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## **ITU-T Recommendation Q.1709/Y.2806**

# **Framework of Handover Control for NGN**

### **Summary**

This Recommendation specifies the framework of handover control for Next Generation Networks. The handover control functionality is responsible for providing seamless services for mobile users by minimizing service disruptions during handover. The handover control schemes are classified into the host-based and network-based schemes. This Recommendation describes the design considerations, functional architecture and information flows for handover control.

### **Keywords**

NGN, Mobility Management, Handover Control

### **Introduction**

This Recommendation describes a framework of handover control (HC) for mobility management (MM) in 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 services to NGN users.

This Recommendation is a part of the MM framework for NGN. The MM framework for NGN will be designed with a series of Recommendations rather than a single Recommendation. This is because the design of the MM framework includes a variety of technical issues to be addressed. Furthermore, those design issues are associated with a wide variety of mobility scenarios and protocols. In this respect, the MM framework for NGN will be described with a family of the following Recommendations:

- Rec. Q.1707/Y.2084: 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; and
- Rec. Q/Y.SMF: Framework of Mobility Management in Service Stratum for NGN (working in progress, to be completed by 2009).

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## 1 Scope

This Recommendation describes the framework of IP-based handover control (HC) for NGN, which includes design considerations, functional architecture, and procedural information flows for handover control. This Recommendation focuses on the terminal mobility where mobile terminals move around and change their IP address in the NGN. This Recommendation also focuses on the mobility management (MM) schemes that operate in the network layer (or IP layer), whereas the issues on the mobility support in the service stratum will be addressed in another ITU-T MM Framework 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 Supplement 52 to Q-series Recommendations Q.sup52 (2004), *Technical Report on Mobility Management Requirements for Systems beyond IMT-2000*.
- [2] ITU-T Recommendation Q.1706/Y.2081 (2006), *Mobility Management Requirements for NGN*.
- [3] ITU-T Recommendation Q.1707/Y.2804 (2008), *Generic Framework of Mobility Management for Next Generation Networks*.
- [4] ITU-T Recommendation Q.1708/Y.2805 (2008), *Framework of Location Management for NGN*.
- [5] ITU-T Recommendation Y.2111 (2006), *Resource and Admission Control Functions in Next Generation Networks*.
- [6] ITU-T Recommendation Y.2014 (2008), *Network Attachment Control Functions in Next Generation Networks*.
- [7] ITU-T Recommendation Y.2001 (2004), *General overview of NGN*.
- [8] ITU-T Recommendation Y.2011 (2004), *General principles and general reference model for Next Generation Networks*.
- [9] ITU-T Recommendation Y.2012 (2006), *Functional Requirements and Architecture of the NGN of release 1*.
- [10] 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 ITU-T 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 ITU-T 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 ITU-T Recommendation Y.2091.

#### 3.2 Terms defined in Q.1708/Y.2805

This Recommendation uses the following terms defined in ITU-T Recommendation Q.1708/Y.2805:

- 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 PLID and TLID.

#### 3.3 Terms defined in this Recommendation

This Recommendation defines a following term:

- 3.3.1 **LID Binding Query (LBQ):** An operation performed by a correspondent UE or network to find the current TLID of a mobile UE.

### 4 Abbreviations

2G	2nd Generation
3G	3rd Generation
3GPP	3rd Generation Partnership Project
AAA	Authentication, Authorization, and Accounting
AHC-FE	Access HC-FE
ALM-FE	Access LM-FE
A-MMCF	Access MMCF
AP	Access Point
CHC-FE	Central HC-FE
CLM-FE	Central LM-FE
C-MMCF	Central MMCF

CN	Core Network
CPE	Customer Premise Equipment
CPE-BE	CPE-Border Element
CUE	Correspondent UE
FE	Functional Entity
HC	Handover Control
HCF	Handover Control Function
ID	Identifier
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IP	Internet Protocol
ISP	Internet Service Provider
LID	Location ID
LM	Location Management
LMF	Location Management Function
LBQ	LID Binding Query
LBU	LID Binding Update
LTE	Long Term Evolution
MIH	Media Independent Handover
MIHF	MIH Function
MIP	Mobile IP
MM	Mobility Management
MMCF	Mobility Management Control Function
MUE	Mobile User Equipment
NACF	Network Attachment Control Function
NGN	Next Generation Networks
PD-FE	Policy Decision-FE
PE-FE	Policy Enforcement-FE
PLID	Persistent LID
PoA	Point of Attachment
QoS	Quality of Service
RACF	Resource Admission Control Function
TCP	Transmission Control Protocol
TLID	Temporary LID
UDP	User Datagram Protocol

UE	User Equipment
UID	User Identifier
WiMAX	Worldwide Interoperability for Microwave Access
WLAN	Wireless Local Area Network

## 5 Design Considerations

This Recommendation describes the framework of handover control (HC) for NGN. The goal of the HC functionality is to provide a mobile user equipment (MUE) with the seamless services whenever it moves around in NGN. For this purpose, the seamless handover should be supported for the MUE, by which any on-going session or services could continue without service disruption regardless of the change of Location ID (LID).

As described in ITU-T Recommendation Q.1708/Y.2805, MM identifiers are divided into User ID (UID) and Location ID (LID). The LID is further classified into Persistent LID (PLID) and Temporary LID (TLID). This Recommendation focuses only on the IP address used as an LID. The UID binding operation is responsible for managing the information of mapping between UID and PLID, whereas the LID binding operation is used to manage the information of mapping between PLID and TLID. The LID binding operation is realized through the LID Binding Update (LBU) operation.

It is noted that the LBU operation is performed for LM as well as HC. The LBU operation itself will be performed by LM functional entities (LM-FEs) with the help of HC functional entities (HC-FEs). This Recommendation will focus on the LBU operation in the viewpoint of HC functionality.

By moving into a new IP subnet, which is called a layer 3 (L3) handover, an MUE changes its TLID. The configuration of TLID will be performed differently depending on the host-based or network-based HC. The LID binding information shall be updated by the LBU operation with the new TLID.

### 5.1 Handover and Seamless Handover

The L3 handover occurs when an MUE changes its IP address (i.e., TLID) by moving between different IP subnets. This Recommendation focuses on IP handover or L3 handover. It is noted that L3 handover also accompanies layer 2 (L2) handover. The HC operations can be further classified into those for handover and seamless (or fast) handover, as described in Clause 6.2.2 of ITU-T Recommendation Q.1706/Y.2801.

For the handover operations, when an MUE moves into a new IP subnet and thus gets a new TLID, the LBU operation will be performed. In the LBU operation, the information of mapping between PLID and TLID will be updated by interworking among suitable LM-FEs and HC-FEs.

The seamless (or fast) handover operation will be performed to minimize the service disruption during handover (e.g., packet loss and delay). For this purpose, some optimization schemes may be introduced such as handover tunnel establishment, fast access authentication, pre-emptive HC signalling, etc.

## **5.2 Handover Operations**

The L3 handover of an MUE is typically associated with the operations described in the following clauses.

### **5.2.1 Movement Detection**

The movement detection (or handover detection) implies an operation that detects a handover situation or predicts an imminent handover. The movement detection can be further classified into L2 and L3 movement detections. The way of performing the L2 movement detection is outside the scope of this Recommendation. However, the notification of L2 movement event needs to be delivered to a HC function (HCF) to trigger the immediate L3 movement detection and to initiate the subsequent HC procedure.

### **5.2.2 Network Selection**

To control a handover between different access networks, the HCF needs to identify the candidate list of point of attachment (PoAs) currently accessible by an MUE. Based on this information, the MUE can choose one of the reachable PoA to establish a new communication link.

In the network selection operation, the HC function may get some useful information such as signal quality or available resources of the candidate PoAs. For this purpose, the HCF may interact with the Resource and Admission Control Function (RACF) defined in ITU-T Recommendation Y.2111.

The network selection operation can be performed with the help of the IEEE 802.21 Media Independent Handover (MIH) scheme, as described in the Appendix I of this Recommendation.

### **5.2.3 TLID Configuration**

When an MUE moves into a new access network (or IP subnet), its TLID shall be newly configured. To do this, the MUE may get an IP address as a new TLID from the network, or the IP address of a specific network component can be used as a TLID of the MUE.

### **5.2.4 LID Binding Update**

To complete HC procedure, the new TLID should be registered with the suitable LM-FE through the LBU operation. This LBU operation shall be performed between MUE and LM-FE in the host-based HC scheme. It can be also performed only between LM-FEs in the network-based HC scheme, as described in ITU-T Recommendation Q.1708/Y.2805.

For handover optimization, the LBU operation needs to be performed as soon as a handover (movement) is detected. For this purpose, the HC-FE shall trigger the LBU operation performed by the relevant LM-FE. Communications between HC-FE and LM-FE for LBU operation may be performed by way of an internal reference point (interface) depending on implementation method.

## **5.3 Operations for Handover Optimization**

To provide seamless services for an MUE during handover, a variety of schemes for handover optimization can be used. Some of those optimization schemes for seamless handover are described below.

