IMS | Circuit Switching | Conversion to IP-based Network

Technology Reports

Special Articles on Technology Supporting Large-capacity and High-efficiency Communication in the Flat-rate Era

Converting to the IP-based FOMA Voice Network for Advanced Services and Economization

As part of the current NTT DOCOMO progress in implementing the All-IP Network, we are converting the circuit-switched core network that provides FOMA voice services to an IP-based network. The objectives are to achieve higher network capacity and efficiency and to provide the users new benefit, such as continuity of services that span access networks and adding new services to the network for voice services.

Core Network Development Department

Shigeki Okubo †

Makoto Furukawa

Noriaki Hagiya

1. Introduction

NTT DOCOMO began the "Pake-hodai"[*1] flat-rate i-mode packet service in June, 2004, and subscribers have been increasing favorably ever since, reaching 12.74 million contracts by the end of March 2008 (29% of FOMA subscribers, including "Pake-hodai Full"[*2]). "Pake-hodai" is a flat-rate charging plan for data communication, but we have also recently introduced a flat-rate system for voice communication that is restricted to calls to family members within Japan. Coping with voice communication as a flat-rate business will be essential in the future.

Introducing flat-rate services creates a synergism between enrichment of i-mode content and expansion in the number of users, but for NTT DOCOMO to adapt to flat-rate business into the future requires the continuous creation of more advanced and value-added services as new sources of revenue and economizing of the network. One way to satisfy both requirements is conversion of the core network to an IP-based one.

In this article, we explain the results of NTT DOCOMO's efforts regarding the All-IP Network (AIPN) [1][2] and the conversion of the FOMA voice network (hereinafter referred to as "the circuit-switched core network") to an IP-based one for the next step in providing voice services, etc.

2. Conversion of the Core Network to an IP-based One

When NTT DOCOMO began the FOMA services, the core network was constructed over the Asynchronous Transfer Mode (ATM)[*3] [3], but we have moved stepwise toward an IP-based network since then (**Figure 1**).

2.1 Circuit/Packet Separation for the Core Network

At the onset of FOMA services, voice traffic was mainstream and the adoption of ATM technology allowed efficient transmission of multimedia service traffic at various levels of quality. Traffic for both voice and packets

† Currently Network Technical Support & Operations Center

*1 **Pake-hodai**: NTT DOCOMO's flat-rate service for i-mode.

*2 **Pake-hodai Full**: NTT DOCOMO's flat-rate service that allows i-mode viewing of Web sites to PCs.

*3 **ATM**: A communication method in which fixed-length frames called cells are transferred successively.

