LTE | Core Network Control Method | EPC

Technology Reports

Special Articles on "Xi" (Crossy) LTE Service—Toward Smart Innovation—

Core Network (EPC) for LTE

In parallel with the deployment of LTE radio access technology to cope with dramatic increases in traffic, NTT DOCOMO is introducing EPC as a core network for accommodating LTE and other radio access systems. The EPC consists of MME, S-GW, P-GW and PCRF functions for performing authentication, mobility management, bearer control, charging and QoS control. The EPC and SGSN support mobility management between the LTE and 3G access systems, and HSS supports the management of LTE subscriber information.

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1. Introduction

The recent jump in data communications traffic is expected to continue into the future as the penetration of smartphones escalates and the provision of rich content expands. NTT DOCOMO is responding to this demand by deploying LTE radio access featuring higher transmission speeds, shorter delays and larger capacities. It is also introducing Evolved Packet Core (EPC), which was specified at the same time as LTE (3GPP Release 8), as the core network to accommodate LTE and other radio access systems [1]. The EPC consists of the Mobility Management Entity (MME)[*1], Serving Gateway (S-GW)[*2], Packet Data Network Gateway (P-GW)[*3], and Policy and Charging Rules Function (PCRF)[*4]. It adopts an architecture that separates the MME and PCRF for controlling the Control Plane (C-Plane), and the S-GW and P-GW for controlling the user plane (U-Plane), to make it easier to cope with growing traffic on the U-Plane [2][3]. The EPC also cooperates with the Serving GPRS (General Packet Radio Service) Support Node (SGSN)[*5] and the Home Subscriber Server (HSS)[*6] to control interworking with 3G and subscriber's contract information. In this article, the portion of the network consisting of the EPC, SGSN and HSS is denoted as the "EPC network."

The EPC provides a variety of functions including user authentication, user-contract analysis, authentication for the Packet Data Network (PDN)[*7], setting of transfer paths for user data packets, Quality of Service (QoS) control[*8], and mobility management.

It adopts the "Always-ON" continuous-connection concept as a bearer[*9] control method in which the mobile terminal is allocated an IP address when turned ON so that IP communications can be performed the same as in the fixed network. The EPC also supports policy and charging rules to control billing and QoS and mobility management between different radio access systems.

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*1 **MME**: A logical node accommodating eNodeB base stations and providing mobility management and other functions.

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

*3 **P-GW**: A gateway acting as a point of connection to a PDN (see *7), allocating IP addresses and transporting packets to the S-GW.

*4 **PCRF**: A logical node controlling QoS (see*8) and charging in user data transfers.

This article provides an overview of EPC network configuration and equipment and describes the basic EPC functions and signaling flows.

2. Overview of EPC Network Node Configuration

The node configuration of the EPC network is shown in **Figure 1**. This newly developed EPC consists of the MME and PCRF for processing only control signals and the EPC Serving and PDN GateWay (ESPGW)[*10] for processing the transfer of user data. The MME and PCRF are the same as the ones in 3GPP standard architecture and ESPGW corresponds to S-GW/P-GW.

2.1 Overview of Newly Developed Equipment

The MME performs mobility management such as location registration, paging[*11] and handover as well as bearer establishment and release. It also performs user authentication based on authentication information received from the HSS, and it provides a function for encrypting the signal between mobile terminals.

The PCRF, in turn, provides functions for determining the QoS and charging policy to be applied to data packets sent and received by the user. On determining a QoS value, the PCRF passes it to the P-GW, S-GW and base station (eNodeB), each of which performs QoS control on user data packets according to that value.

The S-GW, meanwhile, relays user data packets received from the eNodeB to the P-GW or vice versa, and functions as an anchor point for user data packets on the occasion of a handover between LTE and 3G radio access. Additionally, in the event that user data packets happen to be received from the P-GW for a mobile terminal for which a radio bearer is not currently established, S-GW instructs the MME to perform paging to reestablish a radio bearer.

The P-GW connects the mobile terminal with the PDN. It is also equipped with functions for allocating an IP address to the mobile terminal and collecting charging data.

2.2 Extensions in Existing Equipment

1) Additional SGSN Functions

In addition to performing location registration, paging and the transfer of user data packets on 3G as in the past, the SGSN also performs mobility management with LTE and establishes and releases bearers with the S-GW.

