Network Node for IMT-2000

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Fujitsu has developed a Mobile Switching Node for IMT-2000 3G Networks. This system is an extended version of the GSM/GPRS. It can offer an efficient and flexible service by integrating the circuit switching function and packet switching function based on ATM technology. The software of this system has a hierarchical layer configuration. This paper outlines the new hardware and software architecture of this Mobile Switching Node system and its high performance, high reliability, and high expandability.

1. Introduction

Fujitsu has developed a Mobile Switching Node system for International Mobile Telecommunication-2000 (IMT-2000) third-generation (3G) networks. One of the main functions of IMT-2000 networks is to provide efficient mobile multimedia communications. Services in a multimedia communication environment must be flexible, and the exchanges and transmission systems must be able to handle various media efficiently and uniformly.[1)]

Fujitsu's Mobile Switching Node system integrates circuit switching and packet data switching to handle mobile multimedia information uniformly. This integration was achieved by applying ATM (Asynchronous Transfer Mode) technology and by introducing new hardware and a new software architecture for IMT-2000. This Mobile Switching Node system is based on the logical network architecture model (**Figure 1**) proposed in the ITU-T (ITU-Telecommunication Standardization Sector). The system has been used successfully in NTT DoCoMo's IMT-2000 3G network, starting in 2001.[2),3)]

This paper outlines the new hardware and software technologies of this high-performance, high-reliability, and high-expandability Mobile Switching Node.

2. Core Network configuration

Figure 2 shows an IMT-2000 network configuration based on the GSM (Global System for Mobile communication)/GPRS (General Packet Radio Service) method.

In the next section, we describe the characteristics of the Core Network configuration and compare them with those of the existing PDC network (Personal Digital Cellular Telecommunication network).[note)]

1) A VLR (Visitor Location Register) that includes circuit and packet subscriber data information is arranged dynamically in an MSC (Mobile Switching Center) according to the subscriber's movement.
2) The M-SCP (Mobile-Service Control Point) has HLR (Home Location Register) information and a mobility control function.
3) The SCP (Service Control Point) is arranged separately from the M-SCP and provides a service control function in the Intelligent Network.[4)]

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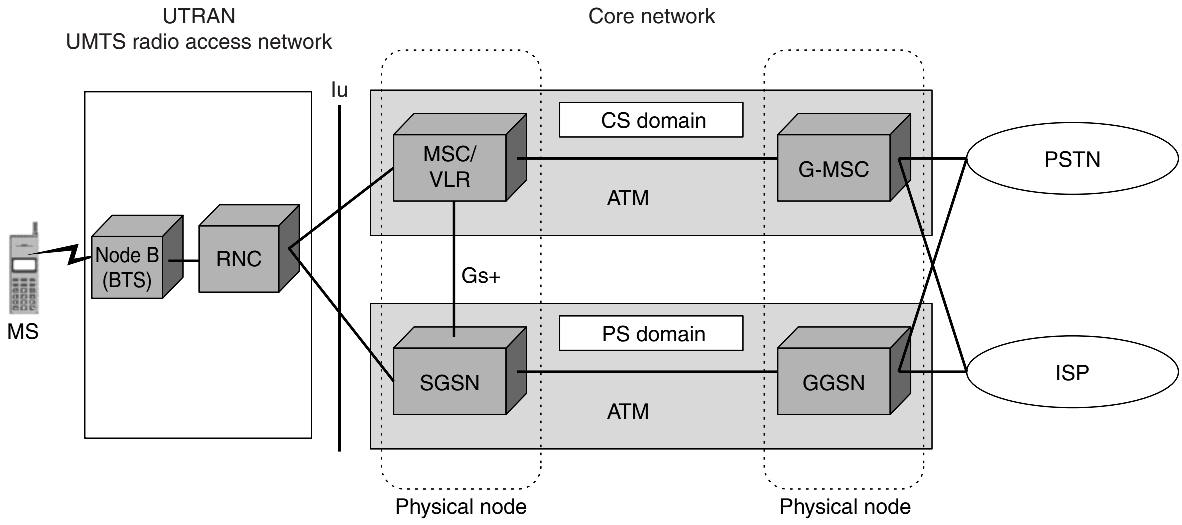
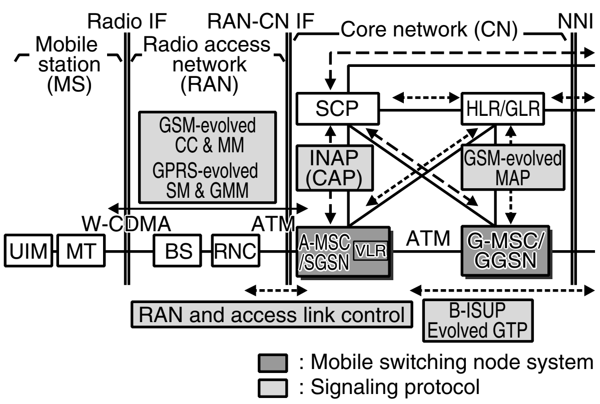
note) Second-generation mobile communication network