### **5.3.1 LBU Triggering by HC-FE**

L3 movement is usually detected by using the Router Advertisement and Solicitation messages. This may incur quite long handover latency. To provide seamless handover, the HC-FEs can trigger the LBU operation of LM-FEs as earlier as possible.

### **5.3.2 Routing Path Optimization**

For efficient data packet delivery or for seamless handover, the routing path between MUE and CUE needs to be optimized. Specifically, it can be beneficial for CUE to send data packets over TLID rather than PLID. For this purpose, the LID Binding Query (LBQ) operation may be used. The LBQ operation can be classified into the following two cases:

- LBQ from CUE to MUE; and
- LBQ between HC-FEs.

The LBQ operation between CUE and MUE can be shown in the example of the IETF Mobile IP (MIP) Route Optimization scheme between mobile node and correspondent node. This operation can be performed directly between end UEs without the help of the network. This type of the LBQ operation is for further study and the details will not be described in the Recommendation.

In the LBQ between HC-FEs, the HC-FE associating with CUE finds the TLID of MUE by contacting with the relevant LM-FE. Then the data packets to MUE will be delivered over the TLID. This Recommendation will describe the details of this type of LBQ operation.

### **5.3.3 Handover Tunnel Establishment**

To provide seamless handover, a handover tunnel may be established between two access routers (or two tunnel endpoints controlled by HC-FEs) concerned with handover of the MUE. The handover tunnel is used to minimize the data packet loss during handover.

### **5.3.4 Other Schemes for Handover Optimization**

In addition, the other schemes may be used for handover optimization, which include multicasting, pre-emptive LBU, etc. The details of the other optimizations schemes are for further study.

## **5.4 Host-based and Network-based Handover Control**

The HC schemes can be classified into following two categories:

- Host-based scheme that HC signaling is performed based on (or controlled by) MUE; and
- Network-based scheme that HC signaling is performed (or controlled) by HC-FE.
- In the host-based HC, when an MUE moves into another network region (or IP subnet), it activates the HC operations with the concerned LM-FEs and HC-FEs. The MUE may perform some handover signaling operations. In the network-based handover control, an HC-FE takes a role of MUE. The HC-FE may perform the most of handover signaling operations such as LBU initiation and handover tunnel establishment.

## 6 Functional Reference Architecture

This clause describes the functional entities for HC in NGN. The reference points to illustrate the information flows for HC are also described.

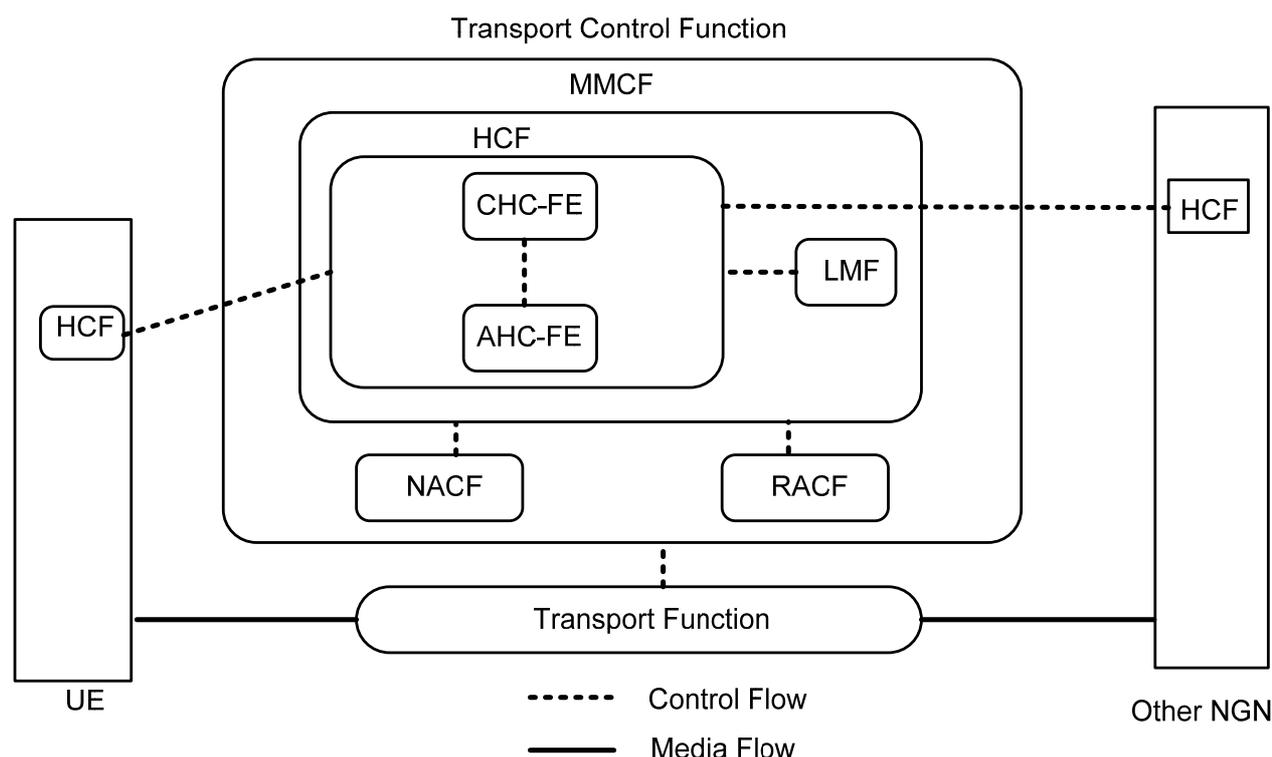
### 6.1 Functional Entities

As described in ITU-T Recommendation Q.1707/Y.2804, the Mobility Management Control Function (MMCF) consists of Location Management Function (LMF) and Handover Control Function (HCF). The HCF can be achieved with the following function entities (FEs):

- Access HC-FE (AHC-FE); and
- Central HC-FE (CHC-FE).

These are the logical FEs defined for HC operations. Some of those FEs may be located on a single physical entity, or an FE may be separated onto one or more physical entities, which is outside the scope of this Recommendation.

Figure 6-1 shows the functional architectural model of HCF with the related HC-FEs.



**Figure 6-1: Functional architecture of handover control**

The AHC-FE is generally located at the access network. It will interact with the CHC-FE and its neighbouring AHC-FEs. The CHC-FE is generally located at the core network (CN) and interacts with the AHC-FEs in the same NGN and the peering CHC-FE in the other NGN (for inter-CN handover).

Each HC-FE performs the HC operations by interworking with MUE, LM-FEs, and other HC-FEs. Specific HC operations depend on the host-based HC or network-based HC scheme. In particular, the HC-FE shall initiate the LBU operation with the associated LM-FE in the network-based HC scheme. In this respect, the LM-FE may be located (or implemented) with the corresponding HC-FE on a single device, which depends on implementation.

The HC-FE also interacts with other functions in NGN (e.g., NACF, RACF, and Transport Functions) to request/control HC-related operations provided by those NGN functions. For example, the HC-FE may invoke AAA or IP address allocation function of the Network Attachment Control Function (NACF) if it is required to control a UE's handover. The RACF may allocate network resources requested by the HC-FE to support QoS-guaranteed handovers.

### **6.1.1 AHC-FE**

In the host-based HC, the AHC-FE is responsible for:

- Data tunnel establishment with the CHC-FE;
- Control of data tunnel path on MUE's handover; and
- Establishment of handover tunnel with neighboring AHC-FE.

In the network-based HC, the AHC-FE is responsible for:

- Movement detection of MUE;
- LBU initiation with the corresponding ALM-FE;
- Data tunnel establishment with CHC-FE or AHC-FE;
- Control of data tunnel path on MUE's handover;
- Establishment of handover tunnel with neighboring AHC-FE (optional); and
- LID Binding Query (LBQ) operation with CHC-FE.

### **6.1.2 CHC-FE**

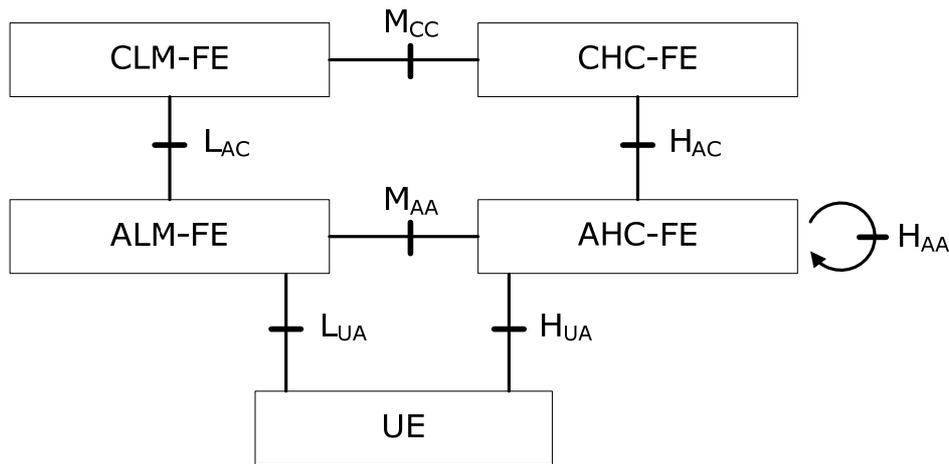
In the host-based HC and network-based HC, the CHC-FE is responsible for:

- Supporting network selection of MUE;
- Data tunnel establishment with AHC-FEs;
- Control of data tunnel paths on MUE's handover; and
- LBQ operation with AHC-FEs.

