



INTERNATIONAL TELECOMMUNICATION UNION

**ITU-T**

**Q.1708/Y.2805**

TELECOMMUNICATION  
STANDARDIZATION SECTOR  
OF ITU

(10/2008)

SERIES Q: SWITCHING AND SIGNALLING

Signalling requirements and protocols for IMT-2000

SERIES Y: GLOBAL INFORMATION

INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS  
AND NEXT-GENERATION NETWORKS

Next Generation Networks – Generalized mobility

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**Framework of Location Management for NGN**

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## **Framework of Location Management for NGN**

### **Summary**

This Recommendation specifies the framework of IP-based location management for Next Generation Networks. The location management is responsible for mapping among user identifier and location identifiers of the user equipment. This Recommendation describes the design considerations, functional architecture, and information flows for the location management function.

### **Keywords**

NGN, Location Management

### **Introduction**

This Recommendation describes the framework of mobility management (MM) for Next Generation Networks (NGN). This work has been motivated from the observation that NGN continues to evolve toward the convergence of fixed and wireless/mobile networks, and thus the mobility management is an essential functionality to provide seamless mobility for the NGN users and services.

This Recommendation is a part of the MM framework for NGN. The MM framework will be designed with a series of Recommendations, rather than a single Recommendation, as a suite of the framework of mobility management for NGN. The design of the MM framework includes a variety of technical issues to be addressed. Those design issues are associated with a wide variety of mobility scenarios and protocols. The MM framework Recommendations are:

- Rec. Q.1707/Y.2804: Generic Framework of Mobility Management for NGN;
- Rec. Q.1708/Y.2805: Framework of Location Management for NGN;
- Rec. Q.1709/Y.2806: Framework of Handover Control for NGN;
- Rec. Q/Y.SMF: Framework of Mobility Management in Service Stratum for NGN (work in progress, to be completed by 2009)

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## 1 Scope

This Recommendation describes the framework of IP-based location management (LM) for NGN, which includes design considerations, functional architecture, and information flows for location management. This Recommendation focuses on the terminal mobility where mobile terminals move around and change their IP addresses in the NGN. This Recommendation also focuses on the mobility management (MM) schemes that operate in the network or IP layer, whereas the issues on the mobility support in the service stratum will be addressed in another Recommendation.

## 2 References

The following ITU-T Recommendations and other references contain provisions, which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published.

The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation

- [1] ITU-T Recommendation Q.1706/Y.2801 (2006), *Mobility Management Requirements for NGN*.
- [2] ITU-T Recommendation Q.1707/Y.2804 (2008), *Generic Framework of Mobility Management for Next Generation Networks*.
- [3] ITU-T Recommendation Q.1709/Y.2806, *Framework of Handover Control for NGN*.
- [4] ITU-T Recommendation Y.2111 (2006), *Resource and Admission Control Functions in Next Generation Networks*.
- [5] ITU-T Recommendation Y.2014 (2008), *Network Attachment Control Functions in Next Generation Networks*.
- [6] ITU-T Recommendation Y.2001 (2004), *General overview of NGN*.
- [7] ITU-T Recommendation Y.2011 (2004), *General principles and general reference model for Next Generation Networks*.
- [8] ITU-T Recommendation Y.2012 (2006), *Functional requirements and architecture of the NGN of release 1*.
- [9] ITU-T Recommendation Y.2091 (2007), *Terms and definitions for Next Generation Networks*.

### 3 Definitions

#### 3.1 Terms defined in Q.1707/Y.2804

This Recommendation uses the following terms defined in the Recommendation Q.1707/Y.2804:

**3.1.1 User Identifier (UID):** a series of digits, characters and symbols or any other form of data that are used to identify a subscriber (user) or user equipment in the NGN. Refer also to the Recommendation Y.2091.

**3.1.2 Location Identifier (LID):** A topological location identifier of a UE. An IP address can be used as a location identifier. Refer also to the Recommendation Y.2091.

#### 3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

**3.2.1 Persistent LID (PLID):** an LID which does not change even when an MUE moves across different access networks or IP subnets.

**3.2.2 Temporary LID (TLID):** an LID which changes when an MUE moves across different access networks or IP subnets.

**3.2.3 LID Binding Update (LBU):** an operation of location management to manage the mapping between persistent LID (PLID) and temporary LID (TLID).