ATM : Asynchronous transfer mode
GGSN : Gateway GPRS support node
G-MSC : Gateway mobile switching center
MSC/VLR : Mobile switching center/Visitor location register
RNC : Radio network controller
SGSN : Serving GPRS support node

Figure 1
IMT-2000 logical network architecture model.



A-MSC : Anchor Mobile switching center
B-ISUP : Broadband ISDN user part
BS : Base station
CAP : CAMEL application part
CC : Call control
GMM : GPRS mobility management
G-MSC : Gateway mobile switching center
GPRS : General packet radio service
GSM : Global system for mobile communication
GTP : GPRS tunneling protocol
HLR/GLR : Home/Gateway location register
INAP : Intelligent network application protocol
MM : Mobility management
MT : Mobile terminal
NNI : Network network interface
RNC : Radio network controller
SCP : Service control point
SM : Session management
UIM : User identity module
VLR : Visitor location register

Figure 2
IMT-2000 network configuration.

3. Core network technologies

This section describes the core network technologies that are used in the IMT-2000 Mobile Switching Node.[5)]

3.1 Wireless access control

1) Control function between MT (mobile terminal) and MSC

A mobile terminal (MT) has two control functions: a user-communication call control function and a mobility control function. In circuit switching, the user-communication call control function is covered by the Call Control (CC) protocol and the mobility control function is covered by the Mobility Management (MM) protocol. Moreover, in packet switching, the user-communication call control function is covered by the Session Management (SM) protocol and the mobility control function is covered by the GPRS Mobility Management (GMM) protocol.

In addition to the basic call control operations such as call setup and call disconnect, the

CC/SM controls the bearer changing control and the additional service control. The CC/SM also has a function to achieve multi-call control, asymmetrical speed communication control, and other control functions. The MM/GMM function controls mobility management at location registration and the authentication function for confirming the accessibility of mobile terminals.

The MM/GMM function is also related to security control and replaces the subscriber identifier (International Mobile Subscriber Identifier [IMSI]) with a temporary identifier (Temporary Mobile Subscriber Identifier [TMSI]).

The CC/SM protocol and the MM/GMM protocol are based on GSM/GPRS.

2) Control function between RNC and MSC

The call control signals and the mobility management control signals are exchanged directly between the MS (Mobile Station) and MSC through a RAN (Radio Access Network). These signals are forwarded transparently between an RNC (Radio Network Controller) and the MSC. The call control function and the mobility management function control paging and authentication between the RNC and MSC from the Core Network to the RAN. These two functions are provided by the RANAP (Radio Access Network Application Part) protocol.

Moreover, AAL (ATM Adaptation Layer) Type-2[6] multiple transmission is applied, which makes it possible to achieve highly effective transmission.

The AAL Type-2 signaling protocol,[7] which is standardized in ITU-T, is applied for handover connection control. This protocol also establishes the connections between the Anchor Mobile Switching Center and the Drift-Mobile Switching Center.

3.2 ATM technology

The IMT-2000 network is expected to provide high-speed communication, for example, for real-time movie viewing, and speed-asymmetrical communication, for example, for Internet access services. The network is also required to efficiently handle traffic ranging from low-speed to high-speed traffic. Moreover, QoS (Quality of Service) and traffic control will be required.

To meet these requirements, ATM technology was used as the core network technology.[8] Also, in the ATM environment, to handle the various types of QoS information, the circuit switching data traffic is transmitted at a constant bit rate (CBR) and the packet switching data traffic is transmitted at an unspecified bit rate (UBR). The Mobile Switching Node can also set the QoS requirements to guarantee the quality (throughput, delay, loss ratio, etc.) required for each service being provided. As a result, this system can offer data communications at a higher quality than a legacy IP network.

