IPv6 S1-Flex Registration to multiple TAs

Technology Reports

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

Technology Supporting Core Network (EPC) Accommodating LTE

To handle the rapidly increasing amount of traffic, EPC is being introduced as the next-generation core network, along with LTE radio access. Technical features of EPC include S1-Flex, Registration to multiple TAs, and support for IPv6. S1-Flex achieves MME load equalization and reliability improvement through a full-mesh connection among MMEs and eNodeBs. Registration to multiple TAs distributes the load of location registration by allocating a location registration area individually to each mobile terminal. For IPv6 support, EPC supports a dual IPv4/v6 stack and gives special consideration to mobile network characteristics in allocation of IPv6 addresses.

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1. Introduction

At the 3GPP, standardization of LTE was done at the same time as that of All-IP networks. As a result, the Evolved Packet System (EPS), as an overall packet network including various wireless systems, and the Evolved Packet Core (EPC) as the core network, were specified as the 3GPP Release 8 specifications [1][2]. EPC accommodates LTE radio access as well as the 2G and 3G radio access systems specified by 3GPP (GSM, Universal Mobile Telecommunications System (UMTS)[*1]), wireless LAN, WiMAX and 3GPP2 radio access systems (CDMA2000 1x EV-DO, etc.)[3].

With the introduction of LTE radio access, NTT DOCOMO is also introducing EPC in its core network. EPC is an architecture that expands on the General Packet Radio Service (GPRS)[*2] used with FOMA, and is designed to be able to control mobility between GPRS and other wireless systems easily.

With 3G, after the initial 3GPP Release 99 specification, functionality was added in stages as packet services matured. With EPC, these added functions are provided as basic functions, enabling simpler and more flexible control.

For example, Iu Flex[*3][4], which was specified in 3GPP Release 5, was implemented with a scope able to support pre-Release 5 mobile terminals, limiting the number of nodes that can be processed in the same area. With

*1 **UMTS**: A Third-Generation mobile communications system. Used widely mainly in Japan and Europe. cdma2000 is another such system, used mainly in North America.
*2 **GPRS**: The packet communications system used by GSM and UMTS.
*3 **Iu Flex**: A control system of an area by multiple core nodes in the same area.

LTE and EPC, the mobile terminals, radio access and core network are all newly designed, so protocols were designed with S1-Flex as a basic function, allowing for more flexible operation than 3G.

In this article, we describe three distinguishing technologies comprising EPC, namely S1-Flex, Registration to multiple Tracking Areas (TA)[*4], and IPv6 support. Each of these functions is designed to be improved in LTE and EPC based on experience gained with 2G and 3G.

2. S1-Flex

LTE and EPC make use of S1-Flex technology, which allows base stations (evolved NodeB (eNodeB)) to belong to multiple Mobility Management Entities (MME)[*5]. Within the same Pool Area[*6], call control can be done without changing MMEs, even if the TA changes (**Figure 1**).

2.1 Control Method

During the registration procedure, an MME Code is included in the temporary user identity allocated to the mobile terminal. The MME Code is stored within the mobile terminal, and the next time it accesses the network, the mobile terminal notifies the eNodeB of this MME Code.

The eNodeB identifies the MME within the Pool Area from the MME Code, and forwards the signalling message. If the MME cannot be identified from the MME Code, the eNodeB forwards the signalling message to an arbitrary MME within the Pool Area (**Figure 2**).

The MME can also notify the eNodeB of its processing capacity at any time, and the eNodeB can select an MME based on this capacity. It can also be given logic to detect MME failure and MME load conditions, and select other MMEs as necessary.

2.2 Merits of S1-Flex

S1-Flex has the following three merits.

- MME load equalization

  The relatively large Pool Area is handled with multiple MMEs, so even if there is a localized load imbalance, MME loads are designed to equalize, improving equipment utilization rates.

