Traffic Isolation | M2M | 3GPP Release 13

Standardization

Dedicated Core Networks to Isolate Traffic Based on Terminal Type

Standardized specifications for a new method of separating core networks by the terminals accessing them have been approved in 3GPP SA2. This system leverages dedicated core networks designed to handle traffic according to the characteristics of individual communications from terminals. This system eliminates the need for terminal modifications and enables terminals to be served by the desired core networks by redirecting communications from switching equipment based on terminal identification parameters held in subscription information on the core network. This system is expected to be applied to M2M communications. This article describes technical features of this system, basic call controls, trends in standardization, and the outlook for the future.

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1. Introduction

Since the commencement of LTE high-speed data communications services in 2010, NTT DOCOMO has also commenced services for Mobile Virtual Network Operator (MVNO)*1, international LTE data roaming [1] [2], and in 2014 commenced Voice over LTE (VoLTE) [3] to provide voice and SMS services, as smartphones have rapidly penetrated the mobile communications market. In addition, the expectation for the popularization of Machine-to-Machine (M2M)*2 devices has gradually grown since they have become inexpensive, and hence, it is predicted that the number and variety of terminals and devices connected with LTE will increase.

Going forward, to accommodate such a diverse range of terminals and devices on the network, separation of core networks*3 will enable even greater flexibility and optimal network control such as localization of network loads and efficient accommodation design to suit the characteristics of traffic and priorities. For example, in cases where network congestion*4 and failures caused by large numbers of low-priority M2M devices connected to the network could hinder high-priority smartphone user communications, separating the core networks that accommodate low-priority M2M devices would limit network congestion and failures to these core networks while these low-priority devices can be controlled without any impact on high-priority communications. Moreover, suitable reliability and cost reductions will be achievable since it is possible to design networks that can adjust the level of services

*1 **MVNO:** An operator that provides voice and data communications services etc. by renting network infrastructure from a mobile telephone carrier.

*2 **M2M:** Systems for automated communications at regular intervals or under certain condition between machines, which do not entail the involvement of humans.

to suit the traffic characteristics and priority levels of the accommodated terminals and devices.

3rd Generation Partnership Project (3GPP) has previously specified some functions for separating core networks, these, however, require functions to be implemented on terminals and devices, which is difficult to apply to terminals already in use in the wider community. Hence, as a result of NTT DOCOMO emphasizing the need for systems that do not impact on terminals, dedicated core network (hereinafter referred to as "DCN") studies on separating core networks have been endorsed as a Work Item (WI)*5 in Release 13 of 3GPP Service and System Aspects (SA) 2. In this WI (called "DECOR"), NTT DOCOMO has become the rapporteur*6 to lead these studies. Architecture standardization in 3GPP SA2 was completed in May of 2015 [4]. These functions are standardized as specifications that can be implemented with both LTE and 3G systems [5].

This article describes technical features of DCN, an overview of call control procedures related to core network rerouting and reselection, the latest trends in standardization, and the outlook for the future.

2. DCN Technical Features

Figure 1 shows the DCN architecture. Here, an example of accommodating M2M devices on a DCN is given. Rerouting terminals to DCN and using DCN have the following characteristics.

- Rerouting to a DCN is possible including existing terminals already in use. The terminal identifier*7 for rerouting (UE Usage Type) is included in subscription information in the Home Subscriber Server (HSS)*8, and does not require notification to terminals.
- Rerouting to a DCN can be executed in basic call processing procedures during Attach*9 and Tracking Area Update (TAU)*10/Routing Area Update (RAU)*11. No special requests are required from terminals - everything is controlled automatically on the network. When Attach/TAU/RAU requests are sent from terminals to the conventional core network (the default core network) (Figure 1 (1)), the switching equipment (Mobility Management Entity (MME)*12/Serving General Packet Radio Service (GPRS) Support Node (SGSN)*13) firstly attempts to acquire the terminal identifier from the information held in the switching equipment in the old area (old MME/SGSN) over Identification Request/Response with Attach or Context Request/Response with TAU/RAU (Figure 1 (2), (3)). Next, if the terminal identifier cannot be acquired through this procedure, the terminal identifier included in the subscription information is acquired through the Authentication Information*14 Request/Response procedure from HSS (Figure 1 (4), (5)). The switching equipment references the acquired terminal identifier and determines whether to reroute to a DCN.
- Even if there is more than one piece of switching equipment on a DCN, control is possible with conventional technologies. When rerouting to DCN, a redirect command is issued by the switching equipment to radio equipment (eNodeB*15/Radio Network Controller (RNC)*16) to send the information from

*3 **Core network:** A network consisting of switching equipment and subscription information management equipment etc. Mobile terminals communicate with the core network via radio access networks.

