● Development Reports ●

FOMA Core Network Circuit/Packet Switching Separation Technology

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As a part of the ongoing efforts toward adoption of ALL-IP in the DoCoMo network, we have separated the packet switching part from a circuit/packet integrated ATM switch (MMS) to develop a device that can be connected to an IP network.

1. Introduction

The range of environments surrounding mobile internet including Freedom Of Mobile multimedia Access (FOMA) are expanding, led by non-voice services such as i-mode. In the future, it will be necessary to build the optimal network for controlling the ever-increasing Internet Protocol (IP) traffic in an efficient and flexible manner. DoCoMo has been examining conversion of networks to ALL-IP in its research and development as a measure to solve these problems and is making efforts toward innovation of network technologies based on IP to be used for communication systems of the third generation and beyond.

As the first step to realize such future concept of ALL-IP networks, a packet processing node that specially handles packet calls based on IP can be applied to the FOMA core network.

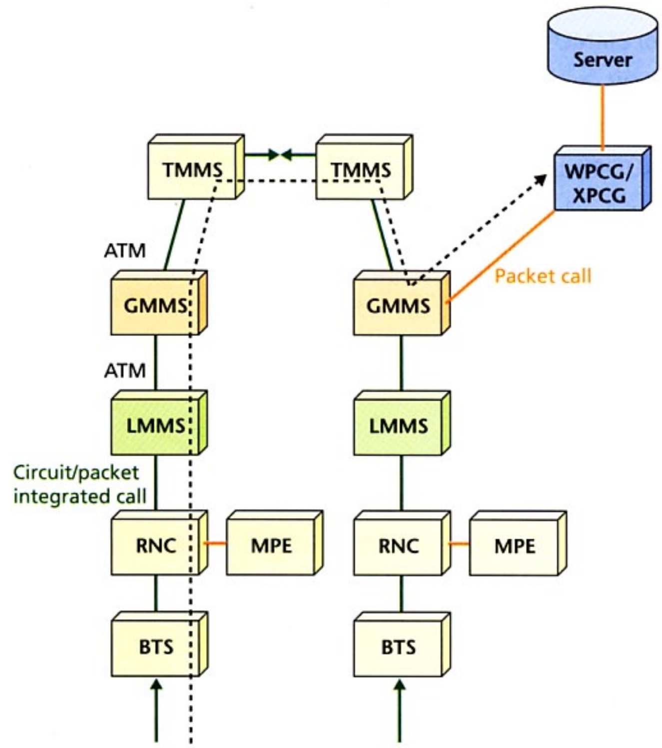
The current FOMA core network adopts Mobile Multimedia switching Systems (MMS), which are Asynchronous Transfer Mode (ATM) switching systems integrating circuit/packet switching, and utilizing Asynchronous Transfer Mode-Switched Virtual Channel (ATM-SVC) network routing. The specified interfaces between Local Mobile Multimedia switching Systems (LMMS) and Radio Network Controller (RNC), the Iu interfaces, are composed of ATM-SVC network nodes in the same way as for the core network. On the other hand, the interfaces of packet processing nodes are based on IP and do not support ATM-SVC. This means that, in order to connect an MMS node to a packet processing node, it is necessary to add a new function to convert the interface for the MMS. It is also necessary to complete the migration to IP-based technologies without interrupting the current FOMA commercial services; in other words, a migration method that allows separating the packet processing part without interruption must be established.

Based on the background outlined above, this article focuses on the description of a migration method for separating the packet processing part as a node from an MMS node and connecting the MMS to a packet processing node without interrupting services, along with a newly developed IP multiplexer for use with the MMS. It then describes various fundamental technologies for the IP-based core networks of the future.

2. Migration Method for Connecting with a Packet Processing Node

2.1 PS Separation Network

As shown in **Figure 1**, the current FOMA network is composed of ATM networks that operate with integrated circuit/packet switching. A packet call is delivered to an i-mode server or similar destination from a Base Transceiver Station (BTS) via an RNC, an LMMS and a Gateway Mobile Multimedia switching System (GMMS), and a Transit Mobile Multimedia switching System (TMMS). **Figure 2** shows the new network configuration, which this development aims for, where packet calls are separated at the LMMS and routed to a packet processing node. This configuration is called a Packet System (PS) separation network. In this configuration, the transfer path of a packet call takes a form where the call is connected from the LMMS through the packet processing node, via the IP router network and then to the i-mode server (dotted line in Fig. 2), and it can be noticed that it is a more efficient path than that shown in Fig. 1.



