LTE Data Roaming Standardization

Technology Reports

Implementing LTE International Data Roaming

On completion of EPC standardization at 3GPP, specifications for international roaming between mobile operators were established at GSMA. NTT DOCOMO was actively involved in those standardization activities contributing a variety of proposals, and in December 2013, it launched an LTE roaming service incorporating those provisions in the NTT DOCOMO network. This article describes the network configuration for implementing LTE roaming and call processing methods unique to LTE roaming including connection processing when camping on 3G and DNS address resolution.

Core Network Development Department

Motohiro Abe
Hisayuki Inaba
Keisuke Suzuki
Zhen Miao

1. Introduction

Once standardization of the Evolved Packet Core (EPC)*1 network accommodating LTE was completed at the 3rd Generation Partnership Project (3GPP) and issued as Release 8 specifications, guidelines and test items for implementing LTE international data roaming based on those specifications were formulated at the GSM Association (GSMA)*2 [1].

NTT DOCOMO was a key player in those standardization activities making major contributions including many technical proposals. It has since followed up those contributions by launching an LTE international data roaming (hereinafter referred to as "LTE roaming") service conforming to the GSMA specifications in the NTT DOCOMO network in December 2013.

The implementation of LTE roaming enables a roaming user to use LTE data communications within the NTT DOCOMO network. In other words, a user from overseas can now be provided with high-speed communications while in Japan.

In this article, we first describe the LTE-roaming connection scenario and the network configuration adopted by NTT DOCOMO from a standards perspective. Next, we explain the connection method with the LTE-roaming core network and the Domain Name System (DNS)*3 selection method to achieve a service the same as in 3G roaming. Finally, we describe the Voice over LTE (VoLTE) terminal control method in LTE roaming.

2. Communication Method with Overseas Operators

2.1 Roaming Scenarios

For the case that a terminal belonging to a Home-Public Land Mobile Network

*1 **EPC**: An IP-based core network specified by 3GPP for LTE and other access technologies.
*2 **GSMA**: An association that supports and manages activities of the mobile industry, such as formulating roaming rules. The largest mobile communications industry association in the world, with

(HPLMN)*4 is roaming in a Visited-Public Land Mobile Network (VPLMN)*5, GSMA PRD IR.88 guidelines specify roaming scenarios in which LTE and 2G/3G radio access exist in the VPLMN network (**Figure 1**) [2]. Specifically, these are scenarios in which the connection InterFace (IF) with HPLMN is only a Packet data network GateWay (P-GW)*6 (Fig. 1 (a) and (c)) and scenarios in which the connection IF also includes a Gateway General packet radio service Support Node (GGSN)*7 the same as in 3G roaming (Fig. 1 (b) and (d)). These scenarios can also be classified into those in which the VPLMN Serving General packet radio service Support Node (SGSN)*8 and the HPLMN P-GW connect by a Gp-IF*9 (Fig. 1 (a) and (b)) and those in which the VPLMN SGSN/Serving GateWay (S-GW)*10 and HPLMN P-GW connect by a S4-IF*11 and S8-IF*12 (Fig. 1 (c) and (d)). In LTE roaming, each operator has to adopt one of the scenarios shown in the figure. In the roaming service provided by NTT DOCOMO, VPLMN and HPLMN are taken to be NTT DOCOMO and an overseas operator, respectively. It appears that many overseas operators will be adopting S4/S8-IF as a HPLMN scenario and that few operators will be supporting only Gp-IF, so NTT DOCOMO has decided to adopt a scenario having the S4/S8-IF (Fig. 1 (d)).

2.2 Network Configuration

The NTT DOCOMO network configuration for LTE roaming is shown in **Figure 2**. In this configuration, the HPLMN and VPLMN connect via an international IP relay network called an IP eXchange (IPX)*13 to transfer data between operators. Here, the connection between the Mobility Management Entity (MME)*14 and Home Subscriber Server (HSS)*15 uses Diameter*16 protocol. In the case that Diameter signals are routed between mobile operators, GSMA PRD IR.88 specifies that a Diameter Edge Agent (DEA)*17 be deployed between the mobile operators. This has the effect of preventing an outflow of information on network