*4 **Congestion:** A condition in which communications signals are concentrated in a short period of time and the processing capabilities of switching equipment are exceeded causing communications to fail.

*5 **WI:** A study theme in 3GPP standardization.

*6 **Rapporteur:** The position in 3GPP that entails summarizing discussions, editing technical reports capturing the results of discussions, and managing progress on subjects of study such as individual work items on LTE etc.

*7 **Terminal identifier:** An identifier included in subscription information that indicates the type of terminal or device and its use.

*8 **HSS:** A subscription information database in a 3GPP mobile network that manages authentication and location information.

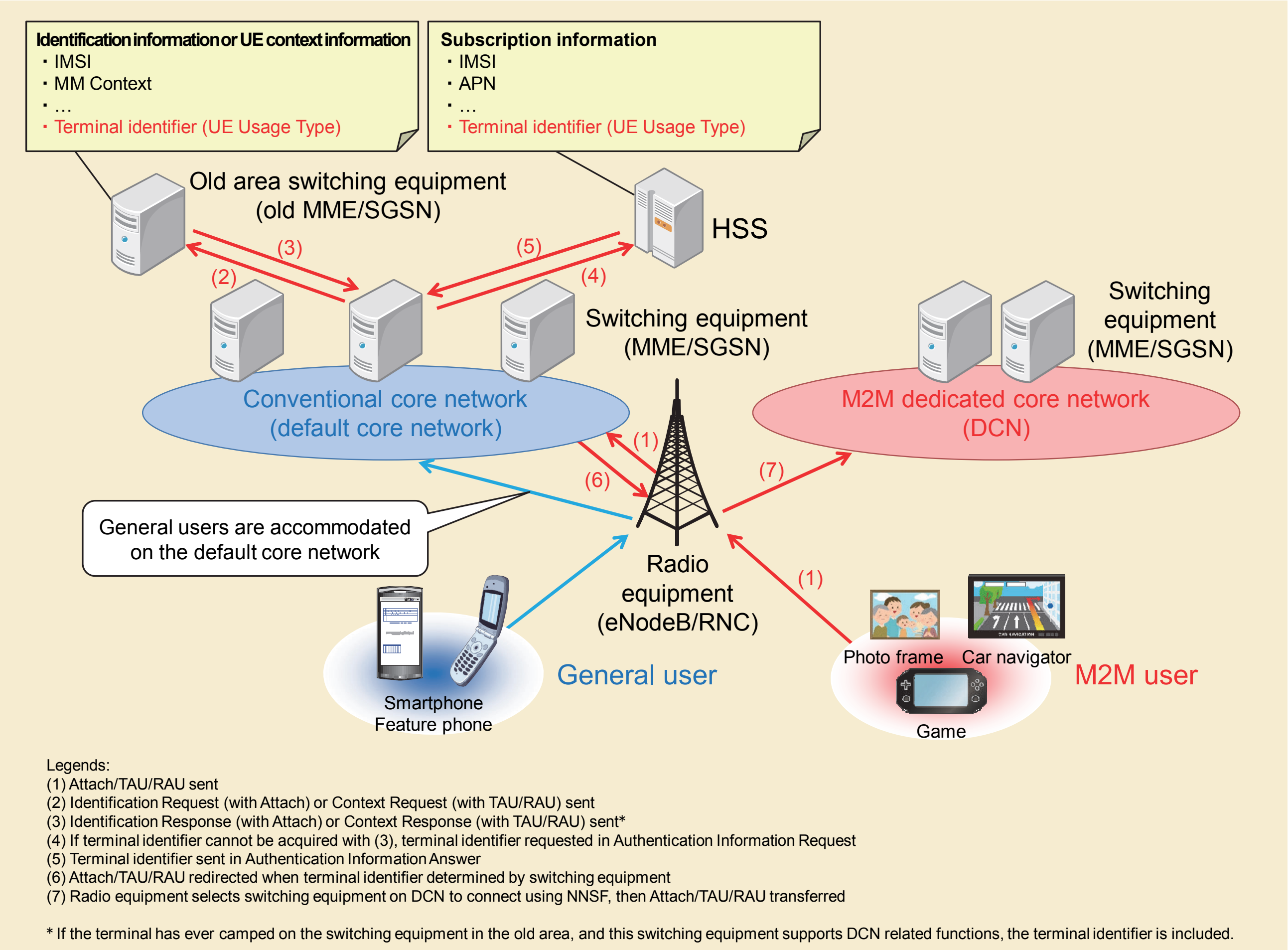

Figure 1　DCN architecture

the terminal to the desired DCN (Figure 1 (6)). The radio equipment uses the conventional Network Node Selection Function (NNSF)*17 to select the DCN switching equipment (Figure 1 (7)).

