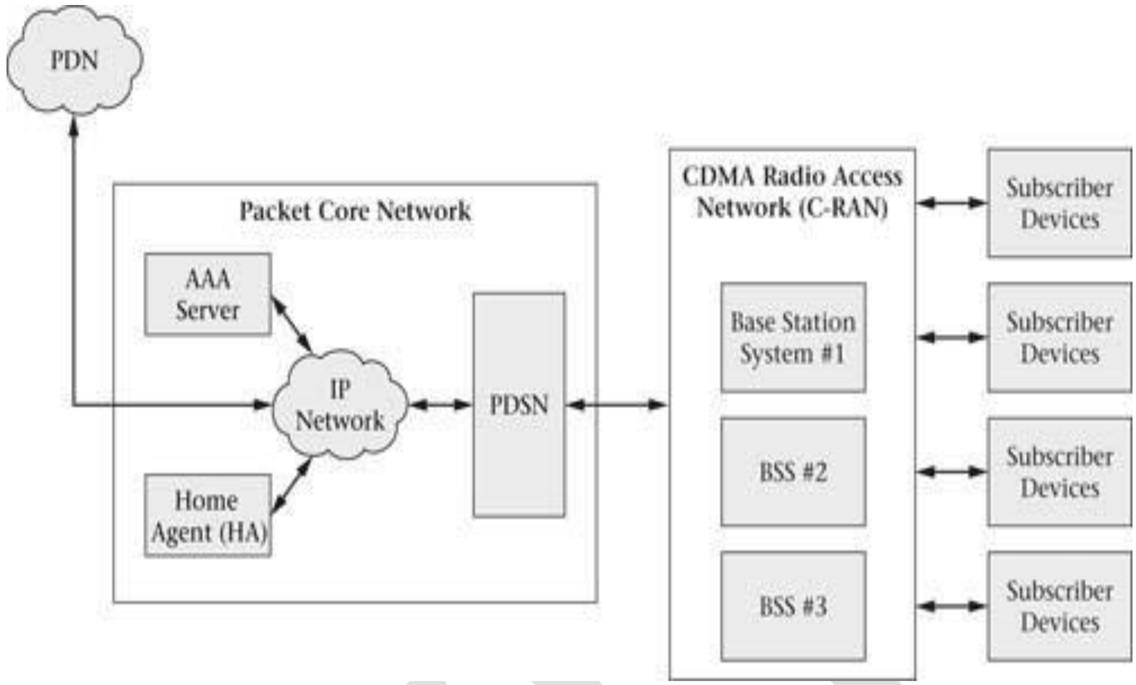

Fig 3.8 Elements of the cdma200 Packet core Network

In cdma2000 system the packet data serving node provide the needed IP transport capability to connect C-RAN and subscriber to the public data network.

Packet core network provides a standard interface for wireless packets which Data Services between the C-RAN and the public data network.

PCN has three nodes namely,
1. AAA→ Authentication, authorization and accounting server,
2. Home agent
3. Packet data serving node (PDSN)

Figure 3.8 depict the elements of PCN and their interconnection teach other in the relationship of the PCN and PDN and C-RAN
The AAA server both indicates and authorise a subscriber devices to employ the available network services and applications to facilitate this operation a server manager is the database that contains user profiles use profile information will also be included information about quality of service for the PDN.

In cdma2000 system the home agent (HA) has the task for forwarding all packets at a distant for the subscriber devices to the PDSN over the IP packet.

Network Management System has following
- Network Management

- Sub-network Management and Element Management
- System Communication links
- Subcarrier Devices

Modern wireless cellular system employs supported network management system to cover the operation of the entire network service providers have one or several Network operations centers.

Network Management

The highest level of network management gives and overarching view of the entire network including all of the net subnetwork that it comprises there are **five functions** of Wireless network management system

- network surveillance or fault management
- performance management,
- trouble management
- configuration management and
- Security management.

Fault Management is concerned with the detection isolation and repair of network problem to prevent network faults from causing unacceptable network degradation or downtime.

Performance management functions are concerned with gathering and reporting of 11 network performance statistics that can be used continuously analyse Network operations.

Trouble management functions allow for the display and subsequent description of occurrence that have affected the network.

Configuration management functions are used to support Administration and configuration of the network,

The **security management** functions manage user accounts and provide the ability to control and set user based access levels.

Sub-network Management and Element Management

Sub network management platform provides management of execute packet and radio network that compose the typical CDMA system the circuit Core network management system is mainly concerned with the CDMA mobile services switching centers it provides fault performance configuration Software and Hardware management functions that support the operations of this particular network element at the sub network level.

Network interface for CDMA systems

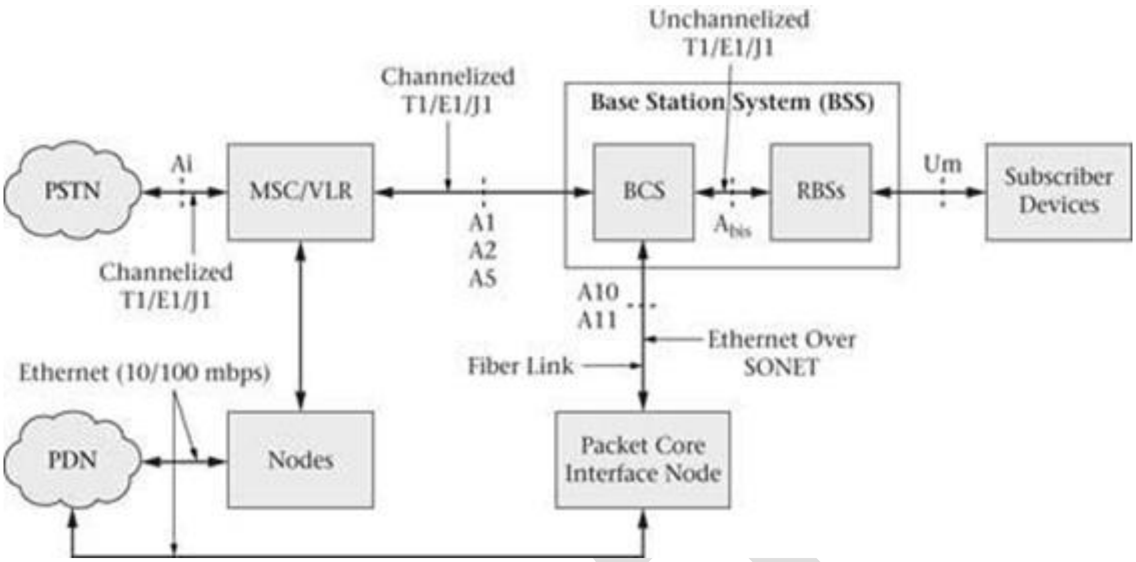

Fig 3.9 Network interfaces for CDMA system

System Communication links

- Equipment vendors are still using Legacy channelize T1 /E1/ J1 copper pairs for connectivity to from the MSC to the PSTN.
- CDMA equipment vendors have started to add fiber-optic interfaces delivers on its signals a data rate of 155.52 MB per second as shown in figure 3.9
- Different network interfaces for CDMA systems are shown in figure with the control information is used for a interface between the MSC and BSC

Subcarrier Devices

It is the generic term used to describe several types of wireless phones and data devices that perform CDMA and coding decoding and encoding operations for the transmission of voice for data in wireless mobile environment.

Each subscriber device is a band or set of radio band over which it can operate and various modes of possible operations.

PART II:

CBMA Basics

3.3.CDMA Channel Concept

- Cellular Telephone Network use various **control and traffic channels** to carry out the **operations necessary to allow for the setup of a subscriber lady** or drink for the transmission of either data or a **voice conversation** and the subsequent system supports for the **subscribers mobility**.
- The **CDMA one and cdma2000** cellular systems are based on the use of CDMA Technology provide additional user capacity over a limited amount of **radio frequency**

spectrum.

- This is accomplished by using a **spread spectrum** and **coding technique** that provides for numerous radio channels. Basic Spectrum spreading operation is shown in figure 3.10.
- The orthogonal **Walsh spreading codes** are used for channel encoding.

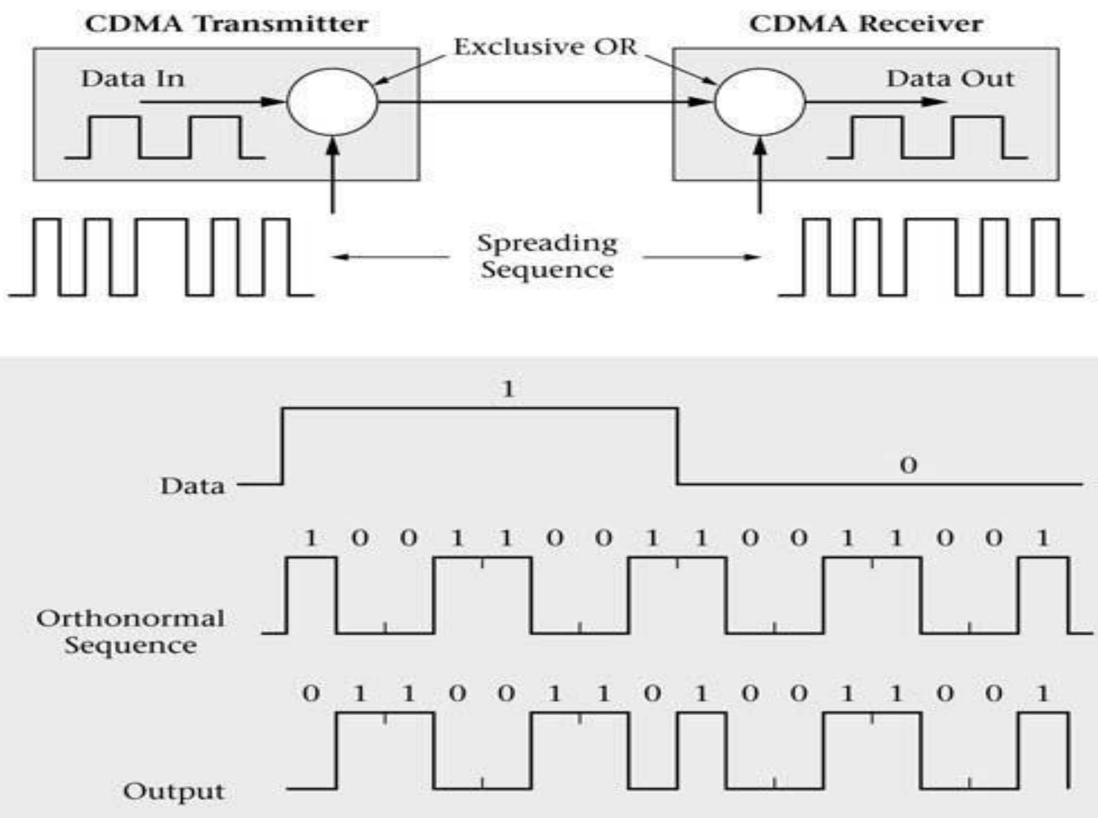

Fig. 3.10. The Basic Spectrum spreading operation

The IS-95 CDMA system is a narrow band radio system.

Bandwidth is limited to 1.25 MHzand a chip rate of 1.2288 Mcps.

The system is intended to provide voice and low bit rate data service using circuit-switching techniques. Data rate varies from 1.2 kbps to 9.6 kbps.

Forward (base station to mobile) and reverse (mobile to base station) link structures are different and each is capable of distinctive capacity.

Forward transmission is coherent and synchronous while the reverse link is asynchronous.

The 'channelization' in each link is achieved by using 64- chip orthogonal codes, including provision for pilot, synchronization, paging, and network access.

Consequently, the number of active users able to simultaneously access the network is limited by the level of interference, service provisions and the number of 'channels' available.

In IS-95B, an active mobile always has afundamental code channel at 9.6 kbps and when high data rate is required, the base station assign the mobile up to 7 supplementary code channels.

The Wideband CDMA (W-CDMA) system is the major standard in the next-generation Global Mobile Telecommunications standard suite IMT-2000. The W-CDMA supports high data rate transmission, typically 384 kbps for wide area coverage and 2 Mbps for local coverage for multimedia services.

Thus W-CDMA is capable of offering the transmission of voice, text, data, picture (still image) and video over a single platform.

However, in addition to the drawbacks arising from the mobile environment and multiple access interference, high bit rate transmission causes Inter-symbol interference (ISI) to occur.

The ISI therefore has to be taken into account during transmission. The W-CDMA has 2 versions: frequency division duplex (FDD) and time division duplex (TDD).