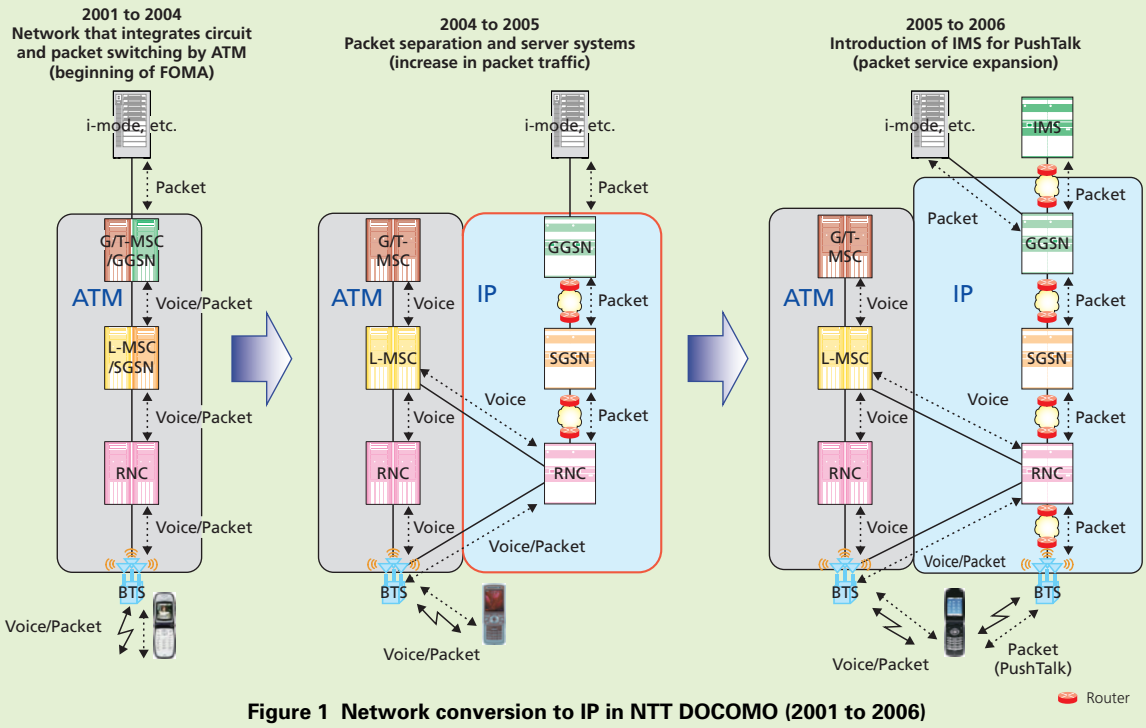


Figure 1 Network conversion to IP in NTT DOCOMO (2001 to 2006)

was handled by integrated ATM switches. Nevertheless, an explosive increase in packet traffic after the beginning of FOMA services led to the introduction in 2004 of the IP-based serving/gateway General packet radio service Support Node (xGSN)[*4] [4][5] and the IP backbone [6], which processed packet traffic more efficiently and separated the packet-switched core network from the circuit-switched core network.

2.2 Introduction of IMS

In 2005, the IP Multimedia Subsystem (IMS)[*5] [7] was introduced to provide the PushTalk service. The PushTalk service provides half-duplex, one-to-many voice communication rather than the conventional one-to-one communication, as well as user group management, presence service and functions for using them simultaneously (e.g., checking user presence information while conversing). IMS makes it possible to provide voice and data communication and various multimedia services over the packet network, and so is the most suitable system for PushTalk services [8].

3. Scenario for Conversion of the Circuit-switched Core Network to an IP-based Network

3.1 Requirements for the Conversion

In mobile communication, voice will continue to be a key service as we move into the future. The ability to provide voice services over AIPN is essential for a smooth migration of the core network to AIPN, and NTT DOCOMO is dealing with that issue in the next step of developing an IP core network. Conversion of the circuit-switched core network to an IP-based one has the following three requirements.

1) A Network must be Both Flexible to Increases in Traffic from a Flat-rate System and Economical

With full implementation of a flat-rate system, we can expect an expansion in network facilities to accompany the increases in traffic, but on the other side of the coin is the importance of increased network economization as a

*4 **xGSN**: A packet communication processing device in the FOMA network. It has both the Serving General packet radio service Support Node(SGSN) function and the Gateway General packet radio service Support Node (GGSN) function specified by 3GPP.

*5 **IMS**: A communication system standardized by 3GPP for implementing multimedia services. IMS uses IP and the SIP protocol used for Internet telephony to integrate the communication services of the fixed telephone and mobile communication networks.

premise for the flat-rate system. At the same time, ecological aspects have become essential in response to the environmental problems of recent years.

2) A Network must Allow Ease of Continued Service with Expansion of Diverse Access Networks

When the access networks change, as in the migration from Second-Generation (2G) to Third-Generation (3G), the user is aware of the differences between access networks and can only use services in individual forms because services are provided independently by each network in the conventional network. However, for user convenience and the continued expansion of access networks that provide services efficiently, it is important the user be able to use services provided from various access networks in common and be able to continue to use the same services even when moving between access networks. To achieve those goals, the network must provide common call and service control for multiple access networks.

3) A Network must Flexibly Introduce New IP-based Services

The fast and efficient provision of IP-based services such as typified by Instant Messaging (IM)[*6] and presence, and the implementation of services that are developed beyond the basic services are important matters.

3.2 Approaches to Migration

The ways to implement conversion of a circuit-switched core network to an IP-based one include the Mobile Switching Center (MSC) server[*7] [9] approach and the IMS approach. Both approaches promise economization compared to legacy switches, thus satisfying requirement 1). The MSC server is coming into wide use around the world, and currently operators that are providing services with legacy switches generally first migrate to MSC servers. The MSC server, however, is architecturally specialized for 3G circuit-switched access networks, and so cannot satisfy requirement 2). IMS, on the other hand, is independent of the access network, and so can perform common call and service control over multiple access networks. Concerning requirement 3), the MSC server defines an interface for services that use the CAMEL Application Protocol (CAP), but IMS allows the IMS Service Control (ISC) interface to be selected as well. ISC uses the more general Session Initiation Protocol (SIP), thus allowing use with a wider range of Application Servers (AS). That promises to encourage service development.

