The CDMA Mobile System Architecture

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CONTENTS

ABSTRACT

The architecture of the CDMA mobile system (CMS) is developed based on three function groups - service resource, service control, and service management groups. In this paper, the CMS architecture is discussed from the point of view of implementing these functions. The variable length packets are used for transmission. The synchronization clock signals are derived from the GPS receiver. The open loop and closed loop techniques are used for the power control. The internationally accepted signaling and network protocols are employed. The call control for the primary services is designed to provide efficient mobile telecommunication services. The softer handoff is implemented in one card. The mobile assisted handoff and the network assisted handoff are employed in the soft and hard handoffs. The authentication is based on the secret data which includes random numbers. The management functions, which include the location management, resource management, cell boundary management and OAM management, are implemented to warrant the system efficiency, maximum capacity and high reliability. The architecture ensures that the CMS is flexible and expandable to provide subscribers with economic and efficient system configuration. The dynamic power control, adaptive channel allocation, and dynamic cell boundary management are recommended for future work.

I. INTRODUCTION

The CDMA mobile system (CMS) architecture is an outgrowth of an ETRI's activity to develop a CDMA cellular system between 1989 and 1995. ETRI and Qualcomm jointly engaged in the development at early stage. Qualcomm provided radio waveform design and signal processing techniques. Having the time division exchange (TDX) expertise, ETRI assumed the responsibility to develop the CMS infrastructure which includes the base station (BS), the mobile switching center, and location registers. This paper deals with the ETRI's effort.

The CMS uses pseudorandom noise (PN) codes to provide multiple communication channels in a designated radio frequency band. It uses path diversity and time diversity in the radio paths and offers privacy, high service quality, and a large link capacity. It provides better handoffs than other cellular systems such as TDMA systems. The ability to support a reliable performance in a severe noisy environment provides the means to alleviate overcrowding in the radio frequency spectrum as well as to allow subscribers more flexibility in cellular services [1], [2].

The CMS, on the other hand, has operational requirements. For example, tight clock synchronization is indispensable to the CDMA signal acquisition. Fast packet transmission is needed for the efficient transmission of the variable length information. Transmit power from both mobiles and base stations must be optimally controlled to secure the system capacity. The appropriate communication protocols and interfaces are required to warrant economic and efficient networking.

The CMS architecture has taken above operational requirements into account [1], [2]. It has achieved cost efficiency without degrading the system performance. A fast packet switching network is employed to facilitate high speed data transfer among subsystem components. The packet transmission with 'staggering' is adopted to prevent the trunk efficiency degradation that is caused by the variable length packet transmissions. Echo canceler is equipped to remove the echo from the voice. The international standard open network protocols [3] have been employed to provide compatibility with other cellular systems or networks. The CMS can support a large capacity to improve the service—decrease the call blocking probability—even in the metropolitan area where heavy traffic load is anticipated.

For the convenience of subsequent discussions, in this paper, we define the CMS functions required for CDMA mobile communications as the CDMA mobile functions. In section II, the CDMA mobile functions are categorized into three groups. The CMS services are supported by these functions. In section III, the service resource functions are described. The basic functions needed for the CMS operation are included in the service resource

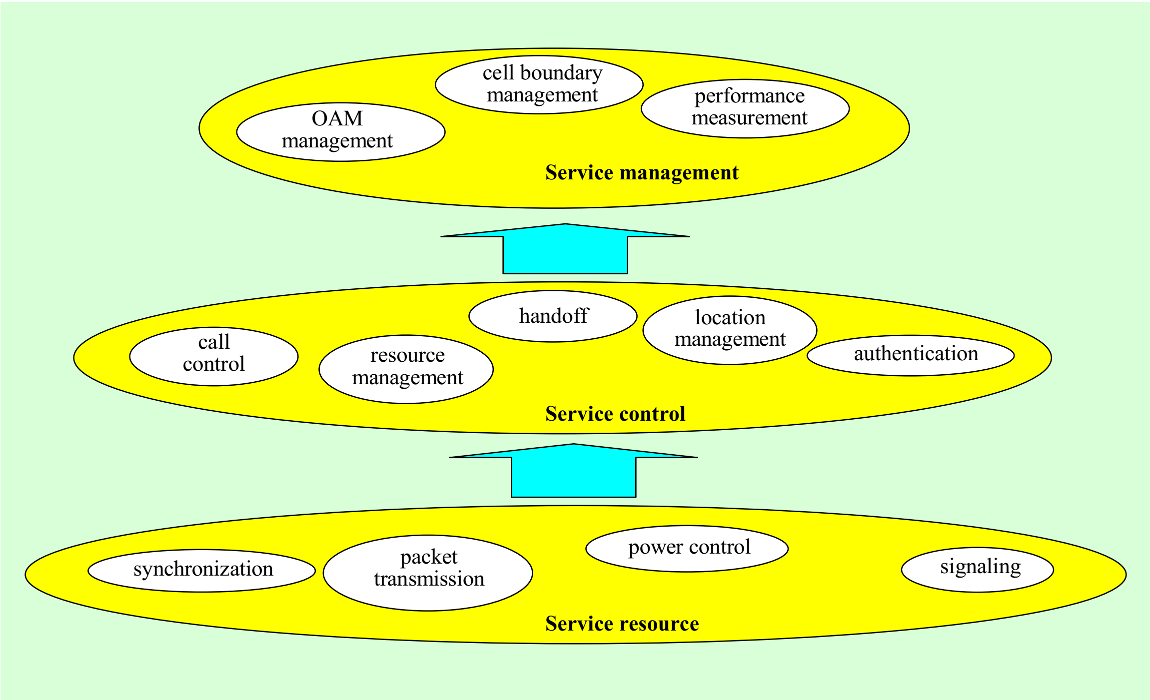

Fig. 1. Group structure of CDMA mobile functions.

group. In section IV, the service control and management functions are described. The major functions including the call control, system management and performance measurement are discussed. Section V is concerned with the CMS design. The CMS structure and configuration are presented. Section VI suggests the future research areas and section VII concludes this paper.