The FDD version of W-CDMA will operate in either of the following paired bands: Uplink:
1920 - 1980 MHz Downlink: 2110 - 2170 MHz
Uplink: 1850 - 1010 MHz Downlink: 1930 - 1990 MHz

The 3GPP architecture of the Universal Mobile Telecommunications System (UMTS) is composed of IP-based core network (CN) connected to the user equipment through UMTS Terrestrial Radio Access Network (UTRAN).
The UTRAN consists of a set of radio network subsystem comprising a radio controller and one or more node base station.
The network controller is responsible for the handover decisions that require signalling to the user equipment.
Each subsystem is responsible for the resources of its set of cells and each node B has one or more cells.

CDMA Channel Concept

- Forward logical channels
- Pilot channel
- Synchronization channel
- Paging channel
    - Traffic/power control channels

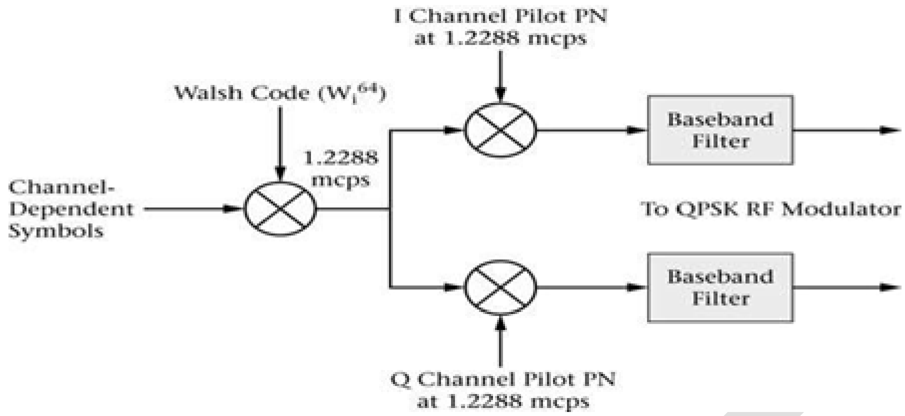

Fig.3.11: Basic spreading procedure used on CDMA forward channels

- The basic spreading procedure used on the forward CDMA journal is shown in figure 3.11.
- The Digital Signal to be transmitted over a particular forward channel is spread by first exclusive "OR"ing it with the particular "Walsh code".
- Then the signal is further scrambled in the in-phase and quadrature phase lines by two different short pseudo noise (PN) spreading codes.
- These short PN spreading codes are not orthogonal codes, but they have excellent cross correlation and autocorrelation properties that make them useful for this application.
- Each channel is spread sufficiently over the entire bandwidth of 1.25 MHz channel.
- The short inphase (I) and quadrature Phase (Q) and spreading codes are generated by two linear shift registers of length 15 with the set polynomial value used to configure the feedback paths.
- The resulting in short PN spreading codes are repeating binary sequences that are approximately equal number of zeros and ones then the length of 327 68.
- the output of the inphase and quadrature phase signals are passed through the baseband filter and then applied to the RF quadrature modulator Integrated circuit that convert the final output signal to be U HV frequency bands.
- This channel element signal is linearly combined with the other forward channel element signal amplified and composite Band pass band signal is transmitted over the air interface.
- Short film spreading codes provide the CDMA system with ability to differentiate between different base stations are cells transmitting on the same frequency.
- Same short PN code sequence is used by all CDMA base stations, however for each base station the PN sequence is offset from the sequences used by other area base stations. The offset is analogous to the frequency reuse plans described for other access techniques.
- Figure 3.12 shows use of this reuse scheme.

- The use of this office team requires that the base stations used in CDMA is the must be must all be time synchronized on the downlink radio channels.
- This precise timing synchronization is achieved through the use of the Global positioning system (GPS) purchase system time that has the required accuracy.
- The initial -95 CDMA system implementation uses four different typical types of logical channels in the forward direction.
  - The Pilot channel
  - synchronization channel
  - paging channel
  - Traffic and power control channels.

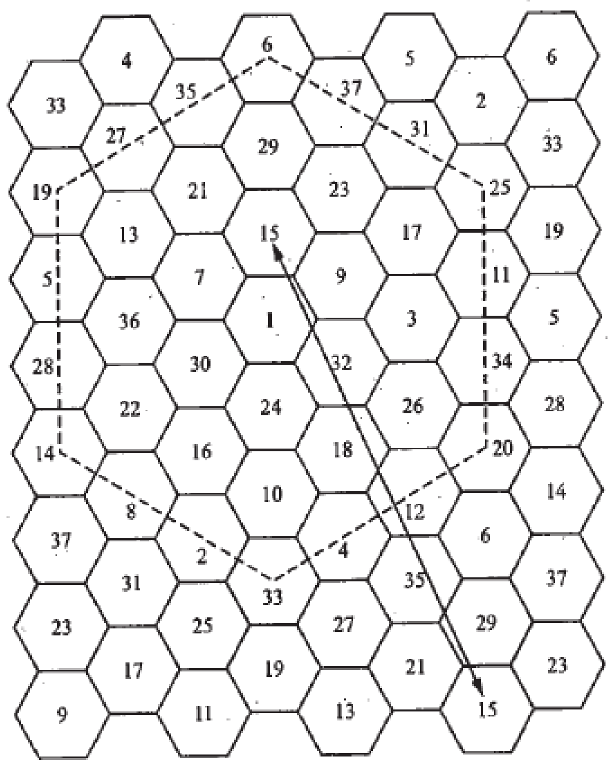

Fig. 3.12: CDMA base station timing offset reuse pattern

- **Pilot Channel**

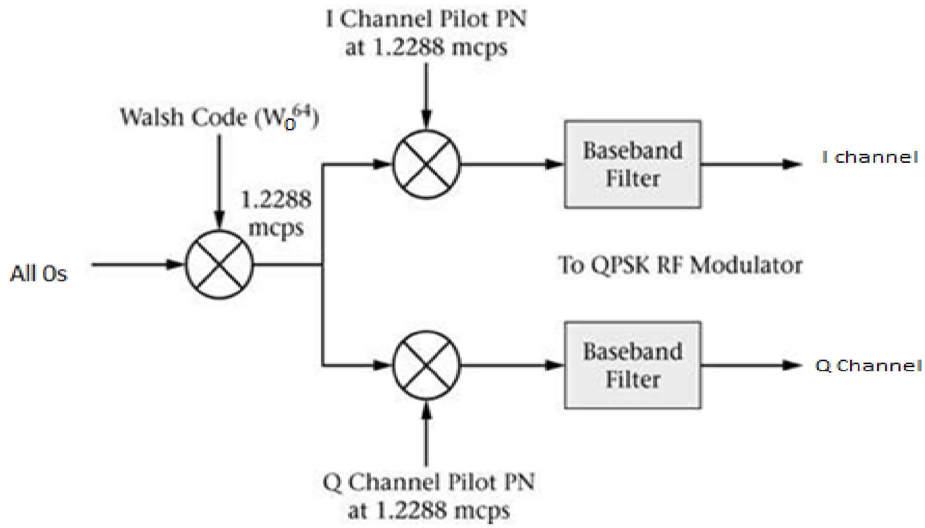

Fig.3.13: Generation of the CDMA pilot channel signal

- CDMA pirate channel is used to provide a reference signal for the SDs within a cell.
- Figure 3.13 depicts the generation of pilot channel signals.
- The all zeros Walsh code is used for the initial signal spreading on the sequence of all zeros.
- This results in a sequence of all zeros that are for thus producing the short PN spreading sequences resulting in a sequence of zeros and ones.
- I and q signals drive a quadrature modulator. Therefore the resulting pilot signal is unmodulated spread spectrum signal.
- The short PN spreading code is used to identify the base station and the pilot signal is transmitted at fixed output power usually 46 DB stronger than any other channel.
- The Pilot channel transmitted continuously is used as a phase difference for the borrower and the modulation of all other channels it also serves as the reference for signal strength measurement and other signal power comparison.

CDMA Synchronization channel signal

- CDMA synchronization channel is used by the system to provide initial time synchronisation.
- Figure 3.14 shows the generation of synchronisation channel signal.
- in this case Walsh code W_{32}^{64} (Thirty-two 0's followed by thirty-two1's is used to spread the synchronization channel message.
- Again the same short PN spreading code with the same offset is used to further spread the signal
- as shown in figure 3.15 the initial synchronisation channel message has a data rate Of 1200 BPS .

- the synch messages and undergo convolutional encoding symbol repetition and finally the block interleaving. This process raises the final sync message data rate 4.8 kbps.
- The information contained in the sync message includes the system or network identification codes, identification of paging channel data rates, the offset value of the short PN spreading code, and the state of the long PN spreading code.
- Like The Pilot channels synchronization channel has a fixed output power.

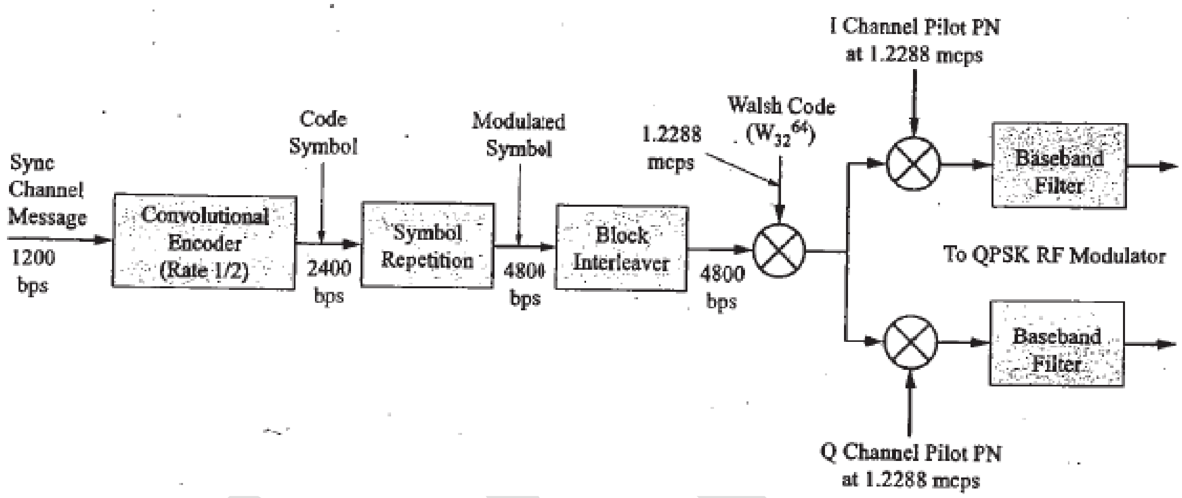

Fig.3.14: Generation of the CDMA Synchronization channel signal

Paging Channel

- The Is-95 paging channels of the purpose of the property with paging channel in the GSM cellular system.
- Tthe Channels used to page the subscriber devices when there is a mobile terminated call and to the send control messages to the subscriber devices(SD) when call setup is taking place.
- Figure 3.15 shows the generation of the paging channel message for IS- 95 CDMA there can be as many as seven page in channels in operation at any one time.
- Walsh codes W_1^{64} through W_7^{64} are used for this purpose.
- As shown in figure 3.15 the paging channel undergoes an additional scrambling operation using the long PN spreading code sequence.
- The long PN code is generated by using 42bit linear feedback shift register (LFSR) that deals repeating sequence of length2^{42}.
- The paging channel message also goes through the conventional and encoding process, symbol the petition and block interleaving before being scrambled by the slower version of the long PN code.