## **6.2 Reference Points**

This clause identifies the reference points to describe the information flows for the cases of the host-based HC and network-based HC.

The following Figure 6-2 shows the reference points for HC.



**Figure 6-2: Reference Points for Handover Control**

It is noted that HC-FEs are tightly coupled with LM-FEs in the viewpoint of LBU operation. For LBU operation, AHC-FE or MUE shall request the LBU operation to ALM-FE via reference point  $M_{AA}$  or  $L_{UA}$ . Then the LBU operation is performed between ALM-FE and CLM-FE via  $L_{AC}$ , as described in ITU-T Recommendation Q.1708/Y.2805. After the completion of LBU operation, CLM-FE may interact with CHC-FE for handover signaling via  $M_{CC}$ , which will be described later. It is noted that the reference points,  $M_{AA}$  and  $M_{CC}$ , may be implemented via an internal interface, if a HC-FE is located with the corresponding LM-FE in the same device.

In the host-based HC, MUE will detect the movement and initiate the HC operations. In this case, the reference point  $H_{UA}$  between UE and AHC-FE can be used. For LBU initiation, the MUE interacts with ALM-FE via  $L_{UA}$ . For establishment of handover tunnel, AHC-FE may interact with the other AHC-FE via the reference point  $H_{AA}$ . In the network-based HC, AHC-FE will detect the movement of MUE and initiate the HC operations. For LBU initiation, AHC-FE interacts with ALM-FE via  $M_{AA}$ . For establishment of handover tunnel, AHC-FE may interact with the other AHC-FE via the reference point  $H_{AA}$ .

In the figure, the reference point  $H_{AC}$  between AHC-FE and CHC-FE can be used to perform the signalling operations for handover optimization such as bicasting, which are still for further study.

## 7 Information Flows for Host-based Handover Control

In the host-based HC scheme, MUE initiates the HC operations whenever it moves into another network region (or IP subnet). The associated HC-FE performs the handover signalling procedure by interacting with other HC-FEs and LM-FEs relevant to the handover situation. This Recommendation describes following two host-based HC cases:

- Generic host-based handover control; and
- Handover control based on the handover tunnel.

Information flows for host-based HC are conceptually referred to the operations of MIP and FMIP protocols in IETF.

## 7.1 Generic Host-based Handover Control

In the host-based HC scheme, MUE initiates the operations of MMCFs to control a handover. Figure 7-1 shows the generic architecture of host-based HC scheme. MUE performs the LBU operation with an associated LM-FEs as soon as a handover between different AHC-FE's regions is detected. LBU\_Request and LBU\_Response messages are used for signaling of HC as well as LM among MUE and MMCFs.

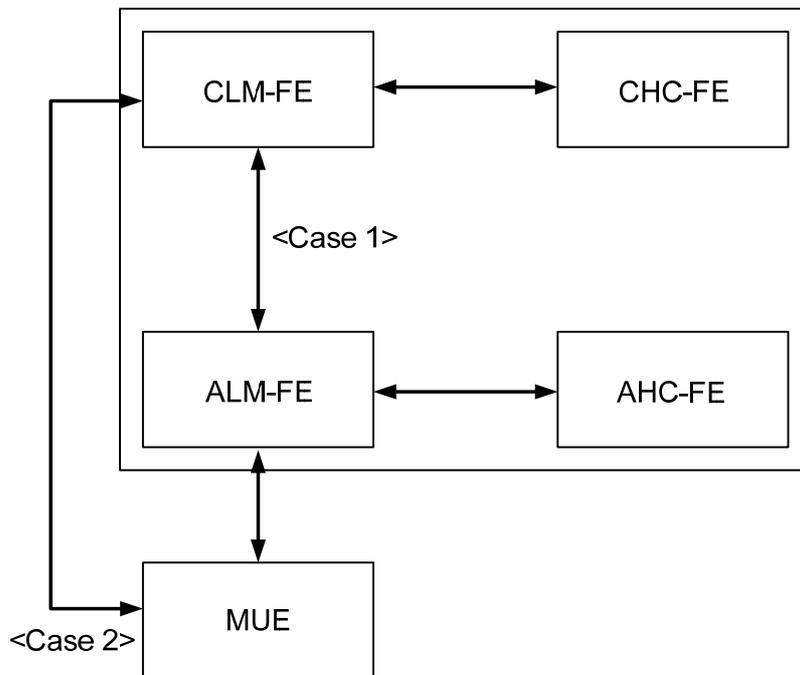


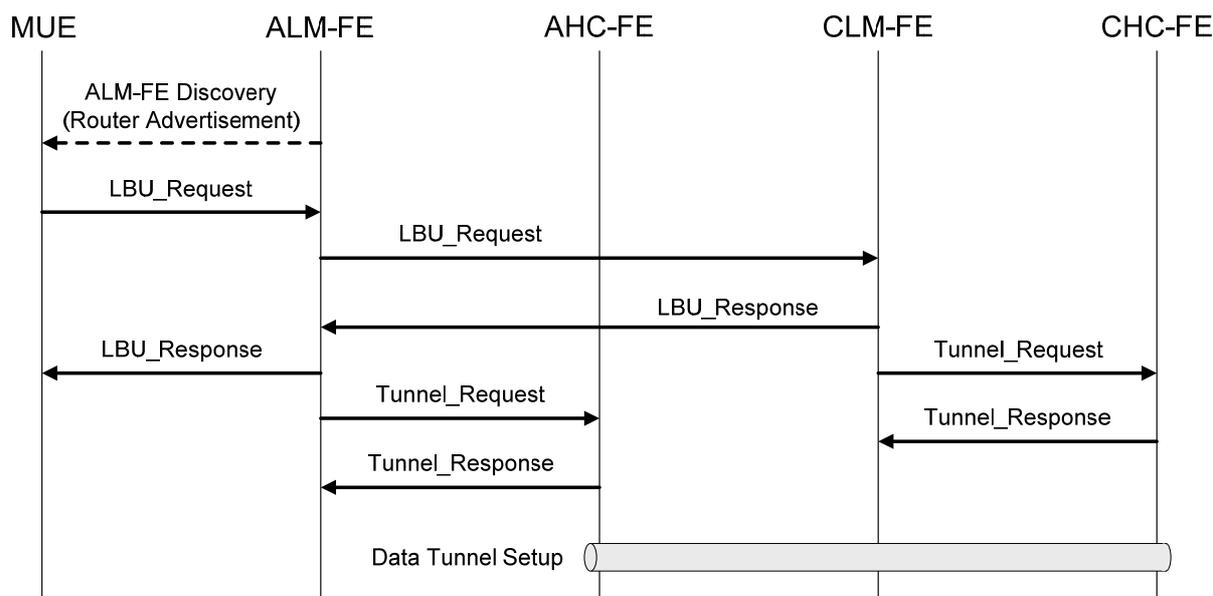
Figure 7-1: Generic Host-based HC Architecture

A data tunnel to deliver packets destined to MUE is established along the following two paths:

- Between two endpoints controlled by CHC-FE and AHC-FE; and
- Between MUE and an endpoint controlled by the CHC-FE.

The signaling interfaces used for those two cases are represented as Case 1 and 2 in Figure 7-1. To setup or update a data tunnel for MUE, LM-FEs exchange data tunnel control messages with the associated HC-FEs.

Figure 7-2 illustrates an information flow to handle the MUE's initial connection establishment to NGN based on the generic host-based HC architecture. Since one of the important roles of HCF is to adjust the data tunnels used by the packets destined to MUEs, the tunnel setup operations in the initial connection step are strongly related to the type of HC scheme. The flow in Figure 7-2 shows the case that a data tunnel for MUE is established between two endpoints controlled by CHC-FE and AHC-FE (Case 1).