- With LTE, Serving GateWay (S-GW)*18/Packet data network GateWay (P-GW)*19 can also be installed specifically for a DCN to enable separation of smartphone and M2M traffic. These nodes can be selected as required by configuring node information in switching equipment or by using a Domain Name System (DNS)*20 with the terminal identifier as the key.

Due to the above characteristics, it is possible to deploy a DCN that makes best use of existing call processing procedures and that does not require terminal modifications.

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*9 **Attach:** Processing to register a mobile terminal on a network when the terminal is turned on etc.

*10 **TAU:** Processing to re-register a mobile terminal on a network or update network registration equipment when the mobile terminal has moved to an LTE network.

*11 **RAU:** Processing to re-register a mobile terminal on a network or update network registration equipment when the mobile terminal has moved to a 3G network.

*12 **MME:** A logical node accommodating eNodeB (see *15) and providing mobility management and other functions.

*13 **SGSN:** A logical node accommodating RNC (see *16) and providing mobility management and other functions.

*14 **Authentication information:** Authentication and security information provided by HSS to mobile terminals.

*15 **eNodeB:** A base station for the LTE radio access system.

*16 **RNC:** 3G radio network control equipment.

3. Procedures for Controlling Calls to a DCN

This chapter describes the operation of this system. In this description, terminals are to be rerouted to a DCN. The first MME/SGSN is on the default core network, while the second MME/SGSN is on the DCN. Also, radio equipment (eNodeB/RNC) can connect to either MME/SGSN.

3.1 Rerouting Procedure

Rerouting to DCN is shown in **Figure 2**. The first MME/SGSN determines to require rerouting to DCN from the terminal identifier acquired from the HSS or the old area MME/SGSN (refer to Section 3.2) and sends Reroute NAS Message Request as a reroute request to eNodeB/RNC at Figure 2 (1). As well as the original Attach/TAU/RAU message received from the terminal, the MME Group ID (MMEGI)[*21] (with LTE), or the Null Network Resource Identifier (Null NRI)[*22] or the SGSN Group ID[*23] (with 3G) required to identify the DCN for rerouting (hereinafter referred to as the “DCN identifier”), and under certain conditions the terminal identifier, are included in this message. As a condition of inclusion of terminal identifiers, there are cases in which the old area MME/SGSN cannot provide the first MME/SGSN with the terminal identifier, e.g. because the old area MME/SGSN does not support DCN related functions.

In Figure 2 (2), eNodeB/RNC performs NNSF based on the DCN identifier received at Figure 2 (1) to decide the second MME/SGSN to which the terminal is to connect, and then sends the original Attach/TAU/RAU message and DCN identifier at Figure 2 (3). The purpose of including the DCN identifier at Figure 2 (3) is to indicate that the forwarded Attach/TAU/RAU isn’t sent directly from the terminal but is rerouted. At the same time, it is acting as a flag to prevent rerouting of the Attach/TAU/RAU message at the second MME/SGSN. With the terminal identifier included at Figure 2 (1), the same terminal identifier is included at Figure 2 (3). This enables omission of terminal identifier query processing to the HSS at the second MME/SGSN.

In consideration of the impacts of the rerouting procedure on communication conditions, rerouting is only performed for terminals that are in the idle state[*24].