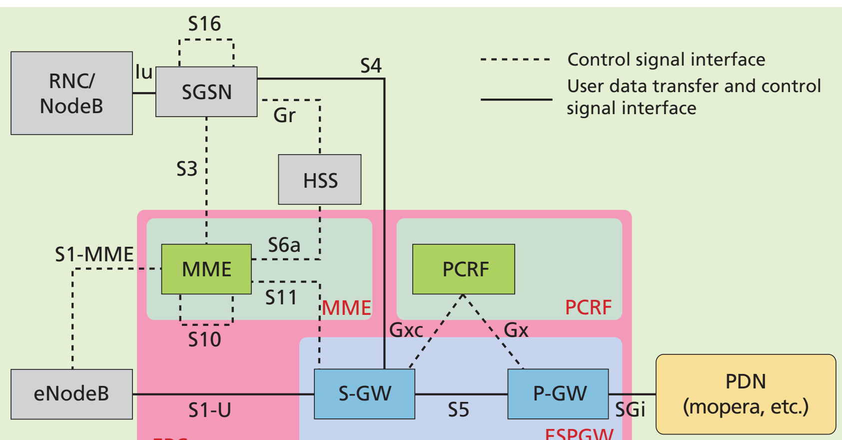
2) Additional HSS functions

The HSS manages subscriber profiles and authentication information for LTE users and passes that information to the MME at the time of location registration. It also has a function for limiting the use of an LTE terminal to only the LTE subscriber based on the type of user terminal and LTE subscriber profile.

3. Basic Functions and Signaling Flows

3.1 Always-ON

The LTE system and EPC adopt the "Always-ON" concept whereby a bearer is established and an IP address is allocated to the mobile terminal when



*Alphanumeric characters such as "S5" are standard interface names
RNC: Radio Network Controller

Figure 1 EPC network architecture

*5 **SGSN**: A logical node having packet communication functions specified by 3GPP standards.

*6 **HSS**: A subscriber information database in a 3GPP mobile communication network; it manages authentication information and network visiting information.

*7 **PDN**: An external network connected to by EPC.

*8 **QoS control**: A technology for controlling the quality of communications by various means such as specifying the priority of packet transmissions.

*9 **Bearer**: In this article, the path taken by user data packets.

*10 **ESPGW**: Equipment having the capabilities of S-GW and P-GW.

the power to the terminal is turned ON. This IP address is always allocated to the mobile terminal so that servers on the service-provision side can provide IP services the same as in a fixed communications network without having to be aware that the access network is actually a mobile communications network. The always-on bearer is situated inside the EPC (between the S-GW and P-GW), but if a non-communicating state continues, the radio bearer (mobile terminal—eNodeB—S-GW) is released to make more efficient use of radio resources[*12]. This means that, when an attempt to communicate reoccurs, only the radio bearer has to be reestablished to reopen the communications link, which shortens the connection delay (**Figure 2**).

3.2 PCC

In EPC, a process called Policy and Charging Control (PCC) achieves flexible control of QoS and charging with respect to packet data according to the user's contract, Access Point Name (APN)[*13], and application in use. This process is divided into policy control[*14] and charging control. In addition to QoS management, policy control provides gate control to allow the outflow and inflow of packets to and from the network [4].

The current EPC development introduced here provides charging control in part. When packet connections are established in attach[*15], the PCRF references the charging policy it stores for each APN. In the case of "no-charge," the PCRF instructs for the P-GW to perform no-charge control and to suppress the generation of detailed billing data for the packets of that APN.

3.3 Attach Procedure

The attach procedure performed when turning power to the mobile terminal ON is shown in **Figure 3**.

- Steps (1) - (4):

  The mobile terminal sends an attach request message to the MME, which performs user authentication based on authentication information received from the HSS and obtains and manages subscriber's contract information from