1) Introduction of AAL Type-2 traffic

To efficiently cope with the wide range of traffic speed, AAL Type-2 traffic was introduced in this network for voice transmission and Hand-Over data information to improve network bandwidth resource utilization and the handling of delay-sensitive traffic. Therefore, in the case of speech communication between mobile terminals, traffic is transmitted in the core network transparently as AAL Type-2 information without encoding according to the μ-law. To switch this AAL Type-2 traffic, a composite cell switching trunk (CMP) was developed. The CMP converts AAL Type-2 information into AAL Type-2 partial filling cell information for each connection. AAL Type-2 switching is executed using AAL Type-2 partial filling cell information in the ATM environment.

2) Integration of circuit switching and packet switching

This system has both a circuit switching function and a packet switching function, which provides two merits. The first merit is a higher efficiency. In this system, the subscriber's status is defined to combine the circuit switching function and the packet switching function. Therefore, some call processing procedures can be achieved very efficiently by combining procedures such as the location update procedure, routing area update procedure, and paging procedure. The other merit is better network flexibility. By considering the service requirements of 3G networks, this system can flexibly and economically adapt to variations in the volume of circuit switching data traffic and packet switching data traffic.

3.3 Mobility control

Mobility control is a special feature of mobile communication networks. It provides functions such as location registration, authentication, and paging, which are executed by the MAP (Mobile Application Part) protocol. Global roaming has been achieved by applying an evolved-GSM MAP that expands the GSM MAP in an IMT-2000 network.

In the currently used Location Register method of a PDC network, the user profile is forwarded to the MSC by access to the HLR at the time of each call establishment. On the other hand, in the case of IMT-2000 MSC, the user profile is transferred from the HLR to the MSC when the subscriber moves into the MSC cover area. This second method is called the VLR method. When the location is registered by this VLR method, the access to the HLR in each call establishment is assumed to be unnecessary because the user profile in the VLR of the MSC is used instead. That is, by using the VLR method, the access load on the HLR can be reduced compared with the existing method.

In this location registration procedure, a temporary mobile subscriber identifier (TMSI) is allocated by the Mobile Switching Node to identify the subscriber in the radio access procedure.

Security can be improved by allocating a temporary identifier instead of a fixed allocated subscriber identifier (IMSI).

Moreover, the efficiency of location management processing is increased by combining the location registration procedure of circuit switching and packet switching, as mentioned above.

3.4 Additional service control

To achieve additional services such as an Intelligent Network, we adopted a protocol that was developed by the ETSI (European Telecommunication Standards Institute), which is a European standardization group. The protocol, called CAMEL (Customized Applications for Mobile network Enhanced Logic),[9] consists of a high layer service control function and a call connection control function and is based on the Intelligent Network concept. The SCP has this high layer service control function, and the MSC/VLR has the call connection control function. CAMEL provides important information that helps the core network node acquire SCPs. This information is included in the user profile stored in the HLR and is forwarded to the VLR when a new location is registered.

4. System configuration of the Mobile Switching Node

Figure 3 outlines the system configuration of the Mobile Switching Node, and **Figure 4** shows a photograph of the new system. The Mobile Switching Node hardware configuration consists of the switching equipment and the control equipment.

The switching equipment provides an ATM (Asynchronous Transfer Mode) switching function and an STM (Synchronous Transfer Mode) switching function and IP information transfer function. The switching capability is 40 Gb/s, and the system can handle more than 80 000 circuit connections and 250 000 packet connections. The following special equipment is used to connect to the IMT-2000 system: the PSU (Packet Subscriber Unit), PGU (Packet Gateway Unit), IPU (IP multiplex Unit), and CMP (Composite cell switching trunk). The PSU/PGU equipment provides the GTP (GPRS Tunneling Protocol) Packet function and a function for collecting traffic information. The IPU equipment converts between ATM-SVC Packet data and IP Packet data and also provides a physical termination function.