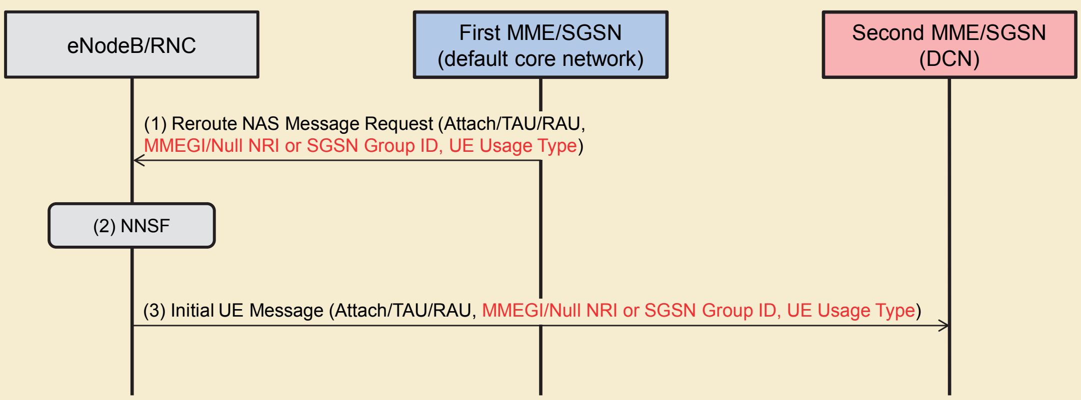

Figure 2 Procedure for rerouting to DCN

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*17 **NNSF:** Processing facilitated by eNodeB/RNC to select a suitable node in consideration of load distribution etc. from among multiple MME/SGSN.

*18 **S-GW:** The area packet gateway accommodating the 3GPP access system.

*19 **P-GW:** A gateway acting as a connection point to an external network (PDN), allocating IP addresses and transporting packets to the S-GW.

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

*21 **MMEGI:** A unique global identifier for determining the MME group (refer to *26 Pool Area).

*22 **Null NRI:** NRI is an identifier that identifies SGSN. Defined in DCN as an identifier for identifying the SGSN group (refer to *26 Pool Area).

*23 **SGSN Group ID:** A newly defined identifier instead of the Null NRI to identify the SGSN group (refer to *26 Pool Area).

Standardization

Standardization

3.2 Attach Procedure

The Attach procedure including the DCN rerouting procedure is shown in **Figure 3**. The Attach Request is sent from terminals via eNodeB/RNC to the first MME/SGSN (Figure 3 (1)). If the terminal previously camped on a different old MME/SGSN and the old MME/SGSN supports DCN-related functions, the first MME/SGSN can acquire the terminal identifier from the UE context available in the old MME/SGSN (Figure 3 (2), (3)).

If the first MME/SGSN cannot acquire the terminal identifier from the old MME/SGSN because the terminal has never camped on an old MME/SGSN, or the old MME/SGSN does not support DCN-related functions, the first MME/SGSN sends an Authentication Information Request (AIR) to acquire the terminal identifier with an Authentication Information Answer (AIA) from the HSS (Figure 3 (4), (5)). In this case, authentication information can be acquired in addition to the terminal identifier if necessary.

The first MME/SGSN determines whether to reroute to a DCN from the terminal identifier at Figure 3 (6), and if rerouting is required, the DCN rerouting procedure described in Section 3.1 is performed at Figure 3 (7). If rerouting is not required, the terminal camps on the conventional core network or Attach is rejected, in accordance with operator policies.