II. CDMA MOBILE FUNCTIONS

The CMS services consist of fundamental services and operation, administration, and maintenance (OAM) services. The fundamental services consist of the primary services and supplementary services. The primary services consist of voice, data, and short message services. All or a part of these services are available to individual subscriber. The supplementary services which include call forwarding, conference call, and calling party identification are additional services and are provided as options to the subscriber. The OAM services make sure that the fundamental services are provided to customers with high quality. These CMS services are provided utilizing the CDMA mobile functions.

The CMS architecture is based on the CDMA mobile functions. These can best be described in terms of three groups as shown in Fig. 1. The top is service management group (group 3), the middle is service control group (group 2), and the bottom is service resource group (group 1). The group 3 is concerned with the management functions re-quired to warrant the system capacity and reliability. The other two groups are concerned with the functions needed to provide the CMS fundamental services. The higher group functions receive supports from the lower group functions as well as the peer functions. For example, the account, one of the OAM management functions in group 3, is supported by such service control functions as the call control and authentication in group 2. The call control in group 2 is accomplished by the signaling and packet transmission in group 1. The packet transmission is supported by the synchronization in the same group 1.

The group 3 consists of OAM management and CDMA performance functions. These are responsible for the system operation and the performance analysis. The OAM management functions have four major functions: program download, configuration management, fault management, and account. The CDMA performance functions are cell boundary management and performance measurement. The group 2 consists of five major functions: call control, handoff, authentication, location management, and resource management. These functions are used in providing direct user services. The group 2 and 3 are implemented mainly in software in contrast to group 1 which is hardware oriented. The group 1 is the engine of the CMS and supports all upper groups. It consists of transmission, power control, synchronization and signaling.

III. SERVICE RESOURCE FUNCTION

1. Transmission and Synchronization

Transmission is the most important within the service resource group. The transmission system model is shown in Fig. 2. The radio transmission is critical to the system performance. The CDMA is interference limited. In order to minimize the interference in the radio link, the variable length packet transmissions with the data rate of 1∼8 kbps have been adopted. The mobile station transmits packets every 20 ms. These packets are combined with the signaling message, utilizing the dim-and-burst or the blank-and-burst method [4].

The fast packet routers are utilized for transmission in the BS. They enhance the BS integrity without causing excessive transmission delay between the basestation transceiver subsystem (BTS) and the basestation controller (BSC). These also ensure the maximum BS trunk efficiency. The BS packets are HDLC formatted and are transferred to the destination. During the soft handoff, two or three BTSs send packets to one selector simultaneously. A selector

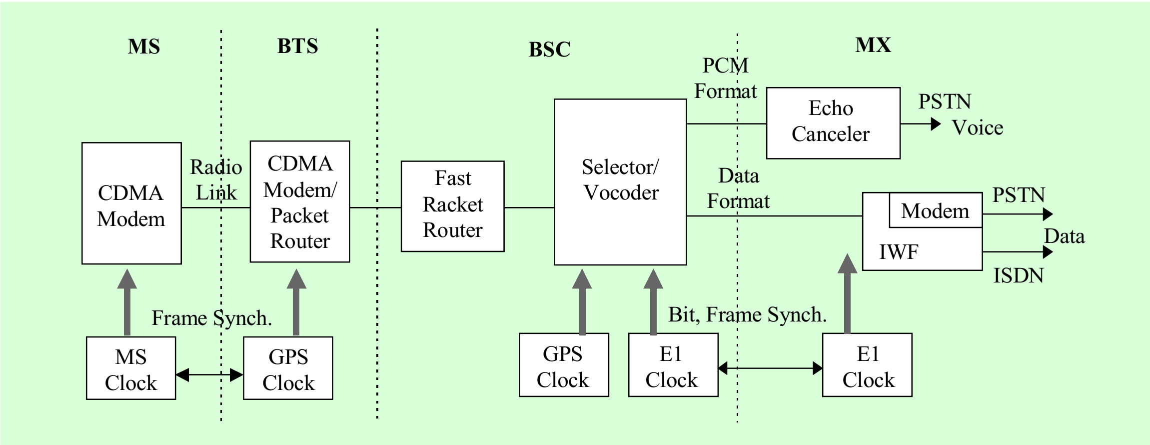

Fig. 2. CMS transmission system model.

chooses the best packet among the received packets which bear the same information.

In the case of voice services, the variable length packets of the radio link are converted into PCM at the vocoder and transferred to the mobile exchange (MX). The MX cancels echo contained in the voice from PSTN and sends the voice to the mobile stations (MSs). In the case of data services, the packets transferred from MSs are converted into 64 kbps formatted data at the BSC and transferred to the interworking function (IWF) via the MX. At the IWF, in the case of public swithed telephone network (PSTN) access, the data are converted to voiceband data and sent to PSTN through a modem. In the case of integrated services digital network (ISDN) or packet switched public data network (PSPDN) access, the data are transmitted to ISDN or PSPDN with the 64 kbps ISDN-type format.

