FOMA International Roaming Service

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"WORLD WING," an international roaming service that has been awaited ever since the launch of FOMA, has finally become available. This article describes the features of this new service and it's technology overview.

New**T**echnology**R**eport

1. Introduction

"WORLD WING," an international roaming service for FOMA[*] was launched in June 2003.

To access the FOMA international roaming service, FOMA users can use their mobile stations for domestic use or User Identity Modules (UIMs) for FOMA (FOMA cards) overseas.

This article presents an overview of the control schemes used within DoCoMo's network for the FOMA international roaming service.

2. Conventional International Roaming Services

Up to now, mobile telecommunications standards adopted around the world had been different from country to country. Personal Digital Cellular (PDC) has been the main standard used in Japan to date, but more than 400 mobile telecommunications services operators (hereinafter "overseas operators") in Europe and Asia adopt other standards, such as Global System for Mobile communications (GSM). While international roaming services have been available for some time among the overseas operators using GSM, DoCoMo began offering "WORLD WALKER" in April 1997, an international roaming service that allowed PDC users to access mobile communications services through overseas operators that used standards other than PDC. This enabled PDC users to enjoy voice communications services both incoming and outgoing in most of the major geographical areas abroad.

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* FOMA: DoCoMo's Third-Generation mobile communication system (IMT-2000). The abbreviation of Freedom Of Mobile multimedia Access.

3. FOMA International Roaming Service

In May 2001, DoCoMo was the first in the world to offer a service under the name of "FOMA" that was based on Wideband Code Division Multiple Access (W-CDMA), a global standard for Third-Generation (3G) mobile telecommunications services known as International Mobile Telecommunications-2000, IMT-2000, (hereinafter "3G"). The use of a global standard in creating the FOMA international roaming service made it possible to offer a true international roaming service that can be accessed in two ways as described below.

(1) Mobile Station Roaming

Mobile stations used within Japanese 3G service networks (mobile stations enabled for international roaming) can also be used overseas where W-CDMA 3G services are available. The users can access voice communications services (incoming and outgoing) and other services. This type of accessing services is known as "mobile station roaming."

(2) Plastic Roaming

The compatibility of 3G-enabled UIMs with GSM networks is ensured by international standards. As a result, a FOMA user can access voice communications services (incoming and outgoing) as well as other services overseas by inserting a proper UIM into a GSM mobile station (a standard GSM-compatible mobile station).

This type of accessing services is called "plastic roaming."

The FOMA international roaming service launched in June 2003 offers plastic roaming to FOMA users. **Figure 1** shows the plastic roaming procedure. While traveling overseas, a FOMA user can insert a (international roaming-activated) FOMA card used within Japan into a purchased or rented GSM mobile station to access voice communications services (incoming and outgoing) within the service areas of overseas operators with whom DoCoMo has a roaming services agreement. Depending on the conditions of the networks, utilization of service control features (supplementary services, menu-guided operations) and implementation of operator determined barring functions may also become possible.

4. Network Procedures

Figure 2 shows network architecture for providing the FOMA international roaming service. A variety of control operations are performed between the DoCoMo network and overseas operators' networks that are connected through an international No.7 signaling network for non-circuit-related signaling information and through an international network for circuit-related signaling information. The actual control activities are discussed in the paragraphs to follow.

4.1 Location Updating Procedures

Figures 3 and **4** show control processes and processing sequence, respectively, for location updating for a FOMA user roaming within an overseas operator network.

