LTE | Data Roaming-out | Standardization

Technology Reports

Implementing LTE International Data Roaming-out

In conjunction with standardization activities at 3GPP and GSMA toward LTE international data roaming services, NTT DOCOMO launched an LTE international data roaming-in service in December 2013 and an LTE international data roaming-out service in March 2014. This article describes distinctive functions and methods for achieving this LTE international data roaming-out service including its network configuration, call processing and service control methods, and control methods on the mobile-terminal side.

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1. Introduction

Looking to achieve wide-ranging international roaming services as a telecommunication carrier, NTT DOCOMO has contributed to the formulation of standards at the 3rd Generation Partnership Project (3GPP) by making many technical proposals and has served as the chair of the Packet*1 working group in the Global System for Mobile communications Association (GSMA)*2. NTT DOCOMO has also been involved in standardization activities at GSMA including the authoring of GSMA PRD IR.88 [1] (hereinafter referred to as "IR.88") that describes roaming scenarios for establishing connections between operators [2]. Following the early launch of LTE commercial services by NTT DOCOMO in Japan, users have expressed a desire to use LTE high-speed data communications outside of their country. In response, NTT DOCOMO launched an LTE international data roaming-in service conforming to 3GPP and GSMA standards and specifications in December 2013 and an LTE international data roaming-out service (hereinafter referred to as "LTE roaming-out") in March 2014. As a result, NTT DOCOMO users can now make use of LTE high-speed data communications overseas.

This article begins by explaining the connection scenarios and network configuration adopted by NTT DOCOMO for LTE roaming-out from a standards perspective. It then describes the call processing methods within the core network*3, terminal control after network reply at the roaming destination, the LTE OFF/ON function, distinctive methods in location information service control, and the control method for Voice over LTE (VoLTE)*4 terminals in the core network in LTE roaming-out.

2. Communication Method with Overseas Operators

2.1 NTT DOCOMO Roaming-out Scenarios

For LTE roaming-out in which a terminal belonging to a Home-Public Land Mobile Network (HPLMN)*5 is

*1 **Packet:** A working group in GSMA (see *2).
*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 members in related businesses including mobile communications providers, IPX operators, and terminal, equipment and software vendors.

roaming in a Visited-Public Land Mobile Network (VPLMN)*6, IR.88 specifies roaming scenarios assuming the coexistence of LTE and 2G/3G radio access as shown in **Figure 1**. In LTE roaming-out, VPLMN corresponds to an overseas operator and HPLMN to NTT DOCOMO. For LTE roaming-in, the only scenario that NTT DOCOMO adopted is the one having S4/S8-IF*7 (Fig. 1 (d)) [3]. However, as there are many overseas operators that adopt only Gp-IF*8 for communications between the Serving General packet radio service Support Node (SGSN)*9 and the Packet data network GateWay (P-GW)*10, NTT DOCOMO has also adopted Gp-IF in addition to S4/S8-IF so that users can use the LTE roaming-out service in as many regions as possible (Fig. 1 (b) and (d)).

2.2 Considerations for 3G Roaming-out Connections

In LTE roaming-out, there are new considerations for the 3G roaming-out scenario. If the roaming-out user is camped on 2G/3G, there are two patterns for connecting to HPLMN (Fig. 1 (b) and (d)): the SGSN–Gateway General packet radio service Support Node (GGSN)*11 route and the SGSN–P-GW/SGSN–Serving GateWay (S-GW)*12–P-GW route. IR.88 specifies which connection route to use according to two conditions: whether an LTE roaming agreement exists and whether the terminal has the capability of connecting to the Evolved Packet Core (EPC)*13, that is, whether it has EPC-Capability*14. If the system determines that an LTE roaming agreement exists and that the terminal has EPC-Capability, the terminal will connect to P-GW. On the other hand, in a region for which no LTE roaming agreement exists, a 3G roaming-out user must connect to GGSN even if having a terminal with EPC-Capability. In the case of NTT DOCOMO, a P-GW connection is not allowed for a 3G roaming-out user, so the overseas operator must connect to NTT DOCOMO's GGSN. However, in the course of expanding the regions targeted for LTE roaming-out, NTT DOCOMO has discovered that many operators are not conforming to the logic specified in IR.88 since they determine the connection route based solely on EPC-Capability without checking to see if an LTE roaming agreement exists (**Figure 2**).

For this reason, operators who are planning to initiate LTE roaming-out should check whether their connection-route determination logic conforms to IR.88.