MPE: Multimedia signaling Processing Equipment
WPCG: Wireless Protocol Conversion Gateway
XPCG: eXtended wireless Protocol Conversion Gateway

Figure 1 Circuit/packet integrated network

2.2 Issues in Transmission Mode

The FOMA core network is composed of LMMS and GMMS nodes. When packet communication is performed, the General packet radio service Tunneling Protocol (GTP) is used to generate a path for transferring user packets between an LMMS and a GMMS by the Control-Plane (C-Plane) that transmits and recieves the control signal, and the user packets are communicated via this path. **Figure 3** shows how the GTP path is determined. The GTP is a protocol for transferring IP packets of individual users transparently over the FOMA network and the LMMS and GMMS are equipped with a function so that they can act as GTP terminals.

A Tunnel Endpoint IDentifier (TEID), which is a GTP path identifier determined for each connection, is specified in the GTP header. The FOMA network transfers packets using a Virtual Channel Identifier (VCI), which is an identifier specified in the ATM header.

The FOMA network then adopts the ATM-SVC protocol for transmission via the U-Plane, which is used for communicating user packets, so that the user packets are transferred to the specified addresses. When performing packet communication, an ATM-SVC path is determined for each connection between the LMMS and GMMS in question, and the GTP path is routed along the ATM-SVC path.

On the other hand, the transmission mode of the packet processing node is based on IP and not equipped with the ATM-SVC routing function, so a direct connection to the LMMS node cannot be established due to the difference in transmission mode. This is the reason why the development of a switching function between ATM-SVC and IP routing became necessary. This problem is solved and it becomes possible to connect with the IP router network by applying the newly developed device, which is described in Section 3.

