E1-E2 UPGRADATION COURSE –CONSUMER MOBILITY

Overview of CDMA 2000 1X & EVDO

CHAPTER-IX

CDMA Network Architecture

System Architecture

The CDMA cellular mobile communication system consists of four independent subsystems: Mobile Station (MS), Base Transceiver Subsystem (BSS), Mobile Switching Subsystem (MSS) and Operation & Maintenance Subsystem (OMM). MS and BSS can communicate directly, while the communication between BSS and MSS is implemented through the standard A interface. Other interfaces, such as B, C, D, E, H, M, N, O and P represents the interfaces among the functional entities. When different functional entities are configured in each physical unit, some interfaces will become internal interfaces that may not follow the unified interface standard. Ai, Di and Pi are the system's interfaces to interconnect with other communication networks. Fig. 2.2-1 shows the architecture and interfaces of the CDMA system:

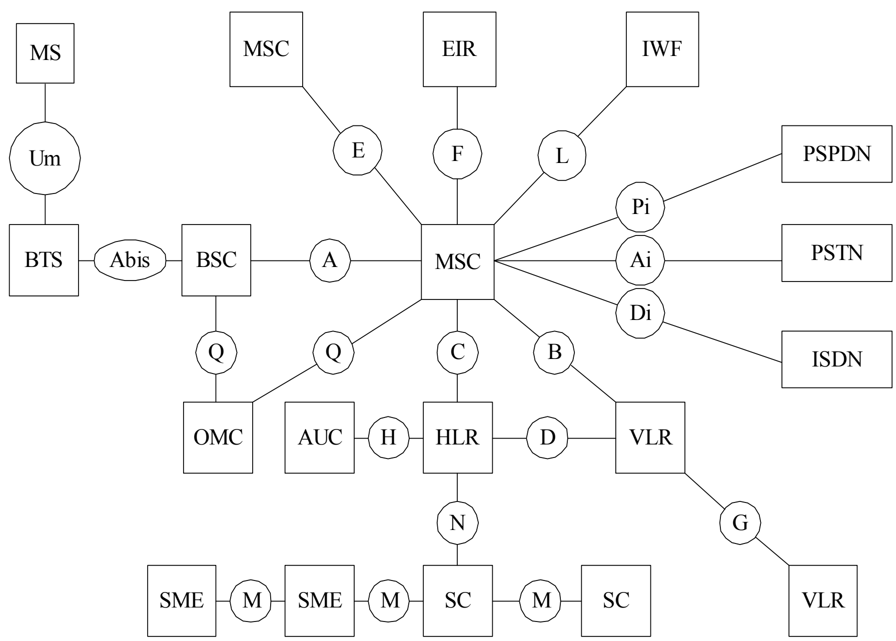

Fig. 2.2-1 Network Architecture of the CDMA Cellular Mobile Communications System

BSC	Base Station Controller	Base station controller
BTS	Base Transceiver Station	Base station transceiver
MSC	Mobile services Switching	MSC

	Center	
OMC	Operation and Maintenance Center	Operations & maintenance center
AUC	Authentication Center	Authentication Center
EIR	Equipment Identification Register	Equipment Identification Register
HLR	Home Location Register	HLR
VLR:	Visitor Location Register	VLR
MS	Mobile Station	Mobile station
ISDN	Integrated Services Digital Network	Integrated service digital network
PSTN	Public Switched Telephone Network	Public Switching Telephone Network
PSPDN	Public Switched Public Data Network	Public Switched Public Data Network
PLMN	Public Land Mobile Network	Public land mobile network
SC	Short Message Center	Short message center

An Introduction to Network Entities

BTS Subsystem

The BTS Subsystem (BSS) is the assembly of radio equipment and radio channel control equipment, serving one or more cellular cells. In certain radio coverage, it is controlled by the Mobile Switching Center (MSC) to implement channel assignment, user access and paging, and information transfer. Normally, the BSS consists of one or more BSCs and BTSs. The BTS is responsible for radio transmission and BSC for control and management.

Base Transceiver

The Base Transceiver (BTS) belongs to the radio part of a basestation system. Controlled by BSC, it serves the radio transceiving equipment of a certain cell, implements the conversion between BSC and radio channels, radio transmission through air interface between BTS and MS and related control, and communicates with BSC through the Abis interface.