2.3 Network Configuration

The LTE roaming-out network configuration is shown in **Figure 3**. In this configuration, the connection between the Mobility Management Entity (MME)*15 and Home Subscriber Server (HSS)*16 employs Diameter*17 protocol, so a Di-

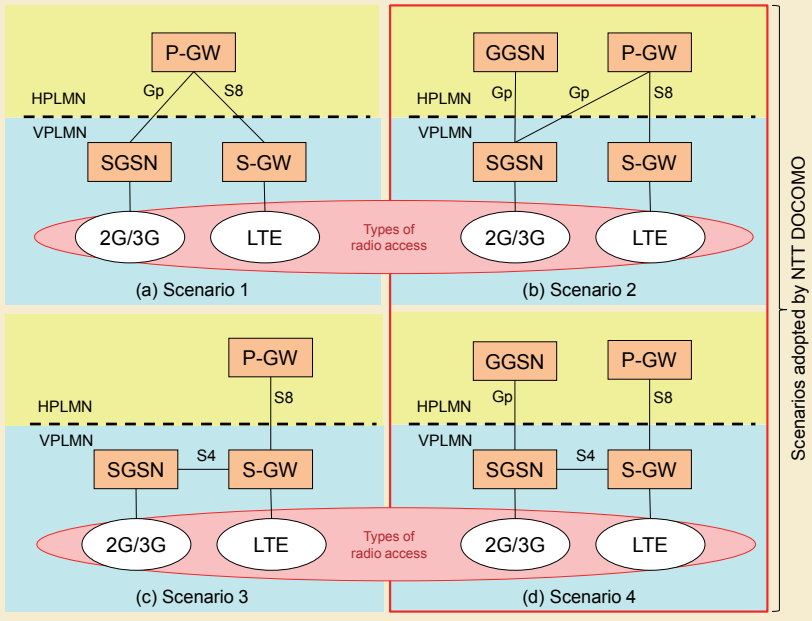

Figure 1 LTE roaming scenarios (HPLMN terminal roaming-out in VPLMN)

*3 **Core network:** A network consisting of switches, subscriber information management systems and other equipment. Mobile terminals communicate with the core network through the radio access network.
*4 **VoLTE:** A function to provide voice services over LTE using packet switching technologies.
*5 **HPLMN:** The subscriber's home operator.
*6 **VPLMN:** The subscriber's roaming-destination operator.
*7 **S4/S8-IF:** The IF between SGSN/S-GW is called S4 and that between S-GW/P-GW is called S8.
*8 **Gp-IF:** Name of interface between SGSN and GGSN or SGSN and P-GW in roaming.
*9 **SGSN:** A logical node having the function of connecting mobile terminals with an external network.
*10 **P-GW:** A logical node having the function of connecting mobile terminals with an external network.
*11 **GGSN:** Gateway connecting PDN and having the function of assigning IP address and forwarding packets to SGSN.
*12 **S-GW:** A packet switch on the LTE Network for sending/receiving user data to/from P-GW.
*13 **EPC:** A core network that can accommodate diverse radio access systems including LTE.
*14 **EPC-Capability:** The ability of a terminal to connect to EPC.

ameter Edge Agent (DEA)*18 will be placed between MME/HSS and the IP eXchange (IPX) operator the same as in roaming-in. As described in section 2.1, NTT DOCOMO has adopted Gp-IF in addition to S4/S8-IF for LTE roaming-out. Here, the protocol adopted for S8-IF between S-GW and P-GW is GPRS Tunneling Protocol version 2 (GTPv2)*19 the same as in roaming-in, but since there are many operators that have not adopted GTPv2, a Gp-IF between SGSN and P-GW using GTPv1 has also been adopted.

3. Call Processing Methods in LTE Roaming-out

The call control procedure for LTE roaming-out is basically the same as the operations for making connections within Japan [4], but on comparing with domestic and LTE roaming-in call processing, it features distinctive methods for obtaining subscriber information from HSS and for resolving addresses. These two methods are described below.

3.1 Method for Obtaining Contract Information from HSS

In closed call control within NTT DOCOMO, contract information that is needed to establish a bearer*20 for a subscriber at the time of location registration is passed from HSS to nodes from S-GW to the Policy and Charging Rules control Function (PCRF)*21 before performing call control for that subscriber [4]. In LTE roaming-out, however, MME/S-GW is situated in the overseas network so that NTT DOCOMO-specific contract information cannot be passed around. Consequently, the method used when a roaming-out user connects to PCRF via Attach*22 is to access HSS at that time to obtain the contract information needed (**Figure 4**). This approach makes it possible to obtain contract information independent of the overseas network and to provide the roaming-out user with the same services as those provided within NTT DOCOMO.