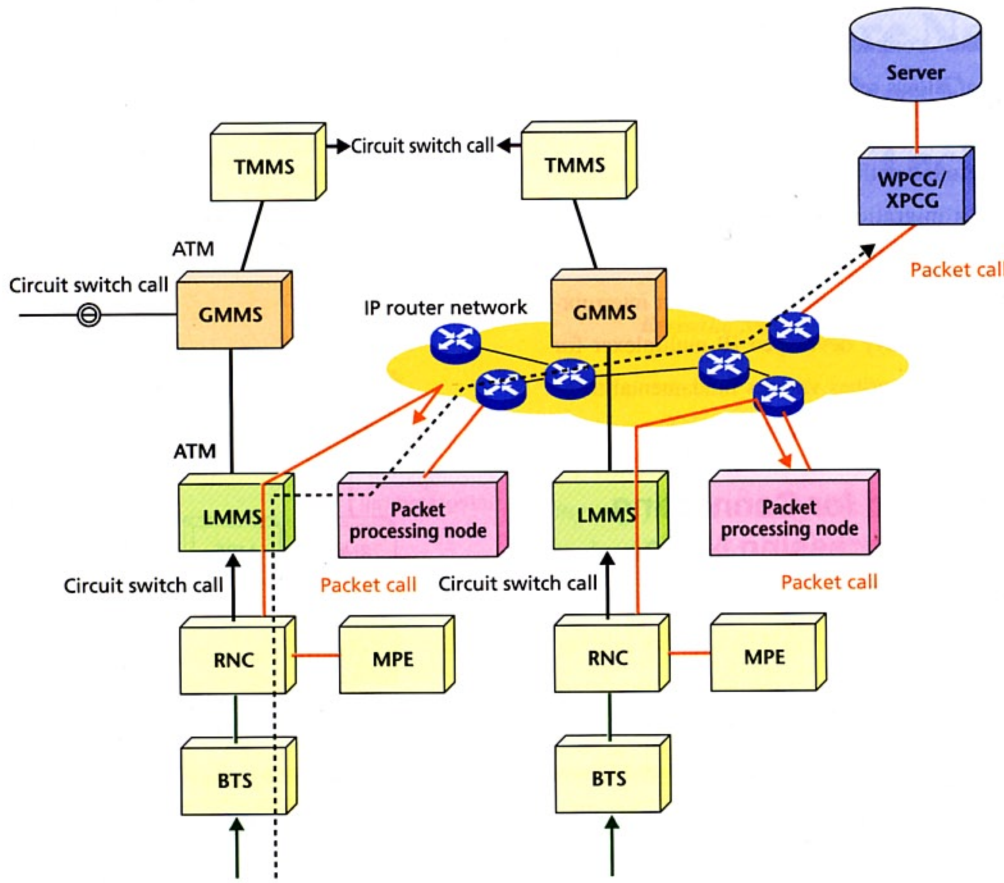


Figure 2 PS separation network

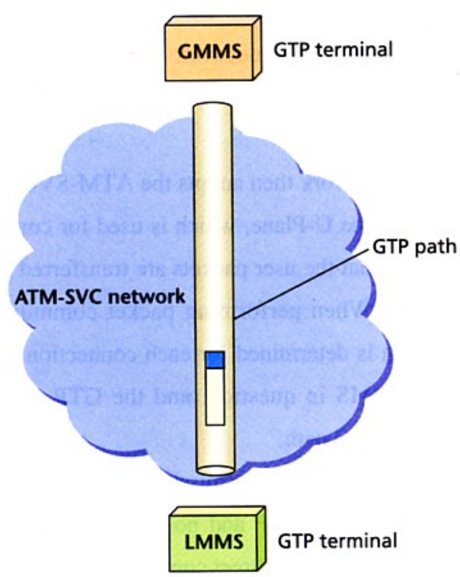


Figure 3 Core network

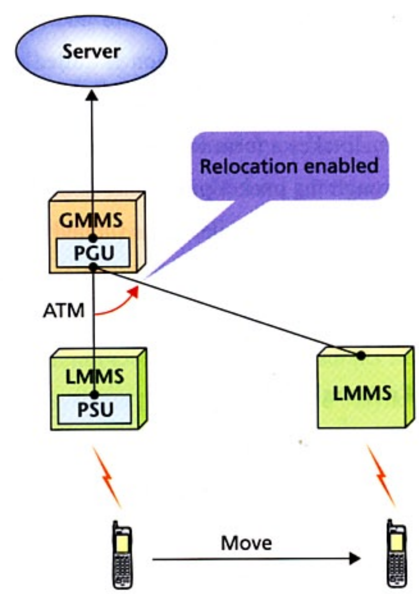


Figure 4 Relocation

2.3 Issues at Migration

The FOMA network provides services continuously without interruption even when a user in a Common cHannel (CH) condition, where one channel is efficiently shared by multiple users because the traffic per user is small, moves to the coverage of another LMMS while performing packet communication, as the GMMS immediately establishes a link to the target LMMS again. This function is called relocation (**Figure 4**). The LMMS has a Packet Subscriber Unit (PSU) and the GMMS has a Packet Gateway Unit (PGU) as GTP terminals. The link is reestablished with the PGU of the GMMS as the base point of relocation.

However, there is a problem with this approach: when switching from an ATM network with integrated circuit/packet switching to a packet processing node of a PS separation network, relocation between the ATM network and the packet processing node cannot be performed. As shown in **Figure 5**, this problem is due to the fact that the GMMS, which is the base point of the reestablished link, has an ATM-SVC interface whereas the packet processing node has an IP interface, and those interfaces are different. In order to solve this problem, as shown in **Figure 6**, it is effective to set a status where all the lines used for packet transmission from the LMMS to GMMS to go through an IP router network before the PS separation. With this status, it becomes possible to perform relocation using an Internet protocol router network Packet Gateway Unit (IPGU), which is a GTP terminal equipped with the IP conversion function of the GMMS, as a base point, thus solving the problem. In this article, this migration stage is called phase 1. Moreover, the stage where all packet calls are separated from the GMMS and connected to the packet processing node from the LMMS (PS separation network) is called phase 2.