## 4 Abbreviations

ALM	Access Location Management
ALM-FE	Access Location Management-Functional Entity
CLM	Central Location Management
CLM-FE	Central Location Management-Functional Entity
CoA	Care of Address
CUE	Corresponding User Equipment
DHCP	Dynamic Host Configuration
FE	Functional Entity
HCF	Handover Control Function
HoA	Home Address
ID	Identifier
IETF	Internet Engineering Task Force
IMSI	International Mobile Subscriber Identifier
IP	Internet Protocol
L3	Layer 3
LBU	LID Binding Update
LID	Location Identifier
LM	Location Management
LMF	Location Management Function
LM-FE	Location Management FE
MIP	Mobile IP
MIPv6	Mobile IPv6
MM	Mobility Management
MMCF	Mobility Management Control Function
MUE	Mobile User Equipment
NACF	Network Attachment Control Function
NGN	Next Generation Network
FRA	Functional Requirements and Architecture for NGN
PLID	Persistent LID
RACF	Resource Admission Control Function
TLID	Temporary LID
UE	User Equipment
UID	User Identifier
URI	Uniform Resource Identifier

## **5 Design Considerations**

### **5.1 MM Identifiers**

The identifiers for MM can be classified into user ID (UID) and location ID. The location ID can be further classified into persistent LID (PLID) and temporary LID (TLID).

#### **5.1.1 User Identifier (UID)**

A UID represents a user or UE in the NGN. The UID can be in a variety of formats such as URI (Uniform Resource Identifier), NAI (Network Access Identifier), IMSI (International Mobile Subscriber Identifier), etc. In this Recommendation, it is assumed that a UID is given to a user that has subscribed to the NGN mobility service.

#### **5.1.2 Location Identifier (LID)**

The location management (LM) functionality is to keep track of mobile user equipments (UEs) in the network by identifying and maintaining the location information of the concerned mobile UEs. Such a location information or location identifier (LID) is classified into 'physical' LID and 'logical' LID. The physical LID represents the geographical location of the mobile UE. The logical LID includes an IP address for routing/forwarding IP packets to the mobile UE in the network.

This Recommendation does not consider the physical or geographical LID. This Recommendation will consider only the logical LID, and focus on the IP address as the LID. In the viewpoint of IP-based LM, a logical LID or IP address can be further classified into Persistent LID (PLID) and Temporary LID (TLID).

#### **5.1.3 Persistent LID (PLID)**

A typical example of PLID is the home address (HoA) which is defined in the Mobile IP (MIP). When a mobile UE (MUE) is connected to the network at an initial power-on, a PLID should be statically or dynamically allocated to the MUE.

In order to support session continuity of an MUE, a PLID may not be changed, even when an MUE moves into another IP subnet. In this sense, this LID is called 'persistent'. In some cases, however, a PLID may be newly configured, for example, when MUE is reconnected to the network after a failure or power-off, or when it enters a new local domain in a localized MM scheme.

#### **5.1.4 Temporary LID (TLID)**

A typical example of TLID is the care-of address (CoA) of MIP. When an MUE moves into another IP subnet, it will obtain a new TLID, as seen in the example of MIPv6 CoA.

In the host-based LM, a TLID should be dynamically allocated to the MUE, possibly with the help of DHCP. In the network-based LM, an IP address of the concerned access router may be used as a TLID of an MUE.

### **5.2 LM Operations**

IP-based LM is used to manage the mappings between UID and LID, and between PLID and TLID for each MUE. In this respect, LM operations consist of:

- UID binding operation for mapping between UID and LID;
- LID binding operation for mapping between PLID and TLID.

This Recommendation focuses on the LID binding operation.

On the other hand, it is noted that the paging management is one of the essential functionality that can be used with the location management. However, the IP-based paging function is for further study. The paging function is outside the scope of this Recommendation.

### **5.2.1 UID Binding Operation**

The UID binding operation is used to manage the mapping between UID and PLID for each mobile UE. A UID is assigned to an NGN user on the subscription basis, whereas a PLID represents an IP address.

The UID binding information should be registered when an MUE gets a PLID. Such information will be updated if the PLID is re-configured by the MUE. It is noted that the UID binding operation schemes are quite dependent on the type of UID associated with the user (e.g., URI, IMSI, or UE identifier, etc.) This implies that there may be a variety of schemes or scenarios for UID binding management. This Recommendation does not deal with the details of UID binding management schemes.

### **5.2.2 LID Binding Operation**

The LID binding operation is used to manage the mapping between PLID and TLID for each mobile UE. The LID binding update (LBU) operation will be used for LID binding management. This Recommendation focuses on LID binding operation, rather than UID binding operation.

When an MUE is initially connected to the network, an 'initial' LBU operation is performed. In the host-based LM, when the MUE gets a TLID from the network, it should register its TLID with the LM-related functional entity. In the network-based LM, in which the IP address of a network agent is used as a TLID, the LBU operation will be performed by the corresponding LM-related function entity in the network. Each time an MUE moves into a new IP subnet and thus its TLID changes, the LBU is performed.