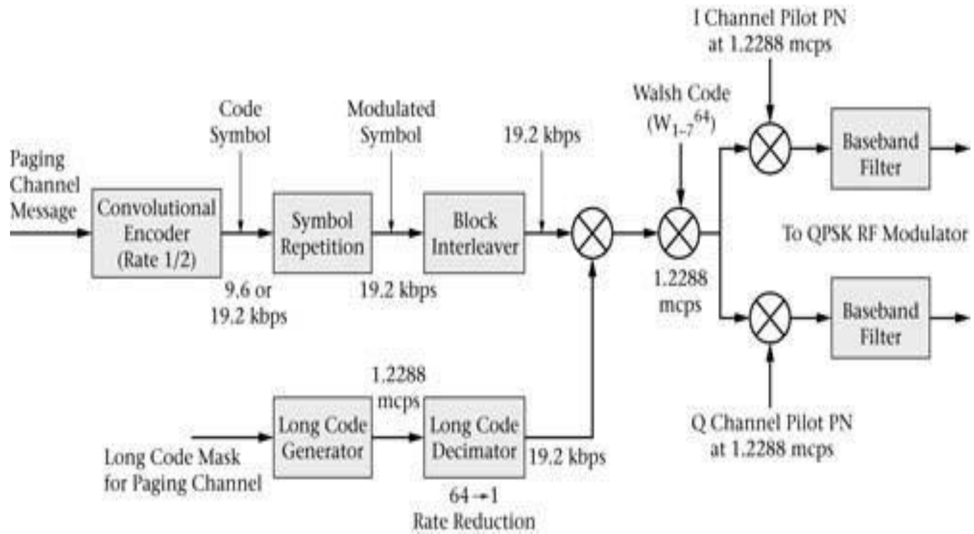

Fig. 3.15: Generation of the CDMA paging channel signals

<u>Traffic/power control channels</u>

The CDMA forward traffic channels carry the actual user transmission.

- This digitally encoded voice and or data can be transmitted several different data Rates for IAS 95 CDMA systems.
- Rate set 1 supports 9.6 kbps maximum and slow rates of 4.8, 2.4 and 1.2 kbps .
- Rate set 2 to supports 14.4 7.2, 3.6 and 1.8 kbps.
- Figure 3.16 and 3.17 shows the generation of forward traffic channel.
- Figure 3.17 shows for the generation of headset to traffic and additional operation is performed of the symbol the petition block for a data rate of 14.4kbps.
- The amount output from the simple definition block will be 28.8 kbps the puncture function blocks selects 4 bits out of every 6 offered and thus reduces the data rate to 19.2kbps which is what the block interleaver needs to see.
- All of the CDMA systems and unused Walsh codes may be used to generate forward traffic channels.
- The traffic channel for the scrambled with both the short PN sequence codes and belongs PN sequence course before transmission as shown in figure 3.16 and 3.17, power control information is transmitted to the mobile stations within the cell over the traffic channel
- This power control information is used to set the output power to the mobile on the reverse link and is multiplexed with the scrambled voice bits at a rate of 800 bps or 1 bit every 1.25 msec.

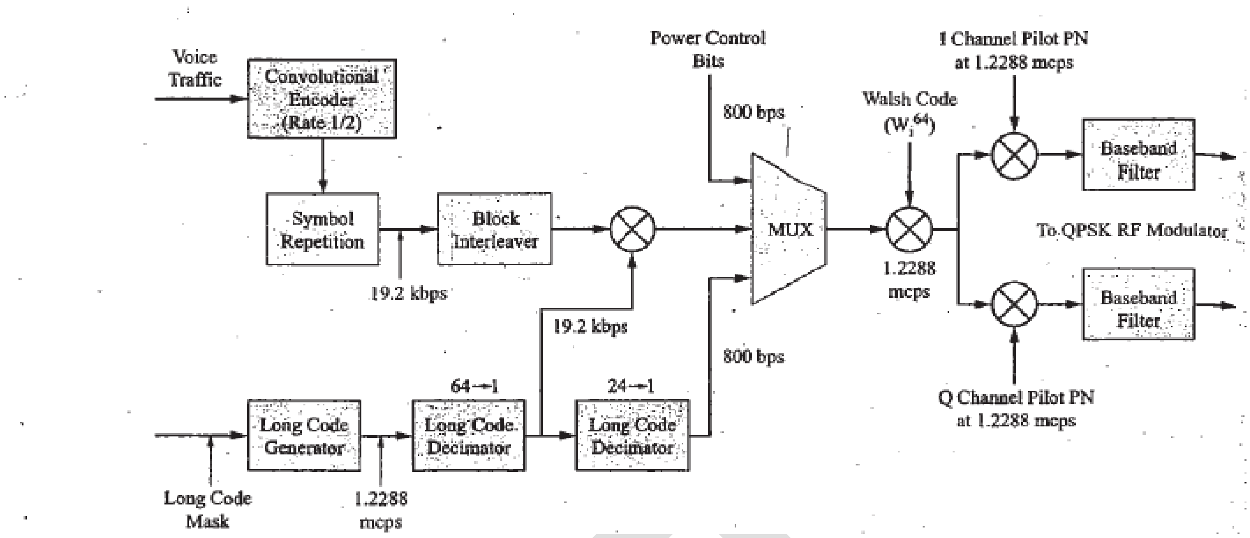

Fig. 3.16: Generation of the CDMA forward traffic/power control channels for 9.6-kbps traffic.

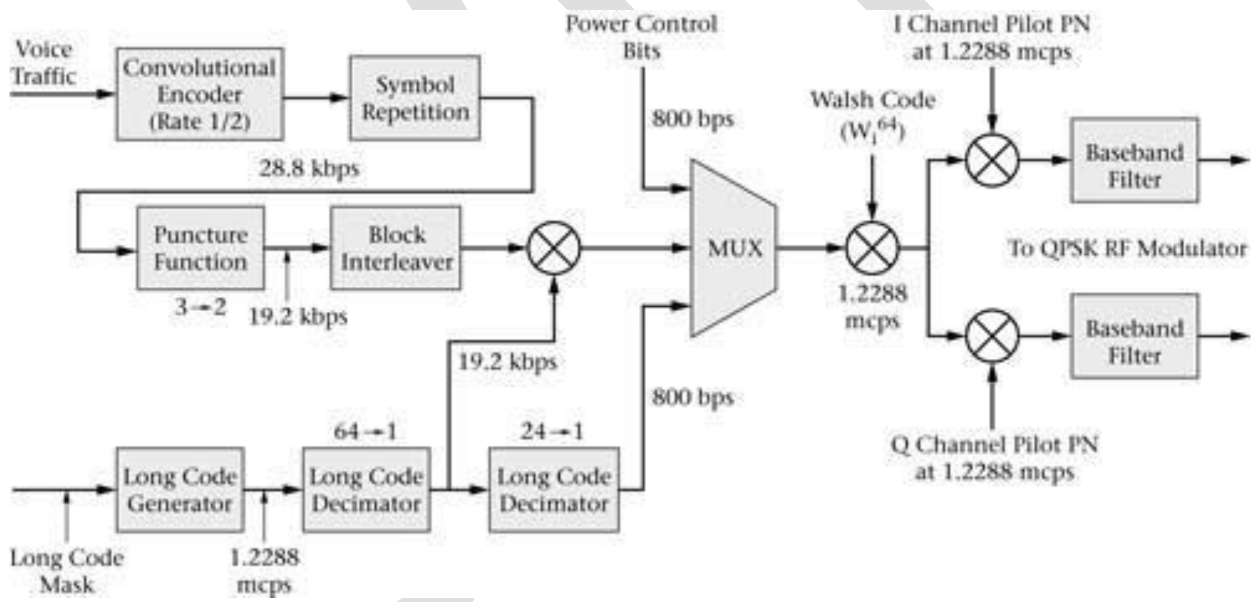

Fig. 3.17: Generation of the CDMA forward traffic/power control channels for 14.4-kbps traffic.

Reverse logical channels

The IS-95 CDMA reverse logical channels exist between the subscriber devices and the CDMA base station.

The encoding of digital information on the reverse channels is performed differently than on the forward channels.

The data to be transmitted is not initially spread by a Walsh codes; instead, the data is mapped into Walsh codes that are then transmitted.

Since there are sixty-four, 64-bit Walsh codes, every 6 bits of data to be transmitted may be mapped to a particular Walsh code.

This technique yields an over tenfold increase in bandwidth since 64 bits are now transmitted for every 6 bits of data; however, the system error rate is reduced in the process. The mapping of groups of 6 data bits to a Walsh code is very straightforward since there exists a one-to-one relationship between the two.

Each reverse channel is spread by a long PN sequence code and scrambled by the short PN sequence code.

The long PN sequence code is derived from the subscriber device's 32-bit electronic serial number (ESN) and therefore provides the means by which the user is uniquely identified within the CDMA system.

There are basically two types of reverse CDMA channels: access channels and reverse traffic/control channels

Fig. 3.18 shows the generation of the CDMA Reverse logic channels

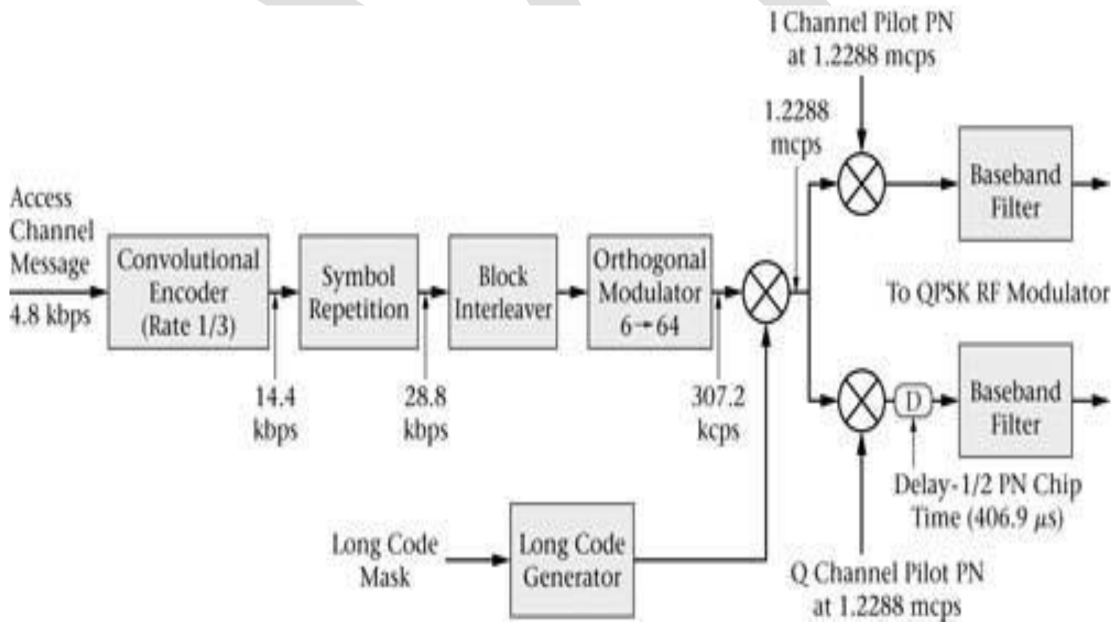

Fig. 3.18 Generation of the CDMA Reverse logic channels

Access Channels:

The CDMA access channels are used by the mobile to answer pages and to transmit control information for the purpose of call setup and tear down.

Figure 3-18 shows the access channel processing for a IS-95 CDMA system.

As shown in the figure, an access message at 4.8 kbps undergoes the familiar convolutional encoding, symbol repetition, and block interleaving that raises the data rate to 28.8 kbps.

At this point, the orthogonal modulation subsystem processes the signal by encoding every 6 bits into a 64-bit Walsh code.

This process raises the signal rate to 307.2 kcps.

The reader should note the use at this time of chips per second (cps) instead of bits per second.

Next, the long PN code spreads the signal by a factor of 4 that yields a chip rate of 1.2288 mcps. The signal is further scrambled by the short PN sequence Codes.

The long PN code is used by the system to differentiate the thirty two possible access channels. At this point, the CDMA signal is applied to an RF quadrature modulator subsystem or IC. However, for the reverse channels, the form of modulation used to produce the final UHF passband signal is slightly different than for the forward channels.

In this case, offset QPSK (OQPSK) is used instead of straight QPSK as in the case of the forward channels. Note the delay block of one-half of a PN implement chip (406.9 ns) used in the Q path to more power the efficient OQPSK modulation.

This form of modulation allows for a linear implementation by the subscriber device's RF electronics.