When a mobile station is turned on within an overseas operator network, the mobile station sends a request for location updating to the overseas network's Visitor Location Register (VLR) (①). Upon receiving the request, the overseas network VLR obtains authentication vectors from DoCoMo's New Mobile Service Control Point (NMSCP) (②) and performs authentication with the mobile station. If the authentication is completed without any problems, then the overseas network VLR sends a location updating request to the NMSCP (③) and
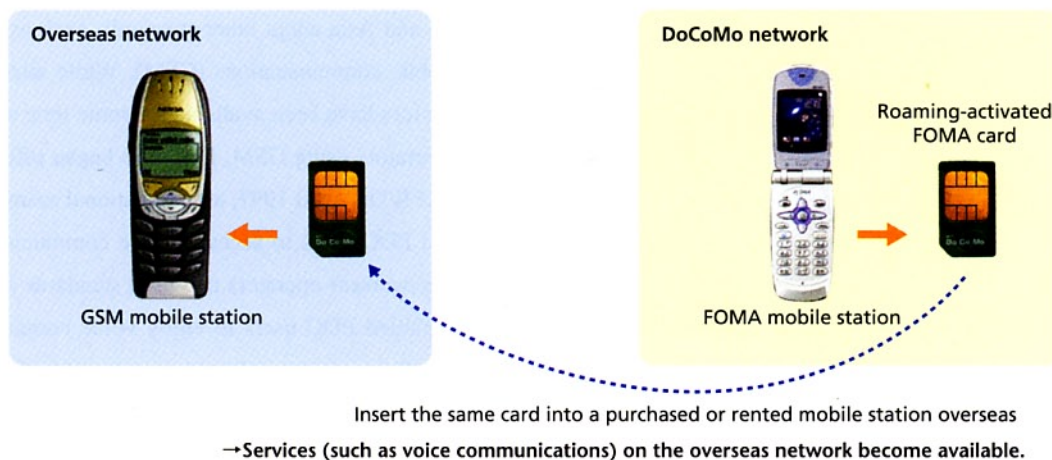

Insert the same card into a purchased or rented mobile station overseas
→Services (such as voice communications) on the overseas network become available.