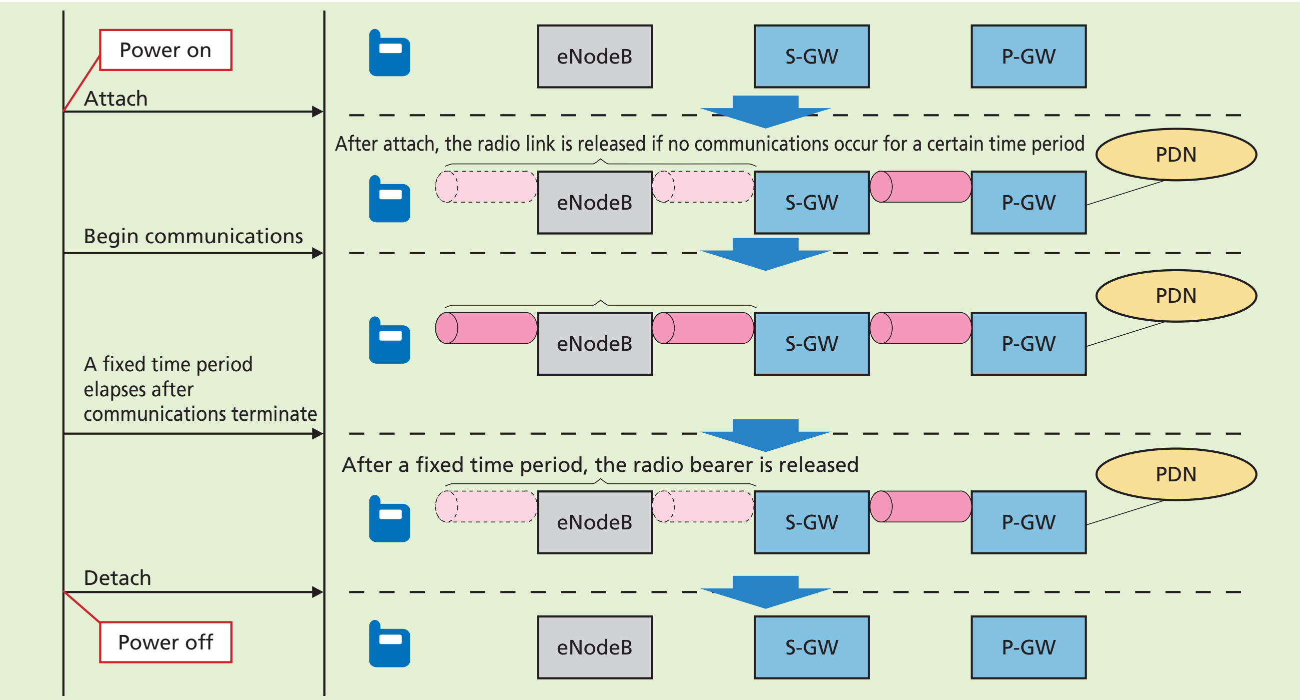


Figure 2 Always-ON

*11 **Paging**: A process that calls all mobile terminals in unison at the time of an incoming call.

*12 **Radio resources**: General term for resources needed to allocate radio channels (frequencies).

*13 **APN**: The name of a connection point; the name of a network connection point prepared by a corporate user as a connection destination.

*14 **Policy control**: Technology for controlling communications as in QoS or the enabling/disabling of packet transfers based on network or subscriber information.

*15 **Attach**: A process for registering a mobile terminal with the network such as when turning terminal power on.