Base Station Controller

One end of the Base Station Controller (BSC) can be connected with one or more BTSs, while its other end can be connected with MSC and OMC. Oriented to radio network, BSC implements radio network management, radio resource management and radio BTS monitoring and management. It also controls the establishment, connection and disconnection of radio connection between MS and BTS, controls the positioning, handoff and paging of MS, provides voice coding and rate adjustment and carries out operation and maintenance of the BSS.

Mobile Switching Subsystem

The Mobile Switching Subsystem (MSS) implements the main switching functions of the CDMA network. Meanwhile it manages the database for user data and mobility.

Mobile Switching Center

MSC is the core of the CDMA network. It controls and implements voice channel connection for MSs within its coverage, namely serving as an interface between CDMA and other networks. The functions MSC carries out include call connection, charging, BSS-MSC handoff, assist radio resource management and mobility management. Besides, each MSC also implements the GMSC function for call route establishment to the MS, namely, to query the location information of each MS. MSC gets all data required for call request processing from three databases, VLR, HLR and AUC.

Visitor Location Register

The Visitor Location Register (VLR) is a dynamic user database, storing the related user data of all MSs (visitors) within the MSC's management range, including user ID, MS's location area information, user status and services available for the user.
VLR gets and stores all necessary data from the HLR of a mobile subscriber. Once the mobile subscriber leaves the control area of the VLR, it will be registered in another VLR, and the previous VLR will delete its data log.

Home Location Register

The Home Location Register (HLR) is a static database, storing the data for mobile subscriber management. Each mobile subscriber should be registered in its HLR. It stores two kinds of information: parameters related with the mobile subscriber, including the subscriber's ID, access capability, user type and supplementary service; current location information of the subscriber for call route establishment. For example: the address of MSC or VLR. No matter where the mobile subscriber roams, its HLR should provide all related parameters and input the latest location into the database.

Authentication Center

The Authentication Center (AUC), a functional entity managing the authentication information related with mobile stations (MSs). It implements MS authentication, stores the MS authentication parameters, generates and sends the corresponding authentication parameters according to the requests of MSC or VLR, including A-KEY, SSD, ESN, MIN and AAV, and then calculates all random numbers to get the authentication result.

Short Message Center

The Short Message Center (SC) is responsible for receiving, storing and forwarding short messages between the CDMA mobile subscribers and fixed line users or between mobile subscribers. It serves as a postal office, receiving mails from every place, sorts them out and then distribute them to the corresponding users. Through SC, the messages can be sent to destination more reliably.The short message services include point-to-point server and cell broadcast service.

Operation and Maintenance Management Subsystem (OMM)

The Operation & Maintenance Center (OMC) provides equipment operators with network operation and maintenance services, manages subscriber information, makes network planning and improves the efficiency and service quality of the whole system. OMC includes OMC-S and OMC-R, depending on the part for maintenance. OMC-S is responsible for the maintenance on the MSS side while OMC-R is responsible for the maintenance on the BSS side. Its specific functions include: maintenance test, obstacle check and handling, system status monitoring, realtime system control, office data modification, performance management, subscriber tracking, alarm and traffic measurement.

Interfaces and Protocols

According to the Open System Interconnection (OSI) model, we can analyze the CDMA network on the aspects of interface, protocol and interface functions in detail.

Interfaces

As shown in Fig. 2.2-1, various interfaces exist in the CDMA system. They can divided into the following categories according to different subsystems: Air interface

Um between mobile terminals and the BSS, A interface between BSS and MSS, and other interfaces between internal entities of the network.

Air interface

The Um interface is defined as the communication interface between MS and BTS. It is the key distinguishing the CDMA network from the GSM network and the most important interface of the CDMA network.

This interface grants compatibility to MSs from different suppliers and networks of different operators, enables MSs to roam, ensures the frequency efficiency of the cellular system, and adopts a series of anti-interference technologies and interference preventing measures. Obviously, the Um interface implements the physical connection from MS to the fixed part of the CDMA system, i.e. the wireless connection. Besides, it transfers information for radio resource management, mobility management and connection management.

Interface between BSS and MSS – A interface

The A interface is located between MSC and BSC. Its physical link is implemented through standard PCM digital transmission link of 2.048Mbit/s. It transfers information for MS management, BTS management, mobility management and connection management.

BSS internal interface (Abis)

An interface between BSC and BTS is called the Abis interface. BSC on the Abis interface provides signaling control information for BTS configuration, monitoring, and testing and service control. Please refer to related documentation about the BTS side.