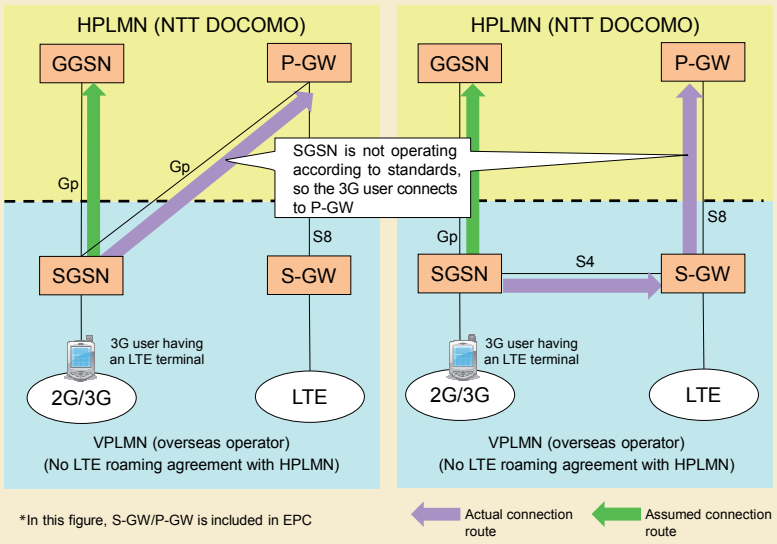

Figure 2 Issues in 3G roaming-out connections

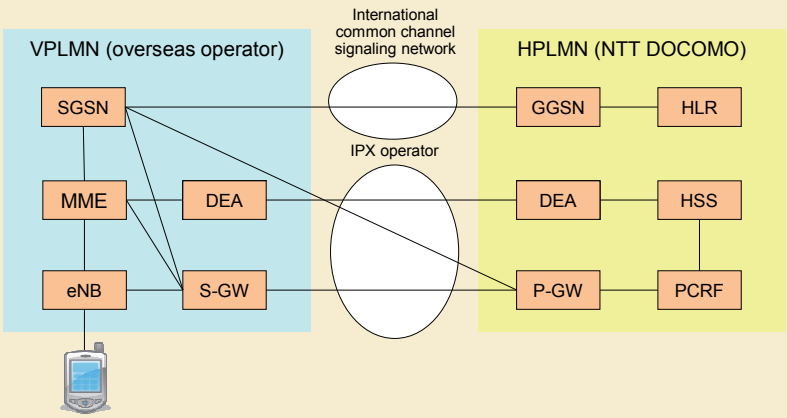

Figure 3 LTE roaming-out network configuration

*15 **MME:** A logical node accommodating a base station (eNB) and providing mobility management and other functions.
*16 **HSS:** A subscriber information database in a 3GPP mobile network that manages authentication and location information.
*17 **Diameter:** IP-based control signal specified by the Internet Engineering Task Force (IETF).
*18 **DEA:** Diameter relay equipment placed between mobile operators to exchange Diameter signals.
*19 **GTPv2:** A communication protocol for user data transmission which provides functions such as establishing communication path and data transfer in core network.
*20 **Bearer:** The path taken by user data packets.
*21 **PCRF:** A logical node for controlling user data QoS and charging.
*22 **Attach:** The processing of registering a mobile terminal with a network when terminal power is turned, or the state of being registered.

Furthermore, in the event that contract information should be changed in HSS subsequent to Attach processing, PCRF can be notified of that change.

3.2 Address Resolution Method in LTE Roaming-out

1) Overview

As described earlier, the connection destination in the case of LTE roaming-out will turn out to be either GGSN or P-GW depending on the scenario adopted by the operator under which the user is camped and on the capabilities of the mobile terminal. This means that MME and SGSN of the overseas operator must select an appropriate IF when performing Domain Name System (DNS)*23 address resolution (querying DNS for a GGSN or P-GW address).

Conventional 3G roaming-out connections use the address resolution procedure specified before 3GPP Release 8 (hereinafter referred to as "pre-Rel. 8"). This procedure uses an Access Point Name (APN)*24 as a key in making an A record*25 query to resolve the NTT DOCOMO GGSN address (**Figure 5**). In LTE roaming-out, however, DNS address resolution is performed by the DNS address resolution procedure specified in 3GPP Rel. 8 (Rel. 8 procedure) (**Figure 6**).

A variety of conditions exist for each of the P-GW and GGSN nodes, such as node capabilities (Proxy Mobile IP (PMIP)*26, GTPv2, GTPv1, etc.) and IFs with other nodes (Gp, S8, etc.). Thus, depending on the connection scenario, a decision must be made as to which P-GW or GGSN with what capabilities and IFs to select. To enable these capabilities and IFs to be determined, the DNS selection method in the Rel. 8 procedure has been extended. In this extension, a NAPTR record query is made using APN as key resulting in a response consisting of information on the capabilities and

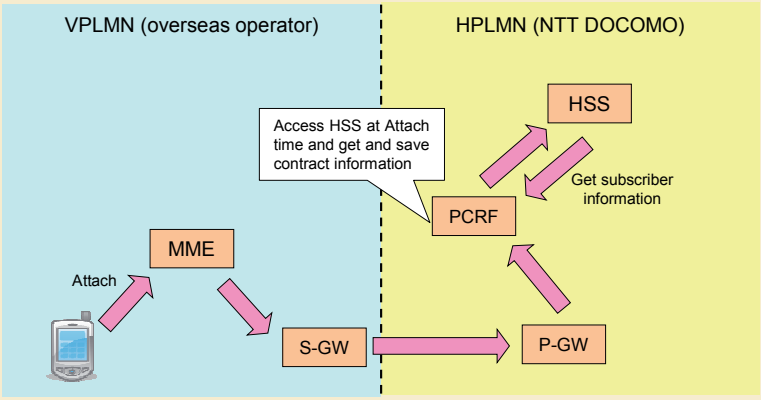

Figure 4 Call processing control in LTE roaming-out

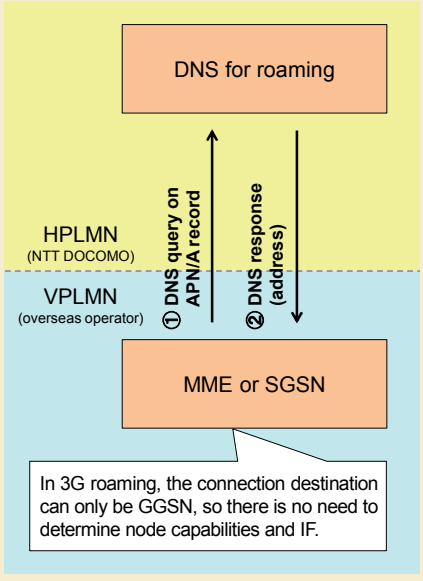

Figure 5 DNS address resolution (pre-Rel. 8 procedure)