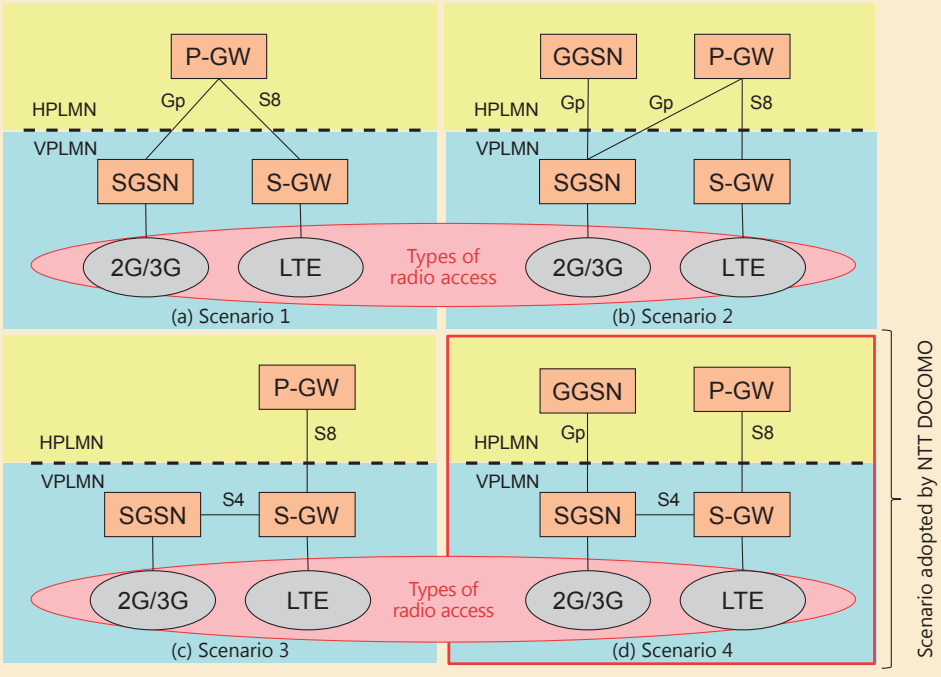

Figure 1 LTE roaming scenarios (for a HPLMN terminal roaming in VPLMN)

members in related businesses including mobile communications providers, IPX operators, and terminal, equipment and software vendors.

*3 **DNS**: A system that associates host names and IP addresses on IP networks.

*4 **HPLMN**: The subscriber's home operator.

*5 **VPLMN**: The subscriber's roaming-destination operator.

*6 **P-GW**: A logical node having the function of connecting mobile terminals with an external network.

*7 **GGSN**: A logical node acting as a connection point with an external network and allocating IP addresses.

*8 **SGSN**: A logical node managing the mobility of mobile terminals that perform packet switching and packet communications.

*9 **Gp-IF**: Name of interface between SGSN and GGSN or SGSN and P-GW in roaming.

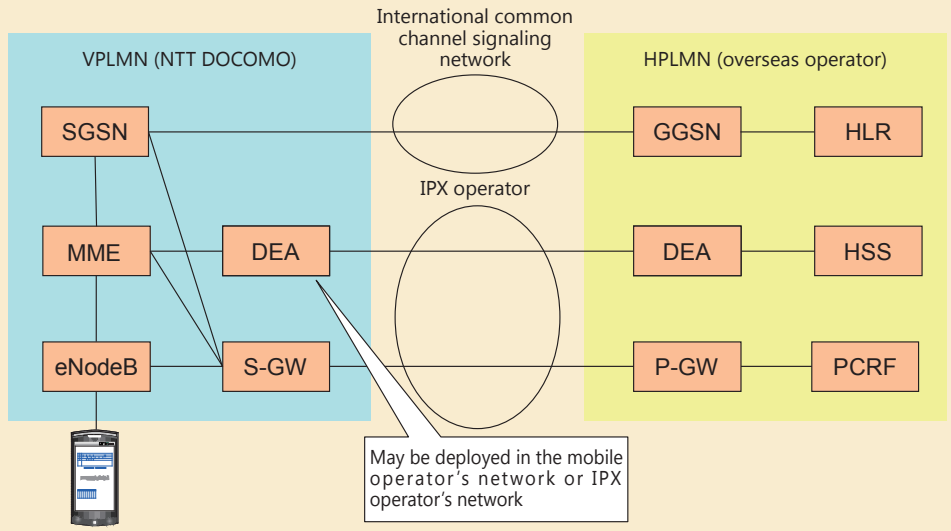

Figure 2 Network configuration for LTE roaming

topology*18 while also consolidating Diameter connections thereby reducing the effect of any change in the configuration of one's own network on another network. NTT DOCOMO as well deploys a DEA between the MME and HSS in conformance with IR.88 specifications, which also specify that the DEA may be placed either in the mobile operator's network or IPX operator's network. Given that NTT DOCOMO can carry out necessary maintenance work at the time of an emergency such as a network fault, the DEA is deployed within its own network.