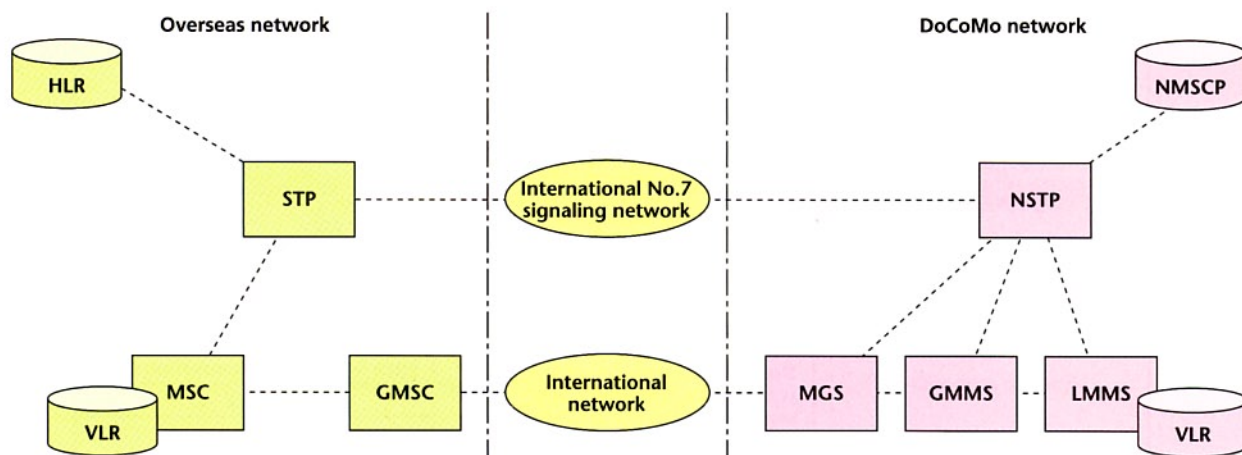**Figure 1 Plastic roaming procedure**

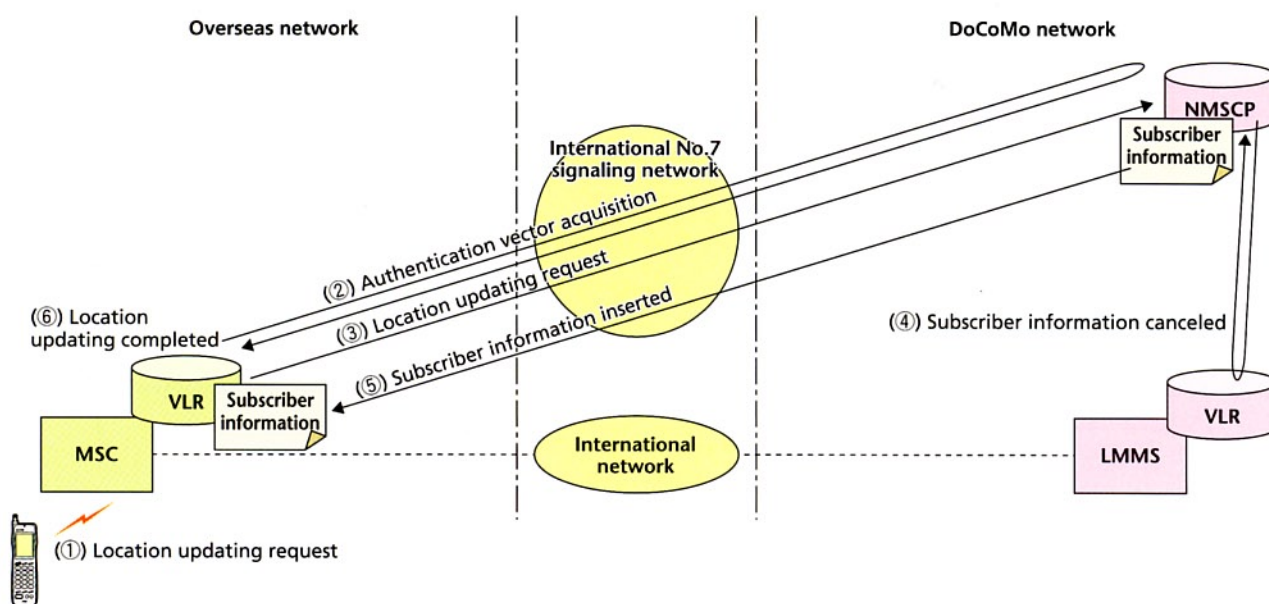**Figure 2 Network connections for FOMA international roaming service**

Figure 3 Location updating procedures

lets the NMSCP know, by means of the VLR number that the user has roamed out to the overseas operator's network. If the user's previous service network is the DoCoMo network (i.e., if this is the first location updating in the overseas network), then the NMSCP obtains Charge Area (CA) information and Location Area Information (LAI) from the Local Mobile Multimedia switching System (LMMS) for charging and stores the information along with the Mobile Switching Center (MSC) number and VLR number of the current service area network before canceling the subscriber information in DoCoMo's VLR (④). Then, the NMSCP determines whether or not the current overseas operator network has a service agreement with the user's home network, whether or not the user subscribes to the roaming service and whether any barring on roaming should apply to the user. The subscriber information in the home net-

work VLR is canceled before these three determination procedures are completed so as to prevent any invalid call procedures being carried out at the NMSCP, since the NMSCP has already correctly authenticated the user as a DoCoMo user and that the user is not within the DoCoMo network service area currently. Once these three determination procedures are completed without any problems, the subscriber information is downloaded to the overseas network VLR (⑤), and the location updating of the user is completed (⑥).