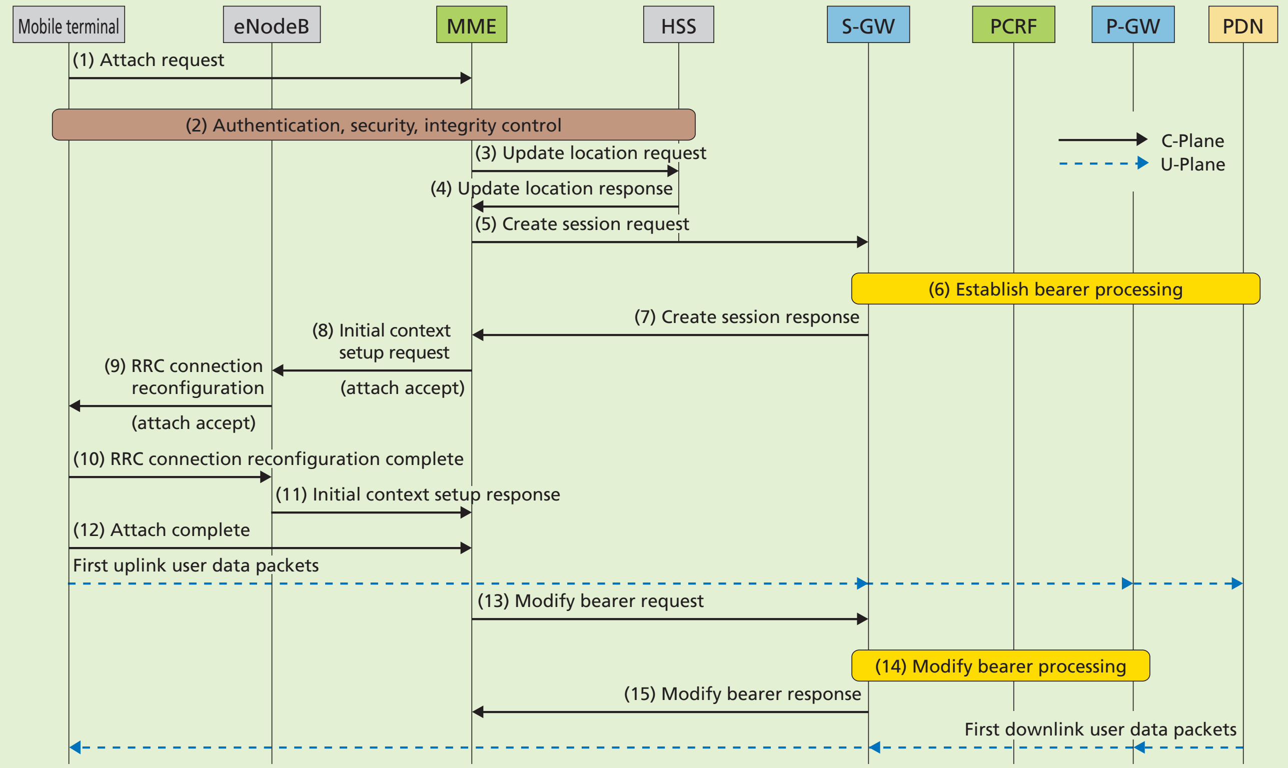


Figure 3 LTE attach procedure

the HSS to establish a bearer.

- Steps (5) - (11):

Based on the APN received from the mobile terminal, the MME selects the S-GW and P-GW to be used as destinations when establishing a bearer in accordance with the Domain Name System (DNS)[*16], and sends a create session request message to the selected S-GW.

The S-GW now performs establish bearer processing with respect to the P-GW specified in the create session request message. The P-GW interfaces with the PCRF to get information on what charging needs to be applied and also performs connection processing with a PDN. On completing bearer setup between the S-GW and P-GW, the S-GW sends to the MME information on propagation conditions for the eNodeB.

The MME sends this propagation information received from the S-GW to the eNodeB as an initial context setup request, which includes an attach accept message for the mobile terminal. The eNodeB now establishes a radio bearer with the mobile terminal and sends it the attach accept message, and then receives an RRC connection reconfiguration complete message from the mobile terminal and passes propagation information for the S-GW to the MME.

- Steps (12) - (15):

On receiving an attach complete message from the mobile terminal, the MME sends the propagation information received from the eNodeB to the S-GW.

Finally, based on the propagation information so received, the S-GW completes the establishment of a bearer between the eNodeB and S-GW. This completes the establishment of a bearer in the manner of mobile terminal—eNodeB—S-GW—P-GW.

*16 **DNS**: A system for assigning a correspondence between a host name and an IP address on an IP network.

3.4 Mobility Management between Different Radio Access Systems

There are two methods for managing mobility between different radio access systems: the handover method, which establishes a bearer for the mobile terminal at its new location beforehand, and the Release with Redirection method, which cuts off the bearer at the mobile terminal's old location and switches the communications path on registering the mobile terminal's new location. NTT DOCOMO is adopting the latter method for its LTE service launch, since the method is a mandatory function in the 3GPP standard.

The procedure of Release with Redirection from LTE to 3G is shown in **Figure 4**.

- Steps (1) - (2):

  The mobile terminal sends a Measurement report to the eNodeB, which uses that information as a basis for releasing the RRC connection and instructing a switch to 3G.

- Steps (3) - (4):

  Based on the switching instructions received from the eNodeB, the mobile terminal selects 3G and sends a routing area update request that includes MME identification information to the SGSN.

- Steps (5) - (8):

  The SGSN specifies a MME based on the MME identification information received from the mobile terminal and obtains bearer context (S-GW IP address, bearer information, etc.).