For those reasons, NTT DOCOMO has decided to migrate from the circuit-switched core network of the legacy switches to an IP-based core network that uses IMS for voice traffic control and transport.

4. Implementation of the CS-IP Network

4.1 Basic Policy

The FOMA circuit-switched core network already has 44 million users. The three points listed below are an important implementation policy for a smooth migration to a large-scale IP-based circuit-switched core network (hereinafter reffered to as “Circuit Switched over - IP (CS-IP) network”).

1) Users shall be able to Use the Mobile Terminals They Already Have without Modification.
2) FOMA Voice Services shall Continue with No Effect on Users Regarding Services.
3) There shall be No Effect on the Networks of Other Operators (Inheritance of the FOMA Roaming Interface)

4.2 Implementation Methods

1) CS-IP Network Architecture

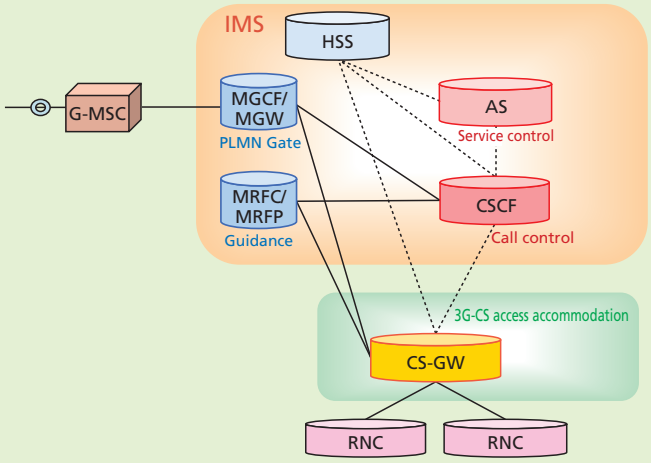
The architecture for implementing the CS-IP network is shown in **Figure 2**.

To accord with item 1) of the policy outlined in Section 4.1, the interfaces with existing Radio Access Network (RAN) and mobile terminals will be inherited intact, so a function for connecting to IMS will be needed. That function is allocated as the Circuit Switching-GateWay (CS-GW) [10][11]. For the Control Plane (C-Plane)[*8], the CS-GW terminates the same Call Control (CC) and Mobility Management

*6 **IM**: A service that allows users to send messages to other users over a network.

*7 **MSC server**: A server defined by 3GPP Release 4 that provides voice services. It executes C-Plane (see *8) processing when providing Third-Generation voice services.

*8 **C-Plane**: This refers to the control plane, a series of control processes that is executed when a call is established and other such times.



Name	Main functions
AS	• Service control inherited from the current FOMA circuit-switched services • Service control for basic voice calls • Service contention and sorting processing • Service scenario
CSCF	• Number translation • Routing • Session control
MGCF/ MGW	• Connection control for other networks and bearer conversion (IP⇔ATM, coding conversion, etc.)
MRFC/ MRFP	• Guidance control • Guidance sending
CS-GW	• Accommodation and authentication of 3G access, and mobility control • Bearer conversion (ATM⇔IP) • CC and MM signals⇔SIP conversion • HLR/HSS access • U-Plane processing (IuUP⇔RTP)

Figure 2 CS-IP network structure

(MM) signaling protocol from mobile terminals as the conventional FOMA, converts it to SIP, and is capable of interworking with the Call and Session Control Function (CSCF) that provides the basic call control function in IMS. For the User Plane (U-Plane)[*9], it terminates the ATM interface from existing RNC and can convert it to IP. In other words, the functions that are particular to the 3G circuit-switched access networks are absorbed by the CS-GW. For implementation of policy items 2) and 3) of Section 4.1, AS that can provide the control functions of existing FOMA services, including roaming, a Media Resource Function Controller/ Media Resource Function Processor (MRFC/ MRFP) that has a guidance control function, and a Media Gateway Control Function/ Media GW (MGCF/MGW) that has a function for connecting to existing STM/ATM networks are provided. Adopting IMS will also allow service control to be performed over access networks other than the 3G circuit-switched networks in the future.