### **5.2.3 Consideration of Multiple Interfaces**

An MUE may have multiple PLIDs when an MUE gets access to the different NGN service providers in which the mobility services are offered to the MUE. An MUE may also have multiple TLIDs. For example, one TLID per each interface may be allocated to an MUE with multiple interfaces, which allows the MUE use various types of network interfaces to maintain wide area network connectivity. Note that an MUE may have one TLID even when it has multiple PLIDs and also may have one PLID even when it has multiple TLIDs.

If multiple PLIDs are allocated to an MUE, the LBU operation for each PLID may be performed with different CLM-FE. In addition, if multiple TLIDs are allocated to an MUE, the LID binding operation should be able to bind multiple TLIDs to each PLID.

As a typical example, an MUE with multiple interfaces may have one PLID and multiple TLIDs, one TLID per each interface. When the MUE is initially connected to an access network through its one of interfaces, its PLID is bound to a TLID for the interface. Then, if there is another available interface for the MUE, the MUE may also be connected to an access network through the interface and its PLID is also bound to the TLID of the interface. Note that when another TLID is bound to a PLID, the existing TLID bound to the PLID should not be overwritten. In addition, there should be a proper mechanism to revoke the binding between PLID and TLID. The detailed architecture and signaling flow are out of scope of this Recommendation and are for further study.

#### **5.2.4 Dynamic Assignment of LM Functional Entity**

The dynamic assignment mechanism of LM functional entity (LM-FE) may be supported during the location registration according to the requirements of load balancing, administrative policies and so on. If LBU request (LBU\_Request) to a location management functional entity is responded by LBU response (LBU\_Response) with failure notification or redirection information, the LBU\_Request to the other location management functional entity will be tried.

### **5.3 LM for Data Packet Delivery**

For data packet delivery or call/session establishment between Corresponding UE (CUE) and MUE, the current location information of MUE needs to be identified. The LM or LM-related functional entity will be used to provide the location information of MUE for data packet delivery or call/session establishment.

The detailed scheme of data packet delivery or session establishment may depend on the associated service control functions or mechanisms (e.g., with or without the session setup signaling). By this, there may be a variety of operational scenarios for finding the location information of MUE (e.g., PLID or TLID) via interworking between LM-related functional entity and service control function. The details of the scenarios for data packet delivery or session establishment are outside the scope of this Recommendation.

This Recommendation focuses on the functional architecture and information flows only for the LBU operation in terms of LM functionality.

## 6 Functional Reference Architecture

### 6.1 Functional Entities

As described in Q.1707, the MM Control Function (MMCF) consists of Location Management Function (LMF) and Handover Control Function (HCF). The LMF can be achieved with the following function entities (FEs):

- Access LM-FE (ALM-FE);
- Central LM-FE (CLM-FE).

These are the logical FEs defined for location management. Some of those FEs may be located on a single physical entity, or an FE may be implemented onto one or more physical FEs. In the NGN-FRA point of view, an LM-FE may be further divided into one or more FEs, which is outside the scope of this Recommendation.

Figure 6-1 shows the architectural model of LM function with the related LM-FEs.