MSS internal interfaces

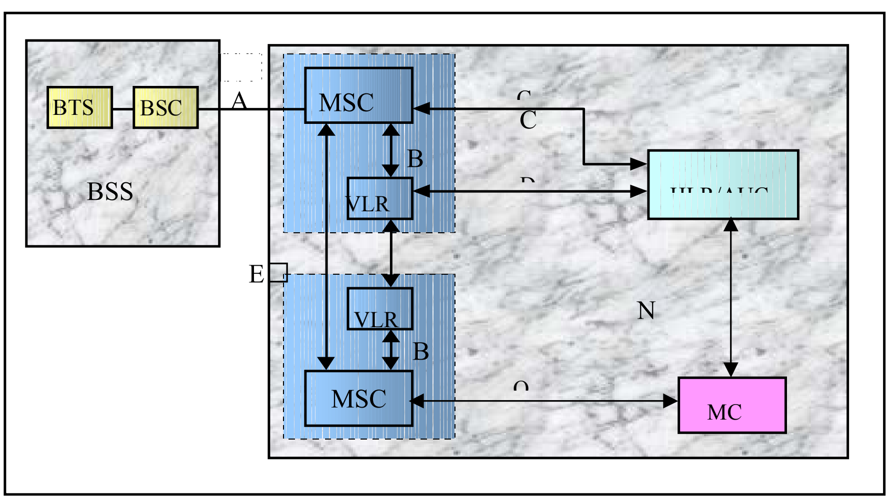

Fig. 2.4-1 Internal Interfaces of the Network

In Fig. 2.4-1, the MSS part contains the names of interfaces between equipment entities. They will be described one by one in the coming part.

B interface

As an internal interface between VLR and MSC, the B interface is used by the MSC to request the current location information of the MS from VLR or notify the VLR to update the location information of the MS.

C interface

As an interface between HLR and MSC, the C interface transfers information for route selection and management. Once a call is required to a MS, the Gateway MSC (GMSC) will request the roaming number of the called MS from the HLR of the called side. The physical link of the C interface is 2.048Mbit/s standard PCM digital transmission cable.

D interface

As an interface between HLR and VLR, the D interface exchanges information related with MS location and user management. It ensures that the MS can establish and receives calls within the entire service area. Its physical link is 2.048Mbit/s standard digital link.

E interface

It is the interface controlling different MSCs of adjacent areas. When the MS moves, during a call, from the control area of one MSC to that of another MSC, this interface can be used to exchange related handoff information to activate and complete handoff, and thus to complete the cross-cell channel handoff process without interrupting the communication. Its physical link is implemented through 2.048Mbit/s standard digital link between MSCs.

N interface

This interface is used to transfer route information related with the called subscriber between MC and HLR. Its physical link is implemented through 2.048Mbit/s standard digital link.

Q interface

It is an interface between MS and MSC transferring short messages.match the OSI reference model. The purpose of this structure is to allow the isolation of different signaling protocols, describing protocols according to continuous independent hierarchy. Each layer of protocol provides specified service at the agreed service access point for its upper layer protocol.

CDMA 2000 1x air interface:-

Forward channels:

Forward links (from base station to mobile station) provide the communication from base station to mobile station.

Channel Types and Functions

The forward links comprise the following logic channels:

- Forward pilot channel (F_PICH)

  It functions the same as the IS-95A forward pilot channel. The base station uses this channel to transmit the pilot signals that identify it and guide the mobile stations to access the network.

- Forward sync channel (F-SYNCH)

  It functions the same as IS-95A forward sync channel. The base station sends the system time and frame synchronization information to the mobile stations via this channel to keep timing and synchronize with the system.

- Forward paging channel (F-PCH)

  It functions the same as IS-95 forward paging channel. The base station transmits paging, command, and traffic channel allocation information to the mobile stations via this channel.

- Forward quick paging channel (F-QPCH)

  It is used by the base station to quickly instruct the mobile station from which time slot to receive the control message on F-PCH or F-CCCH. The mobile station does not need to monitor F-PCH or F-CCCH time slot all the time, so it saves much battery.

- Forward broadcast control channel (F-BCCH)

  It is used by the base station to deliver system messages to the mobile station.

- Common assignment channel (F-CACH)

  The F-CACH is always used together with the F-CPCCH, R-EACH and R-CCCH. When the base station demodulates an R-EACH header, it instructs the mobile station, via F-CACH, which R-CCCH to use to send the access message, and from which F-CPCH sub channel to receive the power control bit.