4.2 Procedures for Establishing Incoming and Outgoing Calls

Figure 5 shows the procedures used for establishing incoming and outgoing calls when FOMA international service users make their speech calls to the NTT fixed-line network. **Figure**
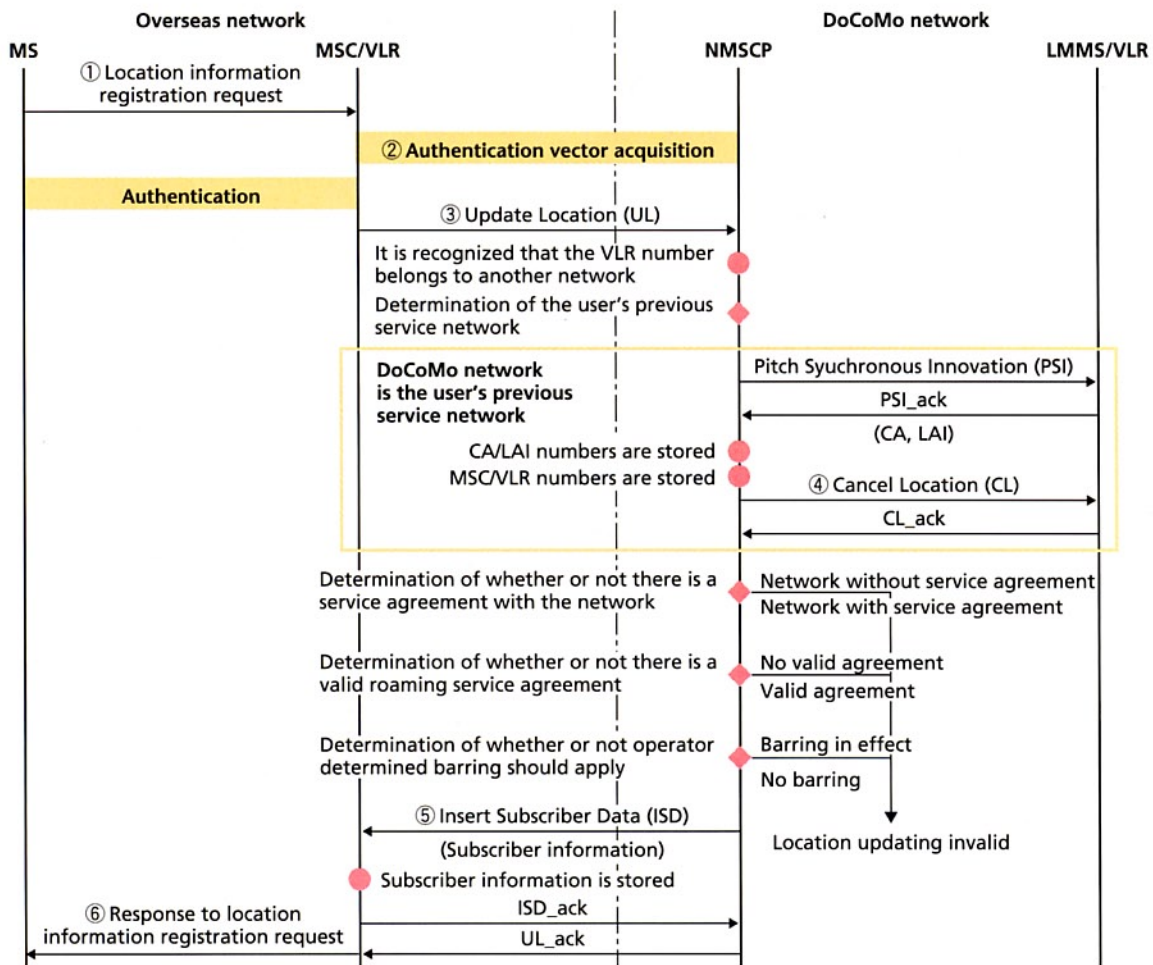
Figure 4 Location updating control processing sequence

6 also shows the processing sequence of a speech call between two users roaming out to overseas networks.

When a user roaming out to an overseas network tries to make a call to the NTT fixed-line network (①), the overseas network MSC and VLR initiate an outgoing call processing sequence. First of all, the overseas network MSC and VLR determine whether the user is barred from making outgoing calls. If there is no barring of outgoing calls, then the overseas network MSC and VLR send circuit-related signaling information to the NTT fixed-line network through an international network to establish a voice communications channel (②). This is the procedure when a user is making an outgoing call from an overseas network.

The handling of an incoming call to a FOMA international roaming service user from the NTT fixed-line network is similar to that for an incoming call when the user is in the home 3G service area network in that a channel connection to a Gateway Mobile Multimedia switching System (GMMS) is first established (③), and an incoming call control sequence is initiated