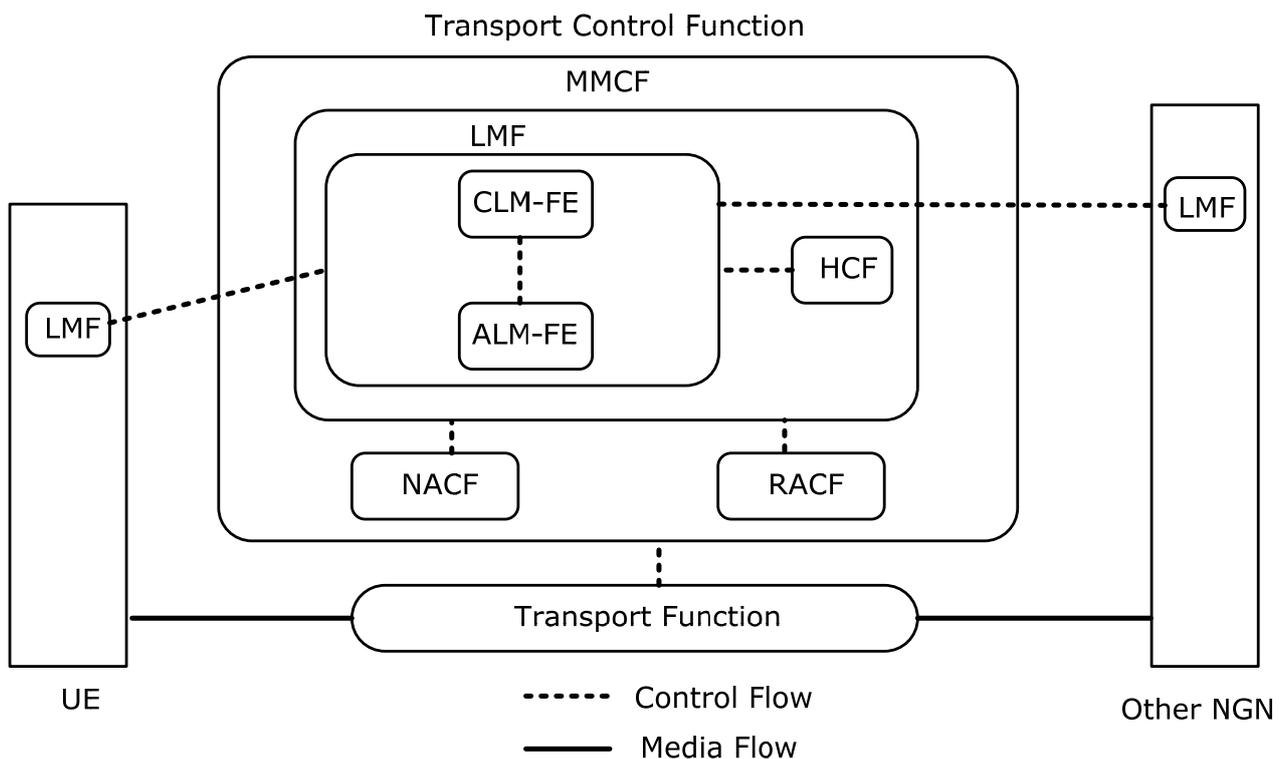


Figure 6-1. Functional architecture of location management

As described in the figure, a UE may perform its own LMF function with the LM-FEs of the network in the host-based LM scheme. The LM-FEs in the network are organized into a two-level hierarchy of ALM-FE and CLM-FE. Each LM-FE performs the LBU operation for location management.

In terms of the MM, the LM-FEs can interact with the Handover Control Function (HCF). Moreover, each LM-FE may have interaction with the following NGN functions:

- Network Attachment Control Function (NACF);
- Resource Admission Control Function (RACF);
- Transport Function (TF).

### 6.1.1 ALM-FE

The ALM-FE is responsible for

- LBU operation with MUE and CLM-FE in the host-based LM;
- LBU operation with CLM-FE in the network-based LM

### 6.1.2 CLM-FE

The CLM-FE is responsible for

- LBU operation with MUE and ALM-FE in the host-based LM;
- LBU operation with ALM-FE in the network-based LM

## 6.3 Reference Points

This clause identifies the reference points or interfaces to describe the information flows for LM.

### 6.2.1 Non-roaming Case

In the non-roaming case, the reference points for LM operations ( $L_{UA}$ ,  $L_{AC}$ ,  $L_{UC}$ ) are shown in the figure below.

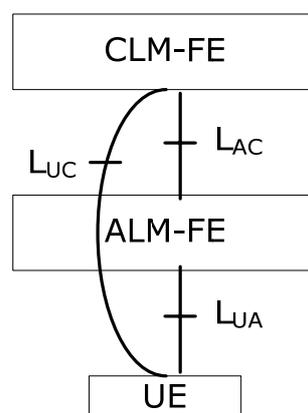


Figure 6-2. Reference points for LM in the non-roaming case

In the non-roaming case, the LM scenarios can be classified as follows:

- Host-based LM with ALM-FE
- Host-based LM without ALM-FE
- Network-based LM

In the case of host-based LM using ALM-FE, the two reference points are used:  $L_{UA}$  between UE and ALM-FE, and  $L_{AC}$  between ALM-FE and CLM-FE. In the case of host-based LM without ALM-FE, the reference point  $L_{UC}$  between UE and CLM-FE is used. In the case of network-based LM, the reference point  $L_{AC}$  between ALM-FE and CLM-FE is used.

### 6.2.2 Roaming Case

In the roaming case, this Recommendation assumes that a roaming agreement has already been made between home NGN provider and visited NGN provider. The issues on authentication and authorization for roaming are outside the scope of this Recommendation.

The reference points for LM operations in the roaming case ( $L_{UA}$ ,  $L_{AC}$ ,  $L_{UC}$ ) are shown in the figure below.

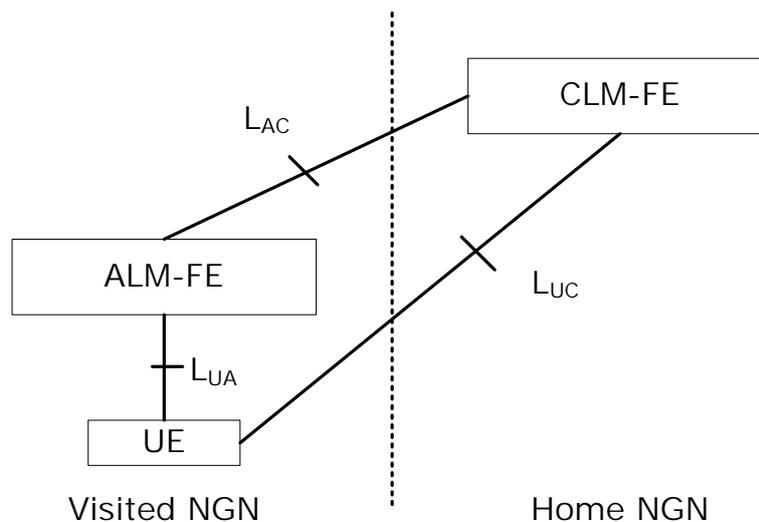


Figure 6-3. Reference points for LM in the roaming case

In the roaming case, the LM scenarios can be classified as follows:

