IMT-2000 Network Architecture

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International Mobile Telecommunication-2000 (IMT-2000) is a third-generation mobile communication system. It has been established as an international standard to realize advanced services and also overcome the performance limitations of the telephone and data communication services that are based on existing second-generation mobile communication systems (i.e., Personal Digital Cellular [PDC], cdmaOne, and Global Systems for Mobile communications [GSM]).
This paper outlines the services recommended in IMT-2000 and describes the base station systems, switching systems, and various servers of the IMT-2000 network architecture. This paper also describes the packet processing mechanism and the techniques for constructing IMT-2000 networks. Finally, this paper describes the technologies related to intelligent networks (IN), which provide additional, highly advanced services.

1. Introduction

Mobile telephone and data transmission services are mainly provided by the second-generation mobile systems that are the domestic standards worldwide. In Japan, the major digital mobile networks are based on the Personal Digital Cellular (PDC) system. On the other hand, a mobile telecommunication service vender has started a commercial service based on the cdmaOne system, which is a North America standard. In other countries, mobile networks are constructed with one of two systems. One is the Global Systems for Mobile (GSM) communications system, which has shown the best results so far, and the other is the cdmaOne system, which is based on the latest technology.

There is a limit to the data communication speed in second-generation mobile networks. Also, it has been pointed out that there is a limit to the supply of high-speed IP packet services, for which there will be an explosive increase in demand in the future.

International Mobile Telecommunication-2000 (IMT-2000) is a new, third-generation mobile network being discussed at international standards organizations to overcome the weak points of second-generation mobile networks. IMT-2000 is expected to consist of multi-vendor networks and to advance the standardization of the interface between the functional elements of networks.

IMT-2000 networks can be functionally classified into Core Networks (CNs), Radio Access Networks (RANs), Intelligent Networks (INs), and other networks installed in center offices.

The IMT-2000 standards are being discussed by two organizations: the 3rd Generation Partnership Project (3GPP) and the 3rd Generation Partnership Project2 (3GPP2). The participants of the 3GPP are ARIB, ETSI, TI, TTA, and TTC, and the participants of the 3GPP2 are ANTI, ARIB, ETSI, TTA, and TTC. The 3GPP aims to construct an IMT-2000 network based on the GSM

network. On the other hand, the 3GPP2 aims to develop standards for the IMT-2000 network by enhancing the cdmaOne system. In the 3GPP, IMT-2000 is referred to as the Universal Mobile Telecommunication System (UMTS) or Wideband CDMA (W-CDMA). In Japan, the ARIB and TTC have advanced the domestic standardization of W-CDMA and cdma2000.

However, although the network configurations of W-CDMA/UMTS and cdma2000 are similar, there is a difference in the packet processing method. This paper outlines the IMT-2000 networks and the differences between the two network technologies.

2. Services in IMT-2000 networks

One of the main purposes of IMT-2000 is to provide global roaming services. In order to offer worldwide communication services that include access to fixed networks and the Internet, IMT-2000 is designed to connect not only land mobile networks but also fixed networks and satellite mobile networks.

Another major purpose of IMT-2000 is to provide broadband services for mobile terminals. Of course, seamless handover is required to provide quality of service (QoS) in high-speed transfer services. The services that IMT-2000 is designed to provide are described below.

2.1 Multimedia communication service

A multimedia service offers the service qualities (transmission rate, line quality, delay time, etc.) required for voice communication and data communication (including video communication). For example, notebook personal computers equipped with a mobile terminal offer a service quality that is equivalent to that offered by fixed networks. As a result, it is now possible to access the World Wide Web, e-mail, electronic commerce services (e.g., electronic bank services), and information services such as electronic newspapers and education courses outdoors.

Moreover, a highly accurate location information service using mobile networks has been examined. For example, traffic information and sightseeing guides for a specific area and navigation services can be provided based on terminal location information.

2.2 Global service

A global service allows a user to communicate anywhere, both indoors and outdoors, regardless of the user's moving speed and location (e.g., city, suburb, or countryside). One of the major achievements of a global service is that it enables global roaming: that is, users can use the same mobile terminal in any country without having to change any of its settings.

To realize a global service, three levels of mobility are required: terminal mobility, user mobility, and service mobility. Terminal mobility means independence from the location and radio conditions. User mobility means that any mobile terminal can be used. Service mobility means that the service environment of the home network can be reproduced in another network.

One of the major technical issues in these global services is how to provide the high levels of security and privacy that are required.

2.3 Seamless service

A seamless service allows a user to connect to a conventional network and the Internet with the same quality regardless of the wireless environment, location, and communication service vendor.