After DCN rerouting is performed,

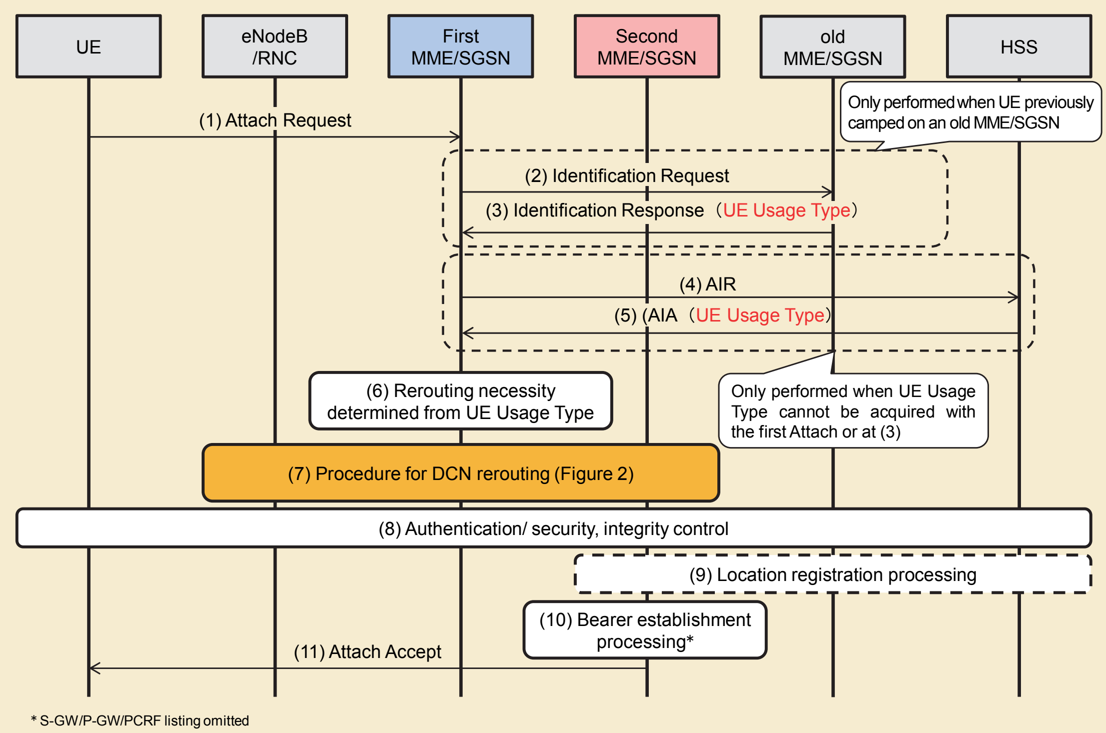

Figure 3 Attach procedure including DCN rerouting

***24 Idle state:** A state in which resources between the mobile terminal and the radio network are released.

the same Attach procedure as the conventional is performed for the second MME/SGSN. After the procedure to Attach to the second MME/SGSN is complete, the terminal camps on the DCN (Figure 3 (8) to (11)).

3.3 TAU/RAU Procedure

The TAU/RAU procedure also supports DCN rerouting described in Section 3.1. This procedure is shown in **Figure 4**.

The TAU/RAU Request is sent from terminals via eNodeB/RNC to the first MME/SGSN (Figure 4 (1)). The first MME/SGSN attempts to acquire the terminal identifier from the old MME/SGSN with the UE context*25 acquisition procedure (Context Request/Response) to determine whether DCN rerouting is required (Figure 4 (2), (3)). If the identifier is acquired with this procedure, the first MME/SGSN temporarily sends the Context Acknowledge message to the old MME/SGSN with a code indicating that the UE context acquisition failed. This fail code instructs the old MME/SGSN to hold UE context without erasing it (Figure 4 (4)), because in subsequent processing, the UE context containing the terminal identifier must be acquired through the UE context acquisition procedure by also accessing the old MME/SGSN from the second MME/SGSN to which rerouting is to be performed (Figure 4 (9)).

If the terminal identifier could not be acquired by the UE context acqui-

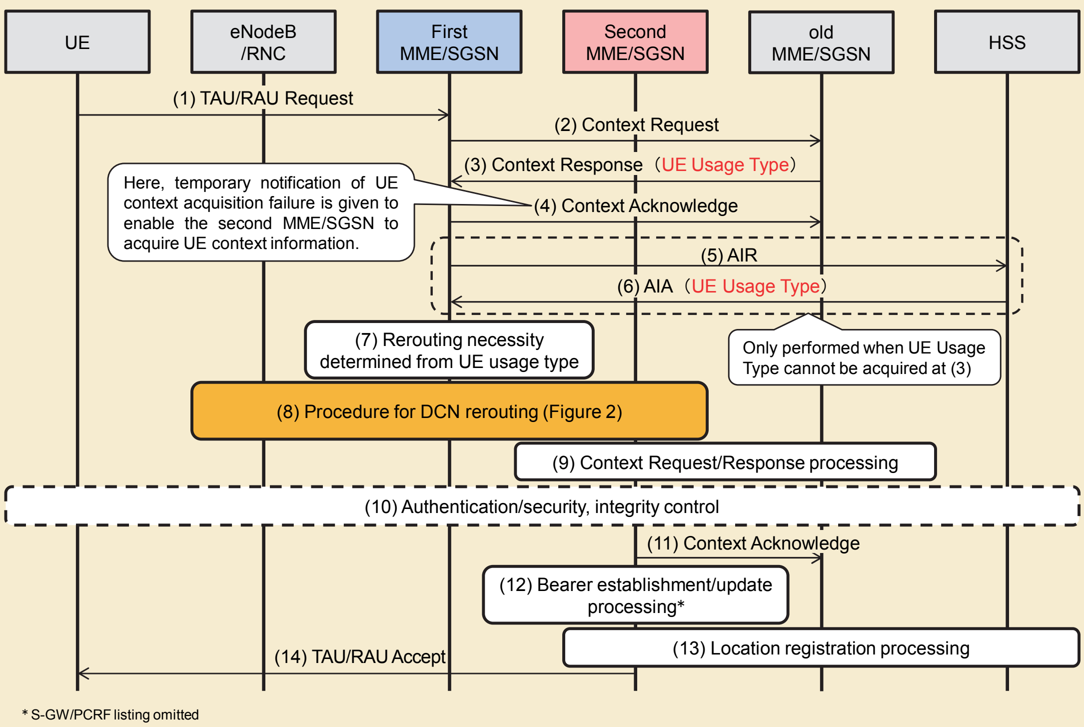

Figure 4 TAU/RAU procedure including DCN rerouting

*25 **UE context:** Information about mobile terminal authentication and security etc. retained in switching equipment.