Time synchronization is requisite for the transmission. The BTS needs the absolute time to acquire the CDMA signal transmitted from the MS [4]. During the soft handoffs, the packet order mismatch can happen at a selector due to the queueing delay of the BS packet routers. In order to prevent this mismatch, all the BTSs and the BSC must be synchronized. The current BS maintains the synchronization by distributing clock signals derived from the global positioning system (GPS) receiver equipped in the BTS and the BSC. The BSC and the MX are synchronized by utilizing the bit-and-frame synchronization of E1 transmission.

MSs are synchronized to their BTS by utilizing the frame synchronization. An MS receives the frame signals from its BTS. In the frame signals, 25 synch channel superframes are transmitted during every even seconds synchronized with the GPS clock. The synch channel superframe length is 80 ms and it consists of 3 synch channel frames [4].

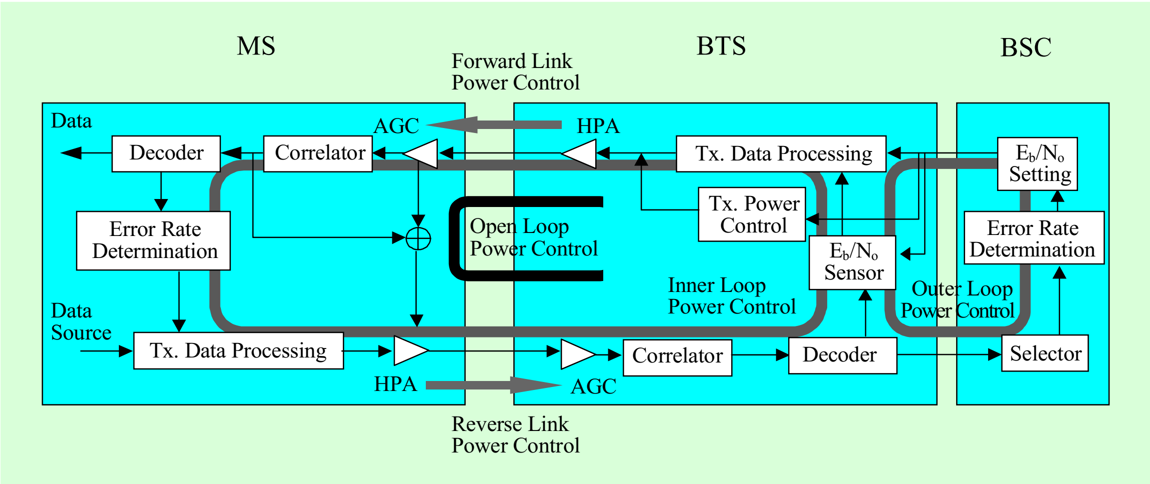

Fig. 3. CMS power control scheme.

2. Power Control

The power control has a significant effect on the radio link performance. The powers properly transmitted from both MS and BTS increase the link capacity. The transmit powers must be kept as low as possible and still be enough to maintain the required frame error rate (FER). Figure 3 shows the power control scheme.

The MS transmit power is adjusted by the two reverse link control mechanisms: open loop power control and closed loop power control. The closed loop power control consists of the inner loop power control and the outer loop power control. In the open loop power control, the transmit power decreases when the receiver signal strength increases, and vice versa, so that the sum of the transmit power strength and received signal strength remains constant. The BTS expects that the signal strength from all of its MSs be maintained equal. The open loop power control is valid only when the propagation losses in the forward link and reverse link are the same.

However, the path loss irregularity between the forward and the reverse link does not warrant the equal received signal strength at the BS. The inner loop power control compensates the discrepancy of the power leveling. It is performed every 1.25 ms by the BTS commands. If the received power level from the MS is less than the preset E_b/N_o at the BTS, the BTS directs the MS to increase the transmit power. The preset E_b/N_o of the BTS is adjusted by the outer loop power control. This is performed every 20 ms by the BSC selector according to the frame quality of Viterbi decoded packets. When the actual frame error rate (FER) at the selector is below the required FER—in other words, when the system performs better than required—continuously,

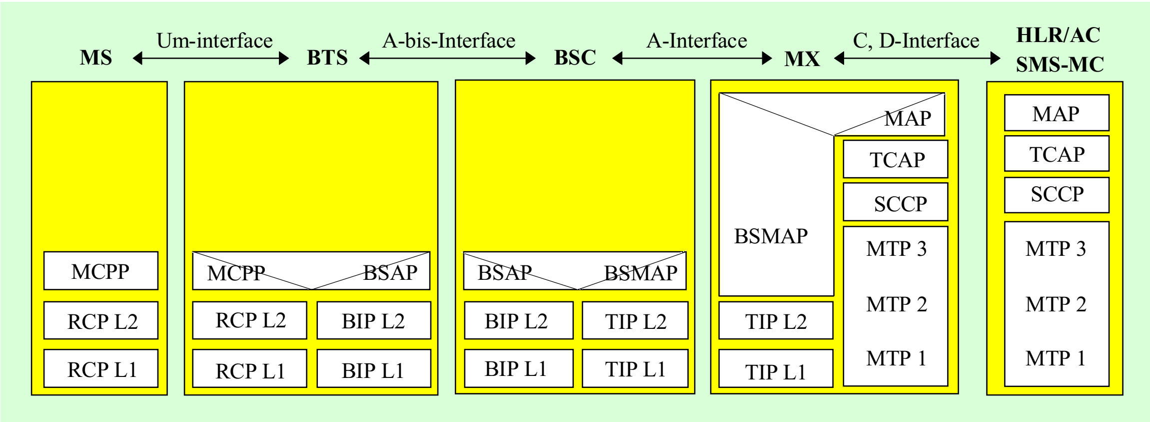

Fig. 4. CMS signaling protocol structure.

the selector directs the corresponding BTS to decrease the preset E_b/N_o.