3. Standardization trend

The 3GPP and 3GPP2 were established to discuss the IMT-2000 from the end of 1998 to the beginning of 1999. The 3GPP makes mobile network system specifications based on the GSM communications/General Packet Radio Service (GPRS), and the 3GPP2 is based on the ANSI-41. The standardization work of Release1999 (the 1999 edition recommendation, or R99 for short) was completed by the 3GPP in December 1999.

R99 basically follows the functions of GSM and GPRS that have already been recommended. In the 3GPP2, the standardization work of Release A was completed in December 1999. Release A basically follows the functions of cdmaOne that have already been recommended.

Both the 3GPP and 3GPP2 have included the achievement of high-speed data transfer in all of their recommendations. The speeds they recommend are 64 kb/s or more in circuit switching mode and 384 kb/s or more in packet switching mode (2 Mb/s for a stationary terminal).

4. Mobile network structure

The migration from conventional networks is the most important issue for realizing IMT-2000 mobile networks. In this section, we describe the architecture of IMT-2000 networks. Then, we introduce the node group needed to construct a mobile network.

4.1 Realization of IMT-2000 networks

To construct IMT-2000 networks from conventional networks, network venders can use either of the following two network construction methods.

1) New installation of IMT-2000 networks

The IMT-2000 network can be installed without influencing conventional operating networks. However, the initial capital investment required to install IMT-2000 is high.

2) Construction of IMT-2000 networks through effective use of existing networks.

In this method, the facilities of the conventional networks are used as much as possible to construct IMT-2000 networks economically. For example, the RAN part of IMT-2000, including the voice circuit-switching, can be connected with conventional core networks. As described above, the standardization of the IMT-2000 network is done based on the existing networks. This method focuses a lot on the usability of existing technologies. Moreover, subscriber databases (e.g., the Home Location Register [HLR]) and the devices related to the IN in the conventional networks can be connected to IMT-2000 networks.

Compared to the first method, this method requires a lower initial capital investment and makes it easier to construct an IMT-2000 network. However, this method requires changes to be made to the conventional networks.

4.2 Necessary nodes for construction of IMT-2000 networks[1)]

As mentioned above, an IMT-2000 network basically consists of the RAN, CN, IN, and other elements (**Figure 1**). This section introduces each of these nodes in the W-CDMA/UMTS system.

1) RAN

The RAN is a wireless network located between the user terminal and the CN. It is composed of Radio Network Controllers (RNCs), Node-Bs, OMC-Rs, and other components.

2) CN[2)]

The CN is a network located between the RAN and another network (e.g., a Public Switched Telephone Network [PSTN]). It is composed of circuit switches (Mobile Switch Center [MSC]/ Gateway Mobile Switch Center [GMSC]), packet switches (Serving GPRS Support System [SGSN]/ Gateway GPRS Support System [GGSN]), subscriber databases (Home Location Register [HLR]/ Visitor Location Register [VLR]), address resolution servers for packet processing (Domain Name Server [DNS]), and the authentication and security centers (Authentication Center [AuC]/ Equipment Identity Register [EIR]).