**Figure 7-2: Initial Connection Establishment for Generic Host-based HC (Case 1)**

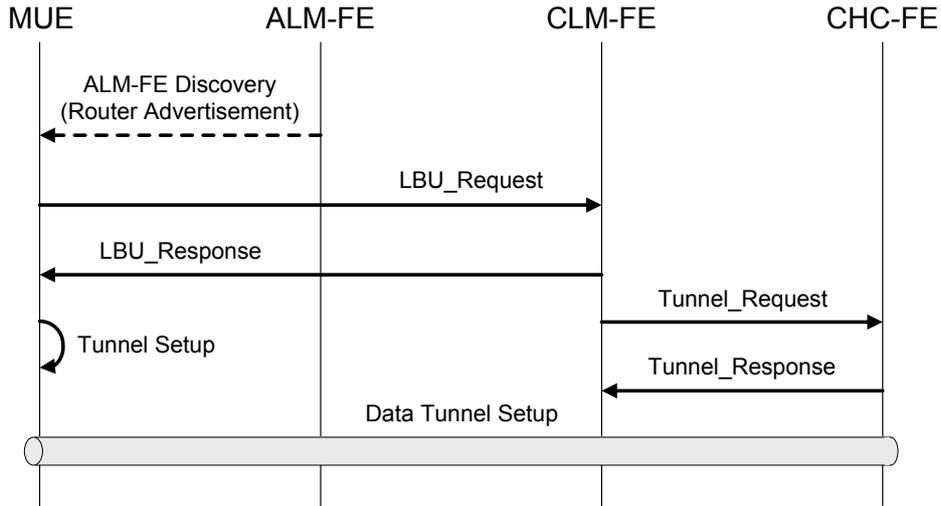
To simplify the description, the tunnel endpoints are illustrated as HC-FEs in Figure 7-2. However, it is noted that the real endpoints of a tunnel are NGN transport functions controlled by those HC-FEs. This simplification will be applied to all the figures presented in this clause. HC-FE and the relevant transport function may be located on a single device, which depends on implementation.

In Figure 7-2, when an MUE is first attached to NGN, it will discover an ALM-FE to request its initial LBU procedure. A Router Advertisement message can be used to inform MUEs of the closest ALM-FE responsible for the region. Then the MUE initiates the LBU procedure by sending an LBU\_Request message to the ALM-FE. The ALM-FE forwards the LBU\_Request message to the CLM-FE to request to create the LID binding information of the MUE. The detailed description of this initial LBU procedure is beyond the scope of this Recommendation.

After an LBU\_Response message is transmitted by CLM-FE, CLM-FE and CHC-FE exchange Tunnel\_Request and Tunnel\_Response messages with each other. This process will request the NGN Transport Functions to setup an endpoint of a data tunnel with which ALM-FE and MUE are bound.

On receiving the LBU\_Response message from CLM-FE, ALM-FE and AHC-FE exchange Tunnel\_Request/Response messages to setup another endpoint of the data tunnel. Thereafter, data packets are delivered to the MUE through the data tunnel between CHC-FE and AHC-FE.

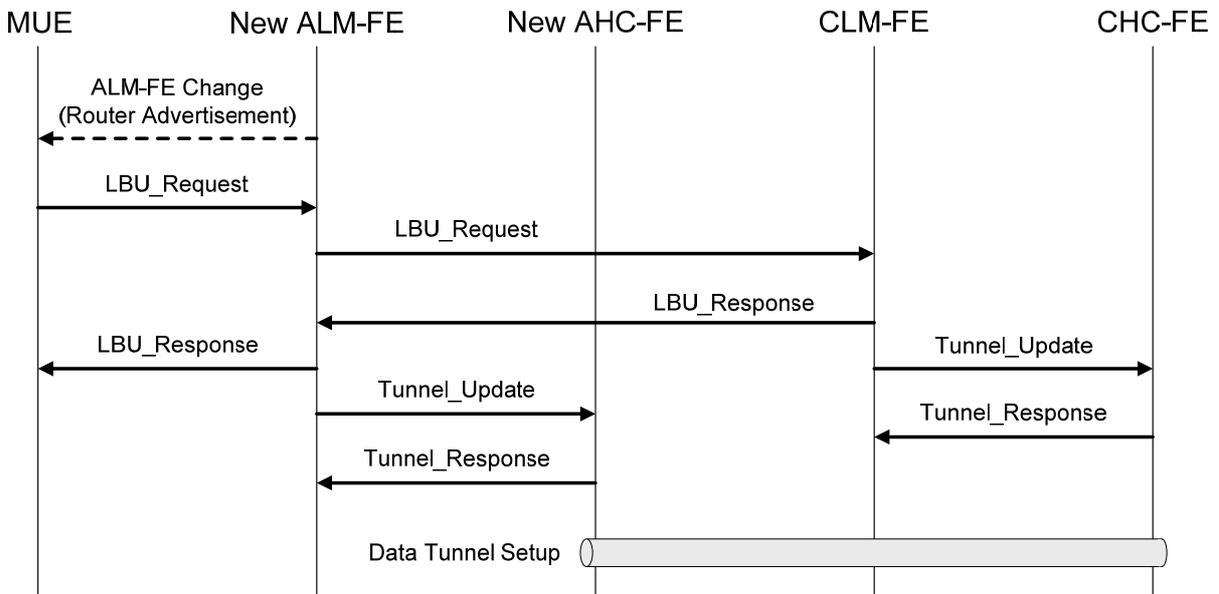
Figure 7-3 shows another information flow to handle the MUE's initial connection establishment to NGN in the generic host-based HC architecture. This flow illustrates a case that a data tunnel for MUE is established between the MUE and an endpoint controlled by the CHC-FE (Case 2).



**Figure 7-3: Initial Connection Establishment for Generic Host-based HC (Case 2)**

In the case of Figure 7-3, an MUE initiates the initial LBU procedure by sending an LBU\_Request message directly to the CLM-FE. To do this, a control message used for ALM-FE discovery can contain the information of the CLM-FE. An endpoint of a data tunnel is configured on the MUE itself after receiving an LBU\_Response message. An MUE should be equipped with the IP-in-IP tunnel endpoint functionalities including encapsulation and de-capsulation of the data packets. The other operations in the flow are equivalent to those for Case 1.

Figure 7-4 illustrates an information flow to control the MUE's handover between two A-MMCFs' regions based on the generic host-based HC architecture. It describes a case that a data tunnel for MUE is established between two endpoints controlled by CHC-FE and AHC-FE (Case 1).

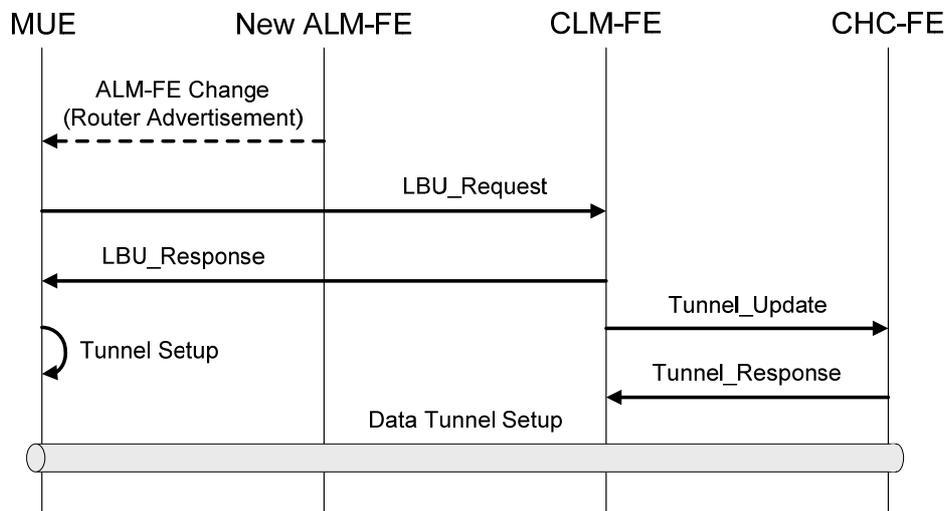


**Figure 7-4: Generic Host-based HC Procedure (Case 1)**

The flow in Figure 7-4 is similar with that of the initial connection procedure but a Tunnel\_Request message is replaced with a Tunnel\_Update message. A Tunnel\_Update message contains the information to enable the AHC-FE and CHE-FE to distinguish the handover situation of MUE from the initial connection situation.

When an LBU\_Request message is delivered from new ALM-FE, the CLM-FE updates the LID binding information of MUE using a newly assigned TLID and replies with an LBU\_Response message. A Tunnel\_Update message delivered from the CLM-FE requests the CHC-FE to search and update the data tunnel binding information of the MUE so that a new data tunnel (toward new AHC-FE) is bound by the MUE. The operations for a Tunnel\_Update message at the AHC-FE are equivalent to those for the initial connection establishment procedure. Subsequently, data packets for MUE are delivered through the tunnel between CHC-FE and new AHC-FE.

Figure 7-5 shows another information flow based on the generic host-based HC architecture. It represents a case that a data tunnel for MUE is established between the MUE and an endpoint controlled by CHC-FE.