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

*24 **APN:** An address name that is set as the destination of a connection when performing data communication over a network connection.

*25 **A record:** A type of DNS record with a format that binds a specific host name with an IP address.

*26 **PMIP:** A communications protocol used for transmitting user data, which provides functions such as transmitting data and configuring a communications path on the LTE core network.

IFs of each P-GW and GGSN. This information makes it possible to select a connection destination applicable to the current connection scenario. Furthermore, for 3G roaming-out connections as well, a SGSN having 3GPP Rel. 8 or later capabilities can determine the capabilities and IFs of connection-destination nodes by the Rel. 8 procedure and make an appropriate connection. Whether to use the pre-Rel. 8 or Rel. 8 procedure for 3G roaming-out connections depends on the operator.

2) Method for Distinguishing the pre-Rel. 8 and Rel. 8 Procedures and its Implementation

To enable the DNS query to be identified as a pre-Rel. 8 or a Rel. 8 procedure, it has been specified that each procedure is to use a different domain. Specifically, "mnc<MNC>.mcc<MCC>.gprs" is to be used for the domain in the pre-Rel. 8 procedure used in conventional 3G roaming while "epc.mnc<MNC>.mcc<MCC>.3gppnetwork.org" is to be used for the domain in the Rel. 8 procedure.

3) 3G Roaming Considerations

The possibility exists that a query may arrive by the Rel. 8 procedure from a SGSN in the overseas network even for a 3G roaming-out connection, so address resolution by either the pre-Rel. 8 or Rel. 8 procedure must be enabled. This point, however, is not clearly specified in IR.88, so NTT DOCOMO is approaching standardization organizations to clarify standards and specifications in this regard.

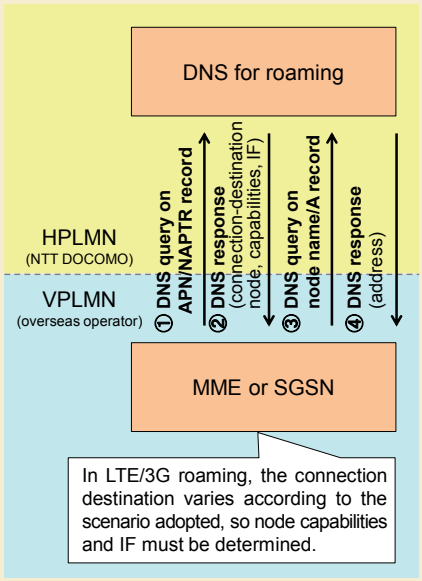

Figure 6 DNS address resolution (Rel. 8 procedure)

4. UE Behavior due to Network Response at Roaming Destination

A NTT DOCOMO user camping on an operator with which a roaming agreement has been concluded will be able to use voice, data, and SMS services overseas once the Attach procedure has been normally completed. On the other hand, if there is no LTE roaming agreement, or if there is an LTE roaming agreement but LTE-related services have yet to be provided at the destination network, an abnormal case can occur in which the Attach procedure does not complete successfully. User Equipment (UE) behavior for abnormal cases has therefore been specified according to conditions at the roaming destination:

- Camping on an operator with no LTE roaming agreement (GSMA compliant/non-compliant)
- Camping on an operator with an LTE roaming agreement but offering no Circuit Switched FallBack (CSFB)*27 processing

We point out here that this article focuses on non-VoLTE-capable UE—VoLTE-capable UE are left for future study. VoLTE-capable UE released by NTT DOCOMO will be required to behave in the same way as non-VoLTE-capable UE during roaming.

*27 **CSFB:** A procedure for switching to a radio access system having a CS domain (see *28) such as W-CDMA/GSM, when a terminal originates/terminates a circuit-switched service such as voice while camped on an LTE network.

4.1 UE Usage Setting

UE behavior in an abnormal case can be classified as follows according to UE usage settings.

- Voice-centric UE
- Data-centric UE
- Data UE

Voice-centric UEs place a priority on the ability to make voice calls—they include smartphones and voice-supporting tablets. In 3GPP, this refers to UEs whose UE usage setting is "Voice Centric," and if the Circuit Switched domain (CS domain)*28 is supported, their UE mode of operation—a UE parameter—is set to "CS/PS mode 1."

Data-centric UEs place a priority on using high-speed, large-capacity LTE data communications—they include non-voice, SMS-supporting tablets. In 3GPP, this refers to UEs whose UE usage setting is "Data Centric," and if the CS domain is supported, their UE mode of operation is set to "CS/PS mode 2."