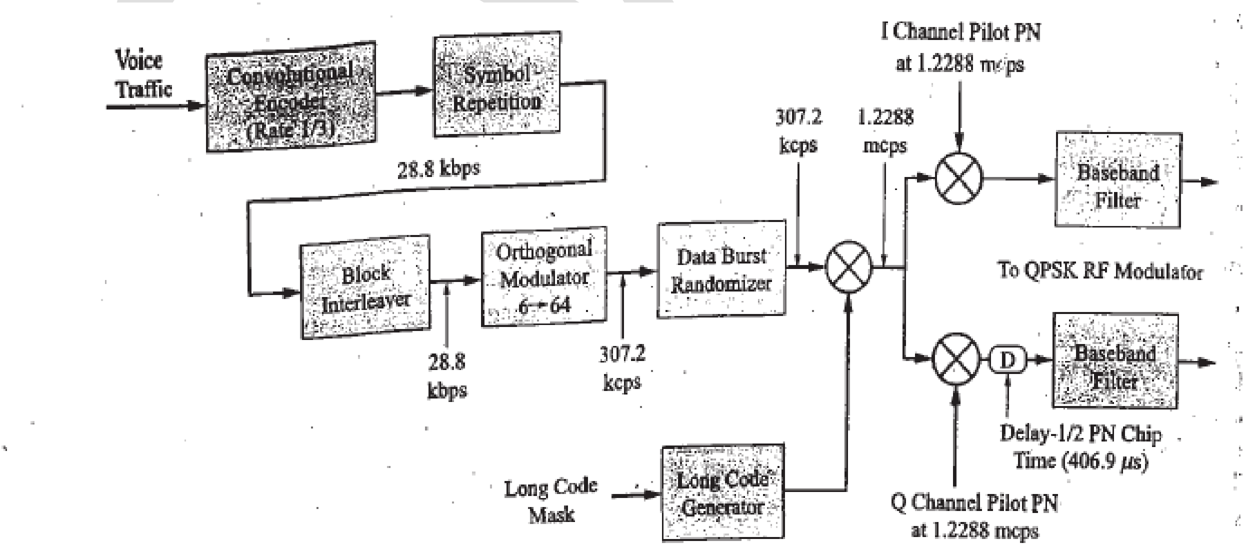

Fig. 3.19 Generation of the CDMA Reverse traffic channels

Traffic/Power Control Channels

- The IS-95 CDMA reverse traffic/power control channels voice and support both data at the two rate sets (RS1 and RS2).
- Figure 3-19 depicts the generation of a reverse traffic channel.
- In either rate set case, the data rate at the input to the orthogonal modulator sub- system will be 28.8 kbps. At the output of this process the signal rate is 307.2 kcps.
- At this point the signal is processed by a data burst randomizer that in essence is used to eliminate redundant data.
- The signal is then spread by a long PN sequence code and further scrambled by the short PN sequence code.
- The final signal rate is the standard 1.2288 mcps with a signal bandwidth of approximately 1.25 MHz.
- Figure 3.19 shows the Generation of the CDMA Reverse traffic channels

CDMA frame format

- It is time to examine the format of a basic CDMA frame and its role in the operation of the system.
- Similar to GSM system operation, CDMA systems take 20-ms segments of digital samples of a voice signal and encode them through the use of a speech coder (vocoder) into variable rate frames.
- Thus the basic system frame size is 20 ms. as shown in figure 3.20.
- The first IS-95 systems employed the 8-kbps Qualcomm-coded excited linear prediction (QCELP) speech coder that produced 20-ms frame outputs of either 9600, 4800, 2400, or 1200 bps (Rate Set 1), with the addition of overhead (error detection) bits.
- The actual net bit rates are 8.6, 4.0, 2.0, or 0.8 kbps.
- A second encoder, the 13-kbps QCELP13 encoder, was introduced in 1995 and produced outputs of 14.4, 7.2, 3.6, and 1.8 kbps (Rate Set 2), with a net maximum bit rate of 13.35 kbps.
- In each case, the speech encoder makes use of pauses and gaps in the user's speech to reduce its output from a nominal 9.6 or 14.4 kbps to lower bit rates and 1.2 or 1.8 kbps during periods of silence.
- The basic 20-ms speech encoder frame size is used in various configurations by several of the logical channels to facilitate CDMA system operation, increase system capacity, and improve mobile battery life.

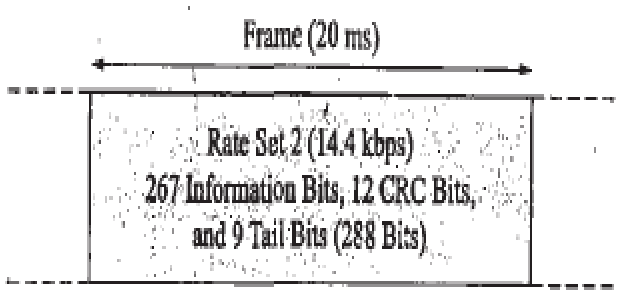

Fig. 3.20 Rate set traffic channel

Forward Channel Frame Formats

Of the four forward logical channels, only the pilot channel does not employ a frame format.

It consists of a continuous transmission f the system RF signal (refer back to Figure 3-14).

The forward traffic channel frames are 20 ms in duration and contain a varying number of information bits, frame error control check bits, and tail bits depending upon the rate set and the data rate.

Figure 3-20 depicts a forward traffic frame for Rate Set 2 at 14.4 kbps. The forward traffic channel frames are further logically subdivided into sixteen 1.25-ms power control groups.

Power control bits transmitted over the forward traffic channels are randomly inserted into the data stream of each 1.25-ms power control group yielding a power control signal rate of 800 bps.

The CDMA forward synchronization (sync) channel provides the mobile or subscriber device with system configuration and timing information.

A sync channel message can be long and therefore the message is typically broken up into sync channel frames of 32 bits each. The sync channel frame consists of a start of message (SOM) bit and 31 data bits.

The start of a sync message is indicated by a SOM bit set to 1 in the first frame and 0 in subsequent frames of the same message. At a data rate of 1200 bps, a sync channel frame is 26.666 ms in duration (the same repetition period employed by the short PN codes).

Three sync channel frames of 96 bits form a sync channel super frame of 80-ms duration (equal to four basic 20-ms frames).

The sync message itself consists of a field that indicates the message length in bits, the message data bits, error checking code bits, and additional padding bits (zeros) as needed.

The forward paging channels are used by the CDMA base station transmit system overhead information and mobile station-specin messages

In IS-95A, the paging channel data rate can be either 4800 or 9600 bps.

The paging channel is formatted into 80-ms paging of eight half frames of 10-ms duration.

Each half frame starts W synchronized capsule indicator (SCI) bit that is functionally similar to the SOM bit.

A synchronized paging channel message capsule begins immediately after an SCI bit set to 1.

To accommodate varying length paging messages and to prevent inefficient operation of the pageing channel, additional message capsules may be appended to the first message capsule if space is available within the half frame or subsequent half frames. A paging message must be contained in at most two successive slots.

CDMA reverse channels

- The reverse traffic channel, like the forward traffic channel, is also divided into 20-ms traffic channel frames.
- The reverse traffic channel frame is also further logically subdivided into sixteen 1.25-ms power control groups. As was the case for the forward traffic channel, variable rate data are also sent on the reverse traffic channel.
- The coded bits from the convolutional encoder used in the reverse traffic channel are repeated before interleaving when the speech characteristics are such that the encoded data rate is less than the maximum.
- When the mobile transmit data rate is maximum, all sixteen power control groups are transmitted.
- If the transmitted data rate is one half of the maximum rate, then only eight power control groups are transmitted.
- Similarly, for a transmitted data rate of one-quarter or one-eighth, only four or two power control groups are transmitted per frame, respectively.
- As mentioned, this process, termed burst transmission, is made possible by the fact that reduced data rates have built-in redundancy that has been generated by the code repetition process.
- A data burst randomizer ensures that every repeated code symbol is only transmitted one time and that the transmitter is turned off at other times.
- This process reduces interference to other mobile stations operating on the same reverse CDMA channel by lowering the average transmitting power of the mobile and hence the overall background noise floor. The data burst randomizer generates a random masking pattern for the gating pattern that is tied to the mobile station's ESN.
- Figure 3-21 shows this process in more detail. The reverse access channel is used by the mobile station to communicate with the base station.
- The access channel is used for short message exchanges, such as responses to Commands from the base station, for system registrations, and for call origination requests.
- The access channel data rate is 4.8 kbps using a 20-ms frame that contains 96 information bits. Each access channel message is typically composed of several access

channel frames.

- Since multiple mobile stations associated with the same paging channel may try to simultaneously access the same access channel, a random access protocol has been developed to avoid signal/data collisions.
- Figure 3.21shows the CDMA reverse channel variable data rate transmission
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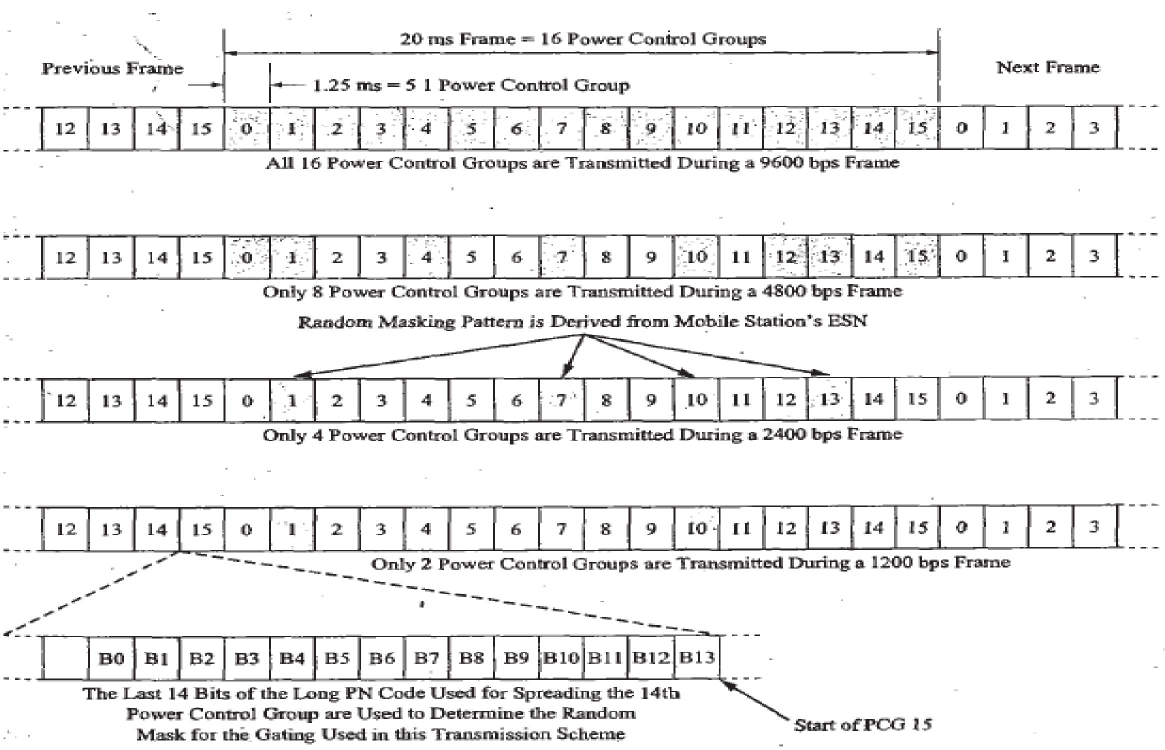

Fig. 3.21 CDMA reverse channel variable data rate transmission

3.4.CDMA System (Layer 3) Operations

<u>Initialization/registration</u>

- As is the case with GSM cellular, CDMA system registration procedures are dependent upon the status of the mobile station.
- The mobile may be either in a detached condition (powered off or out of system range) or in an attached condition.
- When first turned on, the mobile goes through a power-up state (see Figure 3-22) during which it selects a CDMA system and then acquires the pilot and sync channels, which allows it to synchronize its timing to the CDMA system.

- When attached, the mobile Status dependent operation may be in one of three states: the mobile station idle state, the access system state, or the mobile station control on the traffic channel state (see Figure 3-22).
- While in the idle state, the mobile monitors the paging channel (PgC).
- In the system access state the mobile station communicates with the CDMA base station, sending and receiving messages, as shown by Figure 3-24, while performing various operations dictated by the different system access substrates.
- The mobile station control on the traffic channel state the mobile communicates with the base station using the forward and reverse traffic channels while in various traffic channel substrates as shown by Figure 3-25.
- As indicated by Figure 3-23, the mobile may move back and forth between these three states depending upon the movement of the subscriber and the use of the mobile.