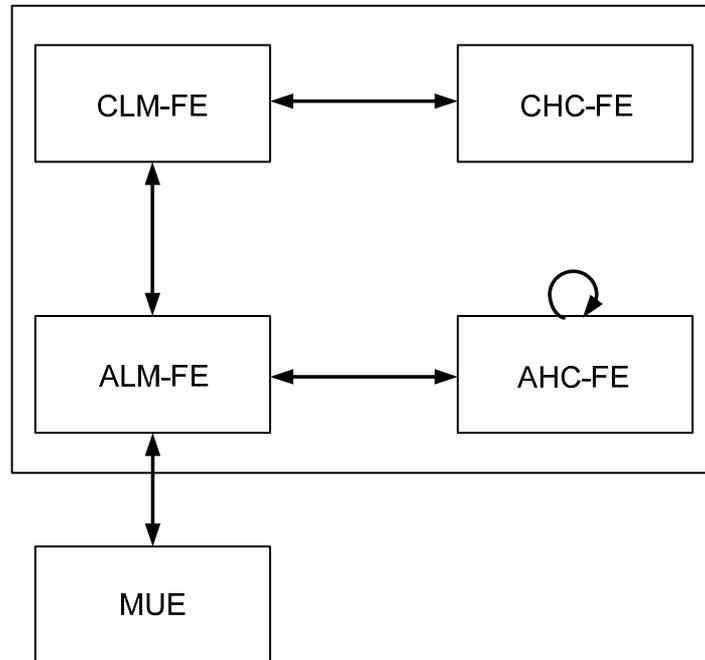
**Figure 7-5: Generic Host-based HC Procedure (Case 2)**

As shown in Figure 7-5, a Tunnel\_Request message in the initial connection establishment procedure is also replaced with a Tunnel\_Update message to distinguish the handover situation. The LBU\_Request and LBU\_Response messages are exchanged directly between the MUE and CLM-FE. The operations to handle those LBU\_Request and Tunnel\_Update messages are equivalent with those of Case 1. The only difference is that the MUE setups a data tunnel endpoint instead of the AHC-FE.

To reduce the overhead that all the packets delivered to the MUE are tunneled by control of the CHC-FE, the CHC-FE may notify two corresponding UEs (i.e., CUE and MUE) or AHC-FEs of the need of data path optimization processing. This may result in the creation of a new data tunnel established directly between those two corresponding UEs or AHC-FEs. Thereafter, the existing data tunnel controlled by the CHC-FE can be replaced with the optimized one directly established between the MUE and CUE. This data path optimization process may be initiated by the MUE instead of the CHC-FE depending on the implementation. The details of the data path optimization are for further study.

## 7.2 Handover Control based on Handover Tunnel

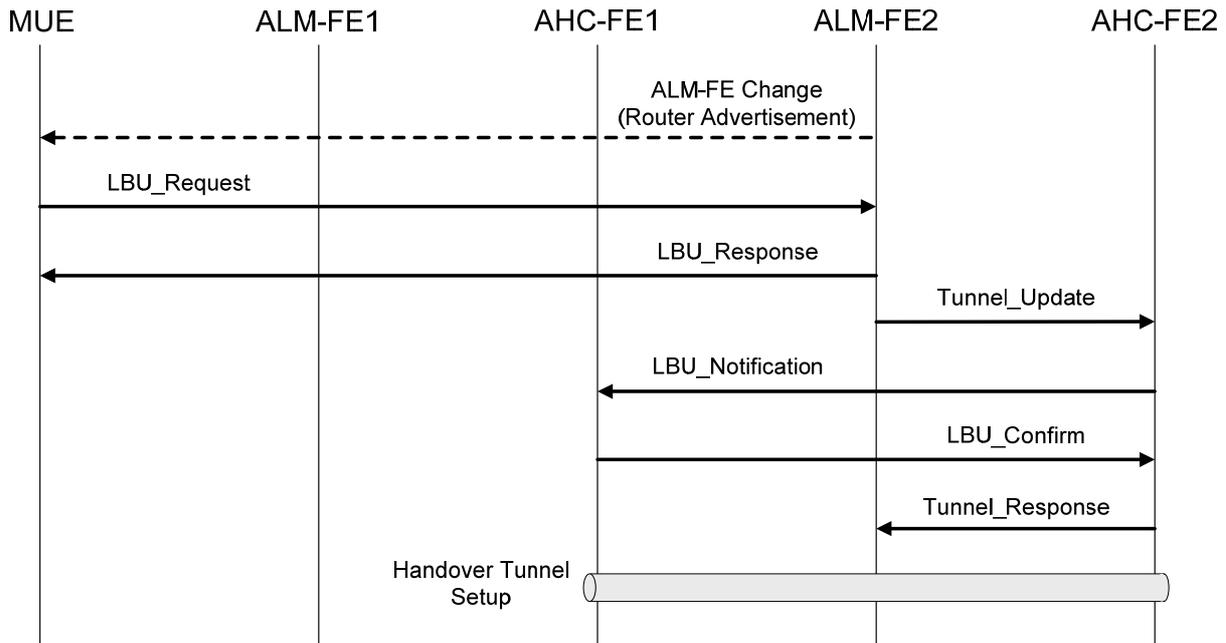
The HC procedure can be performed using a handover tunnel to minimize data packet loss during a handover. A handover tunnel is established between two endpoints controlled by the old and new AHC-FEs concerning with the handover. Figure 7-6 shows the host-based HC architecture using the handover tunnel.



**Figure 7-6: Host-based HC Architecture using Handover Tunnel**

To establish a handover tunnel between two endpoints controlled by the AHC-FEs, an MUE should always perform the LBU procedure by interacting with relevant ALM-FEs (i.e., it cannot directly interact with the CLM-FE). Two neighboring AHC-FEs exchange control messages to setup or update a handover tunnel for the MUE.

The initial connection establishment procedure of MUE follows the generic information flow presented in Figure 7-2. However, the signaling operation to establish a handover tunnel is performed between two neighboring AHC-FEs. Figure 7-7 depicts an information flow to handle an MUE's handover between two AHC-FEs' regions using a handover tunnel. We assume that the MUE was originally located in the AHC-FE1's region and then moves into the AHC-FE2's region.



**Figure 7-7: Handover Tunnel Establishment Procedure**

The MUE initiates the LBU procedure by sending an LBU\_Request message to ALM-FE2. This LBU\_Request message should contain the information to inform ALM-FE2 that the MUE has moved from the region of AHC-FE1. After replying to the LBU\_Request message, ALM-FE2 sends a Tunnel\_Update message to AHC-FE2 to establish a handover tunnel.

On receiving the Tunnel\_Update message, AHC-FE2 requests the NGN Transport Functions to setup an endpoint of the handover tunnel and sends an LBU\_Notification message to AHC-FE1. Then AHC-FE1 also requests the transport functions to setup the other endpoint of the handover tunnel. Thereafter, data packets delivered to AHC-FE1 are forwarded to AHC-FE2 through the handover tunnel. Subsequently, AHC-FE2 forwards the packets to the MUE.

Optionally, the LBU\_Request message from the MUE can be forwarded to the CLM-FE by ALM-FE2. This will enable a new data tunnel between the CHC-FE and AHC-FE2 to replace the existing data tunnel extended by the HC procedure. But this optional flow is not represented in Figure 7-7.

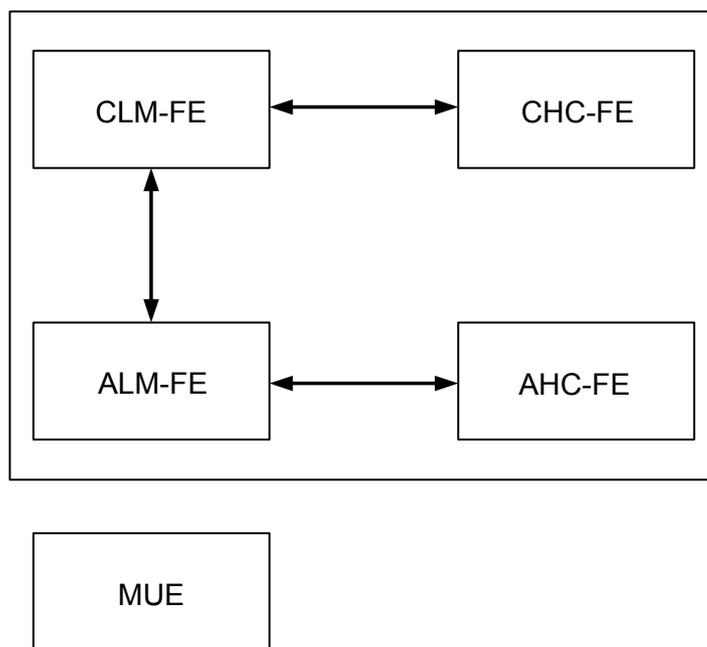
## 8 Information Flows for Network-based Handover Control

In the network-based HC scheme, an AHC-FE initiates the HC operations whenever an MUE moves into another network region (or IP subnet). The HC-FE performs the handover signaling procedure by interacting with other HC-FEs and LM-FEs relevant to the handover situation. The following two HC cases will be described in this Recommendation:

- Handover control based on the LBU operation; and
- Handover control based on the LBU notification.