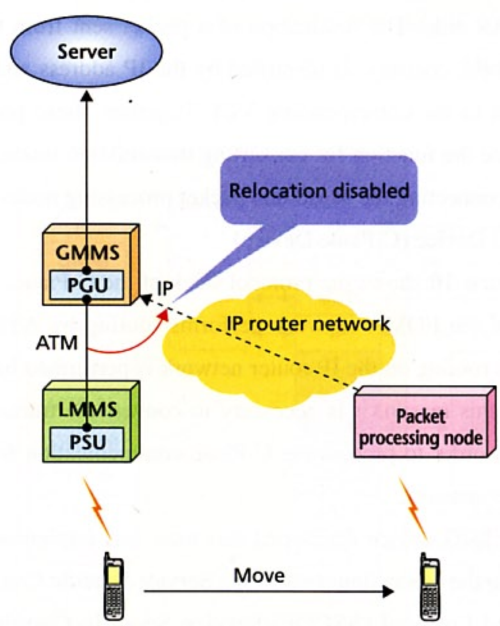


Figure 5 Issues when migrating to PS separation

3. System Configuration

3.1 Configuration of the Entire System

Figure 7 shows a detailed overview of the connections established between the LMMS and GMMS in phase 1. The newly developed devices here are the Internet protocol router network Packet Subscriber Unit (IPSU), which is the User-Plane (U-Plane) device of the LMMS, the IPGU, the U-Plane device of the GMMS, and the Internet protocol router network SIGnaling processing unit (ISIG), which is a C-Plane device. The SIGnaling processing unit (SIG) is a C-Plane device used in an ATM network. An Access Router (AR) is a general-purpose device that acts as a relay between an IP router network and an LMMS or GMMS. The Asynchronous transfer mode Line Unit (ALU) provides an ATM line interface part for transferring user data and control signals. In the figure, red solid lines indicate paths in the U-Plane and blue dotted lines indicate