- Reduced number of location registrations between MME and the Home Subscriber Server (HSS)[*7]

  If a mobile terminal moves within its Pool Area, call processing can still be done without changing

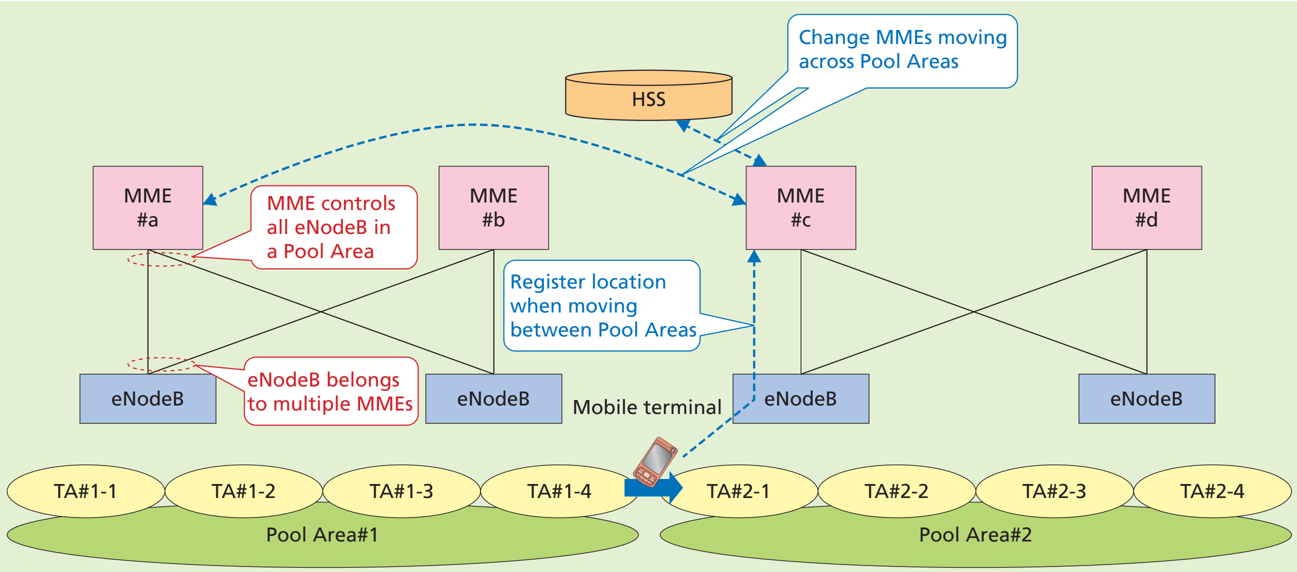

Figure 1 S1-Flex overview

*4 **TA**: A cell unit expressing the position of a mobile terminal managed on a network, and composed of one or more cells.

*5 **MME**: A logical node accommodating a base station (eNodeB) and providing mobility management and other functions.

*6 **Pool Area**: An area with a full-mesh connection among MMEs and eNodeBs. Also called an MME Pool Area.

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

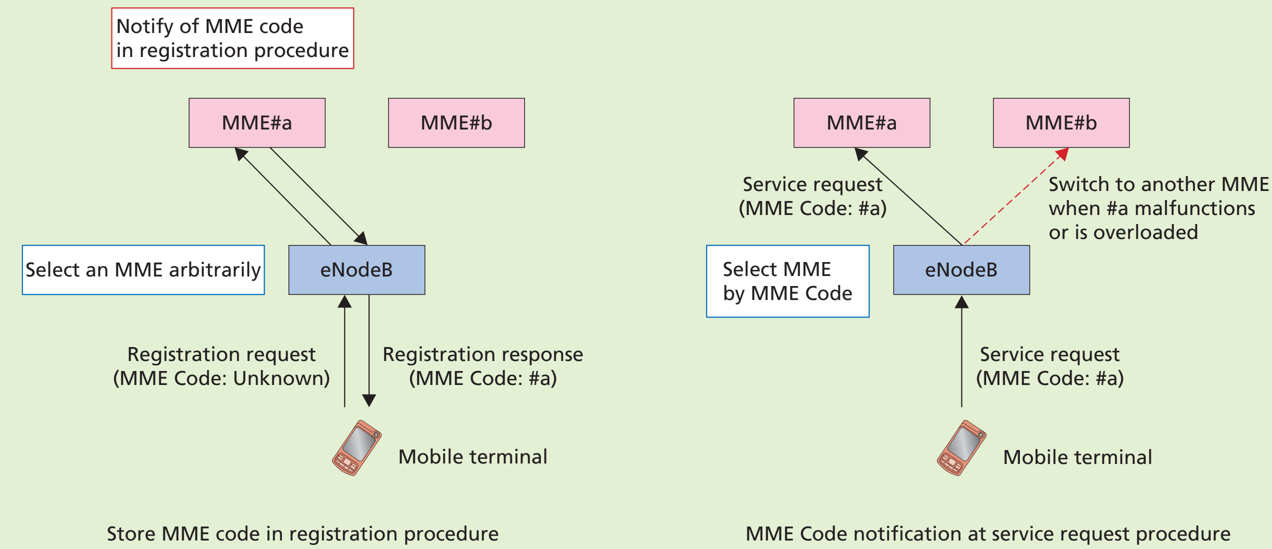

Figure 2 S1-Flex control system

MMEs. This allows location registration processing between MME and HSS to be limited, effectively allowing the amount of equipment to be reduced.