## 8.1 Handover Control based on LBU Operation

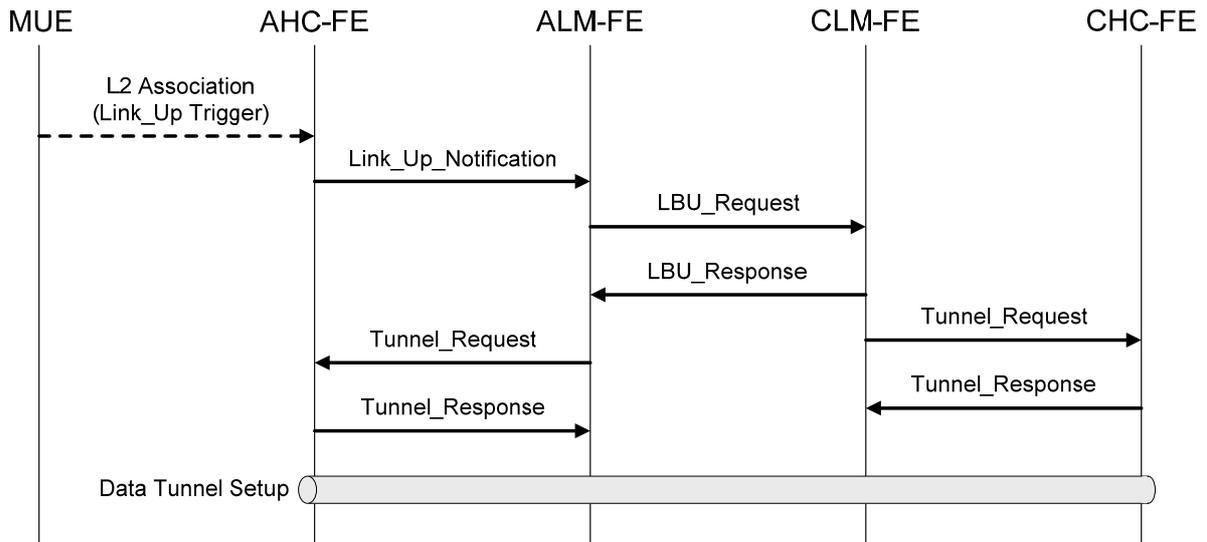
The HC procedure can be performed in a tightly coupled manner with the LBU operation between LM-FEs. In this case, only LBU\_Request/LBU\_Response messages are used for signaling of HC as well as LM between A-MMCF and C-MMCF. CHC-FE and AHC-FE control two endpoints of a tunnel to deliver data packets destined to an MUE, respectively. Figure 8-1 shows the network-based HC architecture based on the LBU operation.



**Figure 8-1: Network-based HC Architecture based on LBU Operation**

As shown in the figure, an MUE is not involved to the HC architecture since the MMCFs in the network is fully responsible for the required HC operations in the network-based scheme. An LBU\_Request message from ALM-FE informs CLM-FE of the MUE's handover situation. Thus CHC-FE and AHC-FE do not directly interact with each other. Each HC-FE has only a message interface between itself and a corresponding LM-FE.

Figure 8-2 illustrates the information flow for handling an MUE's initial connection establishment to NGN in the network-based HC scheme based on LBU operation. When the MUE is first attached to NGN, a Link\_Up event trigger will be generated from link layer and delivered to the AHC-FE responsible for the attachment. Using this trigger, the AHC-FE should know the MUE's L2 ID which is unique in NGN. An International Mobile Station Identity (IMSI) number can be an example of the MUE's unique L2 ID.



**Figure 8-2: Initial Connection Establishment for Network-based HC based on LBU Operation**

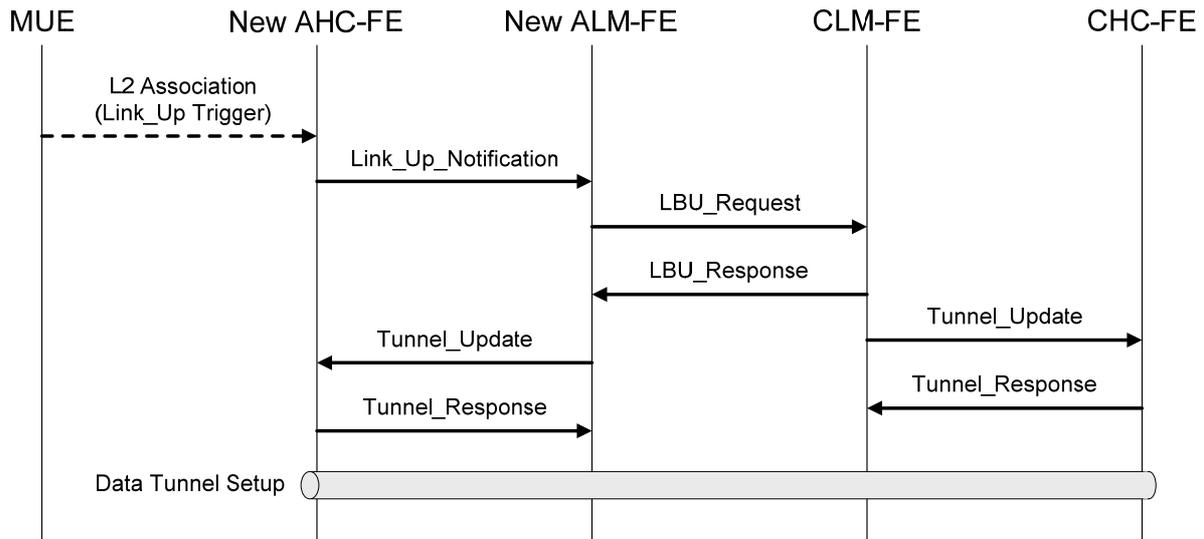
On receiving a Link\_Up trigger, the AHC-FE sends a Link\_Up\_Notification message to the ALM-FE which is included in the same A-MMCF. Then the ALM-FE initiates the LBU procedure by sending an LBU\_Request message to the CLM-FE. The Link\_Up\_Notification and LBU\_Request messages contain the MUE's unique L2 ID since it can be used to identify the MUE and to search an associated PLID. The detailed description of the initial LBU procedure is beyond the scope of this Recommendation.

In this case, a data tunnel to deliver packets to the MUE is established between two endpoints controlled by the CHC-FE and AHC-FE, respectively. This tunnel can be built when the MUE is first attached to the AHC-FE or when the HC-FEs are installed to NGN. The CLM-FE and CHC-FE exchange Tunnel\_Request and Tunnel\_Response messages with each other after an LBU\_Response message is received from the CLM-FE. This process will lead the NGN Transport Functions to setup an endpoint of a data tunnel with which the MUE is bound. If the data tunnel already exists, only a binding information of the MUE and the associated data tunnel will be created.

To simplify the description, the tunnel endpoints are illustrated as HC-FEs in Figure 8-2. However, it is noted that the real endpoints of a tunnel are NGN transport functions controlled by those HC-FEs. This simplification will be applied to all the figures presented in this clause.

After the ALM-FE receives an LBU\_Response message from the CLM-FE, the ALM-FE and AHC-FE exchange Tunnel\_Request/Response messages to setup or update another endpoint of the data tunnel. Thereafter, data packets are delivered to the MUE through the tunnel between the CHC-FE and AHC-FE.

Figure 8-3 depicts the information flow for handling an MUE's handover between two A-MMCFs' regions in the network-based HC scheme based on LBU operation. It is similar with the flow for initial connection establishment but a Tunnel\_Request message is replaced with a Tunnel\_Update message. The Tunnel\_Update message contains the information to enable the HC-FEs to distinguish the initial connection establishment and handover situations of the MUE.



**Figure 8-3: Network-based HC procedure based on LBU Operation**

When an LBU\_Request message from new ALM-FE is received, the CLM-FE updates the LID binding information of the MUE with a newly assigned TLID. Then the CLM-FE replies to the previous LBU\_Request message by sending an LBU\_Response message. Subsequently, the CLM-FE sends a Tunnel\_Update message to the CHC-FE. On receiving the Tunnel\_Update message, the CHC-FE searches and updates the data tunnel binding information of the MUE so that a new data tunnel (toward new AHC-FE) is bound by the MUE. The operation to handle a Tunnel\_Update message at the AHC-FE is equivalent to that of the initial connection establishment procedure. Finally, data packets are delivered to the MUE through the tunnel between the CHC-FE and new AHC-FE.