from the GMMS. The GMMS certifies the information necessary to control incoming calls to the roaming user to the NMSCP. In the process, GMMS obtains the basic information on the roaming user from the NMSCP regarding barring of incoming calls, roaming status, etc. (④). If the collected information indicates that there is no barring of incoming calls necessary for the user and that the user is roaming within an overseas operator's network, the GMMS then proceeds to confirm information on the status of the user's supplementary services such as roaming guidance, voice mail service status, etc. (⑤) with the NMSCP. The GMMS sends guidance announcements to the call originator according to the roaming guidance setting information of the user, i.e., "This phone is roaming overseas. We are now connecting. Please hold the line." if the service is activated, and "We are now connecting. Please hold the line." if the service is deactivated. Then, the GMMS obtains a Mobile Station Roaming Number (MSRN), which provides information on routing the call to the user side, by sending request signals via the NMSCP to the MSC and VLR of the user's roaming
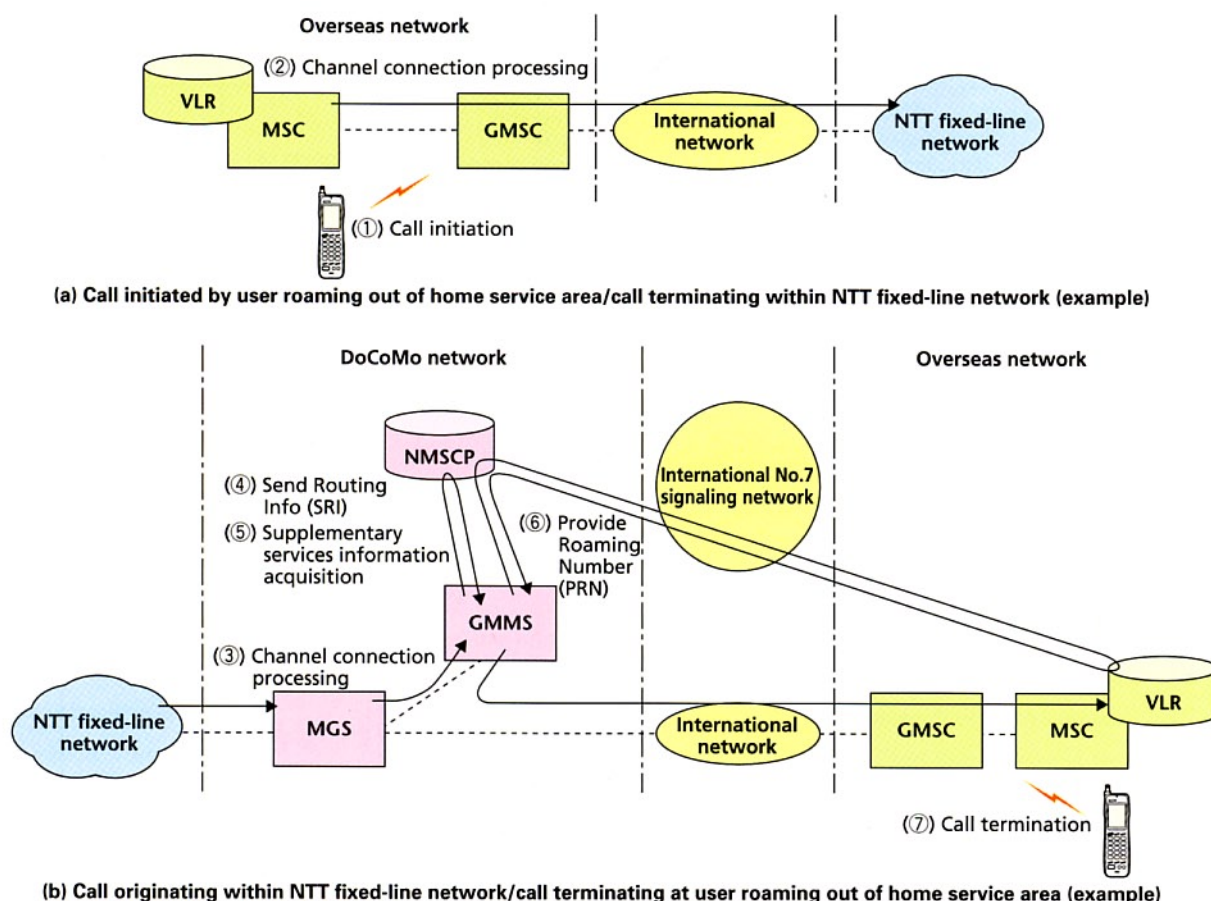
(a) Call initiated by user roaming out of home service area/call terminating within NTT fixed-line network (example)

(b) Call originating within NTT fixed-line network/call terminating at user roaming out of home service area (example)

Figure 5 Incoming and outgoing calls procedures

area (⑥). Based on the MSRN obtained from the MSC and VLR of the user's roaming area, the GMMS then sends circuit-related signaling information to the MSC and VLR in the user's roaming area and establishes a communications channel, thereby making a call possible (⑦).

In the case of a call between both users roaming out, an outgoing call (①) prompts the MSC/VLR on the call origination side to establish a communications channel by sending circuit-related signaling information to DoCoMo network's MGS via an international network (②). The process to follow in this instance is the same as that for an incoming call from the NTT fixed-line network to a user roaming out (③ to ⑦).

4.3 Service Procedures

(1) Supplementary Services Procedures

Figure 7 shows the supplementary services procedures for voice mail service, when a user is roaming out of the home service area.