- Increased reliability

  New calls can be connected using MMEs that are operating normally, even if some of the MMEs are out of order. Service interruption can be avoided even if MMEs break down, so network reliability is increased.

3. Registration to Multiple TAs

On LTE and EPC, multiple TAs can be allocated within a Pool Area, and the TAs in a given Pool Area can be assigned to a TA-list per-mobile-terminal on the network. With this control, even if the mobile terminal changes position and camps on a different TA, if the change is within its TA-list, the mobile terminal does not send a location registration signal to the network. This allows changes in the timing with which each mobile terminal sends its location registration signal to the network. As a result, for example, even when a train is moving and many mobile terminals cross TA boundaries simultaneously, each terminal will be moving either within its TA-list, or out of its TA-list, and only those moving out of their TA-lists need to send location registration signals to the network. This helps to distribute the load of location registrations between mobile terminals and MMEs.

3.1 Control Method

1) Allocation of TA-lists

Within a given Pool Area, mobile terminals send a location registration request signal to the network, configured with the TA that they currently camp on. When the MME receives the location registration request signal, it compares the TA configured within that request with its own TA-lists. Then, it selects a TA-list containing the TA included in the signal, configures a location registration response signal, and sends this notification back to the mobile terminal.

2) Mobile Terminal Location-registration Operations after being Allocated a TA-list

Location registration behavior after allocation of the TA-List is shown in **Figure 3**, with mobile terminal UE#A as an example. The MME allocates TA-list #a_1 (TA#1, TA#2) to UE#1 in the location registration response signal (Tracking Area Update (TAU) accept).