The forward link power control is performed by the direction from the BSC. The BTS transmit power is adjusted by observing the required FER of the MS. The selector of the BSC receives the FER information from its corresponding MS. The MS sends the informations periodically or when the FER exceeds the threshold level. If the FER is too high, the selector directs the responsible BTS to increase the power transmitted to the corresponding MS.

3. Signaling

In the CMS, there are nine functional entities: MS, BTS, BSC, MSC, VLR, EIR, HLR, AC, and SMS-MC. The MSC, VLR, EIR, HLR, AC and SMS-MC correspond to the mobile switching center, visitor location register, equipment identity register, home location register, authentication center and short message service/message center, respectively. The MSC, VLR and EIR are implemented in the MX. The HLR and AC are implemented in the HLR/AC. Figure 4 shows the CMS protocol structure. The interconnections between any two entities are established according to the international standard system reference model of the cellular systems [3]-[5]. The protocols employed in the CMS are found to work well. The lower layer protocols corresponding to layer 1 and layer 2 of the open system interconnection (OSI) are as follows:

- MS-BTS: radio link control protocol (RCP)
- BTS-BSC: BS internal protocol (BIP)
- BSC-MX: TDX interprocessor protocol (TIP)
- MX-HLR/AC: message transfer part 1 (MTP 1) and MTP 2.

The upper layer protocols above the OSI layer 3 are concerned with the call

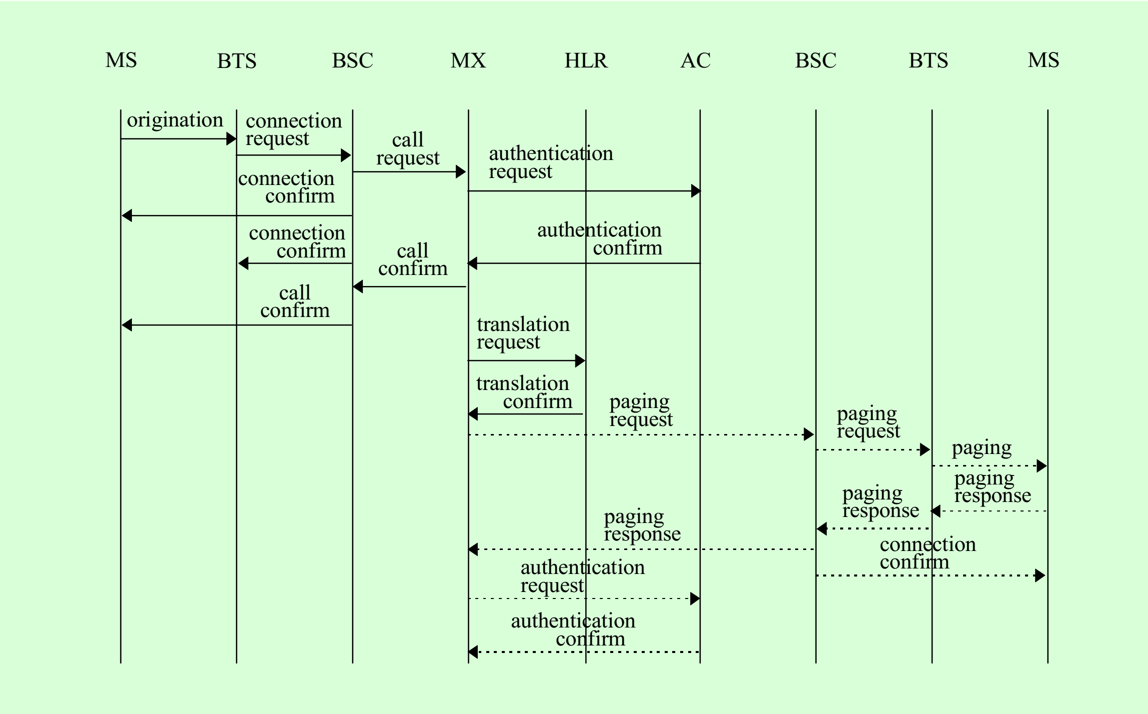

Fig. 5. The voice service control procedure: for mobile originating (plain line) and mobile terminated (dotted line) calls. One MX for the home MX and the visiting MX is assumed.

mana-gement, mobility management, radio resource management, and so on. These transfer, for example, the call control information such as the subscriber identification number and the service type. The upper layer protocols employed are as follows:

- MS-BTS: mobile call processing part (MCPP)
- BTS-BSC: BS application part (BSAP)
- BSC-MX: BS mobile application part (BSMAP)
- MX-HLR/AC or SMS-MC: MTP 3, signaling connection control part (SCCP), transaction capability (TCAP), and mobile application part (MAP).

These upper layer protocols are executed in the control blocks. Each functional entity has its own control block, which consists of a number of processors. The processors in each block employ the fast packet transmission technique to handle a large amount of traffic. All the control blocks performing the management functions have redundant processors to warrant system reliability.

IV. SERVICE CONTROL AND MANAGEMENT FUNCTION

1. Call Control

The call control schemes for the primary services are discussed here. The primary services are voice, data, and short message services.

A. Voice Service

The voice service is the most important among the primary services. Figure 5 shows the call control procedure for the voice communication. The signaling messages for the control are exchanged according to the signaling protocol discussed in the previous section. There exist two types of calls: mobile originated call and mobile terminated call.