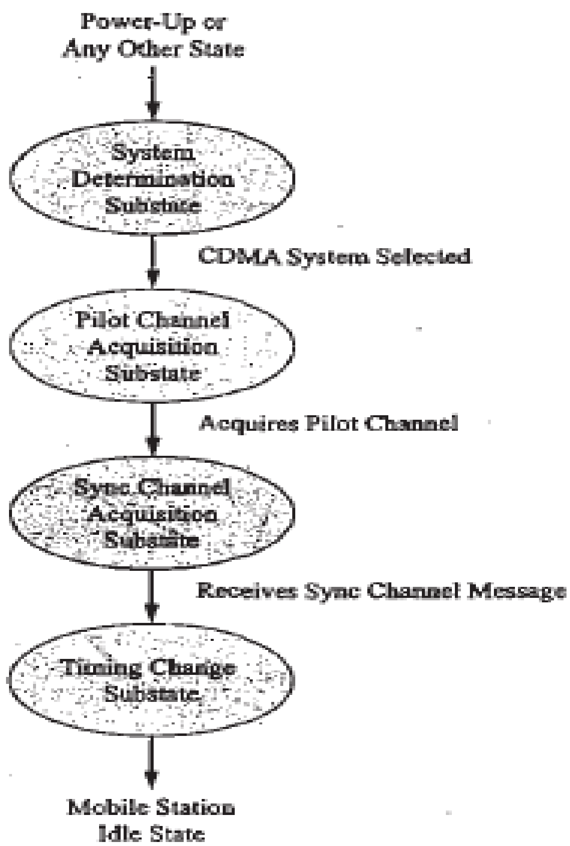

Fig. 3.22 CDMA mobile station initialization state

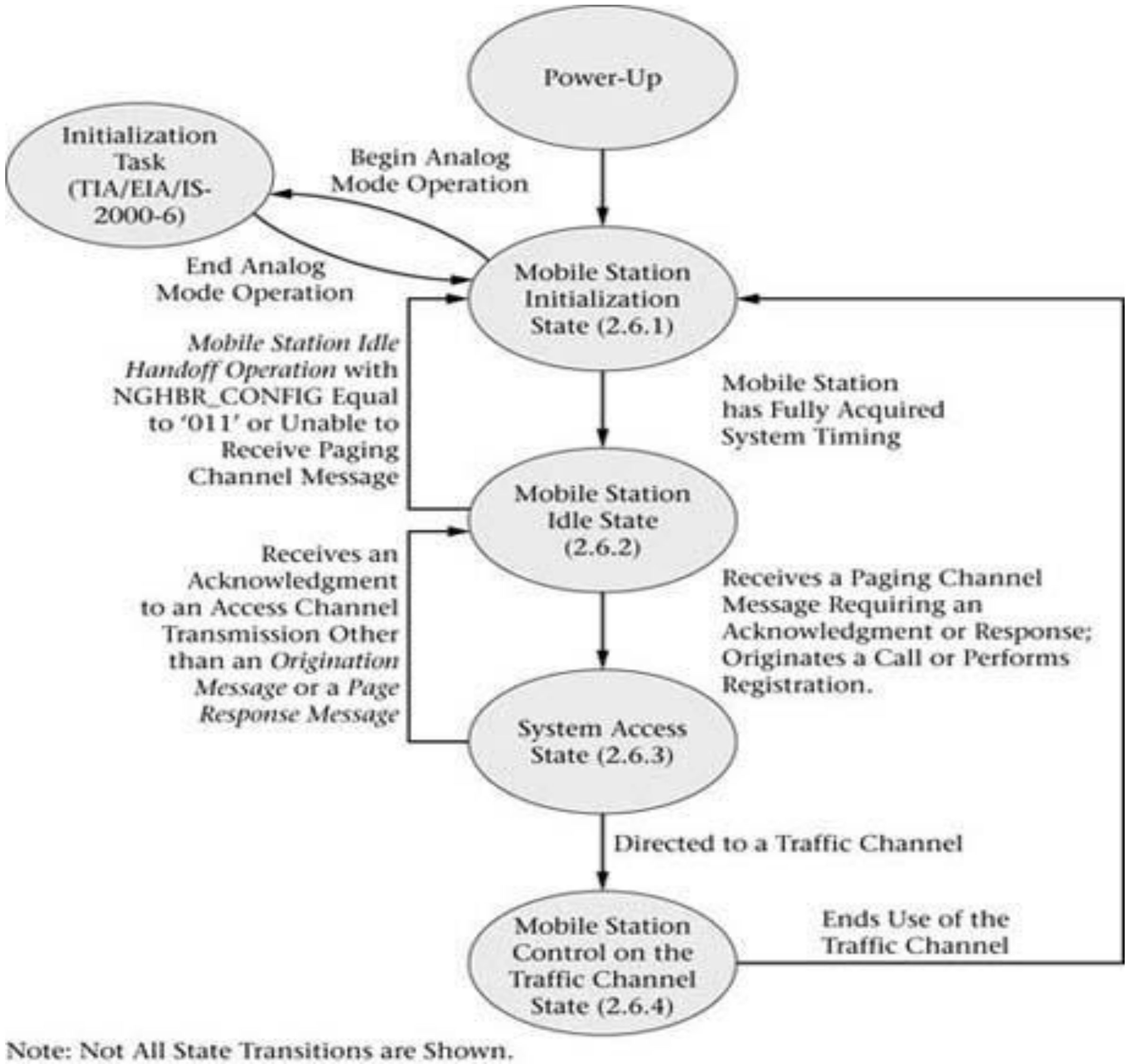

Fig. 3.23: CDMA mobile station call processing states

Figure 3.24shows the CDMA system access state flow chart.

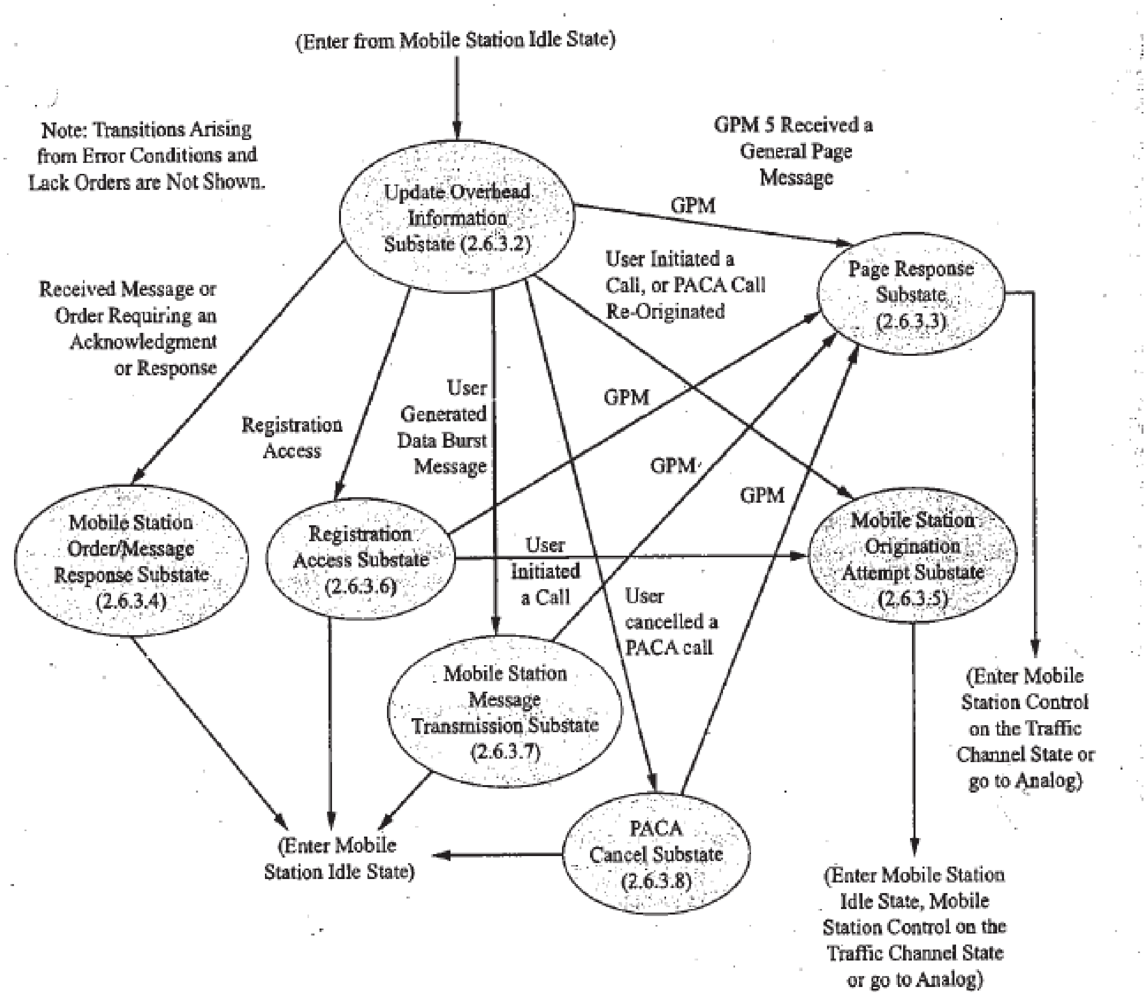

Fig. 3.24: CDMA system access state flow chart

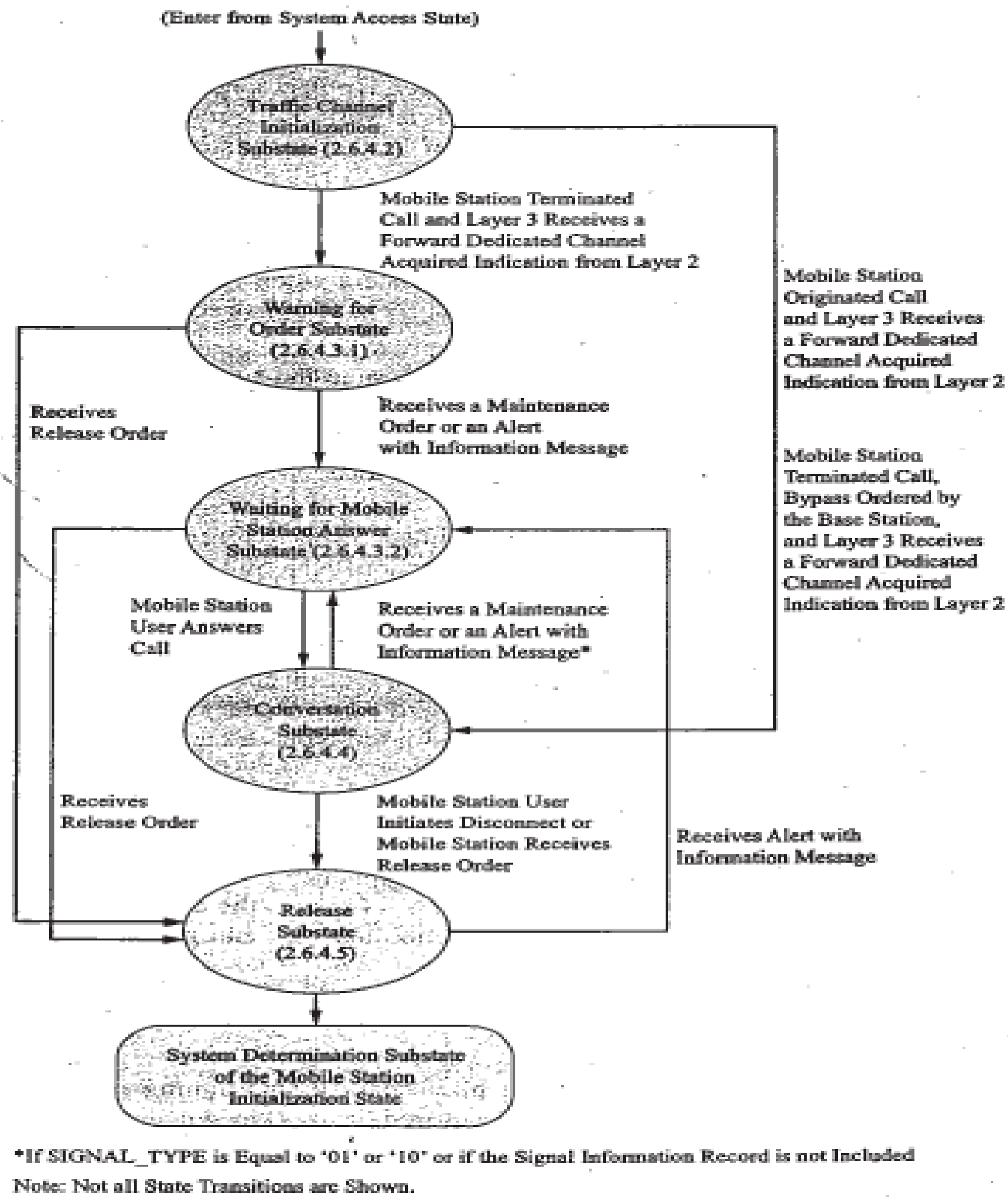

Fig. 3.25 CDMA mobile station control on the on the traffic channel flow chart

Registration is the process by which the CDMA mobile station, through messages to the base station, informs the cellular system of its identification, location, status, slot cycle, and other pertinent information necessary for proper and efficient system operation.