A voice mail service applies to incoming calls and is activated as part of the incoming calls control, which is basically

identical to the control processing described in 4.2 (③ to ⑦). However, if the supplementary services information obtained from the NMSCP(⑤) indicates that the user has a voice mail service agreement and has the service activated, then the GMMS engages the MSC and VLR of the user's current roaming area in a connection sequence (⑥, ⑦) after a pre-set amount of ringing time. That is, the GMMS monitors the ringing time elapsed in seconds while calling the user. If the user does not pick up the incoming call within a pre-set amount of time, then the GMMS sends the information to the NMSCP which, in turn, instructs the GMMS to connect to the Multimedia Information System (MIS) (⑧). The GMMS then connects the incoming call to the MIS (⑨), which activates the voice mail service and records a voice message from the user initiating the call.

(2) Menu Operations

When a FOMA user is roaming out of the home service area, "1416" and other special dialing shortcuts unique to DoCoMo are unavailable, but menu operations and certain remote operations are still available. **Figure 8** shows the con-
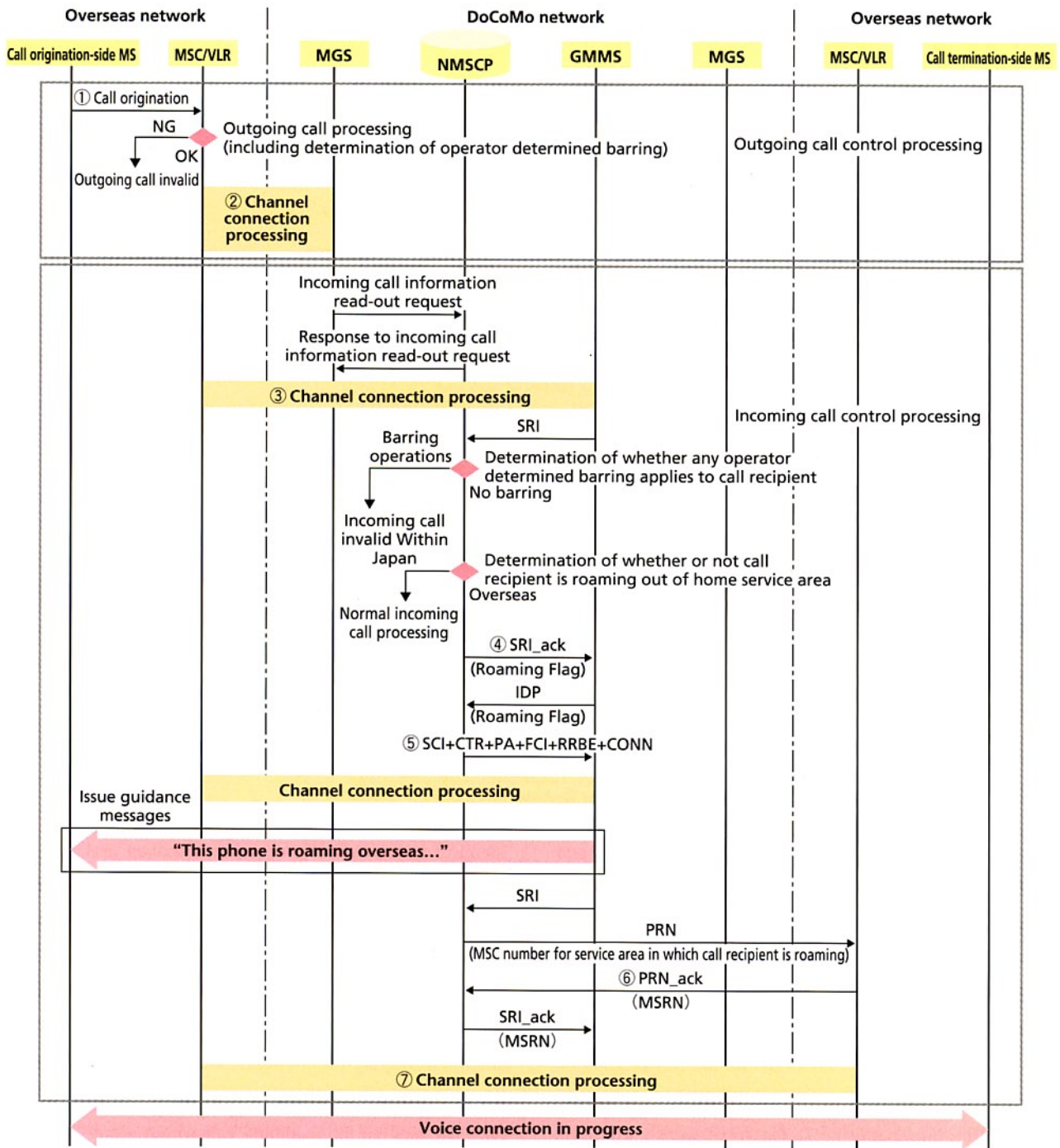
Figure 6 Incoming and outgoing calls control processing sequence (calls between users roaming out of home service area)