Finally, data UEs correspond to card-type terminals and Wi-Fi®*29 routers that do not support services using the CS domain such as SMS.

4.2 When Camping on an Operator with No LTE Roaming Agreement (GSMA Compliant)

This section describes the UE behavior when camping on a location registration area of an operator having no LTE roaming agreement but having a Wideband Code Division Multiple Access (W-CDMA)*30/GSM*31 roaming agreement.

The IR.88 document specifies a recommendation for handling an Attach request from the UE during roaming. Specifically, under the conditions that the Radio Access Technology (RAT)*32 on which the UE is currently camped has no roaming agreement but another RAT does, an Attach request should be rejected with cause value #15 (no suitable cells in tracking area). At this time, it is specified that the UE shall be temporarily prohibited from camping in the current location registration area*33 and shall camp on another location registration area that includes another type of RAT. In short, the UE can camp on W-CDMA/GSM having a roaming agreement instead of camping on LTE having no roaming agreement. The UE behavior when an Attach request is rejected with cause value #15 does not depend on the UE usage setting (left side of **Figure 7**, #15).

4.3 When Camping on an Operator with No LTE Roaming Agreement (GSMA Non-compliant)

The operation described in section 4.2 assumes that the network conforms to IR.88. However, IR.88 is only a set of recommended specifications and all operators may not necessarily follow those specifications. In actuality, there are overseas operators that return cause value #17 (network failure) for a no-LTE-roaming-agreement condition.

Under ordinary circumstances, cause value #17 is returned to the UE when an Attach request cannot be received due to a temporary network issue such as congestion*34 or failure.

According to 3GPP specifications, the UE behavior when receiving cause value #17 is as follows. First, on having its Attach request rejected by cause value #17, the UE will retransmit the request after 10 seconds. This is done because the original idea behind cause value #17 is to reject the Attach request due to temporary network factors with the expectation that the system will again be able to accept the request after a certain amount of time.

After that, if the Attach request should be rejected by cause value #17 for a total of 5 times, a subsequent operation will be taken depending on the UE usage setting (center of Figure 7, #17).

First, in the case of voice-centric UEs, the LTE capability will be disabled, a transition will be made to W-CDMA/GSM, and the UE will then behave as one not supporting LTE. In other words, the UE can then camp on W-CDMA/GSM with a roaming agreement and use voice, data, and SMS services. Camping on LTE with no roaming agreement will

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*28 **CS domain:** A circuit-switched system providing voice, SMS, and other services.
*29 **Wi-Fi®:** A registered trademark of the Wi-Fi Alliance.
*30 **W-CDMA:** A third-generation mobile communications system specified by 3GPP.
*31 **GSM:** A second-generation mobile communications system used by digital mobile phones.
*32 **RAT:** Radio access technologies such as LTE, 3G, and GSM.
*33 **Location registration area:** An area in which a mobile terminal can move without registering location.
*34 **Congestion:** Impediments to communications services due to communications requests being concentrated in a short period of time and exceeding the processing capabilities of the service control server.

cease at this time.

Next, in the case of data-centric UEs and data UEs, the UE stays in the LTE cell and retransmits an Attach request after 12 minutes. However, during the time that the UE is in the LTE cell, it remains in the state in which the Attach procedure has not completed successfully, so no services at all can be used. If the UE were to be camped at this time on W-CDMA/GSM having a roaming agreement, some services might be used, but since the RAT is basically decided by instructions from the network, it is not always possible for the UE to stay in the W-CDMA/GSM cell.

For the above reason, NTT DOCOMO proposed to 3GPP that standards be revised from Rel. 12 to specify that LTE capability be disabled and that a transition to W-CDMA/GSM be made if an Attach request is rejected 5 times by cause value #17 for both data-centric UEs and data UEs, which is the same as the UE behavior of voice-centric UEs. This proposal was accepted, and as a result, an LTE-roaming-supporting UE camping on a GSMA-non-compliant network with no LTE roaming agreement will be able to make a transition to W-CDMA/GSM with a roaming agreement.