- Host-based LM with visited ALM-FE
- Host-based LM without visited ALM-FE
- Network-based LM

In the case of host-based LM using the visited ALM-FE, the two reference points are used:  $L_{UA}$  between roaming UE and visited ALM-FE, and  $L_{AC}$  between visited ALM-FE and home CLM-FE.

In the case of host-based LM without visited ALM-FE, the reference point  $L_{UC}$  between roaming UE and home CLM-FE is used.

In the case of network-based LM, the reference point  $L_{AC}$  between visited ALM-FE and home CLM-FE is used.

## 7 Information Flows for Non-roaming UE

An MUE or ALM-FE starts initial LBU procedure when it is attached to its home network initially. There are two architectures for performing the procedure as follows.

- Host-based Location Management

An MUE starts performing initial LBU procedure by exchanging LID binding update (LBU) messages with CLM-FE directly or via ALM-FE.

- Network-based Location Management

The ALM-FE which detects an MUE's attachment starts performing initial LBU procedure by exchanging LBU messages with CLM-FE in the home network.

Note that this initial LBU procedure may be omitted depending on where the MUE is initially attached in the host-based location management. For example, when the MUE's PLID such as HoA in MIP is topologically correct to its access network, the MUE does not need to proceed with the initial LBU procedure. The initial LBU procedure also needs data path setup procedure which may require HCF functions. The data path setup procedure is the same as in the handover case, which is described in Q.1709/Y.2806 in detail. Therefore, this Recommendation focuses on the location management procedure itself.

### 7.1 Host-based LM

When an MUE is attached to an access network, the MUE performs the initial LBU procedure in the host-based location management architecture. As shown in Fig 7-1, the host-based location management in non-roaming case is using the interaction among MUE, ALM-FE and CLM-FE in a home network. After successful LBU procedure, the relevant LMF entity will maintain the mapping between PLID and TLID.

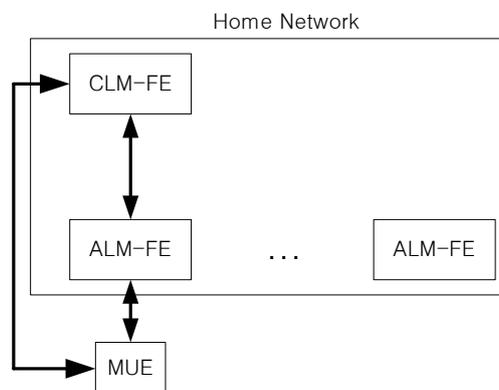


Figure 7-1. Host-based LBU Architecture in Non-roaming Case

Fig. 7-2 and 7-3 show the information flow for the initial host-based LBU procedure in non-roaming case. The MUE attached to its home network initially starts the initial LBU procedure with CLM-FE by exchanging LBU messages directly or via an ALM-FE. Fig. 7-2 and 7-3 are the LBU procedures with and without ALM-FE involvement, respectively. If an ALM-FE is involved, the ALM-FE may act as a proxy for the CLM-FE. When the CLM-FE receives the initial LBU\_Request message, it will respond with an LBU\_Response message to the MUE directly or via ALM-FE. The LBU\_Response message may indicate whether the registration is successful or not. The reasons for failure of the registration may be various, which may include the overload condition of the CLM-FE or administration policies. In case of registration failure, the CLM-FE may respond with additional

information such as redirection indication and a new CLM-FE information for the redirection, which makes the MUE re-initiate the LBU procedure with the new CLM-FE. If the LBU\_Response message is received with only redirection indication without a new CLM-FE information, the MUE may try another candidate CLM-FE from the list of candidate CLM-FEs that the MUE maintains.