For slotted mode operation the mobile provides the base station with the SLOT_CYCLE_INDEX value so that the base station may determine which slots the mobile is monitoring.

Classmark values and protocol revision numbers allow the base station to know the capabilities of the mobile station.

CDMA system has 10 different forms of registration.

Power-up registration: The mobile station registers when it powers or switches between different band classes or PCS frequency blocks, alternative operating modes, or analog and CDMA operation

Power-down registration: The mobile registers when it powers off if it has previously registered in the currently serving system.

Timer-based registration: The mobile registers whenever various timers expire. This process forces the mobile to register at regular intervals.

Distance-based registration: The mobile is forced to register whenever the distance between the current serving base station and the base station where it last registered exceeds a certain threshold. The mobile station calculates this distance by using the latitude and longitude values for the base stations involved.

Zone-based registration: The mobile station registers when it enters a new zone. Registration zones are groups of base stations within a particular system and network. Zone registration causes the mobile to register whenever it enters a new zone that is not on its internally stored list of visited registration zones.

These first five modes of registration are known as autonomous registration and are enabled by roaming status. In each case, they are initiated by the occurrence of some event.

Parameter-change registration: The mobile station registers when specific parameters stored in its memory change or when it enters a new system. This form of registration is independent of roaming status.

Ordered registration: The mobile station registers when requested to by the base station through the issue of an order message.

Implicit registration: Whenever the mobile station successfully sends an origination message or a page response message, the base station is able to deduce the location of the mobile. These circumstances are considered to constitute an implicit registration.

Traffic channel registration: Whenever a base station has registration information for a mobile that has been assigned to a traffic channel, the base station may notify the mobile that it is registered.

User zone registration: Whenever the mobile selects an active user zone, it registers.

Call Establishment.

- Similar to the GSM cellular system, CDMA System call setup requires various system tasks including mobile initialization, idle, system access traffic channel communication, and call termination.

- Additionally, CDMA systems use a sophisticated form of power Control for both the mobile and the base station and a more complex form of handoff to provide subscriber mobility that can be more transparent than that employed by GSM cellular systems.

Initialization State:

- As explained previously, when the mobile is first powered on, it enters the mobile station initialization state.
- During this process the mobile searches for a pilot channel by aligning its short PN code with a received short PN code.
- Once a valid pilot channel is acquired the mobile synchronizes with it.
- The mobile has fifteen seconds to locate and acquire a pilot signal.
- If the mobile cannot perform this operation, it may decide to search for an AMPS control channel and enter an analog operational mode.
- When the mobile locates a CDMA pilot signal, it switches to Walsh code 32, W_{32}^{64}, and looks for the start of the sync channel message.
- The sync channel message contains information about system and the PN codes needed to synchronize its PN codes.
- After decoding sync channel, the mobile aligns its timing to that of the serving base station. Referring back to Figure 3-21, one can more easily visualize sequence of the operations that occur during this initialization state.

Idle State

- Once the mobile has achieved initialization it moves into the ideal state.
- While in the idle state, the mobile is waiting to receive calls or data messages or is ready to originate a call or some form of data transfer.
- To support subscriber connectivity and mobility, the mobile is constantly monitoring radio channel quality, decoding paging channel message to obtain system parameters, access parameters, and a list of neighboring cell sites to monitor.
- After acquiring sufficient system information, batter the mobile may be allowed to enter a sleep mode to conserve mobile battery power.
- This will be facilitated through the use of slotted mode operation by the mobile when monitoring the paging channel as explained previously.

Access state:

- The CDMA mobile will enter the access state when it receives a mobile directed message requiring an acknowledgment, originates a call, or 1s required to perform registration.

- When in the access state, the mobile will randomly attempt to access the system.
- Access to the system is obtained when the mobile station receives a response from the base station on the paging channel. Since multiple mobiles may be associated with a particular paging channel, they may simultaneously attempt to use the same access channel.
- The resulting signal collisions at the base station will most likely result in few if any of the requesting mobiles being granted access to the system.
- Therefore, to alleviate this problem, some form of collision avoidance scheme is necessary to increase the probability of a successful system access by a mobile.
- For the CDMA system, this access protocol is implemented through the use of access class groups with assigned priorities, a gradual increase in access request power level, random time delays for access requests, and a maximum number of automatic access attempts.
- Figure 3-26 depicts what is known as access channel probing.
- The transmission of a series of access probe sequences is known as an access attempt.
- Each access probe consists of an access channel preamble (one to sixteen frames consisting of 0's) and an access channel message capsule of three to ten frames.
- This yields an access probe with duration of four to twenty-six 20-ms frames. Two types of access messages may be trans. mitted by the mobile on the access channel: either a response message or a request message. Within an access probe sequence, the access channel message is the same for each access probe.
- Referring to Figure 3-26 again, one can see that the access channel probing process consists or the mobile station sending a series of sequences of access probes of increasing power levels.

Traffic State

- The mobile enters the traffic state when it begins to transfer user information between the mobile and the base station (refer back to Figure 3-25). As was the case for GSM cellular, this information can be voice or data that originates from the PSTN or PDN or another mobile in the same o another network.
- While in the traffic state, the mobile transmits voice and signalling information on the reverse traffic channel (RTC) and receive voice and signalling information on the forward traffic channel (FTC).
- Signalling over the traffic channel can be performed by either a blank and burst or dim-and-burst process.
- The blank-and-burst signalling method replaces 1.25 ms of speech data with signalling message bursts. The dim and-burst method inserts signalling messages when speech activity is low.
- The 8-kbps QCELP vocoder combines lower-rate voice data and signalling data into a higher-rate frame (only done at the 9600-bps rate) whereas 13-kbps vocoder can use any

frame for both voice and signalling.

- Various mode and flag bits are used to alert the receiver to the signalling method (dim or blank) and structure of the mixed voice and signalling frames. Depending upon the message, the number of frames needed send the signalling information will vary.
- Although the dim-and-burst method will not affect speech quality, it requires more time to transmit the signalling.

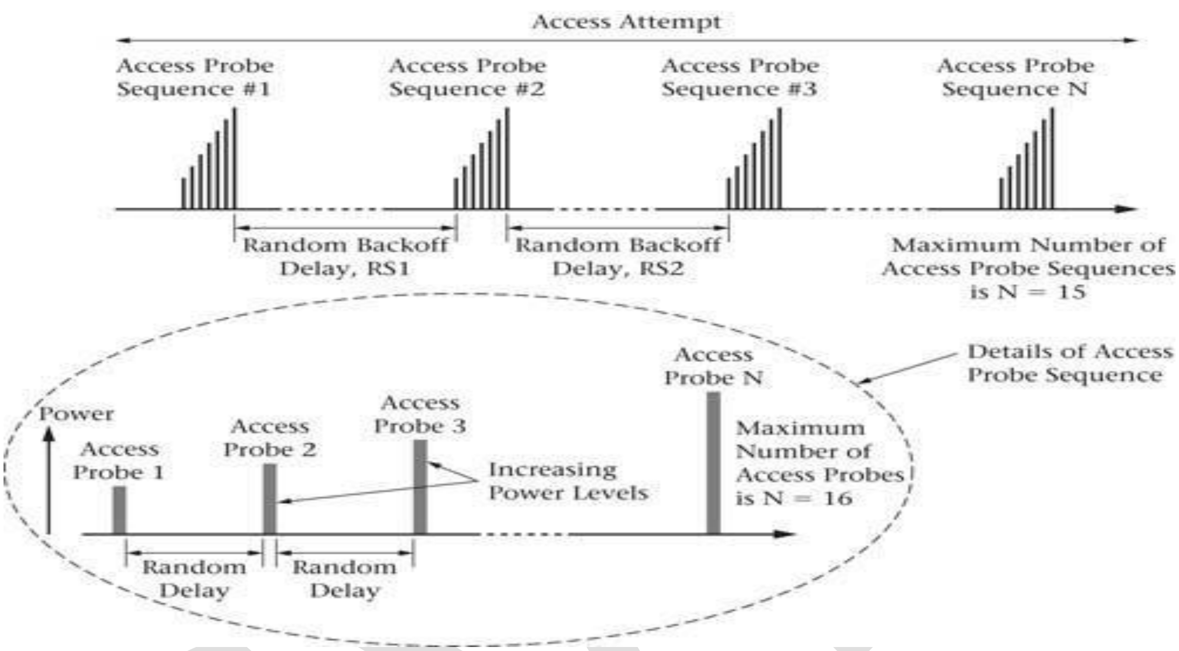

Fig.3.26 CDMA access Channel probing in Access state

Mobile originated call in CDMA

- To originate a call, the mobile sends a system access message on the access channel and then monitors the paging channel for a response from the system.
- If the access is successful, a forward traffic channel is assigned that corresponds to a particular Walsh code and a base station receiver is assigned for the reverse traffic channel long PN code.
- Additionally, the base station sends a paging channel message to the mobile with the Walsh code information and a reverse traffic channel assignment.
- The mobile configures itself and begins decoding null traffic that the base station has started to transmit over the forward traffic channel.
- The mobile starts to transmit a preamble over the reverse traffic channel.
- The base station uses the forward traffic channel to acknowledge the preamble and the mobile responds by starting to send traffic. Figure 3-27 shows these steps in timeline chart form.
- During the call, there are constant power control operations taking place and, if the mobile is moving about, handoffs may occur between different base stations.

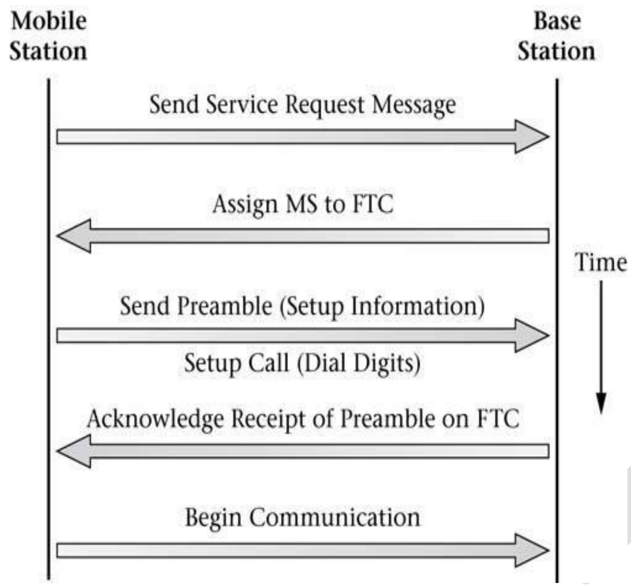

Fig : 3.27 mobile originate call in CDMA

Mobile-Terminated Call

- For a mobile-terminated call, the base station sends a message to the mobile on the paging channel.
- If attached to the system, the mobile sends an acknowledgement response on the access channel.
- The base station receives the acknowledgement, configures a forward traffic channel, and assigns a receiver to the mobile's reverse traffic channel.
- The base station begins to send null traffic on the FTC and sends a PgC message containing Walsh code and RTC information. The mobile configures itself and begins decoding the null traffic 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 3-28.