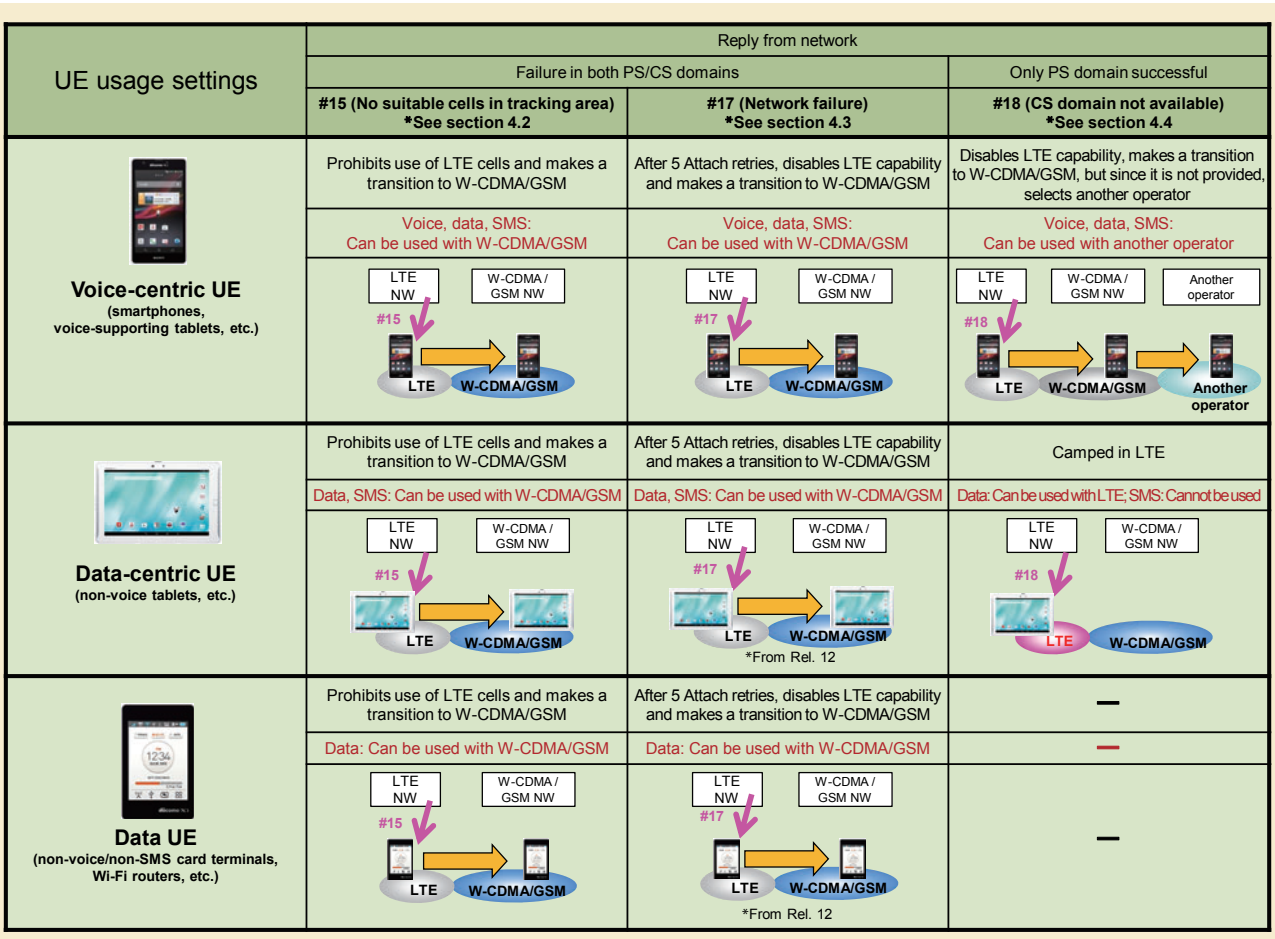


Figure 7 Operation by UE usage settings after network reply at the roaming destination

4.4 When Camping on a CSFB-non-supporting Operator with LTE Roaming Agreement

We here describe the UE behavior when roaming in an operator that provides LTE but does not support W-CDMA/GSM. An operator that does not support W-CDMA does not provide a CS domain and a CSFB function.

According to IR.88, it is recommended that the network's response to an UE camping on an operator providing no CSFB reject the Attach request on the CS-domain side with cause value #18 (CS domain not available) and accept the Attach request only on the Packet Switched-domain (PS-domain)*35 side. The UE behavior when Attach request succeeds only on the PS-domain side with cause value #18 differs according to the UE usage setting as follows (right side of Figure 7, #18).

For voice-centric UEs, the LTE capability is disabled and a transition to W-CDMA/GSM is made. However, as W-CDMA/GSM is not provided, the UE will not be able to find a cell. At this time, the UE will begin to search for another operator if it is in operator-automatic-selection mode. Consequently, if the UE can find an operator providing voice, SMS, etc. in the CS domain, the UE can expect to be able to use those services. In other words, a voice-centric UE prioritizes camping on a W-CDMA/GSM-providing operator with which voice services can be used.

For data-centric UEs, the UE makes no transition to W-CDMA/GSM and stays in LTE thereby enabling data roaming by LTE. In this case, SMS cannot be used.

Finally, data UEs that do not inherently support the CS domain are expected to send an Attach request only to the PS-domain side (i.e., to send no Attach request to the CS-domain side) and will therefore not receive a cause value #18 (CS domain not available) from the network.