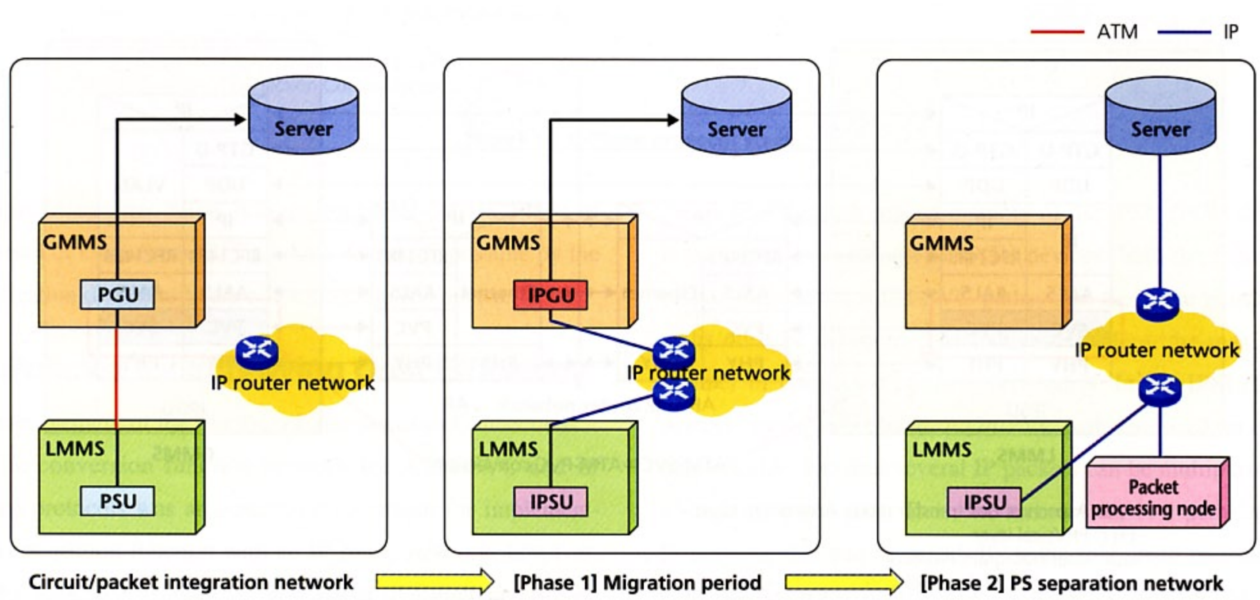


Figure 6 Migration toward PS separation

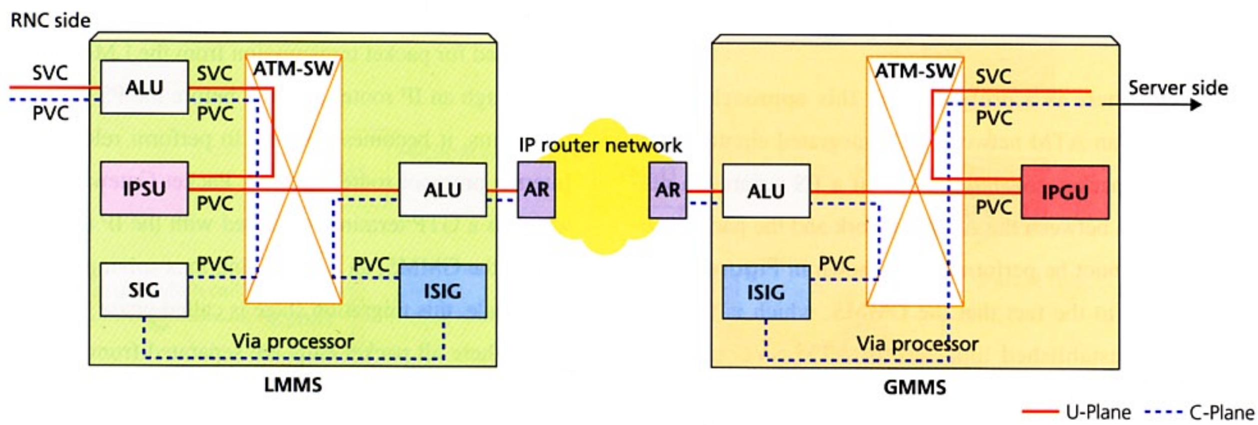


Figure 7 System configuration

paths in the C-Plane.

3.2 Connection Function with the IP Router Network

1) IPSU Device/IPGU Device (U-Plane Device)

The IPSU and IPGU devices are equipped with the GTP termination function and are thus able to rewrite the TEID, the identifier of the GTP. Moreover, as shown in **Figure 8**, the physical layer of the AR is an Asynchronous Transfer Mode-Permanent Virtual Channel (ATM-PVC); thus a conversion function from ATM-SVC to ATM-PVC is required in the IPSU/IPGU devices.

Figure 9 shows the function that handles the conversion of transmission mode between the FOMA network and IP router network. The user of each packet sent from the FOMA network side is identified by the VCI. The identified packet is assigned to the corresponding IP address and TEID and then transferred to the AR side. The destination of a packet sent from the AR side, on the contrary, is identified by the IP address and TEID and sent to the corresponding VCI. Together, these processes constitute the function for converting transmission mode, which allows connecting the MMS and packet processing nodes.

2) ISIG Device (C-Plane Device)

Figure 10 shows the protocol stack of the C-Plane. The C-Plane of the FOMA network performs routing by ATM-SS7, whereas routing on the IP router network is performed based on IP. For this reason, it is necessary to convert the transmission mode in order to process the C-Plane communication from the IP router network.

The ISIG device developed this time was implemented by changing the processing parts of the Service Specific Connection Oriented Protocol (SSCOP)/Service Specific Coordination Function-Network Node Interface (SSCF-NNI) to Multiprotocol