3. Call Control Methods for LTE Data Roaming

The call control procedure for LTE roaming is basically the same as the operations used for making connections within Japan [3]. However, while the S5 protocol*19 between SGW and P-GW within the NTT DOCOMO network is achieved by Proxy Mobile Internet Protocol version 6 (PMIPv6)*20, GPRS Tunneling Protocol version 2 (GTPv2)*21 used by many overseas operators has been adopted for LTE roaming to facilitate interconnectivity. Other differences with domestic connections are the connection method when an overseas user is camping on 3G and the DNS address resolution method as described below.

3.1 Roaming Connection When Camping on 3G

1) Setting of Connection Path

Although the LTE service area is continuously expanding, 3G areas still exist and connections to them will be generated for even roaming users from overseas. In Japan, when 3G camping occurs by a user having an LTE contract, the connection path is determined by the capabilities of the user's mobile terminal. Specifically, a 3G terminal connects to GGSN and a 3G/LTE dual terminal connects to P-GW [3].

In the case of international roaming, connections must be made according to one of the scenarios shown in Fig. 1, and in scenario 4 adopted by NTT DOCOMO, the connection path can be determined by the capabilities of the mobile terminal the same as roaming within the domestic network. In short, a 3G terminal connects to GGSN and a 3G/LTE dual terminal connects to P-GW.

2) Contract Information

The unique characteristics of LTE roaming must also be considered in the handling of contract information. Signals exchanged between the Home Location

*10 **S-GW**: A packet switch on the LTE Network for sending/receiving user data to/from P-GW.
*11 **S4-IF**: Name of interface between SGSN and S-GW.
*12 **S8-IF**: Name of interface between S-GW and P-GW in roaming.
*13 **IPX**: An exchange network that has evolved from GRX and that provides QoS function.
*14 **MME**: A logical node accommodating a base station (eNodeB) and providing mobility management and other functions.
*15 **HSS**: A subscriber information database in a 3GPP mobile network that manages authentication and location information.
*16 **Diameter**: IP-based control signal specified by the Internet Engineering Task Force (IETF).
*17 **DEA**: Diameter relay equipment placed between mobile operators to exchange Diameter signals.

Register (HLR)*22 and SGSN include the GSM-Mobile Application Part (MAP)*23, within which Evolved Packet System (EPS) subscription data (LTE contract information) are specified as a parameter. For connections within Japan, this parameter is referenced to make necessary contract-related decisions, perform Quality of Service (QoS) control*24, etc. This parameter, however, is not specified as being absolutely essential in the 3GPP standard, so there is no guarantee that it will be passed from an overseas HSS/HLR. For this reason, connections made when camping on 3G during LTE roaming make use of GPRS subscription data (3G contract information), an essential parameter. Specifically, EPS-specific information (QoS, etc.) needed for a P-GW connection is generated at SGSN based on information set in GPRS subscription data. In this way, changing the parameter to be referenced from the one used in a domestic connection makes it possible to provide a user camping on 3G with a service equivalent to that when in an LTE area.

3.2 Address Resolution Method in LTE Roaming

As described in section 3.1, the connection destination in the case of LTE roaming may be GGSN or P-GW depending on the capabilities of the mobile terminal, which means that SGSN must be able to support both connection methods. Here, the DNS address resolution method (the method of querying DNS for a GGSN or P-GW address) differs between a GGSN connection and a P-GW connection, so that one or the other must be used accordingly. In the conventional 3G address resolution method, an Access Point Name (APN)*25 is used as a key in making an A record*26 query and resolving the address of the overseas operator's GGSN (**Figure 3** (a)). In LTE, however, DNS address resolution is performed by the Straight forward-Name Authority PoinTeR (S-NAPTR)*27 procedure specified in 3GPP Release 8 (Fig. 3 (b)).