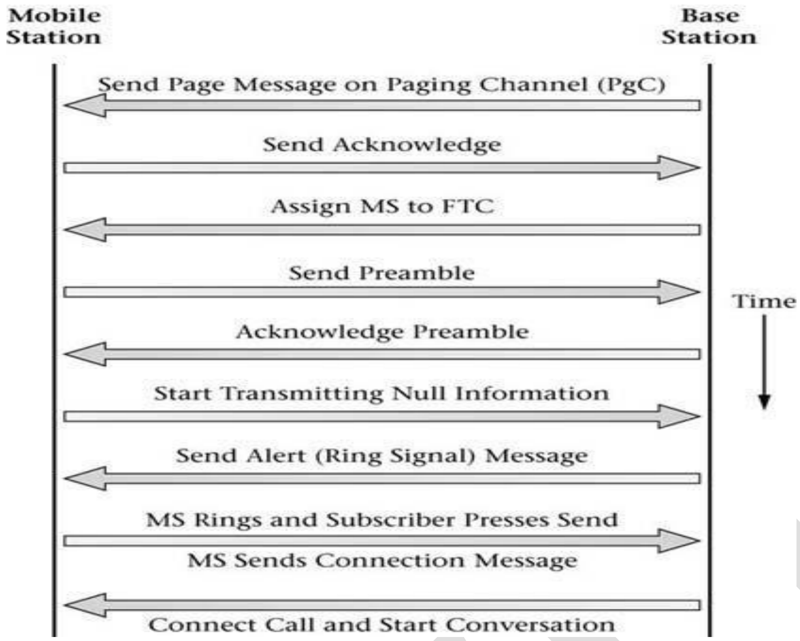

Fig. 3.28: CDMA Mobile terminated call

Call Termination

- Call termination occurs at the end of a call and can be initiated by either the mobile or the base station.
- If the mobile initiates the call termination, it sends a call termination message to the base station, stops transmitting on the RTC, and returns to the mobile station initialization state.
- If the network initiates the call termination (the calling party hangs up), the base station sends a call termination message to the mobile.
- The mobile stops transmitting on the RTC and returns to the initialization state

Call Handoff

- The specifications for IS-95 CDMA delineate three mobile station states during which a handoff can occur.
- Referring back to Figure 3-23, 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.

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

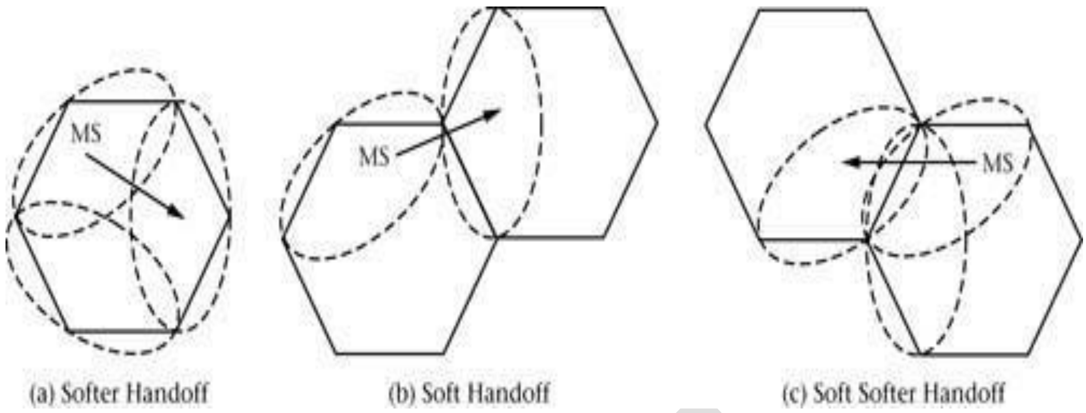

Fig. 3.29 Soft handoff are of three types

Figure 3-29 depicts the three types of soft handoffs defined in the IS-95 CDMA standard.

- **Softer,→** handoff is between two sectors of the same cell.
- **soft →**occurs between two different cells
- **soft-softer handoff→** 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

- In all CDMA handoff procedures a number of base stations and their pilot channels are involved. The procedures for soft and softer handooffs 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 support 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 TADD).
- 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 neighbour 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 3-31 depicts a simplified flowchart of this process

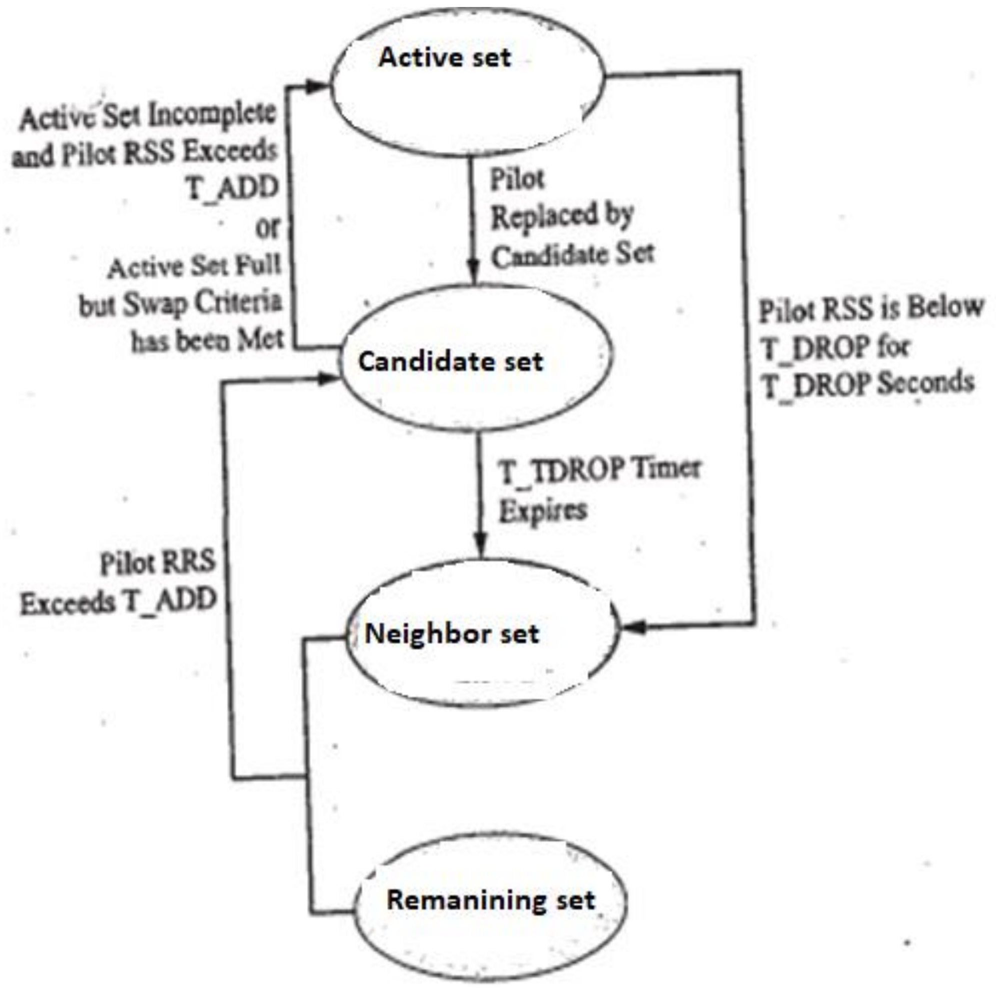

Fig. 3.30 : Flowchart of the generation of the active and candidate pilot set for CDMA handoff operations

Hard handoffs

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 non-contiguous cells to provide additional capacity during system growth or for local high-traffic hot spots.
- Figure 3-31 depicts a possible scenario of situation. A mobile that is using the second carrier and exitin8 the pocket local 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 must 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 non-border cells (sectors).
- In Figure 3-31 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 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

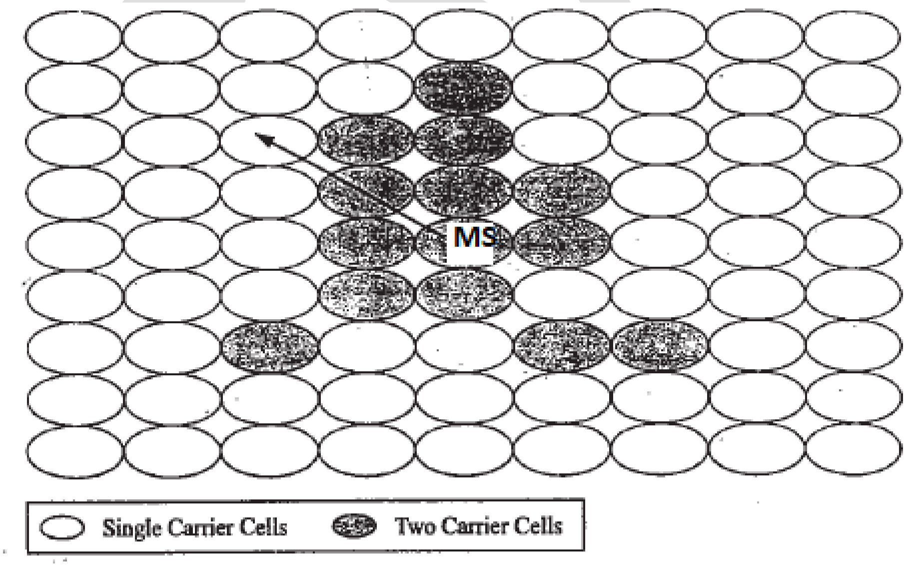

Fig.3.31 Hard CDMA handoffs due to inter carrier handoff

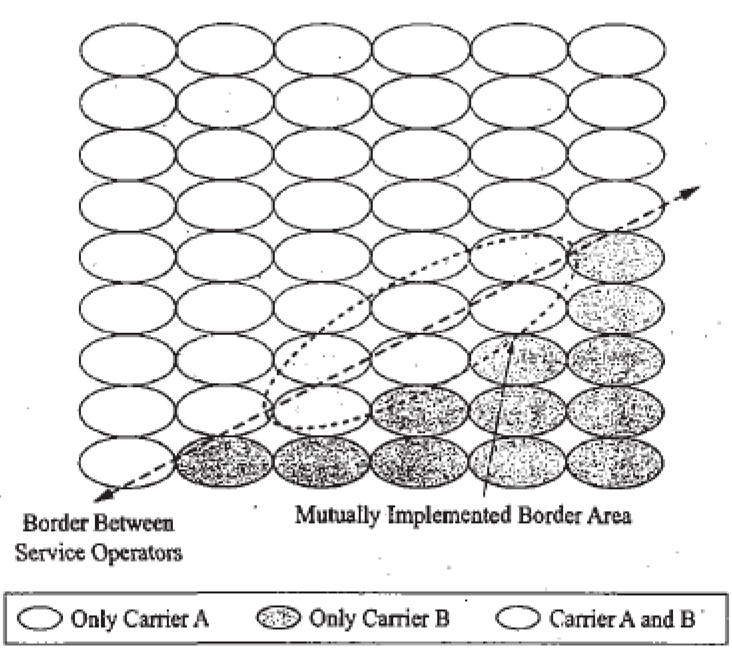

Fig.3.32 Hard CDMA handoffs due to disjoined regions

PART 3: 3G CDMA

3.5.IS-95-B, cdma2000, and W-CDMA

A high market demand and continuing advances in the field of micro electronics technology have motivated the cellular industry to develop numerous wireless standards over the past few years that have led to new services offerings particularly in the mobile data arena.

Also, due to the global nature of the market, cellular standards have been the focus of several international committees such as the 3GPP and 3GPP2 collaborations.

As pointed out earlier, in the effort to establish next-generation (3G) cellular standards a number of proposals have been submitted to ITU-R for evaluation and adoption. The desired harmonization of proposals for W-CDMA, TD-CDMA, TD-SCDMA, and EDGE (a follow-on to GSM) systems are being dealt with by the 3GPP group (UMTS standard) while cdma2000 is under the purview of the 3GPP2 group.

In all cases, the ultimate evolution to true 3G capabilities involves the use of CDMA technology for the air interface portion of the system.

IS-95B

Is 95A CDMA technology that was designed mainly for boys communication.
An evolutionary improvement to IS 95A, IS-95B was adopted in October 1998 and additional mobile data functionality to the earlier standard.
IS- 95 B features that use of combinative channels. That is, a primary channels be combined with up to seven supplementary data channels.