2) IP Backbone

The IP backbone, which transports the traffic of the CS-IP network, uses Differentiated services (Diffserv)[*10] to give priority to CS-IP packets, and performs packet processing according to them. To ensure the same reliability as provided by the circuit-switched core network, the Fast-Reroute[*11] function is used for high-speed rerouting when a route is blocked.

3) Bandwidth Management

IP backbone management of bandwidth for all edge routers during communication makes it possible to secure the bandwidth required for new calls. When insufficient bandwidth remains, admission control is used to restrict accepted calls.

4.3 Network Economizing

Introduction of the CS-IP network aims at the following economization.

- Reduction in CAPital EXpenditure (CAPEX) and OPerating EXpenditure (OPEX) through adoption of Commercial Off The Shelf (COTS) (advanced Telecom Computing Architecture (aTCA)[*12] platform) in all systems
- Network flattening and reduction of relay equipment by conversion to an IP-based network (**Figure 3**)

Because a power consumption reduction of about 40% compared to the legacy switches can be expected, this conversion also has benefits on the ecological aspect.

4.4 Concerns Regarding Migration and Their Solutions

Introduction of the CS-IP network

*9 **U-Plane**: This refers to the user plane, which is the sending and receiving of user data.

*10 **Diffserv**: Technology for providing Quality of Service (QoS) according to various types of data on an IP network that carries a diverse traffic mixture.

*11 **Fast-Reroute**: A traffic transport technology that quickly and automatically reroutes traffic when the communication path fails in a Multi-Protocol Label Switching (MPLS) network.

*12 **aTCA**: Industrial standard specifications for carrier-oriented next-generation communication equipment specified by the PCI Industrial Computer Manufacturers Group (PICMG).

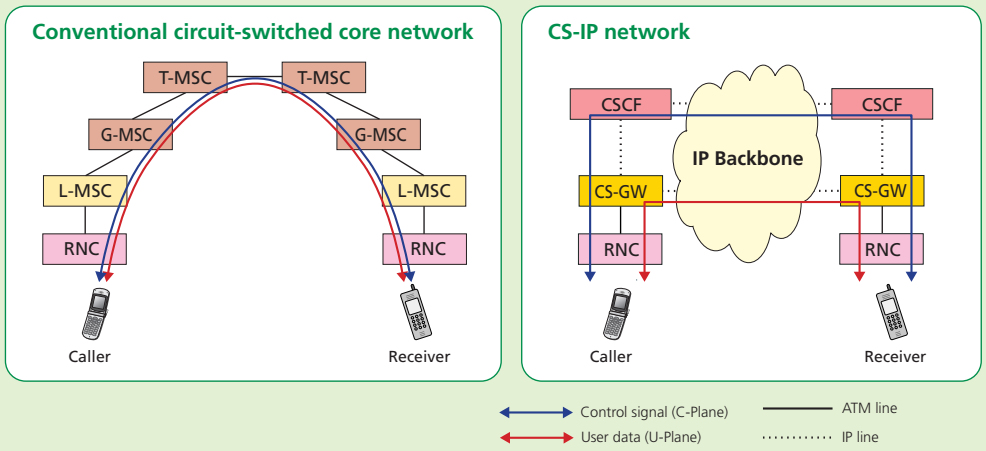


Figure 3 Configuration Comparison of conventional circuit-switched core network and network after conversion to CS-IP

necessarily involves gradual replacement of the ATM switches of the existing circuit-switched core network. The CS-IP network and the existing circuit-switched core network will therefore co-exist in the migration period. The existing circuit-switched core network and IMS differ partially in architecture, and using ATM and IP networks at the same time within the circuit-switched core network presents issues that must be considered. One major difference between IMS and the conventional circuit-switched core network is in assignment of the service control [12]. Specifically, in a circuit-switched core network of conventional ATM switches, the service control for terminating calls (e.g., call transfer control) is performed by the MSC on the originating side. In an IMS network, however, it is performed by the CSCF and AS on the terminating side.