trol sequence used for menu operations during roaming in the FOMA international roaming service.

For menu operations, a mobile station sends Supplementary Service (SS) codes to the network (e.g., activate voice mail service = *121*1#). If the SS code sent by the mobile station can be terminated at an overseas network VLR (e.g., service status report, etc.), then the VLR responds directly to the mobile station. If, on the other hand, the SS code is terminated at the NMSCP (Home Location Register (HLR)) (e.g., service activa-

tion, etc.), then the NMSCP responds to the mobile station.

Remote control operations, such as voice mail service activation/deactivation, changing voice mail service settings, replaying voice messages, activating/deactivating call forwarding service and setting roaming guidance parameters from overseas networks, are available by calling "81-90-310-1XXX."

4.4 Operator Determined Barring

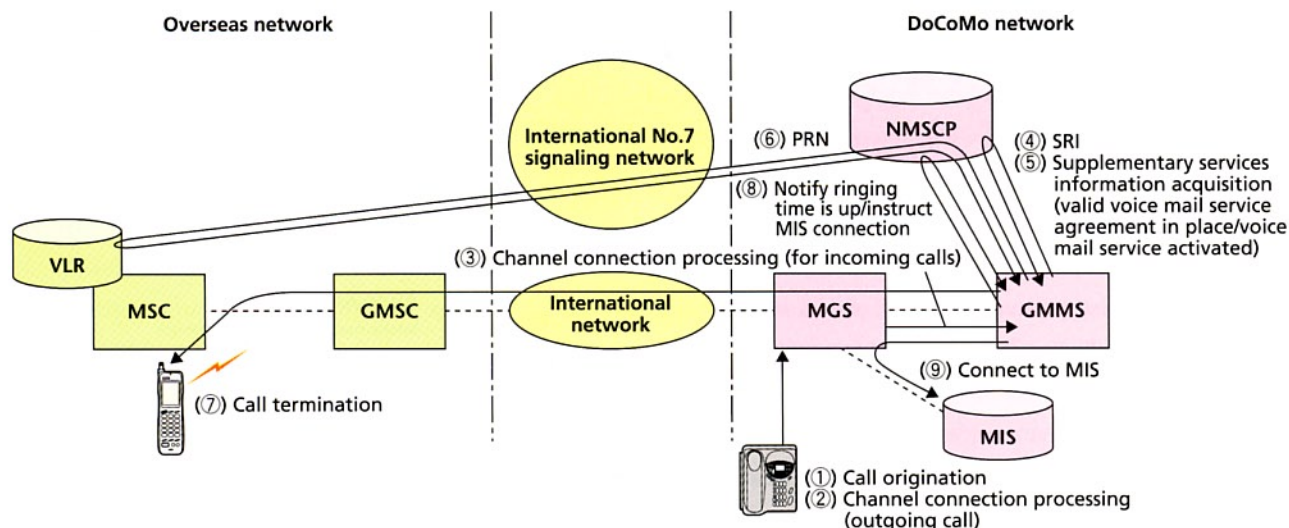**Table 1** lists the current operator-determined barring opera-