sition procedure, the terminal identifier is acquired from the HSS by the AIR/AIA procedure (Figure 4 (5), (6)), similar to the Attach procedure. After determining whether DCN rerouting is required (Figure 4 (7)) from the terminal identifier in the first MME/SGSN and the DCN rerouting procedure (Figure 4 (8)), processing between the terminal and the second MME/SGSN is the same as the existing TAU/RAU processing (Figure 4 (9) to (14)).

If the terminal moves across the MME/SGSN Pool Area*26, the MME/SGSN must be reselected (TAU/RAU), however, it is possible that an MME/SGSN other than the desired DCN will be selected by eNodeB/RNC NNSF at this time. **Figure 5** shows an image of the method of preventing rerouting processing in this case (the figure only applies to LTE). Regarding the home MME/SGSN Pool Area and

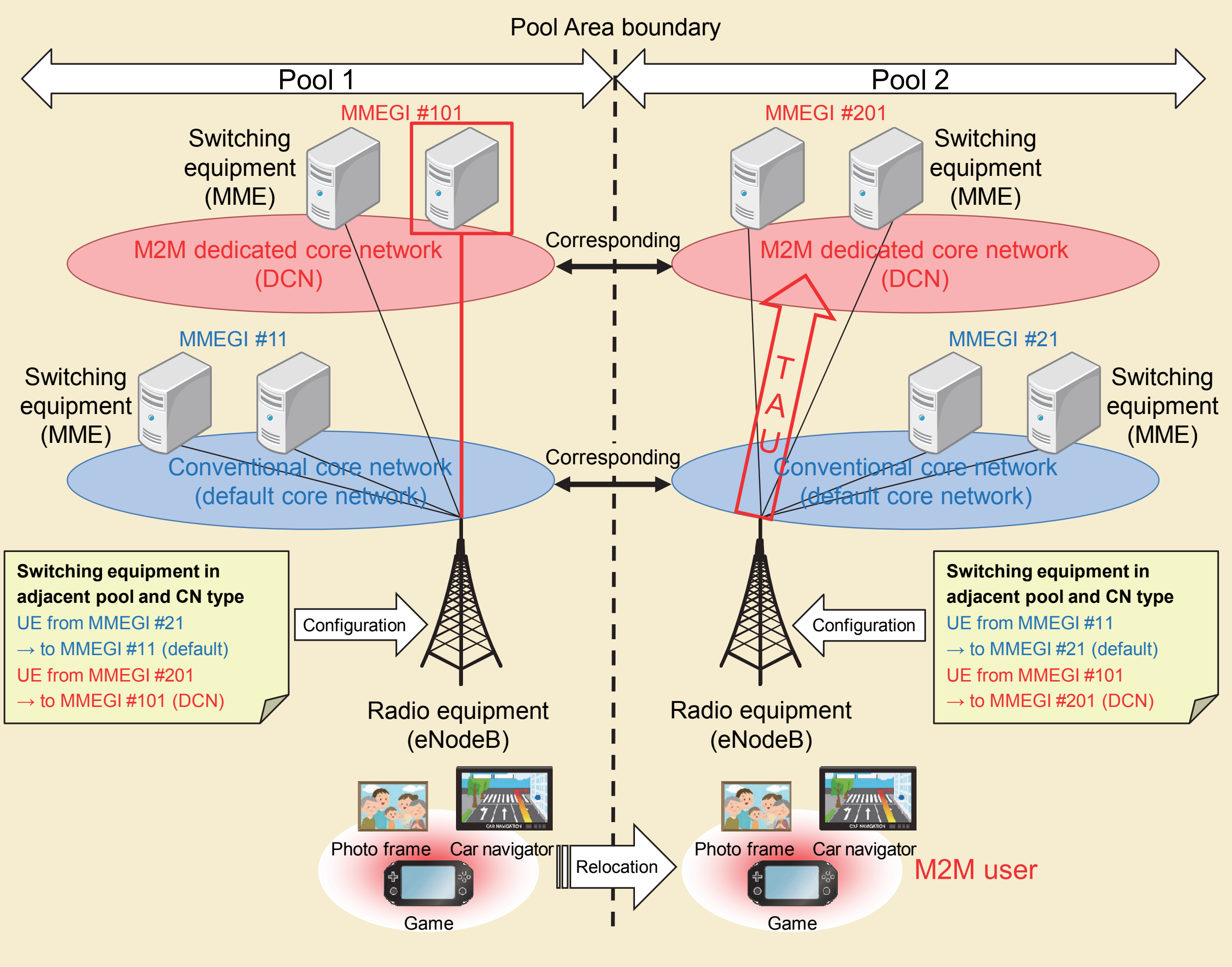

Figure 5 Image of prevention of DCN rerouting procedure when moving across Pool Area (with LTE)