In the period of migration to the CS-IP network, a control method that takes this difference into account is required. Without the method, for the case in which the originating side is a CS-IP network and the terminating side is a conventional circuit-switched core network, the service for terminating call will not be invoked on the terminating network. To ensure that the service is invoked, there must be a capability on the originating CS-IP network side to decide if the terminating side is a conventional network, and if it is, the service control for the terminating call must be executed by the CS-IP network on the originating side.

5. Service Development

Further development of IMS services in the future requires expansion of the AS functions for implementing service control. For smooth introduction of AS functions, CSCF support for the ISC interface and easy connection of new AS are of first importance. In the CS-IP network, CSCF for basic call control and AS for service control are separated architecturally and connected to each other via the ISC interface.

In future CS-IP network development, we plan to introduce new AS functions and provide services in cooperation with voice services. We will also expand the provision of services by IMS to other access networks successively (**Figure 4**).

6. Conclusion

We have explained our efforts for conversion of the NTT DOCOMO core network to an IP-based network so far and the next step of converting the circuit-switched core network to an IP-based one. We will continue to develop and introduce technology for the conversion into our network.

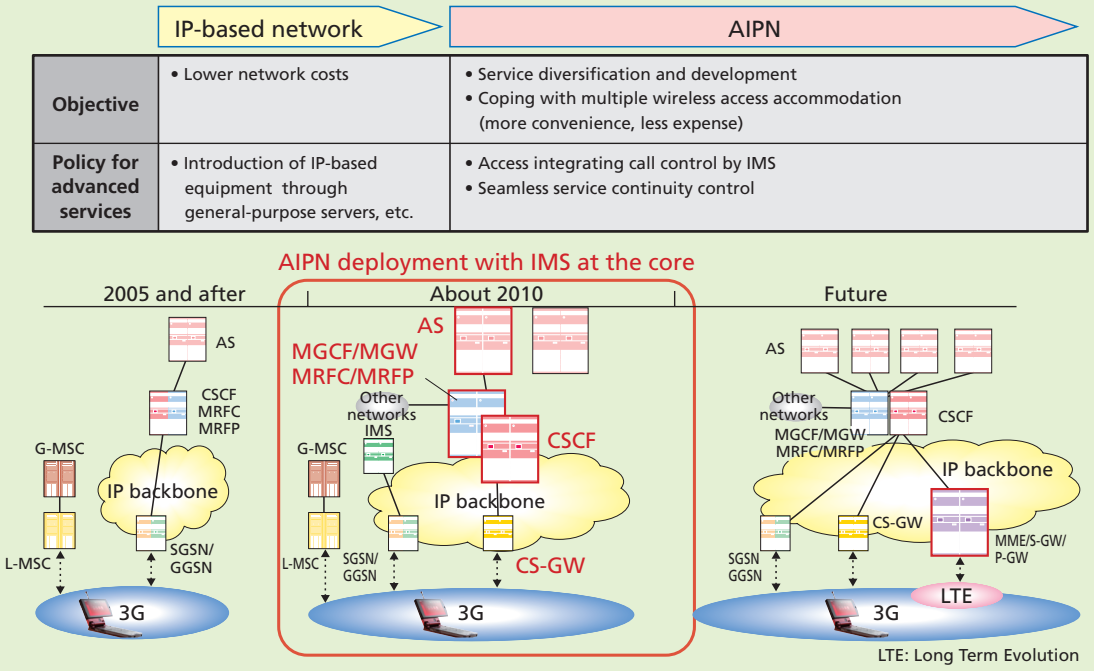


Figure 4 AIPN migration

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Terms Used in Figures

AS: Application Server
BTS: Base Transceiver Station
CSCF: Call and Session Control Function
CS-GW: Circuit Switching - GateWay
G/T-MSC: Gateway/Transit - Mobile Switching Center
GGSN: Gateway General packet radio service Support Node
IMS: IP Multimedia Subsystem
L-MSC: Local - Mobile Switching Center
MGCF: Media Gateway Control Function
MGW: Media GateWay
MME: Mobility Management Entity
MRFC: Media Resource Function Controller
MRFP: Media Resource Function Processor
P-GW: PDN - GateWay
RNC: Radio Network Controller equipment
SGSN: Serving General packet radio service Support Node
S-GW: Serving - GateWay