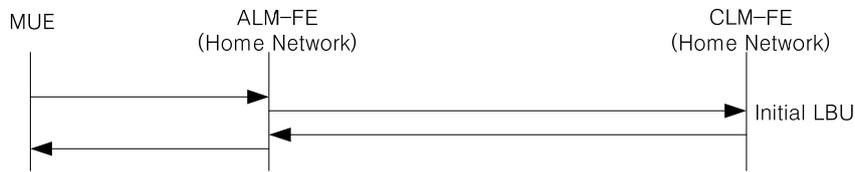


Figure 7-2. Host-based Initial LBU Procedure with ALM-FE in Non-roaming Case

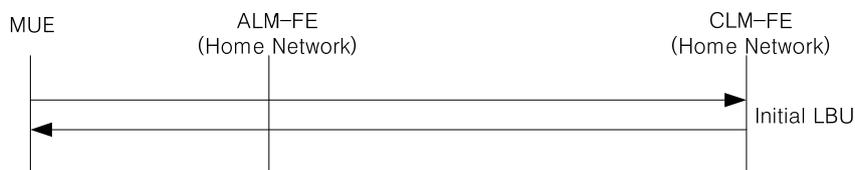


Figure 7-3. Host-based Initial LBU Procedure without ALM-FE in Non-roaming Case

If the MUE has multiple interfaces such as Wi-Fi, HSDPA, WiMAX, etc. and multiple TLIDs are allocated to each interface, it may perform multiple LBU procedures with the CLM-FE, and then LID binding operation may bind multiple TLIDs to a PLID. In addition, if multiple PLIDs are allocated to the MUE, it may perform multiple LBU procedures with multiple CLM-FEs for each PLID.

## 7.2 Network-based LM

When an MUE is attached to an access network, the ALM-FE that detects the MUE's attachment performs the initial LBU procedure in the network-based LM. As shown in Fig. 7-4, the network-based location management in non-roaming case is based on interaction between ALM-FE and CLM-FE. After successful LBU procedure, the relevant LM-FE will maintain the mapping information between TLID and PLID.

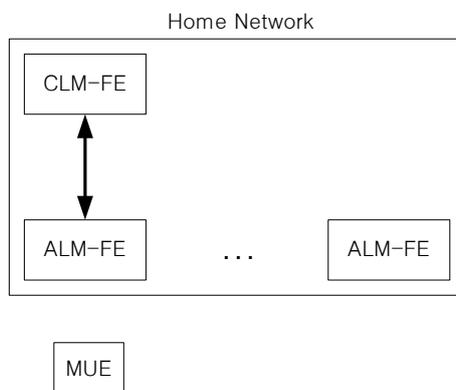


Figure 7-4. Network-based LBU Architecture in Non-roaming Case

Fig. 7-5 shows the information flow for the initial network-based LBU procedure in the non-roaming case. An ALM-FE that detects an MUE's initial attachment starts the initial LBU procedure with CLM-FE by exchanging LBU messages. When the CLM-FE receives the initial LBU\_Request message from the ALM-FE, it will respond with an LBU\_Response message to the ALM-FE. The LBU\_Response message indicates whether the registration is successful or not. The reasons for failure may be various which include the overload condition of the CLM-FE and administration policies. In case of registration failure, the CLM-FE may respond with additional information such as redirection indication and new CLM-FE information for the redirection, which makes ALM-FE re-initiate the LBU procedure with the new CLM-FE. If the LBU\_Response message is received with only redirection indication without new CLM-FE information, the ALM-FE may try another candidate CLM-FE from the list of candidate CLM-FEs that the ALM-FE maintains.

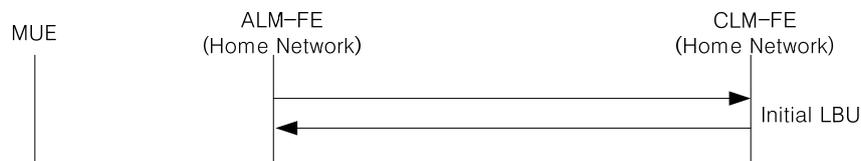


Figure 7-5. Network-based Initial LBU Procedure in Non-roaming Case

If the MUE has multiple interfaces such as Wi-Fi, HSDPA, WiMAX and each interface is attached to different ALM-FEs, each ALM-FE may perform its own LBU procedure with the same CLM-FE, and then LID binding operation may bind multiple TLIDs to a PLID. On the other hand, if multiple PLIDs are allocated to the MUE, it may perform multiple LBU procedures with the respective CLM-FEs for each PLID or multiple LBU procedures with the same CLM-FE to create multiple mappings of TLID and PLID in the CLM-FE.

## 8 Information Flows for Roaming UE

When an MUE roams to a visited network, there are two possible scenarios in the IP address allocation point of view. First, a new IP address may be allocated regardless of which IP address was allocated to the MUE in its home network. That is, a new PLID can be allocated to the MUE in the visited network. On the other hand, PLID will be maintained as the same one, and only a new TLID is allocated to the MUE. This recommendation focuses on only the case where PLID is maintained as the same one and a new TLID is allocated when an MUE is attached to a visited network.

An MUE or ALM-FE starts the initial LBU procedure when it attaches to a visited network. As in the non-roaming case, there are the two architectures to perform the procedure:

- Host-based Location Management

An MUE starts performing the initial LBU procedure by exchanging the LBU messages with home CLM-FE directly or via visited ALM-FE.