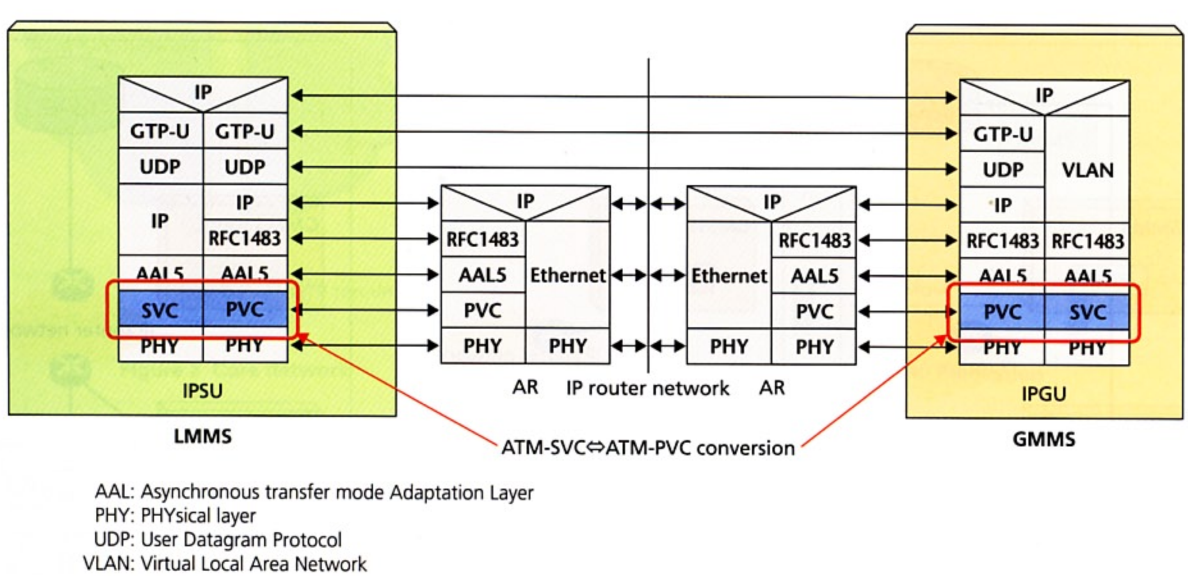


Figure 8 U-Plane protocol stack

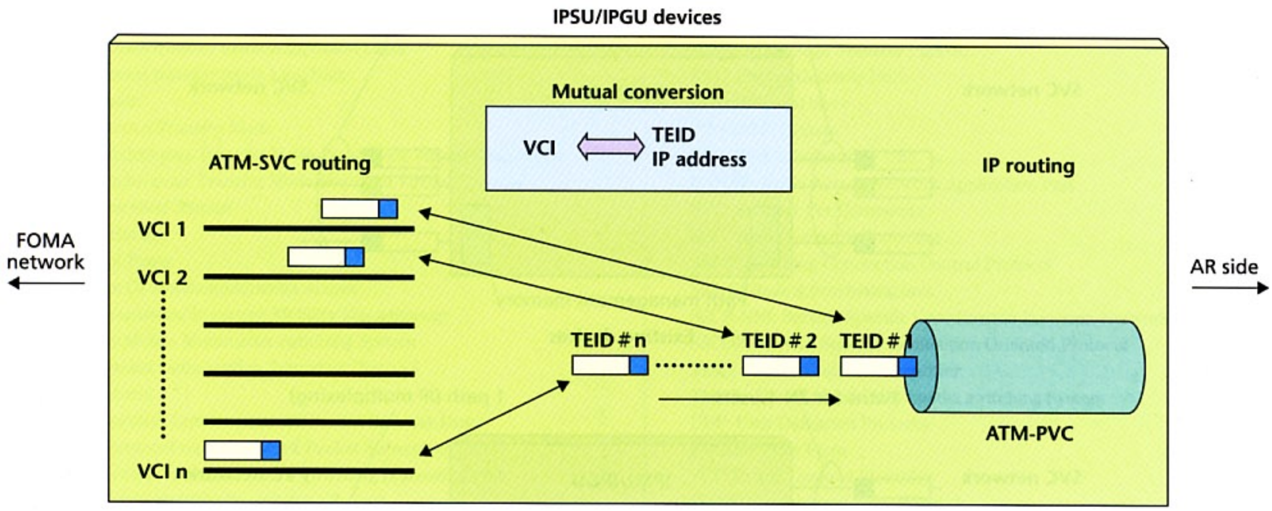


Figure 9 U-Plane processing

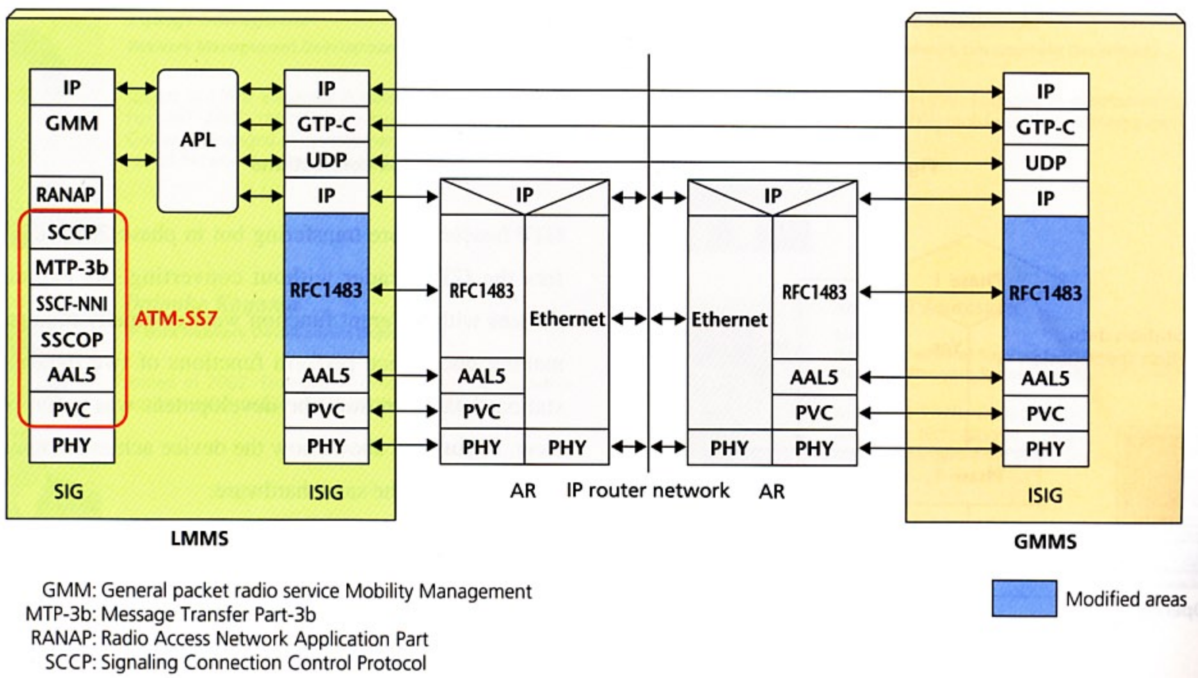


Figure 10 C-Plane protocol stack

Encapsulation over ATM Adaptation Layer 5 (RFC1483) of Request For Comments (RFC), which was made possible by the modification of the hardware of the existing SIG device.

4. Policies for Improving Cost Efficiency

1) Improvement of the Number of Simultaneous Connections

The conversion function between the ATM-SVC and IP routing protocols was an essential requirement for implementing a connection function with an IP router network; however, we also managed to improve the number of simultaneous connections by applying this conversion function. **Figure 11** shows how the path-related memory of the IPSU/IPGU devices is managed. In existing PSU/PGU devices, both the input and output sides adopt ATM-SVC paths; thus the same number of paths must be determined for both sides. Here, the maximum number of connected paths is denoted N. In the IPSU/IPGU devices, on the other hand, ATM-PVC paths are used on the IP network side, and thus several IP packets can be multiplexed on a single path and sent. Thus, the memory for N-1 paths on the IP network side can be saved. By using this saved memory for path management on the FOMA network side (ATM-SVC paths), the number of simultaneous connections that can be