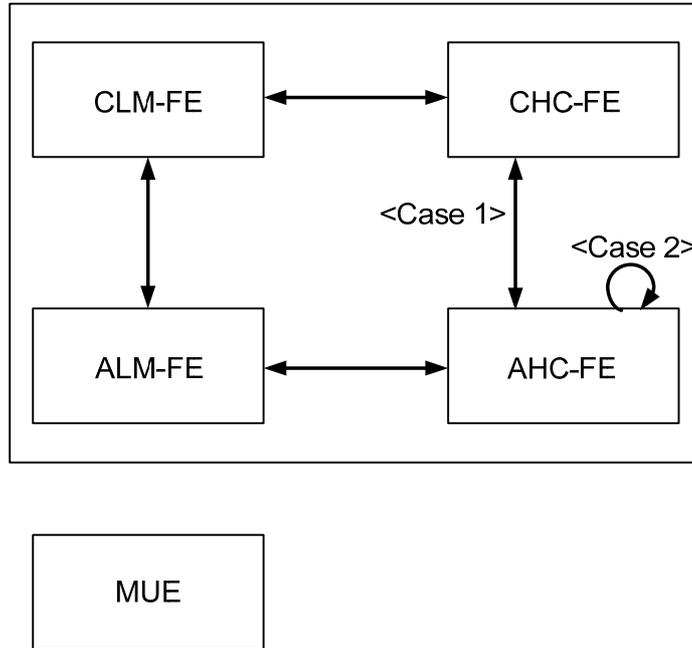
In the network-based HC scheme based on LBU operation, a data tunnel having an endpoint controlled by the CHC-FE can be optimized to reduce the overhead that all the packets delivered to MUEs are tunneled by control of the CHC-FE. The optimized data tunnel shall be established between two endpoints controlled by two corresponding AHC-FEs instead of the CHC-FE. The details of the data tunnel optimization procedure are for further study.

## 8.2 Handover Control based on LBU Notification

To escape a bottleneck at a single point (i.e., a data tunnel endpoint controlled by the CHE-FE), a data tunnel can be directly established between the endpoints controlled by AHC-FEs that two corresponding UEs are associated with. To support this, the HC procedure is performed using additional control messages such as LID Binding Query (LBQ) and LBU\_Notification message as well as LBU\_Request and Response messages.

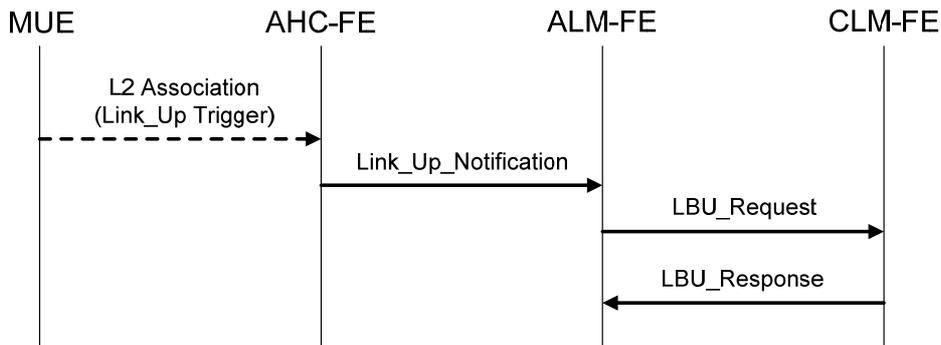
Figure 8-4 shows the network-based HC architecture based on LBU notification. Since this case provides the network-based HC operations, an MUE is not involved to the architecture. The CHC-FE and AHC-FE has an interface to interact directly with each other. When establishing a data tunnel for MUE, the AHC-FE sends an LBQ\_Request message to the CHC-FE to know the other endpoint of the tunnel (i.e., a CUE's TLID). An LBQ\_Notification message can be also delivered through this message interface to create the other endpoint of the tunnel. During the HC procedure, the CHC-FE sends LBU\_Notification messages to the relevant AHC-FEs to create or update the

data tunnel endpoints according to the handover (Case 1). Otherwise, these LBU\_Notification messages can be delivered between two corresponding AHC-FEs (Case 2).



**Figure 8-4: Network-based HC Architecture based on LBU Notification**

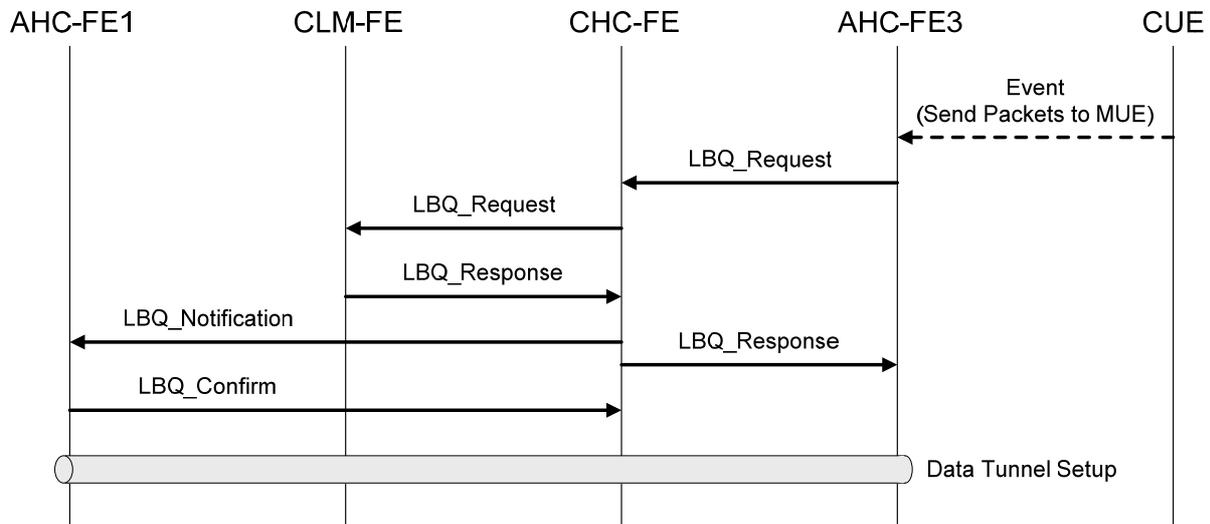
Figure 8-5 shows the information flow for handling the MUE’s initial connection establishment to NGN in the network-based HC scheme based on LBU notification. Since a data tunnel is established on demand when data packets are first delivered from CUE to MUE, the messages to establish a data tunnel are omitted from Figure 8-5.



**Figure 8-5: Initial Connection Establishment for Network-based HC based on LBU Notification**

The Link\_Up\_Notification message contains the MUE’s unique L2 ID and triggers the AHC-FE to initiate the LBU procedure. By exchanging LBU\_Request and LBU\_Response messages, LM-FEs perform the initial LBU operation for the MUE which is first attached to NGN. The detailed description of the initial LBU procedure is not in the scope of this Recommendation.

Figure 8-6 illustrates the information flow for establishing a data tunnel between two corresponding AHC-FEs to deliver packets from CUE to MUE. In the figure, we assume that the MUE is located in the AHC-FE1's region and the CUE is located in the AHC-FE3's region, respectively.

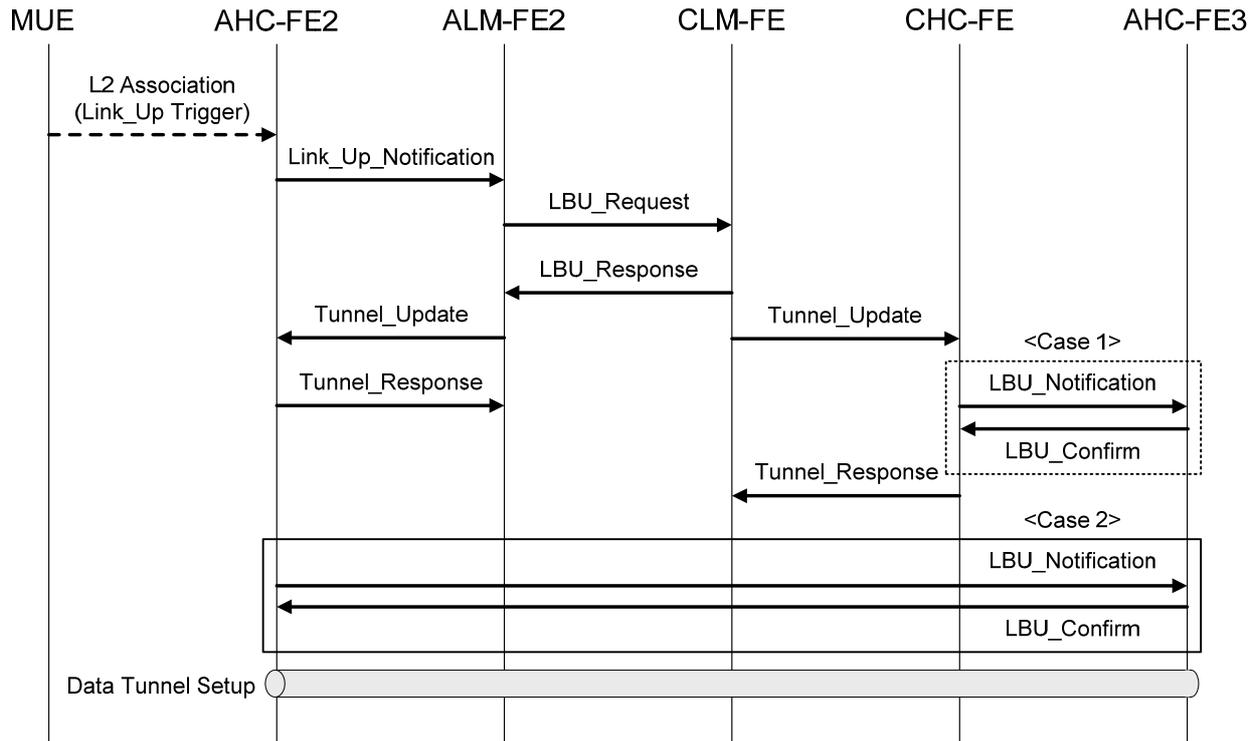


**Figure 8-6: Data Tunnel Setup for Network-based HC based on LBU Notification**

When data packets destined to the MUE's PLID are first transferred by the CUE, AHC-FE3 sends an LBQ\_Request message to the CLM-FE via CHC-FE to know the MUE's TLID (i.e., a data tunnel endpoint controlled by AHC-FE1). The CLM-FE replies to the LBQ\_Request message with an LBQ\_Response message. Then AHC-FE3 can setup a data tunnel endpoint using the MUE's TLID information contained in the LBQ\_Response message.