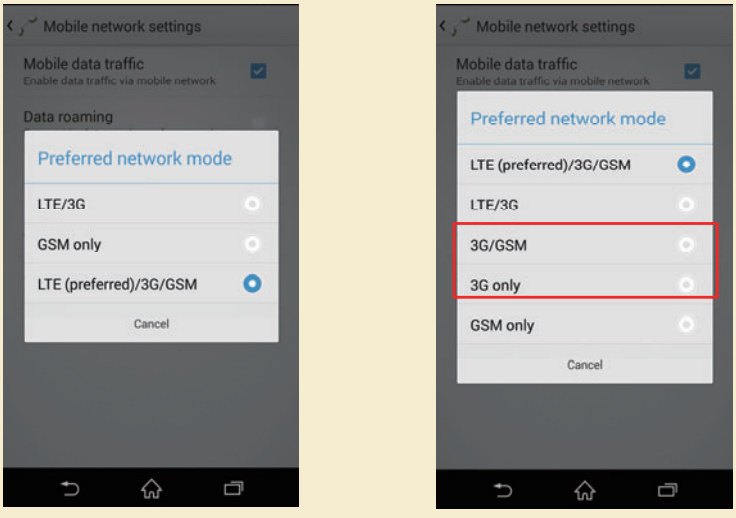
As specified above, roaming is not possible for voice-centric UEs but data roaming is possible for data-centric and data UEs when the UE camps on LTE of an operator not supporting the CS domain or CSFB function.

5. LTE OFF/ON Function

This function enables the user to turn LTE OFF/ON by a user operation. Incorporating this function has the effect of enabling the user to select W-CDMA/GSM that has a proven track record in providing stable use.

It has been achieved by extending network-mode settings, specifically, by adding "3G/GSM" and "3G only" to network-mode options (**Figure 8**). Selecting a non-LTE mode (such as "3G/GSM") from the terminal disables the LTE capability and selecting a mode that includes LTE (such as "LTE/3G/GSM") enables the LTE capability.

On setting out to implement this function, there were concerns that a state



LTE roaming not supported　　LTE roaming supported

Figure 8　Network-mode setting screen

*35 **PS domain:** A packet-switching system providing packet data communications, etc.

inconsistency could arise between the terminal and network with regard to LTE-capability management when changing settings while maintaining the state of communication. For this reason, the function was implemented as follows. If, at the time of changing settings, the terminal is in RRC_CONNECTED, the Radio Resource Control Connection (RRC Connection) will be disconnected and location registration will be performed after enabling/disabling the LTE capability. The Radio Access Network (RAN)*36 and core network will then be appropriately notified of the resulting LTE capability. This scheme solves the above issue (**Figure 9**).

6. Control Processing for Location Information Services

6.1 Base Station Positioning Processing

NTT DOCOMO provides location information services oriented to overseas networks by using base station positioning such as by an overseas i-area*37 function. Up to now, the roaming-out user could only be camped in a 3G network, so HSS would only store information on the SGSN in the overseas network as overseas camping information. As a result, the Gateway Mobile Location Center (GMLC)*38, which issues base-station positioning requests, would derive the operator to which a base station positioning request was to be sent from the 3G camping information obtained by HSS. Now, however, with the provision of LTE roaming, HSS stores camping information on both the MME and SGSN in the overseas network. Consequently, when a mobile user crosses into another country, a situation arises in which information stored by HSS on

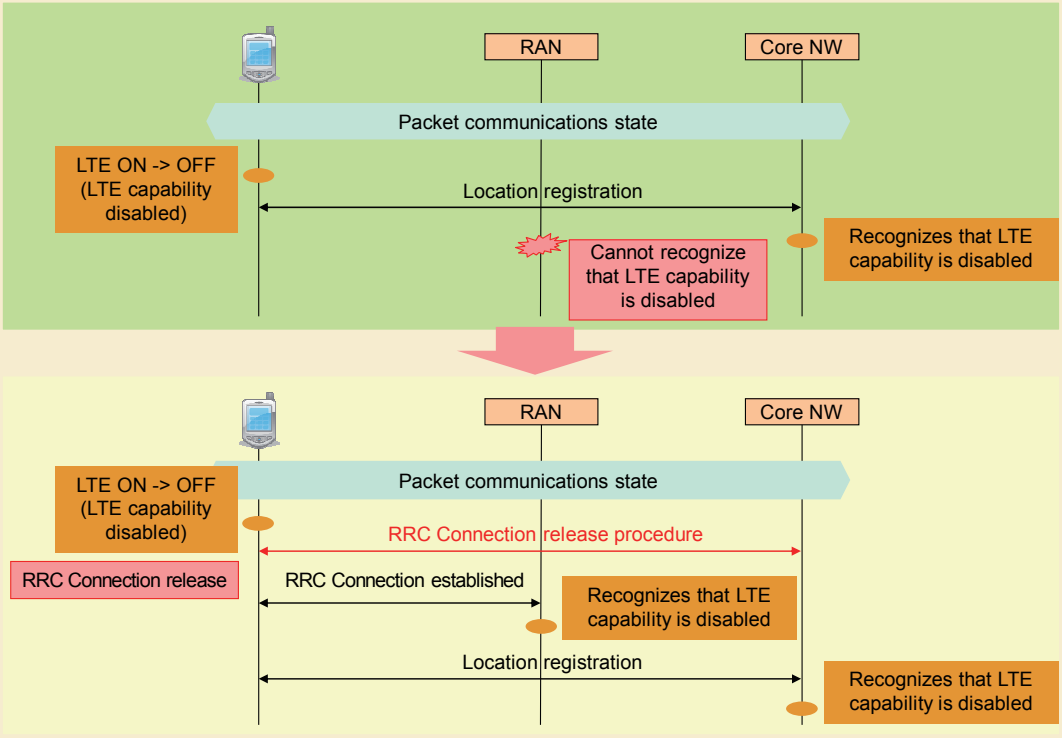


Figure 9 Improved implementation of LTE OFF/ON function

*36 **Radio access network (RAN):** The network consisting of radio base stations and radio-circuit control equipment situated between the core network and mobile terminals.