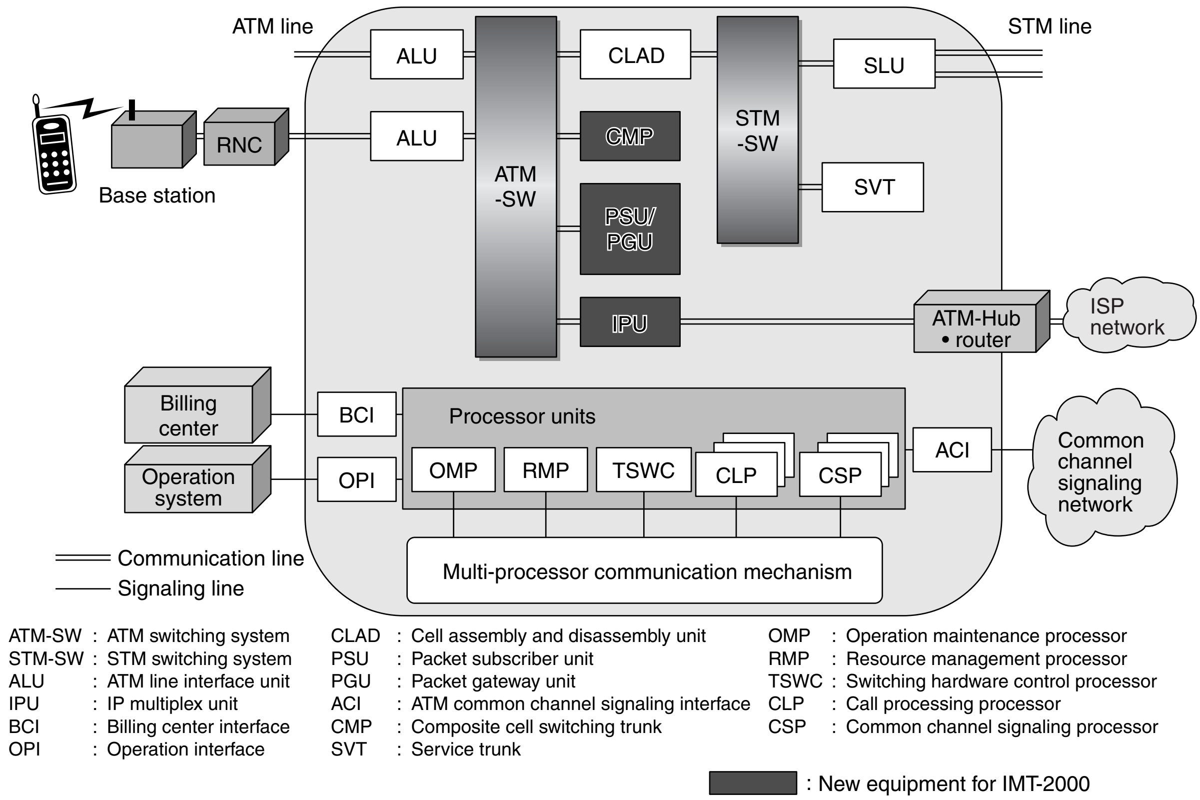


Figure 3
System configuration of Mobile Switching Node.

Figure 4
Fujitsu's Mobile Switching Node.

Table 1
Processor function of multi-processor configuration.

Abbr.	Multi-processor name	Processor function
OMP	O&M processor	Operation/maintenance
TSWC	Switching hardware control processor	System control/hardware control
RMP	Resource management processor	Management of system resources
CLP	Call processing processor	Call control/service control
CSP	Common channel signaling processor	MTP signaling/call distribution

The CMP equipment multiplexes the user data into AAL Type-2 information for voice over ATM connection and also performs the reverse operation. The integration of circuit switching and packet switching is realized by an ATM-based technology.

The control equipment's reliability and performance was improved by adopting a multi-processor configuration. There are five types of multi-processors. **Table 1** shows the function of each multi-processor. The TSWC, RMP, CLP, and CSP processors are connected in multi-processor configurations. The CLP processor has a main call control function and a related hardware control function. The RMP processor has a management function for system resources (e.g., trunk resources and dynamic IP address resources for packet switching).

This multi-processor configuration provides the following advantages.

1) High extendibility

The system can increase its call handling capacity by adding processors according to the load condition. Also, the system can increase its switching capacity independently from the call handling capacity according to the user's traffic condition.

2) High reliability and high service continuation

Call control is executed in each CLP processor independently. Therefore, when a software problem causes a restart, the influence is limited to the CLP processor in which the problem occurred and service is seamlessly continued by switching to another CLP. Also, the TSWC processor for switching device control operates independently from the CLPs. This reduces the CLP restart time, because the TWSC processor does not usually need to be restarted when a CLP fails.