A P-GW may have multiple capabilities (PMIP, GTPv2, GTPv1, etc.) and multiple IFs (Gp, S8, etc.) with other nodes, so which P-GW to connect to with which capabilities and IFs must be selected. For this reason, the DNS selection method has been extended: in LTE roaming, the S-NAPTR procedure is used for a P-GW connection and the A record procedure for a GGSN connection. Changing the DNS selection method between a P-GW connection and GGSN connection in this way enables an appropriate connection to be made to the roaming user's home network.

4. VoLTE Terminal Control

Operations for handling a roaming

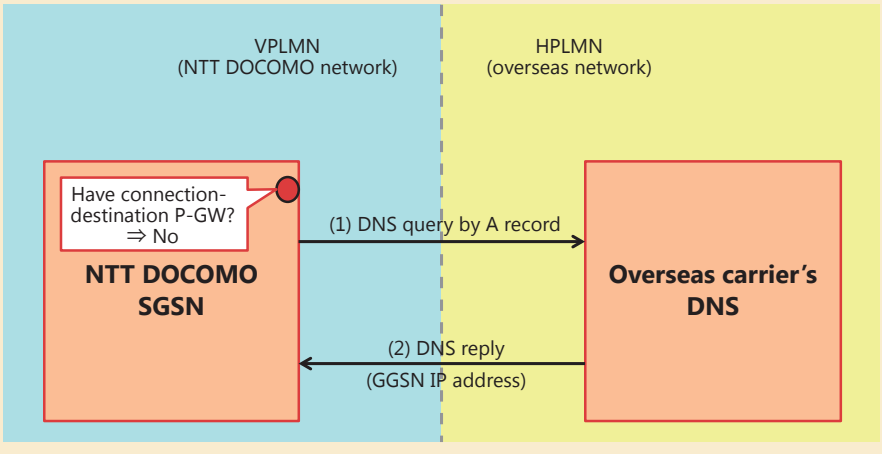

Figure 3 (a) Conventional (3G) DNS address resolution procedure (A record)

*18 **Network topology**: Information related to an operator's network architecture such as host names. The passing of such information to another network is called "network topology outflow."

*19 **S5 protocol**: Protocol used between S-GW and P-GW (S5-IF).

*20 **PMIPv6**: A communications protocol for managing packet transmission paths within a network independent of the type of access system or terminal capabilities.

*21 **GTPv2**: A communication protocol for user data transmission which provides functions such as establishing communication path and data transfer in core network.

*22 **HLR**: A logical node defined by the 3GPP with functions for managing subscriber information and call processing.

user with a VoLTE terminal must be considered when studying the deployment of LTE roaming. VoLTE is a technology for conducting voice communications over LTE, and though standards have been specified, NTT DOCOMO has yet to launch a VoLTE service. Some overseas operators, however, have begun to provide VoLTE as a commercial service and sell VoLTE-compatible terminals. Thus, if a roaming user should have a VoLTE terminal, the terminal may proceed to establish a voice bearer*28 to the HPLMN IMS*29 at the time of location registration. In this case, when the roaming user attempts to originate a voice call, a voice signal will be generated on LTE since a voice bearer is being established despite

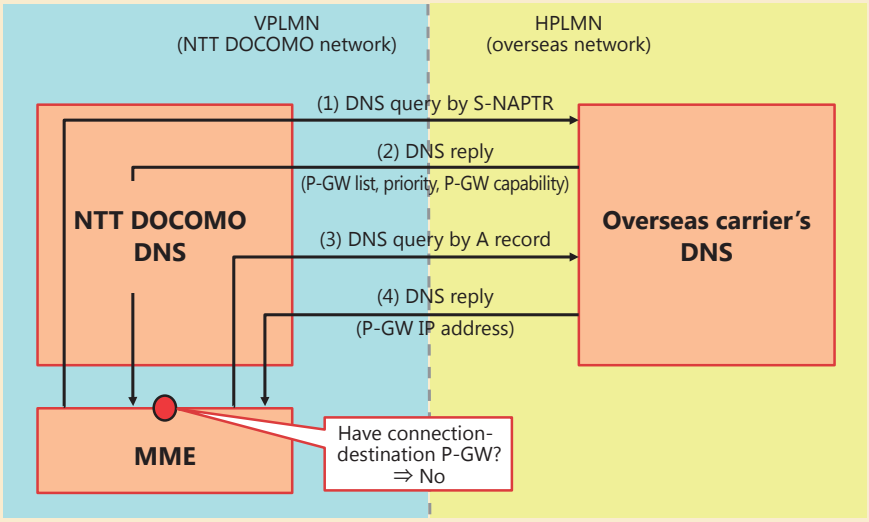

Figure 3 (b) DNS address resolution procedure in LTE (S-NAPTR)