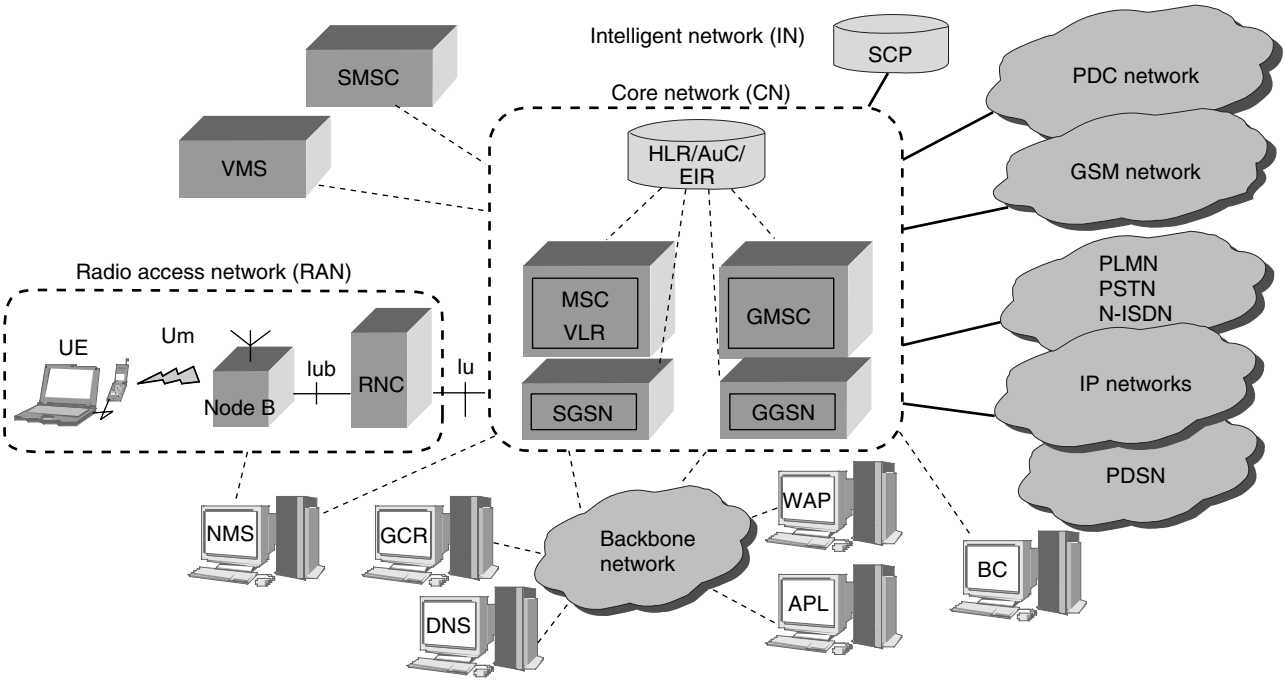
3) IN

The intelligent network is a node group for achieving enhanced services (number portability, freephone, credit card calls, etc.). It is composed of Service Control Points (SCPs).

4) Other devices

Some of the other IMT-2000 network components are:

- Voice Mail System (VMS). This has voice recording and replay functions such as an answer phone. There is also a component



APL : Application server
AuC : Authentication center
BC : Billing center
DNS : Domain name server
EIR : Equipment identity register
GCR : Group call register
GGSN: Gateway GPRS support node
GMSC : Gateway mobile switching center
GSM : Global system for mobile
HLR : Home location register
MSC : Mobile switching center
N-ISDN: Narrowband ISDN
NMS : Network management system
PDC : Personal digital cellular
PDSN: Packet data switched network
PLMN: Public land mobile network
PSTN: Public switched telephone network
RNC : Radio network controller
SCP : Service control point
SGSN: Serving GPRS support node
SMSC: Short message center
UE : User equipment
VLR : Visitor location register
VMS : Voice mail system
WAP : Wireless application protocol

Figure 1
IMT-2000 (UMTS) network structure.

for receiving and re-sending faxes.

- Short Message Center (SMSC). This component is used for transmitting and receiving character information. The SMSC can be used, for example, to notify subscribers that there is a message for them in the VMS.
- Group Call Register (GCR). This is a database for group call services.
- Wireless Application Protocol (WAP) server. This is a server that offers subscribers various information using the Wireless Application Protocol.

5. Packet switching in IMT-2000

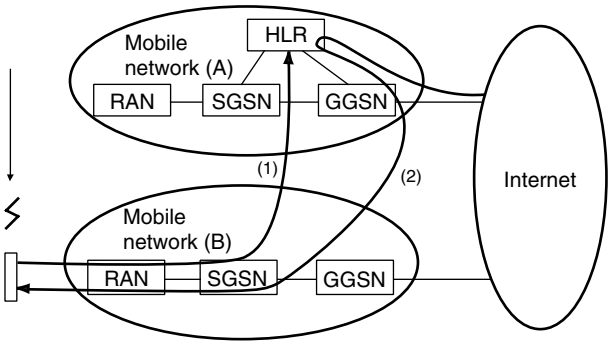
It was mentioned above that there are two kinds of IMT-2000 systems: W-CDMA/UMTS and cdma2000. This section outlines the packet processing of these two systems.

5.1 W-CDMA/UMTS packet processing

The specifications for the packet system of W-CDMA/UMTS are the same as those for the GPRS system that has been used with conventional GSM networks. Currently, mobility management of the subscriber is done using the HLR. When the subscriber moves, the location information in the HLR is renewed. When the packet arrives, the location information in the HLR is referenced and the packet is transmitted to the switch node to which the target mobile terminal is registering (**Figure 2**).

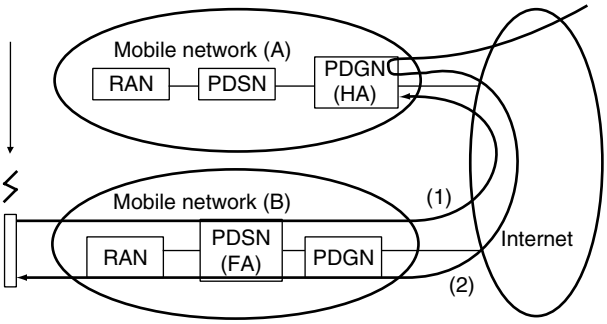
5.2 cdma2000 packet processing

Because the specifications for the packet processing method were not standardized in cdmaOne, they have been standardized in its replacement, cdma2000. The packet processing method of cdma2000 adopts the Mobile IP system,



(1) The location information in HLR is updated along with the subscriber movement.
(2) SGSN is specified by the location information in HLR.