- Network-based Location Management

The visited ALM-FE which detects an MUE's attachment starts performing the initial LBU procedure by exchanging the LBU messages with home CLM-FE in the MUE's home network.

Differently from the non-roaming case, the initial LBU procedure cannot be omitted for host-based location management in the roaming case since the MUE's PLID will never be topologically correct to its access network in the roaming case. As mentioned in the roaming case, the data path setup procedure is described in the Recommendation Q.1709/Y.2806 in details.

### 8.1 Host-based LM

When an MUE is attached to an access network in a visited NGN, the MUE performs the initial LBU procedure in the host-based location management architecture. As shown in Fig. 8-1, the host-based location management is using the interaction among MUE, visited ALM-FE and home CLM-FE. After successful LBU procedure, the relevant LMF entity will maintain the mapping between PLID and TLID.

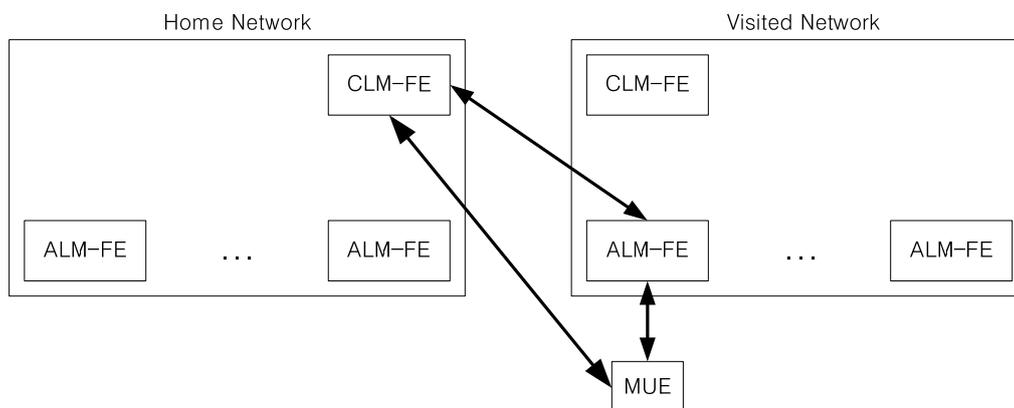


Figure 8-1. Host-based LBU Architecture in Roaming Case

Fig. 8-2 and 8-3 show the information flow for the initial host-based LBU procedure in the roaming case. The MUE which is attached to a visited network initially starts the initial LBU procedure with its home CLM-FE by exchanging LBU messages directly or via a visited ALM-FE. The Fig. 8-2 and 8-3 describe the LBU procedures with and without the visited ALM-FE involvement, respectively. If a visited ALM-FE is involved, the ALM-FE may act as a proxy for the home CLM-FE. When the home CLM-FE receives the initial LBU\_Request message, it will respond with an LBU\_Response message to the MUE directly or via a visited ALM-FE. The LBU\_Response message may indicate whether the registration is successful or not. The failure reasons for the registration may be diverse, which may be ranged from the overload condition of the CLM-FE to administration policies. In case of registration failure, the CLM-FE may respond with additional information such as redirection indication and new CLM-FE information for the redirection, which makes MUE re-initiate the LBU procedure to the new CLM-FE. If the LBU\_Response message is received with only redirection indication without new CLM-FE information, the MUE may try another candidate CLM-FE from the list of candidate CLM-FEs that the MUE maintains.

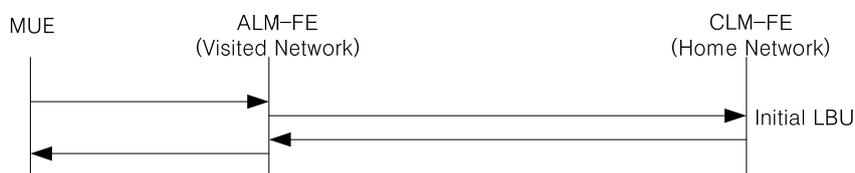


Figure 8-2. Host-based LBU Procedure with Visited ALM-FE in Roaming Case

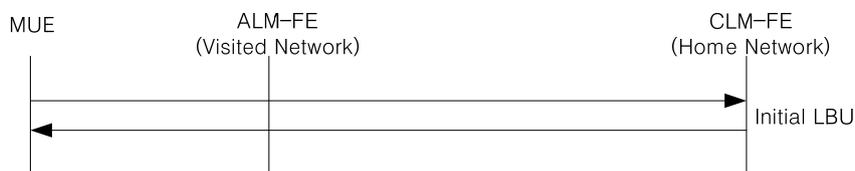


Figure 8-3. Host-based LBU Procedure without Visited ALM-FE in Roaming Case

As in non-roaming case, LID binding operation may bind multiple TLIDs to a PLID for MUEs with multiple interfaces such as Wi-Fi, HSDPA, WiMAX, and an MUE may perform multiple LBU procedures with multiple CLM-FEs for each PLID, or multiple LBU procedures with the same CLM-FE to create multiple bindings of TLID and PLID in the CLM-FE.