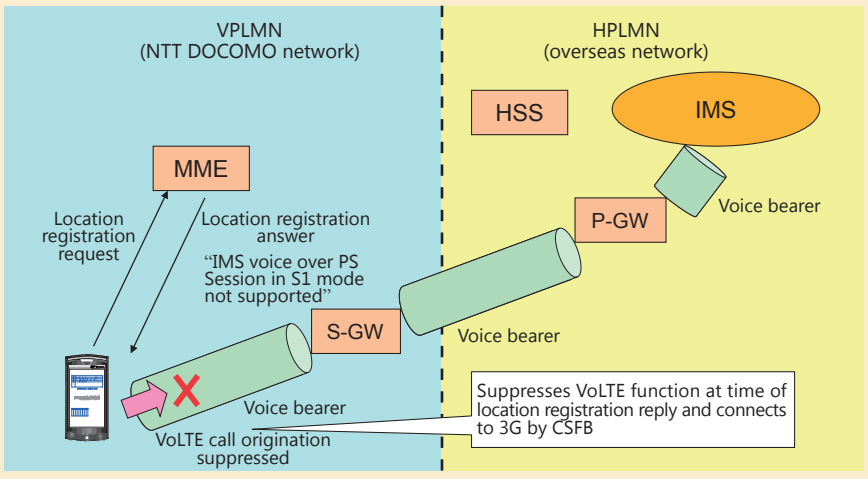

Figure 4 VoLTE terminal control in LTE roaming

*23 **GSM-MAP**: A communications protocol used in 2G/3G between HLR and SGSN.
*24 **QoS control**: Technology to control communication quality such as priority packet transfer.
*25 **APN**: The name of a network connection point used by users to connect to the network when performing data communication.
*26 **A record**: A type of DNS record with a format that binds a specific host name with an IP address.
*27 **S-NAPTR**: A DNS query procedure that enables a protocol and interface to be selected from those available.
*28 **Bearer**: The path taken by user data packets.
*29 **IMS**: A communications system that integrates services provided by CS using Internet technology such as Session Initiation Protocol (SIP).

the fact that VoLTE cannot be used. However, as NTT DOCOMO is not presently providing a VoLTE service, this voice connection must be established by Circuit Switched FallBack (CSFB)*30 to 3G. As a result, the NTT DOCOMO MME returns the parameter "IMS voice over PS Session in S1 mode not supported" to the terminal at the time of location registration thereby suppressing the VoLTE function (**Figure 4**).

In the opposite case of roaming outside Japan, a voice bearer may be established on LTE even though VoLTE cannot be used on the NTT DOCOMO network. This raises a number of issues that must be studied such as how best to handle an incoming voice call to the roaming user. Such issues are being taken up in GSMA IREG meetings with NTT DOCOMO leading the discussions.

5. Conclusion

This article described communication and call-control methods in NTT DOCOMO's LTE international data roaming service. The launch of this service enables overseas users to enjoy high-speed data communications in the NTT DOCOMO network. Preparations are presently being made to propose within fiscal year 2013 specifications for LTE international data roaming that would enable NTT DOCOMO users to enjoy high-speed data communications while overseas.

References

[1] I. Tanaka et al.: "Current Status of LTE Data Roaming Standardization," NTT DOCOMO Technical Journal, Vol.13, No. 2, pp. 49–53, Sep. 2011.
[2] GSMA PRD IR.88 V9.0: "LTE Roaming Guidelines," Jan. 2013.
[3] K. Suzuki et al.: "Technology Supporting Core Network (EPC) Accommodating LTE," NTT DOCOMO Technical Journal, Vol.13, No. 1, pp. 33–38, Jun. 2011.

*30 **CSFB**: A procedure for switching to a radio access system having a CS domain, when a terminal sends/receives a circuit switched communication such as voice while camped on an LTE network.