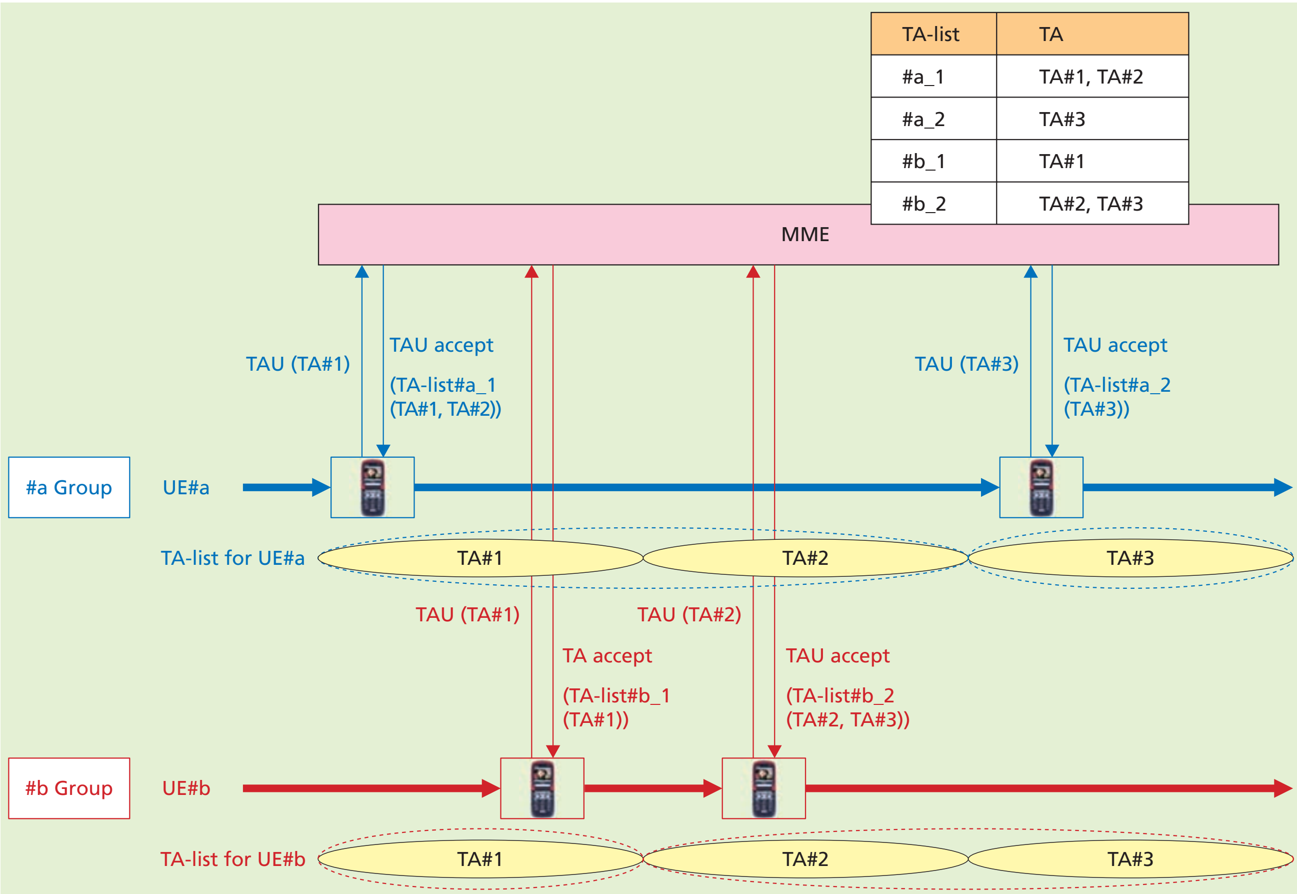

Figure 3 Multi TA registration

As described earlier, even if UE#a moves from TA#1 to TA#2, since it is moving within the TAs in TA-list#a_1, UE#a does not send a TAU to the network. When UE#a moves from TA#2 to TA#3, it is moving out of the TAs in TA-list#a_1, so UE#a sends a TAU configured with TA#3 to the network. When the MME receives the TAU from UE#a, in this example it selects TA-list#a_2 and configures the TAU accept.

3) Paging[*8]

If there is no communication continuously for a set period of time, the mobile terminal is released from the radio link bearer[*9]. Then, if user packet data is sent to the mobile terminal from servers that it was connected to before being released, the MME performs paging because a radio link bearer will be re-established.

If registration to multiple TAs is in operation, the MME manages a TA-list with the mobile-terminal TA information, so it may not be able to uniquely identify the TA where the mobile terminal is camped. so it sends a paging signal to all TAs in the TA-list. If the mobile terminal receives a paging signal, it configures a radio bearer, enabling it to receive the user packet data through the TA where it is currently camped.

4. IPv6 Support

With EPC, if the mobile terminal and Packet Data Network (PDN)[*10] support IPv6, an IPv6 address can be assigned. Also, in contrast with 3G, an IPv4/IPv6 dual stack is supported. When assigning an IPv6 address, EPC

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

*9 **Bearer**: In this article, refers to the user-data packet path.

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

assigns a 64-bit global unicast address[*11] IPv6 Prefix[*12] to each mobile terminal. EPC can assign the IPv6 prefix by either using one stored internally beforehand, or by obtaining it from the PDN. If the IPv6 Prefix is obtained from the PDN, this is done using Radius[*13].

4.1 IPv6 Address Allocation

Mobile terminals maintain an IPv6 link-local address[*14] and a global unicast address. How each of these is configured, and how this differs from general IPv6 address allocation is described below (**Figure 4**).