*26 **Pool Area:** A full mesh connection area between MME and eNodeB or between SGSN and RNC (all sections connected like the mesh of a net).

each adjacent MME/SGSN Pool Area MMEGI (with LTE), or Null NRI or SGSN Group ID (with 3G), the configuration of DCN correspondences and non-DCN correspondences is set in advance in eNodeB/RNC. This configuration raises the possibility that the terminal will move between corresponding DCNs during TAU/RAU, in other words, it reduces the frequency of occurrence of rerouting procedures.

3.4 DCN Reselection Procedure

Figure 6 describes the procedure when the value for the terminal identifier set in subscription information in the HSS is updated and then the DCN onto which the terminal should camp is changed while a terminal is camping on a network.

If the terminal identifier in subscription information managed by the HSS is updated, the HSS sends a request (Insert Subscriber Data Request) to change the subscription information to the second MME/SGSN on which the terminal is camping, and the second MME/SGSN provides a subscription information change response (Insert Subscriber Data Answer) (Figure 6 (1), (2)).

If it is necessary to reroute a terminal to another DCN immediately, and the terminal is in the idle state, it is necessary to make the terminal go to the connected state*27 by second MME/SGSN paging*28 (Figure 6 (3), (4)). If the terminal is in the connected state, with LTE, a process called Globally Unique Temporary UE Identity (GUTI)*29 Reallocation is performed from the second MME to assign non-

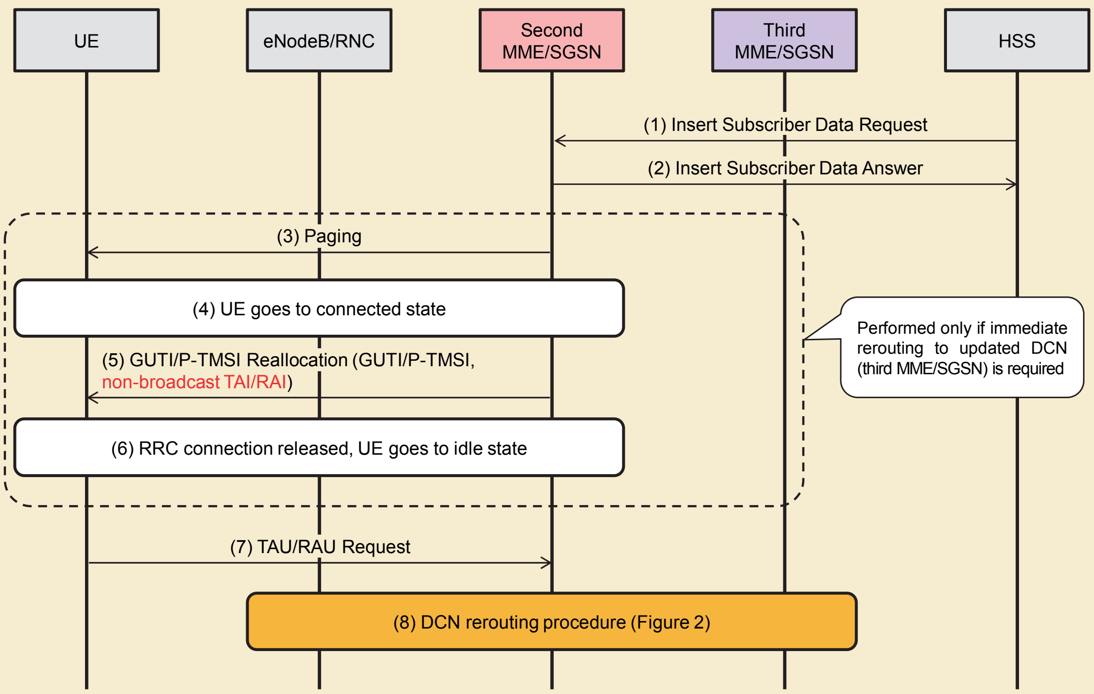

Figure 6 DCN reselection procedure if the terminal identifier value is updated

*27 **Connected state:** A state in which resources are allocated between a mobile terminal and a radio network.