The MS starts an originated call by sending a call origination message to its cell BTS. If the BTS has an available channel for the call, the BTS informs the originating MS of the Walsh code and frame offset corresponding to the available channel. Then, the BTS requests its BSC a connection. The BSC assigns a selector upon request. As soon as the selector confirms the originating MS, the BSC requests the MX a call connection. The MX requests the AC the authentication status of the originating MS. Upon receiving an affirmation from the AC, the MX accepts this call and connect the MS to the destination.

In the terminated call, the routing information of the terminated MS is informed from the HLR. The MX knowing the location area of the terminated MS, requests the corresponding BSC a paging. The BSC, in turn, informs the corresponding BTS of the paging request. The BTS, then, pages the MS. After receiving the response to the paging request from the destination MS, the BTS assigns a Walsh code and a frame offset for the MS. The BSC receives the paging response from the BTS and allocates a selector for the call. After confirming the connection with the MS, the BSC sends the paging respond to its MX. The MX accomplishes the desired connection. For the mobile to mobile calls, both of the above call procedures are performed.

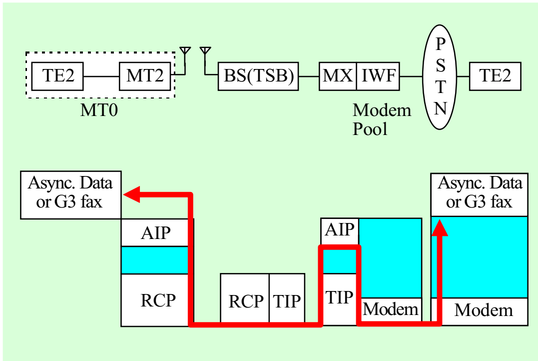

Fig. 6. CMS data communication protocol structure. MT0 transmitting data are transferred to the TSB in the BSC, via RCP in the BTS. TSB is the transcoder & selector bank.

B. Data Service

Figure 6 shows the CMS protocol structure for the data service. Two steps are taking place to provide a data service. The first step is to connect the mobile terminal 2 (MT2) to the MX. The connection procedure is the same as the call control procedure of the voice communication. The second step is to establish the data communi-

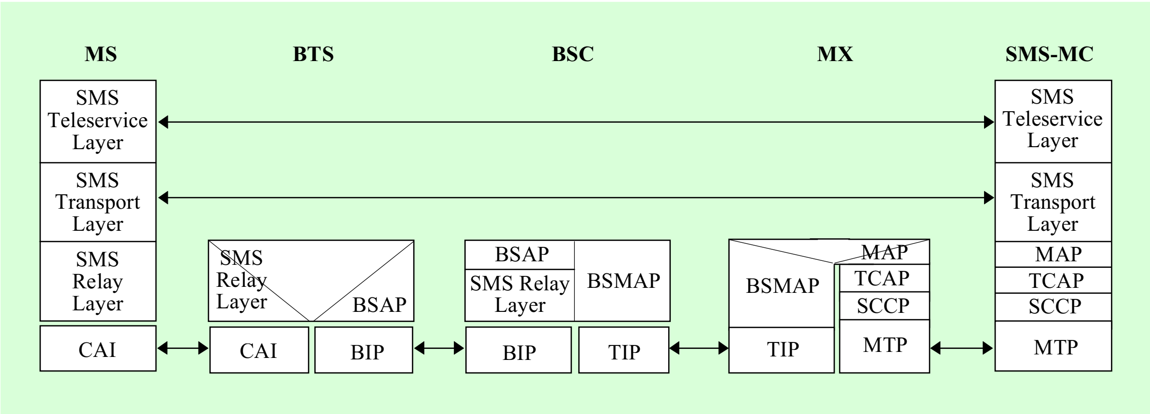

Fig. 7. CMS SMS protocol architecture (CAI is the common air interface).

cations protocol. The MT0 corresponds to the MS.

Data communications include the G3 facsimile services and asynchronous data services such as file transferrings. The MX can communicate with PSTN through the modem pools or communicate directly with PSPDN or ISDN using the digital transmission protocol. The interworking function (IWF) connecting to the MX executes such connections. As shown in Fig. 6, the data services need the terminal equipment 2 (TE2) and the MT2. The MT2 emulates the modem function. The application interface part (AIP) residing in the MT2 establishes the connection with the modem pool of the IWF. Any transmission error that might occur in the link is recovered via ARQ performed by the TSB.

C. Short Message Services

The CMS provides two SMS teleservices: cellular paging teleservice (CPT) and cellular messaging teleservice (CMT). The CPT transfers the maximum 63 characters. The CMT transfers the maximum 255 characters including control information [5]. The short messages are transferred utilizing the signaling messages of the control channel as well as the traffic channel, on the other hand, the voice or data is transferred utilizing only the traffic channel. Figure 7 shows the SMS protocol structure. While the data is transferred in real time through IWF, the short message is transferred in the store and forward scheme. The SMS transport layer corrects any transmission error through retransmission and provides the SMS bearer service. The MS has a short message entity which is used in storing or displaying the received short message.

2. Handoff

The CMS provides three types of handoff: softer handoff, soft handoff, and hard handoff. The softer handoff refers to the handoff between two neighboring sectors in a cell. It is implemented in one channel card. The channel card processes the radio signals utilizing the rake receiver. The soft handoff refers to the handoff between neighboring cells. The selector performs the soft handoff. It chooses the best packet among the transferred packets from 2∼3 BTSs and sends it to the corresponding transcoder.

The hard handoff occurs when the situation needs one of the three changes: the different frequency assignment, the different frame offset assignment, and the change of MX area. The appropriate selector is chosen in each situation. The MX area is changed at the MX. The first two cases occur when the channel of the same bandwidth or frame offset is not available. The mobile assisted handoff (MAHO) and the network control handoff (NCHO) techniques make the frequency handoff possible without the beacon pilot increasing the system complexity. These use the information such as the MS-BTS round trip delay (RTD), the forward link power control, and the received signal strength to execute handoff. The CMS can also use the beacon pilot for the frequency handoff.