*37 **i-area:** A function that can provide a smartphone terminal with its approximate location.

*38 **GMLC:** A gateway node for obtaining the latitude/longitude of a mobile terminal by some positioning scheme and exchanging that information with the outside.

the overseas-network MME and that on the overseas-network SGSN correspond to operator A and operator B, respectively. As a result, GMLC cannot determine under which operator the terminal is actually camped. That is to say, an issue arises as to whether 3G or LTE camping information should be used for deriving the operator to which the base-station positioning request is to be sent. To solve this issue, HSS stores information for identifying whether the most recent location registration involved 3G camping or LTE camping. This enables the visited operator to be derived from the latest information identifying terminal camping when performing base station positioning. Here, if the visited operator is one that can provide base station positioning with respect to that visited network, a base-station positioning request can be sent to the visited network. The scheme prevents a base-station positioning request from being erroneously sent to an operator under which the terminal is not actually camped.

6.2 A-GPS Positioning Processing

NTT DOCOMO provides Assisted-GPS (A-GPS) positioning*39 based on the Secure User Plane Location (SUPL)*40 positioning function in overseas networks too [5]. In the process of deriving reference location*41 information to be passed to the terminal, SUPL must deal with the same issue as described above, that is, it must determine whether that information should be obtained from the 3G or LTE network. SUPL, however, can notify the terminal of camping information corresponding to the time at which the terminal actually sends out a positioning request signal in the positioning process. Thus, for NTT DOCOMO, deriving reference location information from this camping information provided by SUPL prevents the derivation of erroneous reference locations.

7. VoLTE Terminal Control

In Japan, NTT DOCOMO launched a VoLTE service in June 2014 ahead of other operators. It has not, however, launched a VoLTE roaming service in the NTT DOCOMO network, and as a result, it has suppressed the VoLTE function during LTE roaming-out even for NTT DOCOMO VoLTE terminals. However, LTE roaming-out may be possible for an NTT DOCOMO user having a VoLTE-supporting Subscriber Identity Module (SIM)*42 free terminal. In this case, the VoLTE terminal attempts to make a Packet Data Network (PDN)*43 connection to the Internet protocol Multimedia Subsystem (IMS)*44 of the NTT DOCOMO network. Since standards specify that connection operations to IMS be repeated until successful, rejecting this connection to IMS can increase network signal load and terminal battery consumption due to signal resends. NTT DOCOMO prevents this concern from arising by allowing the connection to IMS (**Figure 10**). In addition, the making and receiving of actual voice calls and sending/receiving SMS is controlled on the network side, and in the end, no communications will be performed.

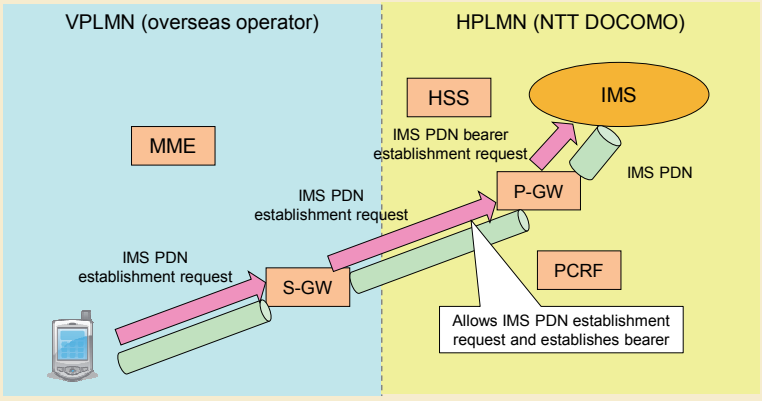


Figure 10 VoLTE terminal control in LTE roaming-out

*39 **A-GPS positioning:** A positioning system in which GPS satellite global positioning data is distributed as assist data from a network to mobile terminals.

*40 **SUPL:** A positioning scheme that uses the U-Plane for exchange of positioning signals between terminal and server.

*41 **Reference location:** One element of the GPS assist data specified by the 3GPP. It includes elements such as latitude and longitude coordinates and a radius of error that expresses likely distance from the true location. Generally, the more accurate this information is, the better GPS positioning performs.

*42 **SIM:** An IC card which stores mobile-phone subscriber information.

*43 **PDN:** An external network to which the EPC is connected.

*44 **IMS:** A communications system that integrates services provided by CS using Internet technology such as Session Initiation Protocol (SIP).

8. Conclusion

This article described call-processing methods on the core-network side and features of mobile terminals in NTT DOCOMO's LTE international data roaming-out service. The launch of this service has made it possible to provide NTT DOCOMO users with high-speed communications at their travel destination. Going forward, we plan to expand roaming-out support to more regions to enhance the convenience of data communications.

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