- Forward common power control channel (F-CPCCH)

  When the mobile station sends data in R-CCCH, the base station transmits reverse power control bit to the mobile station via this channel.

- Forward common control channel (F-CCCH)

It is used by the base station and the mobile station to exchange control messages and short impulsive data when the mobile station has not set up a traffic channel yet.

- Forward dedicated control channel (F-DCCH)

When the mobile station is in traffic channel state, it is used by the base station to transmit messages or low-rate packet and circuit data services to the mobile station..

- Forward fundamental traffic channel (F-FCH)

This channel is used to carry signaling, voice, low-rate packet service, circuit data services or auxiliary service when the mobile station enters traffic channel state.

- Forward supplemental channel (F-SCH)

This channel is used to carry high-rate packet data service on the forward link when the mobile station enters traffic channel state.

- Forward supplemental code channel (F-SCCH)

This channel is used for data transfer.

- Forward power control sub-channel (F-PCSCH)

This channel transmits persistently on the forward traffic channel. It is used for reverse power control.

Reverse links (from mobile station to base station) provide the communication from mobile station to base station.

Reverse Channels:

The reverse channels include:

- Reverse pilot channel (R_PICH)

It is used to assist the base station to detect the data transmitted by mobile stations.

- Reverse access channel (R-ACH)

Its functions are the same as the IS-95A reverse access channel.

- Reverse common control channel (R-CCCH)

It is used by the base station and the mobile station to exchange control messages and short impulsive data when the mobile station has not set up a traffic channel yet.

- Reverse enhanced access channel (R-EACH)

The mobile station sends control messages on this channel to the base station when it has not yet set up a traffic channel, thus improving mobile station accessibility.

- Reverse dedicated control channel (R-DCCH)

When the mobile station is in traffic channel state, it uses this channel to transmit messages or low-rate packet and circuit data services to the base stations.

- Reverse fundamental channel (R-FCH)

It is used to carry signaling, voice, low-rate packet and circuit data services, or auxiliary services on the reverse link when the mobile station enters traffic channel state.

- Reverse supplemental channel (R-SCH)

It is used to carry high-rate packet data service on the reverse link when the mobile station enters traffic channel state.

- Reverse supplemental code channel (R-SCCH)

It is used to send user information to the base station during a call.

- Reverse power control sub-channel (R-PCSCH)

This channel is the sub-channel of reverse pilot channel. It includes reverse main power control sub-channel and reverse auxiliary power control sub-channel. The channel is used for forward power control.

CDMA2000 1x EV-DO

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System Overview

EV-DO in CDMA2000 1x EV-DO is an acronym for Evolution Data Optimized or Evolution Data Only. High-speed data transmission necessitated the evolution from CDMA2000 1x to CDMA2000 1x EV-DO Qualcomm and Lucent jointly developed the 1x EV-DO specification IS-856.1x EV-DO system structure involves a new radio network part overlaying the 1x system. 1x system provides voice services and low/medium-speed data services. 1x EV-DO system provides high-speed packet data services1x EV-DO and 1x systems use different carriers to transfer data. Optimizing voice and high-speed packet data services helps achieve optimum performance. At the same narrowband CDMA frequency bandwidth, 1x EV-DO provides the highest data transmission up to 3.1 Mb/s. Since 1x EV-DO evolved from 1x systems, it inherits the 1x system radio features. It is equivalent to the new frequencies of 1x system. 1x EV-DO system RF equipment is compatible with 1x system.

Network Model

1x EV-DO network model has two developing routines; interoperability specification for High Rate Packet Data Access (HRPDA) Network Interface Revision 0 and Revision A. Difference between the two models is the presence or absence of SC/MM (Spread Carrier/Mobility Management) function in PCF.

System Features.

Forward Channels

Forward links from AN to AT provide communication between ATs in the AN. Forward links have the following features:

- Data rates range from 38.4 Kb/s ~ 3.1 Mb/s.
- Forward channels transmit full power without any power control.
- According to the forward channel C/I measurement, AT selects the best service sector and applies for the highest data rate that the current forward channel can support.
- All users belonging to the same service sector share unique data service channel in the TDMA mode.

As an independent system, 1x EV-DO system follows a completely new channel structure.

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Reverse Channels

Forward links (from AT to AN) provide the communication between ATs and the AN. Following are the Reverse channel features:

- Data rate can reach at most 307.2 Kb/s.
- Reverse channels follow soft handoff.
- Reverse channels follow Dynamic power control.
- Use of Rate control enables reverse link load adjustment.