- Steps (9) - (11):

  Based on the bearer context so received, the SGSN sends the S-GW a Modify Bearer Request message that includes bearer information (SGSN IP address, etc.). The S-GW, in turn, interfaces with the P-GW and PCRF based on the bearer information received and performs modify bearer processing. It then

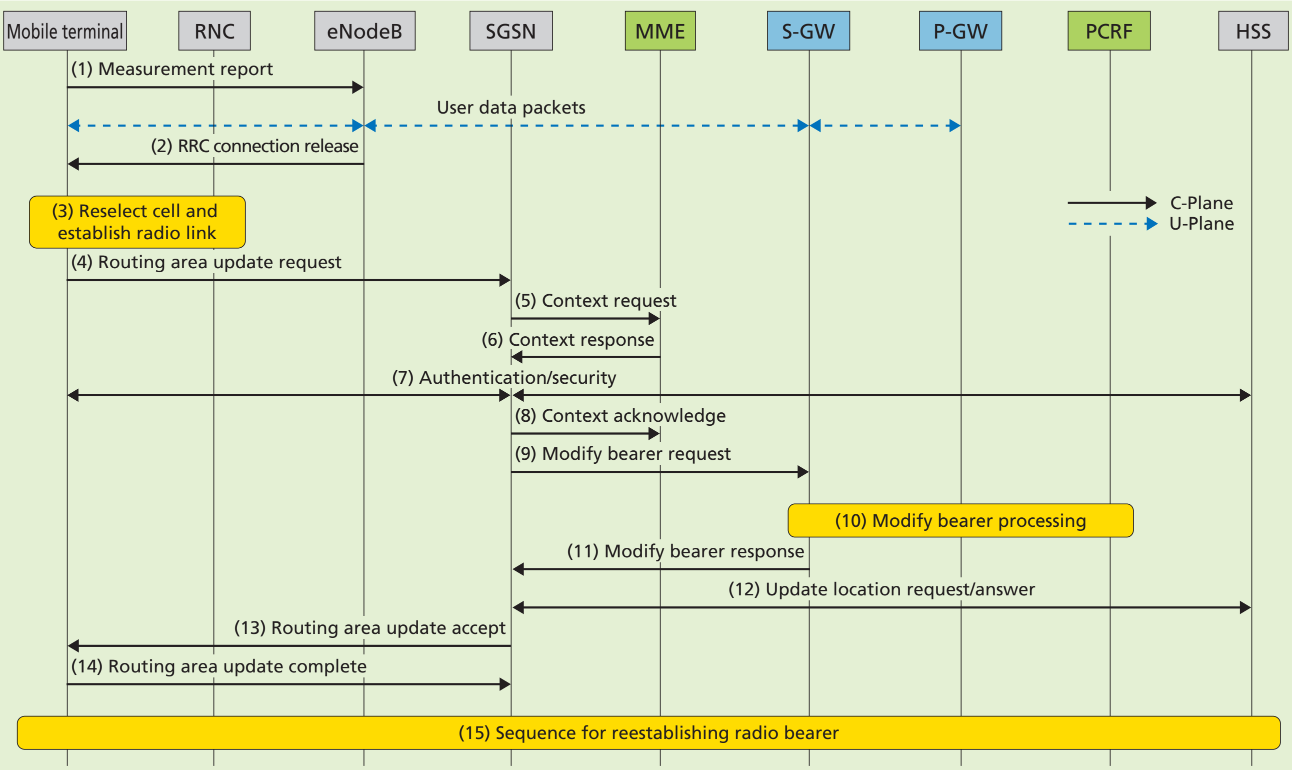


Figure 4 Release with Redirection procedure

switches the communications path to the SGSN and returns a modify bearer response message to the SGSN.

- Steps (12) - (14):

  The SGSN performs a update location request/answer process with HSS and sends a routing area update accept to the mobile terminal. This completes the switching of the user-data-packet transfer path inside the core network to the 3G side.

- Step (15):

  Finally, a procedure for reestablishing the radio bearer is performed to initiate 3G communications.

3.5 Radio Bearer Reestablishment Procedure

In the event that the mobile terminal sends or receives user data packets when a radio-bearer is released, it will reestablish the radio bearer following the procedure described below (**Figure 5**).

- Steps (1) - (3):

  This procedure will be performed only when the PDN sends user data packets to the mobile terminal.

  If the S-GW receives user data packets from the P-GW and the radio bearer has been cut off, it temporarily holds the packets and sends a downlink data notification to the MME.

  The MME now pages the mobile terminal. Subsequent processing begins with step (4) of the procedure.

- Steps (4) - (8):

  The rest of the procedure is performed when the mobile terminal sends user data packets to the PDN or when the PDN sends user data packets to the mobile terminal.