5. Mobile Switching Node software

Figure 5 shows the configuration of the 3G Mobile Switching Node software. The software is arranged in a hierarchical configuration of three layers: the basic OS layer, extended OS layer, and application layer. The basic OS functions are execution control and device drive control. The extended OS functions are switch control, device management, and system management. The application functions are mobile call control, additional service control, and protocol control.

Among these layers, hardware vendors supply the basic OS layer and the extended OS layer as platform software parts together with their hardware systems.

The application layer consists of common

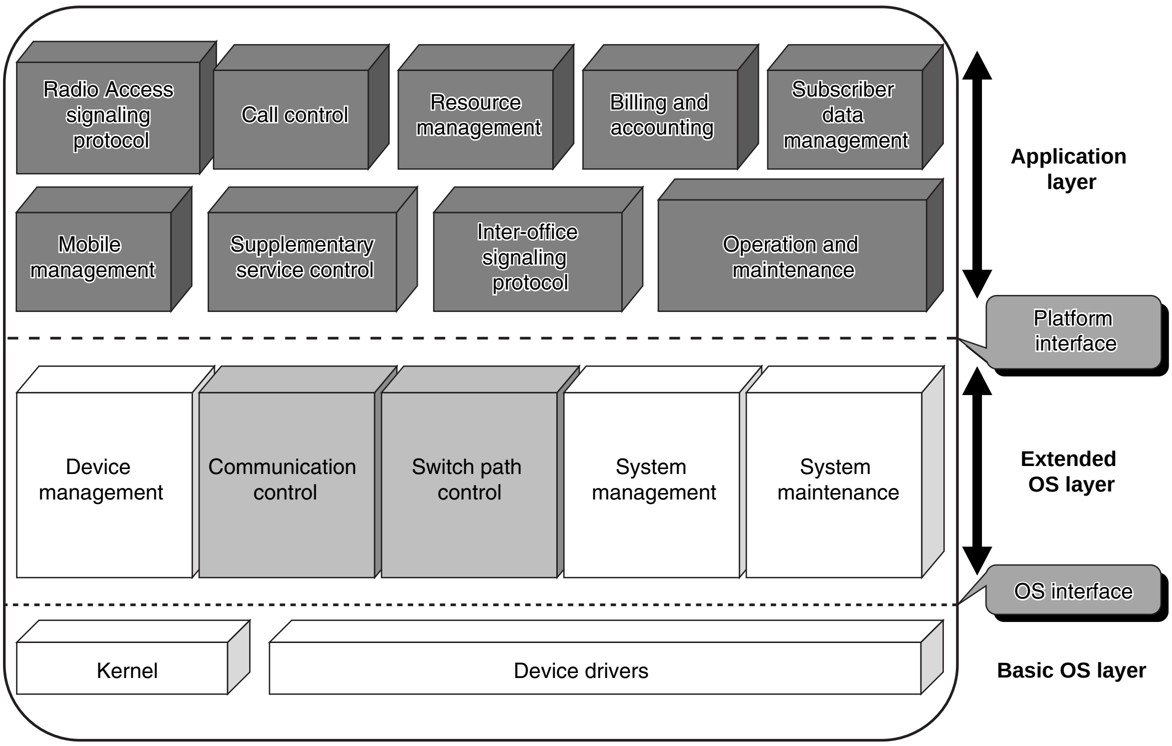


Figure 5
Configuration of the 3G Mobile Switching Node software.

software that is not specific to a vender platform. This is achieved by providing an extended OS platform interface for mobile communication applications.

The Mobile Switching Node software has the following features. The hierarchical configuration minimizes the effects of hardware version upgrades and new hardware on the application software. Also, the extended OS platform interface, which is a simple interface that provides switch-control, resource-control, and system-control functions, enables each layer to add its own functions and hides differences in physical hardware configurations from applications.

6. Conclusion

This paper described the core network technologies and the system and software configurations of Fujitsu's Mobile Switching Node. The architecture of this new product provides high performance, high reliability, and high expandability. For the future enhancement of the Mobile Switching Node, we are now planning the development of a new IP multiplexing interface unit and a new packet gateway to cope with the increasing number of packet users and the expansion of packet services.

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