Figure 2
UMTS packet processing.



(1) The core-of-address (CoA) of mobile terminal is updated in HA along with the subscriber movement.
(2) Incomming packets are re-forwarded by the CoA in HA.

Figure 3
cdma2000 packet processing.

which differs from the HLR system in W-CDMA/UMTS and is being discussed by the IETF. When a user moves to a foreign network, a care-of address is sent from the Foreign Agent (FA) in the foreign network to the Home Agent (HA) in the user's home network. As shown in **Figure 3**, the packets for a moving user are re-forwarded to the FA by the HA according to the care-of address.

6. Intelligent network (IN)

The IMT-2000 IN is the key component for realizing a Virtual Home Environment (VHE), which is a concept for providing the service motilities described in Section 2.2. For example, when roaming is done, the pre-paid card service available in the home network can be made available in other networks. To realize a VHE, the intelligent network centrally manages the service logic at a Service Control Point (SCP) and the SCP controls the Service Switching Point (SSP) to offer the subscriber service as shown in **Figure 4**.

The different protocols of SCP and SSP/HLR were standardized by the 3GPP and 3GPP2. The 3GPP applied the Customized Application or Mobile network Enhanced Logic (CAMEL), and the 3GPP2 applied the Wireless Intelligent Network (WIN).

CAMEL is based on the Intelligent Network

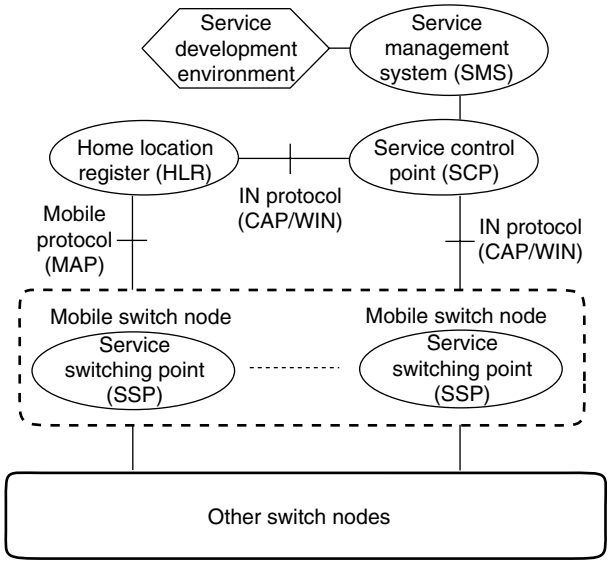


Figure 4
Intelligent network for mobile network.

Application Protocol (INAP) that is being recommended by the ITU-T/ETSI. CAMEL implements a part of the GSM Mobile Application Protocol (MAP) for interconnection between the SCP and HLR and was recommended in the form of the CAMEL Application Protocol (CAP).

On the other hand, for cdma2000 networks, the Wireless IN (WIN) was recommended. The WIN was enhanced from the ANSI-41 MAP, which the Telecommunication Industry Association (TIA)/Electronic Industry Association (EIA) stan-

dardized for the CDMA recommendations. New operations for SCP and HLR communication were recommended for the WIN. Also, the existing MAP was changed to accommodate the introduction of the WIN.

In the future, intelligent networks will occupy the most important positions in networks and will become indispensable for offering a seamless service in mobile and also fixed networks. Intelligent networks integrate the functions of the service control and management and can provide various services between different networks.

7. Conclusion

NTT DoCoMo,Inc. has constructed an IMT-2000 network based on the UMTS system and began IMT-2000 services in May 2001. For the network, Fujitsu developed a Base Transceiver Station for Node-B, an RNC, and a Mobile Multimedia Switching node (MMS) for the CN. Fujitsu's systems efficiently integrate circuit switching and packet switching services by using ATM and Switched Virtual Connection (SVC) systems.

We are convinced that mobile networks will become major parts of the access networks of the 21st century. Communication networks are expected to develop into a new type of network, called a Fixed Mobile Convergence (FMC), which is an integration of fixed and mobile networks. Moreover, a standard for all IP-based IMT-2000 systems without circuit switching will be recommended. IMT-2000 systems have the latent ability to form FMCs.

IMT-2000 is expected to be developed as an infrastructure with new functions and services such as high-speed IP communication over mobile terminals and service portability realized through the use of intelligent networks.

On the other hand, several issues remain: for example, how to guarantee global roaming between W-CDMA/UMTS and cdma2000 systems. These remaining issues must be solved so that IMT-2000 can develop as the infrastructure of a truly global standard. Fujitsu will enhance the functions of IMT-2000 based on the appropriate international standards.

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