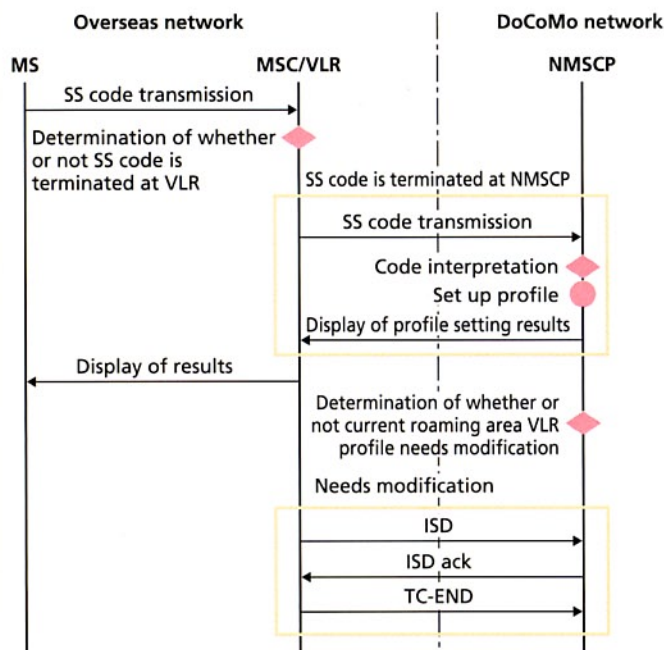**Figure 7 Supplementary service procedures (for voice mail service)**

Figure 8 Menu operation control processing sequence

tions that may be used for lost mobile terminals, extra-minute charges, etc. on users roaming out of the home service area, and the corresponding barring actions. At present, both operator-forced barring of calls and user-requested barring of calls performed within the DoCoMo network apply to users roaming out of the home service area. In addition, in the FOMA international roaming service, barring of roaming outside the home PLMN country, barring of all outgoing international calls except those directed to the home PLMN country and barring of outgoing premium rate calls are all enforced.

Regardless of whether a user is within the service areas of the DoCoMo network or roaming overseas, service orders to perform the barring operations in Table 1 are sent to the NMSCP by the ALl Around DoCoMo INformation system (ALADIN), which manages subscriber information. However, the NMSCP first determines the location of the user so that the barring operations are carried out only when the user is roaming overseas.

Table 1 Barring operations for users roaming out of home service area

	Types of barring operations	Barring actions
Operator-enforced termination of calls User-requested termination of calls	①Barring of all outgoing calls ②Barring of all incoming calls	①Barring is done as part of outgoing call processing by downloading barring parameters to the current network VLR of the roaming user. ②Barring actions are taken by the NMSCP upon receipt of a SRI signal from the MMS.
Barring of roaming outside the home PLMN country	Barring of all location updating	Once this barring condition is set, the subscriber information on the current network VLR is canceled; barring actions are then taken at the time of location updating.
Barring of all outgoing international calls except those directed to the home PLMN country	Barring of outgoing calls	Barring actions are taken for outgoing calls to a third country other than the user's own country and service area network.
Barring of outgoing premium rate calls	Barring of outgoing calls	Barring actions are taken at the time of premium rate calls initiation.

5. Conclusion

This article described the procedure taking place within the DoCoMo network for the new FOMA international roaming service.

Not only we believe that our new FOMA international roaming service is a step towards the globalization of cellular phone services, but also believe that it will spawn brand-new international services. To that end, we intend to establish roaming functions as quickly as possible to add more supplementary services and host application services and extend the roaming areas, so that the FOMA users will find the international roaming service more useful.

ABBREVIATIONS

ALADIN: ALl Around DoCoMo INformation systems
CA: Charge Area
CL: Cancel Location
CONN: CONNect
CTR: Connect To Resource
FCI: Furnish Charging Info
FOMA: Freedom Of Mobile multimedia Access
GMMS: Gateway Mobile Multimedia switching System
GMSC: Gateway Mobile Switching Center
GSM: Global System for Mobile communications
HLR: Home Location Register
IDP: Initial DP
IMT-2000: International Mobile Telecommunications-2000
ISD: Insert Subscriber Data
LAI: Location Area Information
LMMS: Local Mobile Multimedia switching System
MGS: Mobile Gateway Switch
MIS: Mobile Information Storage system
MMS: Mobile Multimedia switching System
MS: Mobile Station
MSC: Mobile Switching Center
MSRN: Mobile Station Roaming Number
NMSCP: New Mobile Service Control Point
NSTP: New Siginaling Transfer point
PA: Play Announcement
PDC: Personal Digital Cellular
PRN: Provide Roaming Number
PSI: Provide Subscriber Info
RRBE: Request Report BCS Event
SCI: Send Charging Info
SRI: Send Routing Info
SS: Supplementary Service
STP: Signaling Tranfer Point
UIM: User Identity Module
UL: Update Location
VLR: Visitor Location Register
W-CDMA: Wideband Code Division Multiple Access