Theoretically IS-95B should be able to support packet data services with up to a maximum transfer throughput of 106.8 kbps

IS-95B forward and reverse channels

- The most dramatic changes to IA-95A are found in the channel structure.
- To implement an increased packet data rate, IS-95B employs what are known as **supplementary code channels** (SCCHs) in both forward and reverse direction.
- Also the former forward and reverse traffic channels are known as fundamental channels (FCHs).
- These channels are still used primarily for voice traffic.
- In IS 95B, the system may assign from 1 to 7 ideal CDMA channel to a user as supplementary code channels (SCCHs) and therefore provide the extra bandwidth capacity needed to increase the packet data transfer rate for a subscriber.
- As a consequence of the use of supplementary code channels IS-95B, the function of the radio resource management is naturally more Complex and sophisticated

Cdma2000

- Cdma2000 is the term used for 3G CDMA system.
- Cdma2000 is the wideband enhanced version of CDMA
- It was compatible with TIA/EIA-95-B.
- It provides the support for data services up to 2mbps, multi media services, and advanced radio technologies.
- First phase of CDMA is known as 1xRTT (radio transmission technology) happening over a channel of 1.25MHz CDMA channel.
- Next implementation phases is called as 1xEV (evolutionary).
- It has two types 1xEV DO (data only-downlink direction data rate 2.4mbps & uplink direction data rate 153 kbps) and 1xEV DV (data and voice-3mbps all over the network)

<u>CDMA 200 difference:</u>

Cdma2000 Forward and reverse channel structures:

For **Cdma2000 vario**us additional forward and reverse logical channels have been defined.
In the forward direction, one can classify the logical channels into three categories namely overhead control and traffic channel.
In the overhead group there are four pilot channels (forward common pilot channel
forward common transmit diversity pilot channel, and an auxiliary pilot channel and auxiliary transmit diversity pilot channel) that are used for enhanced system timing, phase, radio link characteristic estimation, diversity reception, and power reference purposes by the mobile station
Additionally, there is a sync channel used to provide system synchronising information, paging channels to provide IS-95B compatibility, and quick paging channel designed to provide slotted mode operation and save mobile station battery power. Figure 3-34 displays

the forward channel structure for cdma2000. Note the references to spreading rate and radio configurations within the appropriate blocks.
The forward control channel group consists of common assignment channels, common power control channels, and common control channels, broadcast control channels, and packet data control channels. The common assignment channel is used by the CDMA base station to acknowledge a mobile station accessing the reverse enhanced access channel and to supply information to the mobile.

As shown in Figure 3-33, the forward traffic group supports the forward fundamental channel (F-FCH) and up to seven supplemental code channels (SCCHs) for IS-95B compatibility. Additionally, two supplemental channels (SCHs) specifically designed for high-speed data services (RC3 through RC9) and two high-speed packet data channels for RC10 use have been added, along with a dedicated control channel (DCCH) that is used for signaling message support.
The reverse link channel structure is shown by Figure 3-34 for SR1 and SR3. Figure 3-34 depicts two kinds of information. First, various the operational modes of the mobile are arranged into columns and then the types of reverse channels that can be transmitted by the mobile station within each operational group are shown.

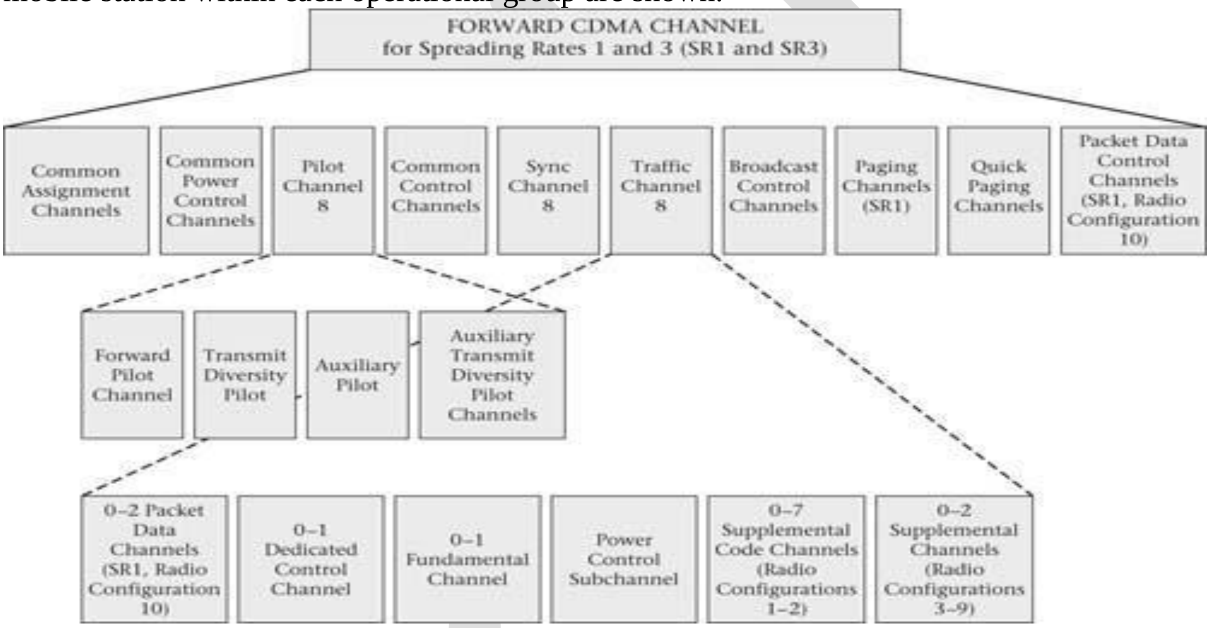

Fig. 3.33: Forward Channel Structure of CDMA 2000 (Courtesy of 3GPP2)

W-CDMA and UMTS

- GSM wireless cellular systems have more such scribers worldwide than any other type of cellular technology.
- In its evolution toward 3G functionality, GSM technology has adopted general packet radio service (GPRS) to provide enhanced packet data transfer rates with a maximum potential rate of 171.2 kbps.
- In- the next phase of its evolution, GSM makes use of advanced modulation techniques to achieve even higher packet data rates.
- This next system upgrade is known as enhanced data rates for global evolution or EDGE. Using the same GSM radio resources, EDGE, in theory, can provide a data

rate of 473.6 kbps when all **eight GSM timeslots** are combined and used by a single subscriber; however, the data throughput rate is actually less.
- EDGE therefore enables a number of 3G data services but really requires numerous GSM carriers to satisfy the 3G functionality requirements.
- A new AMR vocoder has further increased GSM system capacity, but the same basic GSM radio interface using TDMA technology remains.

- In an effort to migrate GSM/TDMA standards to 3G, the third Generation Partnership Program (3GPP) group has recently defined Universal Mobile Telecommunications System (UMTS) that relies on some form of CDMA technology to implement the air interface.
- The form of CDMA used is heavily dependent upon the cellular service provider's spectrum holdings or potential holdings.

- The **UMTS** standard provides different-flavour an both cases. CDMA SO GSM and UMIS core network elements allowed by this interconnection will facilitate network development, provisioning of network components, and introduction of UMTS-based services.
- It is felt that multimode mobile stations for both GSM and UMTS will provide a smooth migration path from GSM to UMTS and 3G services. The UTRAN system allows for several radio interface models: frequency division duplexing (FDD) or wideband CDMA (W-CDMA) for operation in paired frequency bands, or time division duplexing (TDD) for operation in unpaired bands.
- At higher layers of the radio network protocols both FDD and TDD are harmonized and the various nodes (either HDD or TDD) are hidden from the core network.
- The details of FDD or TDD operation are only important to the UTRAN and the end terminals (mobile stations). Therefore, where an operator has paired fre quency bands, the operator will implement W-CDMA using higher chip rates than cdma2000 (3.84 mcps) over 5-MHz widebands.
- If a license holder has unpaired spectrum (typical of European and Asian countries), then time division duplex is the optimized solution for this case.
- With TDD, uplink and downlink traffic can be transmitted on the same carrier frequency but during different timeslots. One version of this radio inter face is time division **CDMA Or TD-CDMA**.
- The standard calls for a single carrier with a chip rate of 3.84 mcps in a 5-MHz bandwidth.

- Another version of TDD is time division synchronous CDMA or TD-SCDMA. This technology combines both TDMA and CDMA principles with other capacity-enhancing techniques. The radio signal is spread by a chip rate of 1.28 mcps and is contained in a 1.6-MHz bandwidth.
- This gives rise to the possible use of three TD-SCDMA carriers in the same 5-MHz bandwidth as used by TD-CDMA.
- See Figure 3-35 for a comparison TD-CDMA and TD-SCDMA spectrum usage. Unfortunately, the details of the W-CDMA (similar to cdma2000), TD-CDMA, and TD-SCDMA radio.

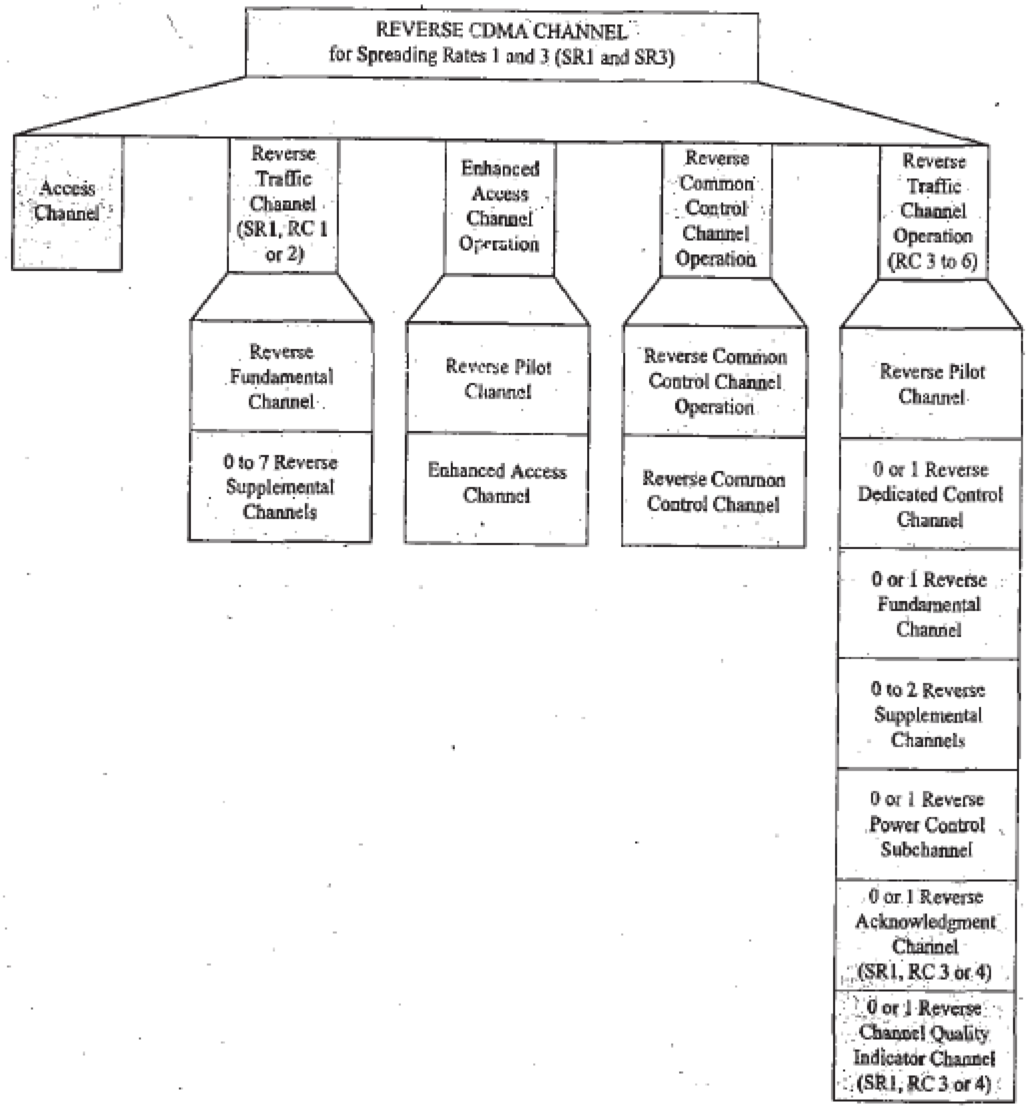

Fig. 3.34: Reverse Channel Structure of CDMA 2000 (Courtesy of 3GPP2)

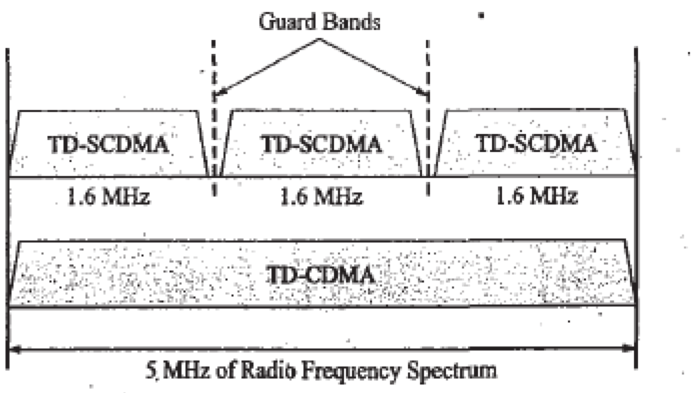

Fig. 3.35. TD-CDMA and TD-SCDMA spectrum usage