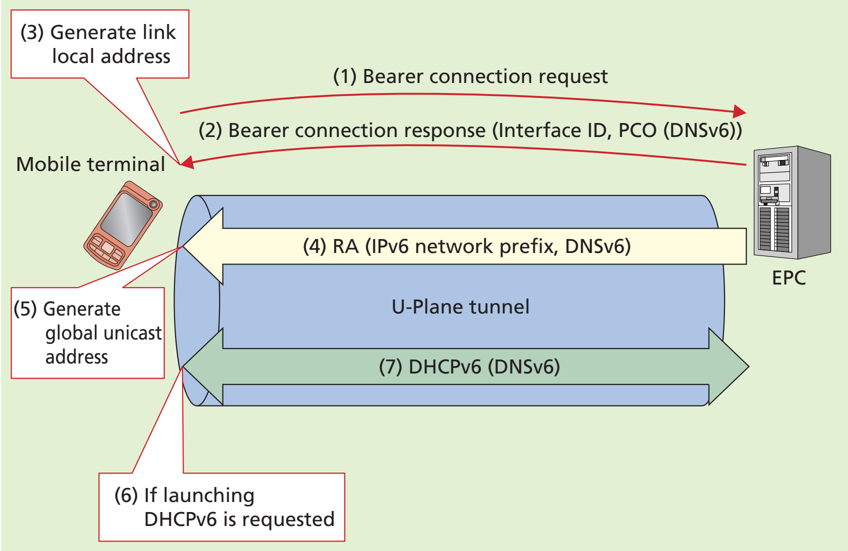

Figure 4 IPv6 address allocation

- Link local address

  When the bearer is established, the EPC notifies the mobile terminal with an Interface ID[*15]. The mobile terminal always uses this Interface ID to generate a link-local address. Mobile terminals do not have an EUI-64[*16], so this use of the Interface ID received from the EPC differs from general IPv6 address allocation.

- Global unicast address

  Once the bearer configuration is complete, the EPC sends a Router Advertisement (RA)[*17] to the mobile terminal. Using the IPv6 Prefix configured in the RA, the mobile terminal generates an IPv6 address (global unicast address) [5]. When doing so, it does not matter what Interface ID is used to generate the IPv6 address (global unicast address). Also, the mobile terminal can change the Interface ID without notifying the network.

4.2 IPv6 Parameter Configuration

EPC can configure IPv6 parameters such as the IPv6 Domain Name System (DNS)[*18] server address (DNSv6) for the mobile terminal. For example, to configure the IPv6 DNS server address, one of the following three notification methods can be used.

1) Protocol Configuration Options (PCO)[*19] Notification

EPC can notify the mobile terminal by configuring the DNSv6 in the PCO of the bearer connection response signal.

2) RA Notification

EPC can send notification including the DNSv6 in an RA sent after the bearer has been established.

3) Dynamic Host Configuration Protocol (DHCP)[*20] v6 Notification

If the mobile terminal is requested to launch DHCPv6 in an RA, it sends a DHCPv6 request signal to the EPC. The EPC can then notify of the DNSv6 in the DHCPv6 response signal [6].

Configuration methods 2) and 3) are the same as an ordinary IPv6 environment, but method 1) is specific to the EPC.

5. Conclusion

In this article, we have described S1-Flex, Registration to multiple TAs, and IPv6 support, which are three distinguishing technologies supporting EPC. The introduction of S1-Flex enables construction of networks with high reliability. Registration to multiple TAs helps to distribute the load of loca-

*11 **Global unicast address**: Defined by IPv6, an address used for one-to-one communication on the Internet.

*12 **IPv6 Prefix**: The first 64 bits of an 128-bit IPv6 address. The same as the network address in IPv4.

*13 **Radius**: A protocol used for authentication and billing.

*14 **Link-local address**: Defined by IPv6, an address used within a link (within a network situated under a single router).

*15 **Interface ID**: The second 64 bits of a 128-bit IPv6 address.

*16 **EUI-64**: A 64-bit interface identifier created from a MAC address.

*17 **RA**: A signal sent from a router to notify terminals within a link of various types of IPv6 information.

tion registration. And IPv6 support allows preparation for the eventual exhaustion of IPv4 addresses.

In the future, we plan to develop the EPC network further, such as by supporting Idle mode Signalling Reduction (ISR), which allows reductions in location registration between LTE and 3G.

References

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[2] K. Nishida et al.: "Basic SAE Management Technology for Realizing All-IP Network," NTT DOCOMO Technical Journal, Vol. 11, No. 3, pp. 4-12, Sep. 2009.

[3] 3GPP TS23.402 V8.9.0: "Architecture enhancements for non-3GPP accesses," June 2010.

[4] S. Kamezaki et al.: "Iu Flex: Preventing Service Interruptions in 3G (CS/PS) Coverage Areas," NTT DOCOMO Technical Journal, Vol. 13, No. 1, pp. 52-60, Jun. 2011.

[5] IETF RFC4862: "IPv6 Stateless Address Autoconfiguration," 2007.

[6] IETF RFC3736: "Stateless Dynamic Host Configuration Protocol (DHCP) Service for IPv6," Dec. 2004.

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

*19 **PCO**: Transmits the various protocol options in the bearer-established signal.

*20 **DHCP**: A protocol used for automatically allocating information (e.g., IP addresses) to computers connected to networks.