Key 1x EV-DO Technologies.

Reverse Link Power Control

Power control maximizes system capacity. In 1x EV-DO system, there is no forward link power control because forward link power is constant. Reverse link follows power control. Reverse link power control aims to control output power of ATs while minimizing interference, maintaining high reverse data link quality. When reverse link signal-to-noise ratio (SNR) per user is lowest for acceptable performance, capacity is highest.

Reverse Link Rate Control

In 1x EV-DO standard, AT can adjust reverse rate ranging from 9.6 Kb/s to 307.2 Kb/s. The system must control the load on reverse links to avoid too many users in the same sector transmitting data to AN at a high rate. This leads to all ATs becoming unavailable. AN follows the two mechanisms described to control the AT transmit rate: Reverse rate limit (RRL): AN restricts the maximum reverse rate of ATto a level below 307.2 Kb/s using Broadcast Reverse Rate Limit or Unicast Reverse Rate Limit.

Forward Link TDM

Different from 1x TDM, 1x EV-DO forward links follow Time Division Multiplexing (TDM) to serve all ATs. Within the same sector, one timeslot can serve one user only. Same as IS-95/1x, 1x EV-DO forward pilot channel helps AT complete channel estimation in system capture and demodulation. In 1x EV-DO systems, AT determines the serving sector and maximum sector rate. Measuring forward pilot and radio channel quality of ATs determine its implementation standards. Since all BTSs send pilot at the same time, and the pilot transmits at full power, AT can calculate accurate pilot strength and reflect BTS signals and interference rapidly.

Forward Link Scheduling Strategy

To ensure maximum service rate provision to users, AT requests for the best data rate according to C/I measured in the AN. According to the AT request, AN determines the service provided to different users through scheduling algorithm. Purpose of scheduling algorithm is to maximize system throughput and ensure service provisioning to all users. Due to radio environment complexity, AT informs the system of the highest acceptable data rate through the DRC channel. In the process of reaching maximum throughput, the system sends data to the AT that reports maximum DRC Value. However, other users are unable to use system services. The scheduling algorithm aims to equalize throughput.

Forward Link Virtual Soft Handoff

Besides supporting various soft/softer handoffs like 1x system, 1x EV-DO introduces a new handoff — forward virtual handoff.

Forward virtual handoff enables only one sector to send data through forward channel to the terminal at any time in the active set through forward channel. According to received pilot signals quality, the terminal uses DRC cover of DRC channel to designate the sector expected to send data. All sectors in the active set monitor reverse channel of the terminal. Upon receiving DRC channel, the network determines serving sector of the terminal. During forward virtual handoff, the terminal does not exchange any signaling with the network. Entire handoff flow is very fast. In addition, handoff requires use of only forward air resources of one sector. It increases utilization of forward channels.

Adaptive Modulation Coding Technology

According to forward RF link transmission quality, the AT can request nine data rates. The lowest rate is 38.4 Kb/s, and highest rate is 3. sends UATI Request message through the access channel to AN requesting for UATI.

1x and 1x EV-DO Comparisons

Table 1 offers comparisons between 1x EV-DO and 1x.

TABLE 1 - COMPARISONS BETWEEN 1X EV-DO AND 1X

Features	1x	1x EV-DO
Service	Voice and data	Data
Maximum rate	Forward: 307.2 Kb/s (RC3) Reverse: 9.6 Kb/s (RC3)	Forward: 3.1 Mb/s Reverse: 1.8 Mb/s
Channel multiplex	CDM in forward and reverse links.	Forward: CDM+TDM Reverse: CDM
Handoff	Hard handoff and soft handoff in forward and reverse links	Forward: virtual soft handoff (VHO) Reverse: Soft handoff
Power and rate control	Fast power control in forward and reverse links. No rate control	Reverse: rate control + power control Forward: rate control
Access procedure	Access channel procedure Enhanced access channel procedure	Same as access channel procedure
RF and code features	Convolutional code and Turbo code 48-order FIR filter	Turbo code FIR filter is same as that in 1x.

Questions

1) Write the different types of interfaces in CDMA 2000 1X Network?
2) Name any four channels in the forward link in CDMA 2000 1X?
3) Name any four channels in the reverse link in CDMA 2000 1X/
4) Write the services provided in CDMA 2000 1X Network
5) Write the salient features of EVDO