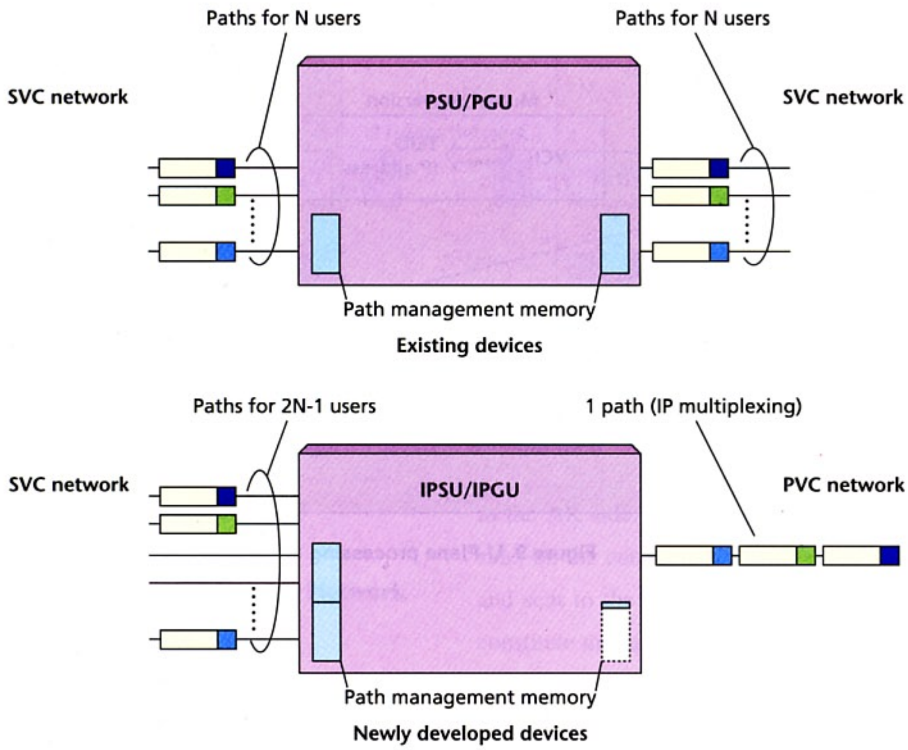


Figure 11 Improvement of the number of simultaneous connections

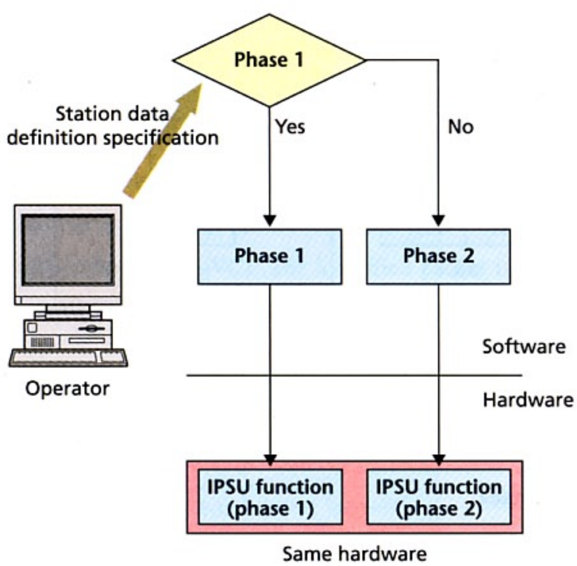


Figure 12 Achievement of multiple devices by station data definition

managed is increased to 2N-1 paths, i.e., almost doubled. As a result, the number of devices required for a given network can be reduced to approximately half.

2) Device Change by Station Data Definition

An IPSU device is required for both phases 1 and 2, but its function differs. In phase 1, the IPSU device terminates the GTP whereas in phase 2, the packet processing node terminates the GTP. In other words, the device in phase 1 converts the GTP header before transfering but in phase 2, the device transfers the GTP header without converting. As explained, two devices with different function were originally required, but by making one device perform functions of two devices through station data definition, the development was made more efficient. **Figure 12** shows how the device achieves either types of functionality in the same hardware.

5. Conclusion

This article explained the migration method for separating the packet processing part as a node from the MMS and connecting the MMS to the packet processing node without interrupting services, as well as the IP multiplexer newly developed for the MMS, aiming at adopting IP in the FOMA core network as a preliminary preparation for advancing toward the fourth generation. This technology has enabled application of the packet processing node (phase 2) and development of the FOMA core network. In the future, we plan to examine more advanced technologies aiming at achieving even more economical and flexible networks.

Abbreviations

AAL: Asynchronous transfer mode Adaptation Layer
ALU: Asynchronous transfer mode Line Unit
AR: Access Router
ATM: Asynchronous Transfer Mode
ATM-PVC: Asynchronous Transfer Mode-Permanent Virtual Channel
ATM-SVC: Asynchronous Transfer Mode-Switched Virtual Channel
BTS: Base Transceiver Station
CH: Common cHannel
C-Plane: Control-Plane
FOMA: Freedom Of Mobile multimedia Access
GMM: General packet radio service Mobility Management
GMMS: Gateway Mobile Multimedia switching System
GTP: General packet radio service Tunneling Protocol
IP: Internet Protocol
IPGU: Internet protocol router network Packet Gateway Unit
IPSU: Internet protocol router network Packet Subscriber Unit
ISIG: Internet protocol router network SIGnaling processing unit
LMMS: Local Mobile Multimedia switching System
MMS: Mobile Multimedia switching System
MPE: Multimedia signaling Processing Equipment
MTP-3b: Message Transfer Part-3b
PGU: Packet Gateway Unit
PHY: PHYsical layer
PS: Packet System
PSU: Packet Subscriber Unit
RANAP: Radio Access Network Application Part
RFC: Request For Comments
RNC: Radio Network Controller
SCCP: Signaling Connection Control Protocol
SIG: SIGnaling processing unit
SSCF-NNI: Service Specific Coordination Function-Network Node Interface
SSCOP: Service Specific Connection Oriented Protocol
TEID: Tunnel Endpoint IDentifier
TMMS: Transit Mobile Multimedia switching System
UDP: User Datagram Protocol
U-Plane: User-Plane
VCI: Virtual Channel Identifier
VLAN: Virtual Local Area Network
WPCG: Wireless Protocol Conversion Gateway
XPCG: eXtended wireless Protocol Conversion Gateway