  To begin with, the mobile terminal sends a service request to the MME. After performing authentica-

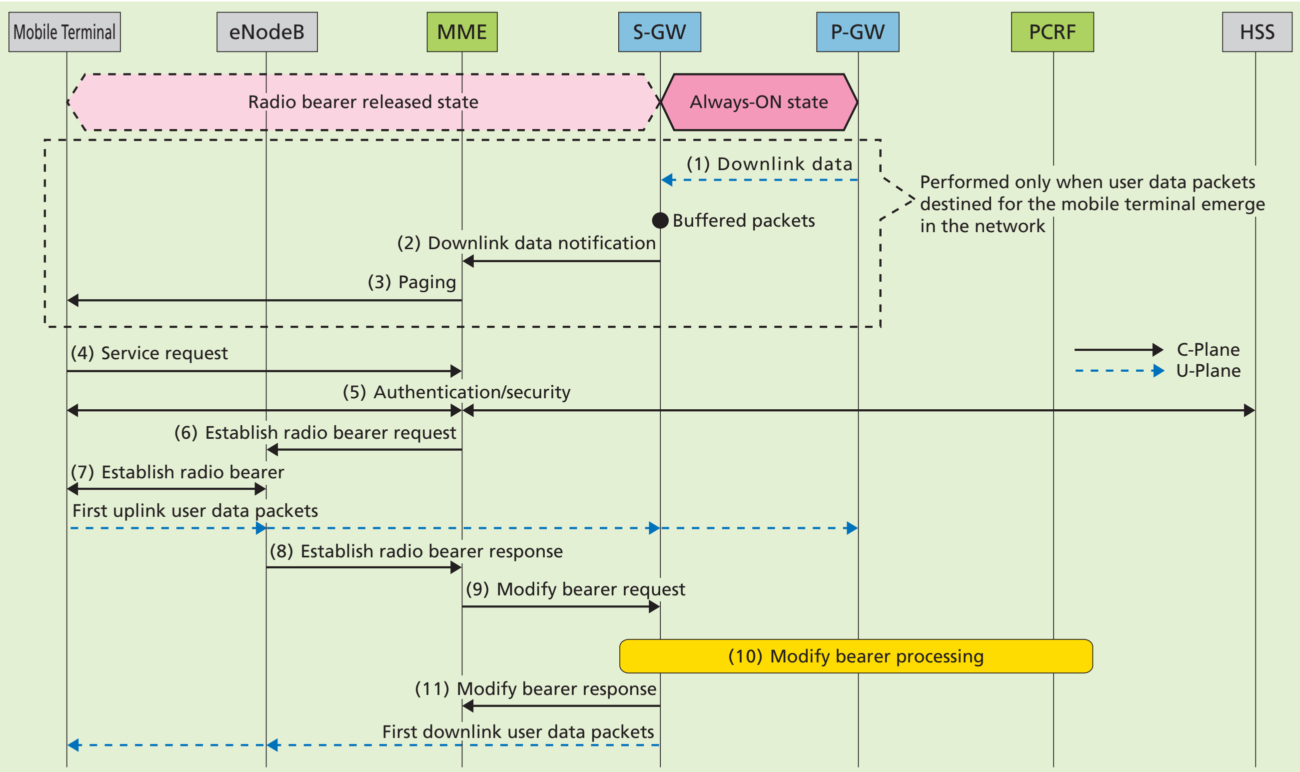


Figure 5 Radio bearer reestablishment procedure

tion and security-related procedures, the MME sends an establish radio bearer request including the S-GW IP address and bearer information to the eNodeB.

The eNodeB now establishes a radio bearer with the mobile terminal and creates a path up to the S-GW. It also returns an establish radio bearer response that includes the eNodeB IP address and bearer information to the MME.

- Steps (9) - (11):

  The MME sends a modify bearer request to the S-GW transferring the eNodeB IP address to it. The S-GW establishes a path to the eNodeB and returns a modify bearer response to the MME.

The above procedure reestablishes the radio bearer from the mobile terminal to the S-GW. At this point, the procedure for establishing a bearer inside the core network can be omitted thereby shortening connection delay when reinitiating communications.

4. Conclusion

NTT DOCOMO has introduced EPC as a core network in combination with its deployment of LTE radio access. This article described the configuration of the EPC network, overviewed the equipment used, and explained the basic functions and signaling flows. The EPC network consists of the MME, PCRF, S-GW and P-GW functional nodes and provides Always-On bearer control, charging control and mobility management between different radio access systems.

Looking forward, our plan is to further enhance the EPC network such as by supporting CS Fallback[*17] [5] to enable an LTE-compatible terminal to make voice calls via 3G radio access.

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*17 **CS Fallback**: The procedure for switching to a radio access technology that supports CS domain when originating or terminating circuit-switched services such as voice calls while in LTE.