## 8.2 Network-based LM

When an MUE is attached to an access network in a visited NGN, the visited ALM-FE detecting the MUE's attachment performs the initial LBU procedure in the network-based location management architecture.

As shown in Fig. 8-4, the network-based location management is based on interaction between visited ALM-FE and home CLM-FE. After successful LBU procedure, the relevant LM-FE will maintain the mapping between PLID and TLID.

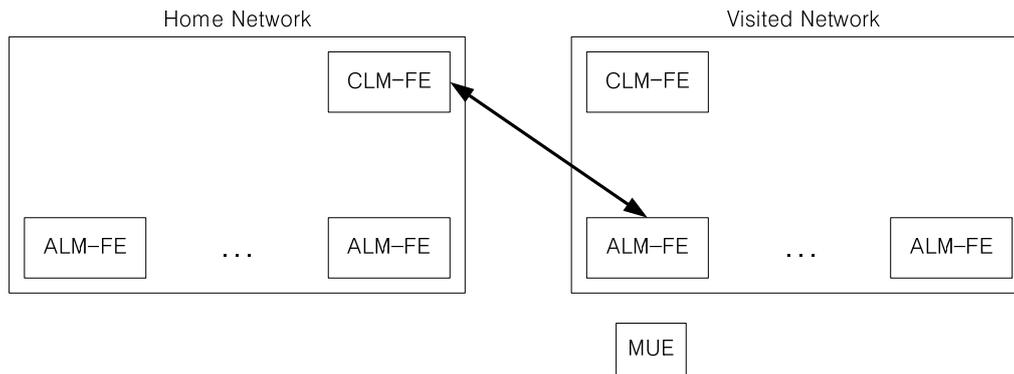


Figure 8-4. Network-based LBU Architecture in Roaming Case

Fig. 8-5 shows the information flow for the initial network-based LBU procedure in roaming case. A visited ALM-FE which detects an MUE's initial attachment starts the initial LBU procedure with the MUE's home CLM-FE by exchanging LBU messages. When the home CLM-FE receives the initial LBU\_Request message from the visited ALM-FE, it will respond with an LBU\_Response message to the visited ALM-FE. The LBU\_Response message may indicate whether the registration is successful or not. The failure reasons for the registration may be diverse, which are ranged from the overload condition of the CLM-FE to administration policies. In case of registration failure, the CLM-FE may respond with additional information such as redirection indication and new CLM-FE information for the redirection, which makes ALM-FE re-initiate the LBU procedure to the new CLM-FE. If the LBU\_Response message is received with only redirection indication without new CLM-FE information, the ALM-FE may try another candidate CLM-FE from the CLM-FE list that the ALM-FE maintains.

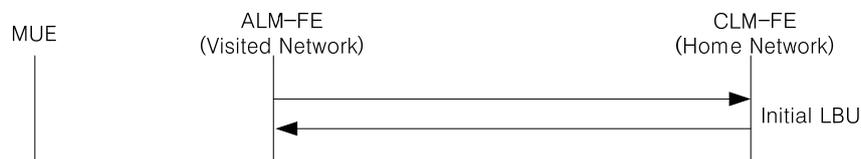


Figure 8-5. Network-based Initial LBU Procedure in Roaming Case

As in non-roaming case, the LID binding operation may bind multiple TLIDs to a PLID for MUEs with multiple interfaces such as Wi-Fi, HSDPA, WiMAX, and ALM-FEs may also perform each LBU procedure with multiple CLM-FEs for each PLID or multiple LBU procedures with the same CLM-FE to create multiple mappings of TLID and PLID in the CLM-FE.

## Bibliography

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- [9] ITU-R Recommendation M.1034-1 (1997), *Requirements for the radio interface(s) for (IMT-2000)*.
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- [1] IETF RFC 3344 (2002), *IP mobility support for IPv4*.
- [2] IETF RFC 3775 (2004), *Mobility support in IPv6*.
- [3] IETF RFC 4830 (2007), *Problem Statement for Network-based Localized Mobility Management (NETLMM)*.
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- [5] IETF RFC 5213 (2008), *Proxy Mobile IPv6*.
- [6] IETF draft-ietf-netlmm-pmip6-ipv4-support-04.txt (working in progress), *IPv4 Support for Proxy Mobile IPv6*.
- [7] IETF draft-ietf-monami6-multiplecoa-09.txt (working in progress), *Multiple Care of Address Registration*.