3. Authentication

Authentication is required to protect and qualify bonafide subscribers. Each subscriber is required to carry a secret data and is served only when the secret data is matched to the one stored in the authentication center (AC). The secret data can be changed during the registration or the call attempt upon request. It consists of a random challenge number (RANDC), an authentication information (AUTH), and a call history count. The secret data is examined by the AC during the authentication. The RANDC protects the authentication algorithm from revelation. It is generated by the basestation manager (BSM) and is used by both the BTS and the AC.

4. Location Management

The information on the subscriber's location is required and maintained by the CMS. The location registrations are based on the time, zone, distance, power on/off, order, parameter change, implicit, and traffic channel registration [3]. The traffic channel registration occurs after the handoff. It is stored in and managed by the VLR and HLR. While the VLR limits it to the subscribers in the corresponding MX area, the HLR includes all the subscribers in the service area. When a subscriber passes from an MX area to another, the VLR is changed by the notification from the HLR.

5. Resource Management

The CMS radio link resources are managed to optimize the link capacity and service quality. Cutting off the ongoing call is a serious damage to the service quality. The CMS reserves a few channels for handoffs with the hierarchical priority. The hierarchical priority is aimed at using the reserved channel effectively. An MS requesting handoff by the weak pilot of the destination cell is assigned a channel with no priority. However, the MS requesting handoff by the strong pilot of the destination cell is assigned a channel with priority. The reserved channel is also assigned the MS in an urgent case. The handoff channels are managed so that the frequency handoff seldom occurs. The frequency handoff takes place when soft handoff is not available.

6. OAM Management

The OAM management consists of four functions: program download, configuration management, fault management, and account. The BS program and configuration information are transferred from the BSM to the BS control blocks. The system fault or failure is detected, isolated, and recovered by the fault management. The alarm generates an alarm signal immediately when any system fault or malfunction is detected. The alarm signal enables the CMS operator to locate the place and time at which the fault has occurred. The account information is stored and managed at the HLR.

These OAM functions use the database and library which are run under the operating system (OS). The database contains the information on the resource, mobility, and operating status to name a few. The call processing data are also contained in the database. The library provides the system programmers with the OS oriented program language. The OAM information on the BS is gathered and managed by the BSM. This information is also gathered and managed by the operation and maintenance center (OMC) that is responsible for the network OAM.

7. Cell Boundary Management

The cell boundary management is to optimize the system performance and the BS total capacity. It includes breathing, blossoming, wilting, and traffic load shedding. The following describes each term:

- The breathing: balances the forward link handoff boundary and the reverse link handoff boundary during the normal operation. It maximizes the link capacity.
- The blossoming: indicates the gradual increase of the BTS transmit power, when a cell is initially activated. A sudden activation causes a sudden increase in the total forward link background power. This results in the degradation of the forward link quality and may cause the call drops of the neighboring cells. The blossoming allows other cell BTSs to adjust their transmit power to maintain the link quality at the acceptable level.
- The wilting: is the opposite concept of the blossoming and gradual decrease of the effective radiated power (ERP) when the cell is deactivated.
- The traffic load shedding: is to balance user traffic loads among adjacent cells by adjusting the cell radii. The heavily loaded BTS shrinks its coverage area, while the sparsely loaded neighboring

BTS increases its coverage area. Figure 8 shows the concept of the traffic load shedding.

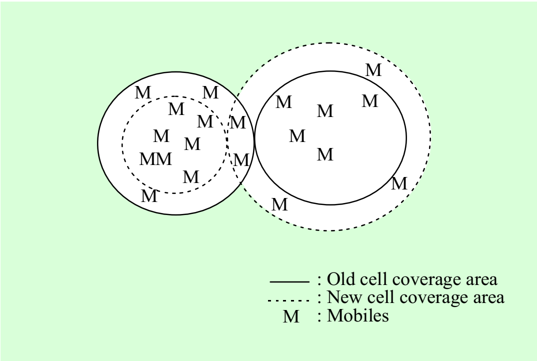

Fig. 8. Traffic load shedding.

8. Performance Measurement

The performance measurement is necessary to assure proper CMS operations. The CMS measures the link performance parameters. The CDMA system analysis tool CSAT collects and analyzes the performance data. There are two types of performance parameters in the CSAT: the performance analysis parameter and the traffic analysis parameter. The traffic analysis parameter contains the number of call attempts/approvals per unit interval, voice activity per call, the number of handoffs per unit interval, and handoff parameters. The performance analysis parameter contains the FERs of the forward and reverse links, burst error rate, the E_b/N_0 received at the BTS and the MS, the number of fingers in operation, and the signal energy contained in each finger. It also derives the power control performance parameters, power control threshold value and transmission gain of the forward traffic channel.

V. CMS DESIGN

1. CMS Structure

All the features discussed previously have been implemented based on the system reference model [3], [5]. Individual function is allocated to the functional entity defined in the model. A subsystem corresponds to a functional entity or a combination of a few entities. The subsystem is designed by considering the control efficiency of the overall system and economy for physical realization.

The MSC, the VLR and the EIR are realized within the physical MX subsystem. The HLR and the AC are realized in the HLR/AC subsystem. The interface with the other networks such as PSTN and ISDN is done at the MX. Figure 9 shows the CMS structure indicating the subsystem components and their interrelationship. The major functions of the subsystems are discussed in the following.