*28 **Paging:** Calling all mobile terminals at once when there is an incoming call.

*29 **GUTI:** Information consisting of a Globally Unique MME Identifier (GUMMEI) and TMSI (see *31). This is a temporary ID used to uniquely identify a mobile terminal instead of using the permanent mobile terminal or user (USIM) ID.

broadcast Tracking Area ID (TAI)*30 to the terminal, or with 3G, Packet-Temporary Mobile Subscriber Identity (P-TMSI)*31 Reallocation is performed from the second SGSN to assign non-broadcast Routing Area ID (RAI)*32 to the terminal. After that, the Radio Resource Control (RRC)*33 connection is released and the terminal goes back to the idle state again (Figure 6 (5), (6)). Although dependent on the terminal implementation, TAU or RAU is performed by the terminal right after non-broadcast TAI/RAI is allocated (Figure 6 (7)).

If it is not necessary to reroute a terminal to another DCN immediately, and the terminal is in the connected state, the second MME/SGSN can wait until the terminal spontaneously goes to the idle state and Figure 6 (7) is performed.

With TAU/RAU procedure in Figure 6 (7), the rerouting procedure described in Section 3.3 is performed by the second MME/SGSN to redirect the UE to the third MME/SGSN, which belongs to another DCN (Figure 6 (8)).

4. Standardization Trends

After DCN architecture specifications were completed in 3GPP SA2, discussion on detailed specifications for new signals and parameters began in the RAN3 and Core network and Terminals (CT) 4 meetings in August of 2015 based on those specifications.

Regarding the S1 Application Protocol (S1AP)*34/Radio Access Network Application Part (RANAP)*35 interface between radio and switching equipment, creating specifications for the new Reroute NAS Message Request signals and updating specifications for the existing Initial UE message*36 signals are ongoing in RAN3 meetings.

Meanwhile, in CT4 meetings, discussions are in progress about details of terminal identifier values, ways to convey terminal identifiers in each interface, and standard specifications for DNS procedures for selecting suitable serving nodes such as S-GW/P-GW with terminal identifiers as keys with LTE.

Both RAN3 and CT4 plan to finish DCN specifications by March of 2016, which is the planned completion date for the Release 13 studies.

5. Conclusion

This article has described technological characteristics of DCN to separate core networks on which terminals should camp based on their type, basic call control procedures and trends in standardization.

In the role of rapporteur, NTT DOCOMO has taken a proactive lead in discussions about these functions which are being studied in 3GPP SA2, and has finished their architecture standardization. Also, in the RAN3 and CT4 groups, NTT DOCOMO is making significant contributions to the creation of specifications for the main technological elements.

Looking ahead to the 5G*37 era, discussions are currently underway in various associations including 3GPP about the next generation of core networks. For example, Next Generation Mobile Networks (NGMN)*38 have revealed in their 5G white paper the concept of network slicing*39 as a future vision [6]. DCN could be one of the fundamental technologies that will achieve that concept. Please refer to this publication's 5G special article for more on this item [7]. Using the strengths of these technologies, NTT DOCOMO will continue to further contribute to standardization of the next generation of core networks.

References

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*30 **Non-broadcast TAI:** TAI is a unique location registration area ID on an LTE network. A non-broadcast TAI is a TAI that has an exceptional value and is not assigned to any area.

*31 **P-TMSI:** A number assigned temporarily for each user on the network using mobile communications, and stored in the User Identity Module (UIM).

*32 **Non-broadcast RAI:** RAI is a unique location registration area ID on a 3G network. A non-broadcast RAI is an RAI that has an exceptional value and is not assigned to any area.

*33 **RRC:** Layer 3 protocol for controlling the radio resources.

*34 **S1AP:** The name of the interface between eNodeB and MME.

*35 **RANAP:** The name of the interface between RNC and SGSN.

*36 **Initial UE message:** A message sent from eNodeB or RNC to MME or SGSN to establish an S1 connection between eNodeB and MME, or an Iu connection between RNC and SGSN.

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*37 **5G:** The next-generation mobile communications system to succeed the 4th-generation system.

*38 **NGMN:** A working group formed of global vendors and operators to study the next generation of networks in the 5G era.

*39 **Network slicing:** One system of achieving the next-generation of networks in the 5G era, studied by NGMN. Optimized architecture that entails splitting core networks by services such as usage cases or business models.