A. Mobile Station

The MS is a physical equipment used by the CMS subscriber. This provides a subscriber with the radio path to the network. There are two types of MS: the mobile equipped MS and the portable MS. The voice communication requires only the

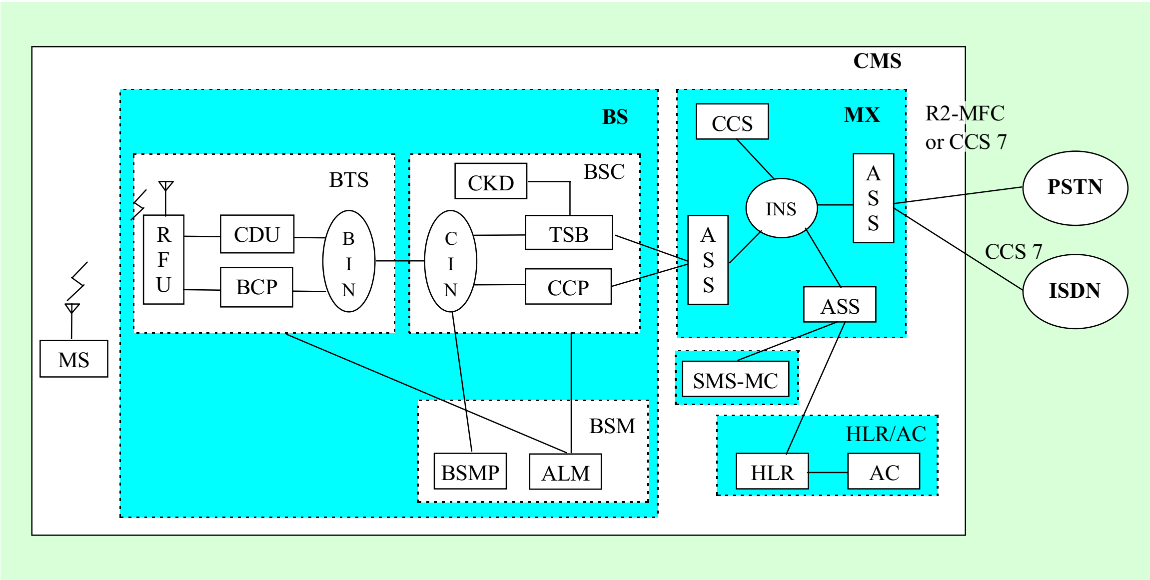

Fig. 9. CMS functional structure (MFC is the multi-frequency control).

mobile termination (MT) function. The other services require the additional functions such as the terminal equipment (TE), the terminal adaptor (TA), or the combination thereof. The MS is equipped with the mobile equipment identity (MEI) and the mobile subscriber identity (MSI) for identification.

B. Base Station

The BS is a physical equipment used in providing the BS area subscribers with the radio paths. The BS consists of three kinds of equipments: BTS for the transmission and reception of the radio signals, BSC for the BS control, and BSM for the BS OAM.

The BTS is the physical equipment needed to communicate with the subscribers of its cell area. For the radio transmission and reception, low noise amplifier, power amplifier, signal combiner/distributor, and frequency converter are installed in the radio frequency unit (RFU). For the radio signal processing, the modulation/demodulation, CDMA channel coding/decoding, and the GPS receiver are in the CDMA digital unit (CDU). The call process and OAM functions are executed in the BTS control processor (BCP). The packet routes and the path between the BTS and the BSC are provided by the BTS interconnection network (BIN).

The BSC manages the BS resources and controls the BS area subscribers. All the traffic packets from MSs are processed in the BSC. The packet selection during the hand-offs and voice packet conversion between code excited linear prediction (CELP) and PCM are executed in the transcoder & selector bank (TSB). The TSB connects to the MX using the E1 trunks. The BSC call process and BSC resource management are executed in the call control processor (CCP). The CDMA interconnection network (CIN) switches the BSC internal packets and provides the path to the BTS. The clock generation & distributor (CKD) provides TSBs with the clock signals derived from the GPS.

The BSM provides the OAM functions for the BS equipment. The program loading for BS operations, fault collection for BS maintenance are executed in the BSMP. The man machine interface (MMI) function for BS operators is also included in the BSMP. The ALM generates alarm signals when the BS equipment finds any fault or malfunction.

C. Mobile Exchange

The MX is a physical equipment needed to communicate with the subscribers of its MX area. For the connection between the originating MS and the destination, the MX call process, PCM based time switch, and MX resource management are carried out in the access switching subsystem (ASS). The loca-tion management and internetworking with PSTN or ISDN is also done via the ASS. The MX location management is performed by the VLR. VLR is realized in the central control subsystem (CCS). The MX communicates with the HLR/AC for the location management and authentication. The interconnection network subsystem (INS) is the MX internal switches.

D. Home Location Register/Authentication Center

The HLR/AC stores and manages the CMS subscriber information including the subscriber locations, and service profiles. The authentication data are also stored in this subsystem. This is a database to register CMS subscriber data. The HLR/AC communicates directly with the MX utilizing the common channel signaling 7 (CCS 7).

E. Short Message Service-Message Center

The SMS-MC is used in providing the short message services. This stores and remits short messages upon subscriber request. The SMS-MC communicates directly with the MX utilizing CCS 7.

2. System Configuration

The CMS channel capacity is determined by the system configuration. The system configuration is changeable by simply adding or removing subsystem cards. The flexibility of the BS configuration is shown in Fig. 10.

According to the tests conducted [6], a radio link in a single sector cell can provide approximately 30 channels. The link capacity turns out to decrease in the three sector cell slightly. Thus, the BTS with three sectors and four frequencies provides approximately 320 channels. Each BTS is designed to accommodate up to eight E1 (or T1) trunks connecting to the BSC.

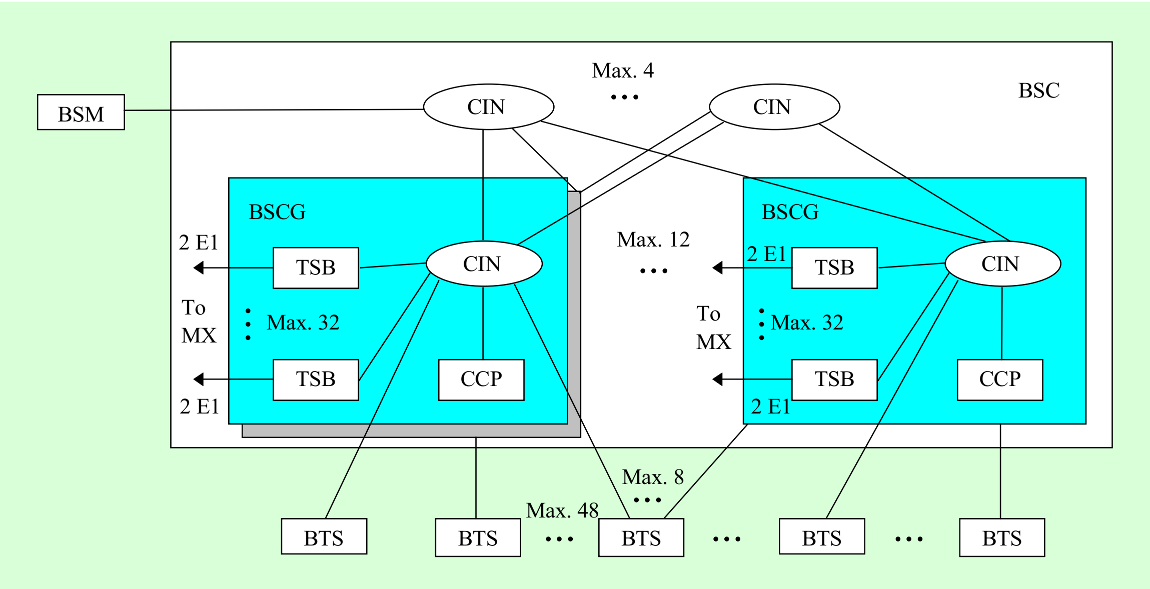

Fig. 10. BS configuration (BSC consists of up to 4 CINs. A BTS has maximum 8 trunks).

One BSC group (BSCG) can accommodate the maximum 48 E1 or T1 trunks connecting with the subordinate BTSs. This means 48 BTSs can be connected to a BSCG if one trunk per BTS is used. The call blocking probability must be considered to determine the optimum number of BTSs per BSCG. The BSC is designed to install the maximum 12 BSCGs and accommodate up to 512 BTSs. One TSB can handle 60 voice channels. One BSCG supports maximum 32 TSBs which correspond to 1,920 voice channels. Each TSB is connected to the MX using two E1 trunks. A BSC accommodates up to 23,040 voice channels.

The MX consists of maximum 31 access switch subsystems (ASSs) corresponding to 60,000 E1 or T1 trunk channels. It interconnects to the BSC utilizing maximum 12 ASS-mobiles (ASS-Ms). The MX provides the maximum 27,000 Erlang and 500,000 busy hour call attempts (BHCA) [7]. The VLR stores the maximum 350,000 subscriber data. The HLR/AC handles up to 64 signaling trunks and stores the maximum 1,000,000 subscriber data. Table 1 summarizes the above figures.

VI. AREAS OF FUTURE RESEARCH

The cell capacity is not fixed but varying. The cell capacity, for example, is affected by the traffic load in the channels of the neighboring cells [8]. Therefore, it is advisable that the radio channels be assigned adaptively to the varying traffic load to secure the optimum cell capacity. Traffic load

Table 1. The maximum capacity of CMS components.

Subsystem	Component	Maximum capacity	Remarks
BTS		320 Ch.	3 sectors & 4 freq.
BSC		23,040 Ch.	12 BSCGs
	BSCG	1,920 Ch.	32 TSBs
	TSB	60 Ch.	
MX		60,000 Ch.	31 ASSs
	ASS	1,920 Ch.	
HLR/AC		1,000,000 Subscribers	

can be redistributed among the neighboring cells by redefining the cell boundaries to optimize the overall channel capacity. We recommend a further research on the adaptive channel allocation, dynamic cell boundary management, and traffic load shedding [9]-[10]. Among others, a further study on the dynamic power control is also recommended. The effective transmit power control of both the MSs and BSs is a key to reduce the channel interference and, thus, to improve the cell capacity.

VII. CONCLUSION

The architecture of the CMS developed by ETRI has been discussed in terms of the CDMA mobile functions. These functions are grouped into service management, service control and service resource functions. The CMS services are supported by these functions. Implementation of these functions are the major concern of the CMS architecture.

The CMS consists of seven subsystems: MS, BTS, BSC, BSM, MX, HLR/AC, and SMS-MC. These subsystems are implemented based on the international standard system reference model of the cellular systems. The signaling and network protocols conform to the OSI structure.

Each subsystem consists of a number of modularized cards. The system size can be customized to meet the user requirement. The CMS capacity is flexible and expandable. The BTS and BSC can provide maximum 320 and 23,040 voice channels, respectively. The MX can accommodate up to 23,040 mobiles at the same time. The CMS control blocks are built with redundancy to warrant system reliability.

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