On the other hand, upon receiving an LBQ\_Response message from the CLM-FE, the CHC-FE sends an LBQ\_Notification message to AHC-FE1 to setup the other endpoint of the data tunnel. This LBQ\_Notification message contains the CUE's TLID (i.e., a data tunnel endpoint controlled by AHC-FE3). By completing the setup of endpoints controlled by AHC-FE1 and AHC-FE3, a bi-directional data tunnel is established to encapsulate and de-capsulate data packets between the MUE and CUE. Finally, AHC-FE1 sends an LBQ\_Confirm message to the CHC-FE as a reply of the previous LBQ\_Notification message.

Figure 8-7 illustrates the information flow for handling an MUE's handover between two AHC-FE's regions in the network-based HC scheme based on the LBU notification. The flow in the figure describes a case that the MUE handovers from the AHC-FE1's region to the AHC-FE2's region. We assume that AHC-FE3 currently controls a data tunnel endpoint associated by the CUE.



**Figure 8-7: Network-based HC procedure based on LBU Notification**

Before the CLM-FE receives an LBU\_Request message from ALM-FE2, the operations performed by the HC procedure are equivalent to those of the initial connection establishment procedure. The CLM-FE can know whether the LBU\_Request message is to handle a handover situation or the initial connection establishment of MUE. In the handover case, the CLM-FE updates the LID binding information of the MUE with a newly assigned TLID and then replies to the previous LBU\_Request message by sending an LBU\_Response message to ALM-FE2. On receiving the LBU\_Response message, ALM-FE2 and AHC-FE2 exchange Tunnel\_Request and Tunnel\_Response messages to setup an endpoint of the data tunnel for MUE.

As shown in Figure 8-7, the data tunnel update operations for AHC-FE3 can be performed by either of the following two ways.

- In Case 1, it is considered that the CHC-FE is able to know the CUE's TLID. The CHC-FE sends an LBU\_Notification message to AHC-FE3 to notify the change of the other endpoint of data tunnel. An LBU\_Confirm message is used for the reply message.
- In Case 2, it is considered that AHC-FE2 is able to receive the CUE's TLID from the old AHC-FE (i.e., AHC-FE1). AHC-FE2 sends an LBU\_Notification message to AHC-FE3 to notify the change of the other endpoint of data tunnel. An LBU\_Confirm message is used for the reply message.

## 9 Further Considerations on Handover Control

This clause describes some consideration issues for HC to be further studied.

## 9.1 Vertical Handover

One of the major requirements for MM in NGN is to support the mobility across a variety of heterogeneous access networks. In this sense, the type of handover can be classified as follows.

- Horizontal handover: a handover within homogeneous access networks.
- Vertical handover: a handover across heterogeneous access networks.

The main concern of horizontal handover is to maintain on-going service although the change of LID by movement of an MUE. In the vertical handover, the underlying access technology is also changed with the new LID of a UE. In this case, the vertical handover needs to consider the change of network characteristics (e.g., link characteristics, MM protocol types, QoS factors, etc.) as well as the change of LID. The HC scheme for vertical handover also needs to consider multiple network interfaces used by a single UE. The link layer handover may be performed in the fashion of ‘make-before-break’ as well as ‘break-before-make’. The details of vertical handover control are for further study.

The comparison between horizontal and vertical handover is given in the table below.

**Table 9-1: Comparison between horizontal and vertical handover**

	Horizontal handover	Vertical handover
Access technology	Homogeneous	Heterogeneous
Network interface	Single	Multiple

## 9.2 Inter-CN Handover

The inter-CN handover represents the handover of MUE to the different NGN network. It is noted that the inter-CN handover typically contains a lot of issues on roaming agreement, authentication and authorization, and agreement for handover support between the different NGN providers. The details of inter-CN handover are for further study.

## Appendix I – Practical Scenarios for Seamless Handover using MIH

### I.1 Seamless Real-time Services with MIH

As for the MIP-based handover, additional support is needed to realize faster handovers to allow seamless real-time services as described in Clause 5.1, “Handover and Seamless Handover”. In this clause, further practical scenarios are explored, in the framework of MM in NGN, where 2G/3G/Long Term Evolution (LTE) cellular networks and WLAN (Wi-Fi and WiMAX) handovers or internet nomadism take place. Specifically, IETF working groups like MIPv6 Signalling and Handoff Optimization (MIPSHOP) have been involved in activities related to the use of mechanisms to reduce and eliminate signalling overhead and packet loss due to handover latency incurred by MIPv6. These related issues are taken as a whole into consideration since both, link layer connectivity and layer 3 mobility management protocols interact at these two different layers

for a number of purposes; i.e., new links configuration, router discovery, and exercise new Care of Address.

Portable devices are frequently used to access the Internet while the user is moving. Handover thus becomes an important issue when users move across different access technologies, especially during active applications such as Voice over IP (VoIP), Video on Demand (VoD), IP Television (IPTV), etc. The Mobile IP protocol can achieve service continuity across different IP networks, but some delay and packet loss are intrinsic in the protocol.

Other standardization activities help to achieve faster Mobile IP handovers. One important activity is the emerging IEEE 802.21 Media Independent Handover Services standard. This standard provides lower layer enhancements to Mobile IP for IEEE 802-based technologies to enable true seamless handover.

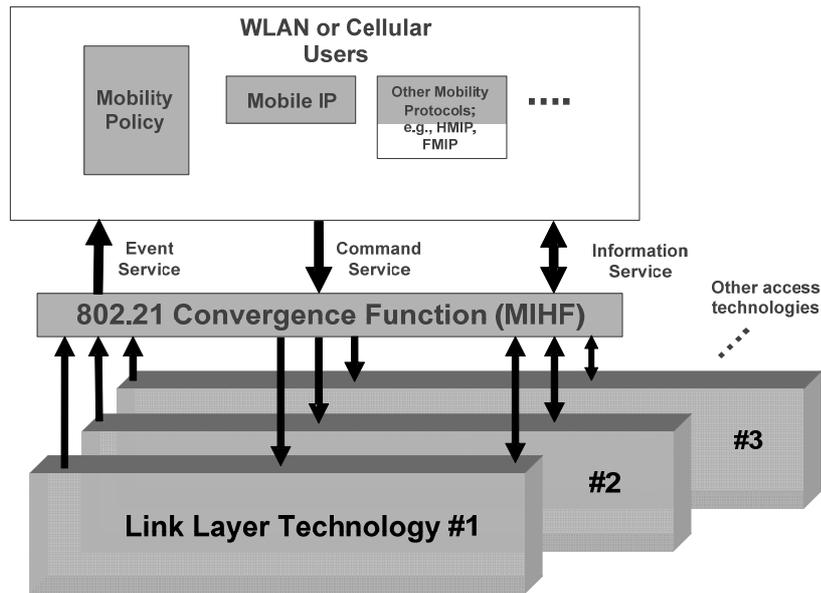
From the user point of view, a terminal can be considered a multi-functional device with one or more of the following features: wireless phone, PDA, camera, music player, web browser, TV service, Global Positioning System (GPS), etc. From a technical point of view, a terminal can be considered as a mobile device that supports an IP stack, and multiple wired or wireless access modes; e.g., radio frequency (RF) interfaces, Ethernet, infrared. Terminals must provide seamless mobility with no application interruption as a user moves between heterogeneous technologies. Thus, an efficient mobility protocol is required to handoff services across such networks with minimal delay, minimal data loss, and minimal user perception of the event.

More specifically, Mobile IP is essentially a Layer 3 (L3) protocol for terminal mobility across IP networks. IEEE 802.21 resides between Layer 2 and 3. This protocol provides lower layer support for terminal mobility across networks involving IEEE technologies such as 802.11 (Wi-Fi), 802.16 (WiMAX) and 802.3 (Ethernet), as well as 3GPP/3GPP2.

As described in Clause I.1, Mobile IP is a well known mobility protocol that maintains the network connection of a terminal despite changes in its network point of attachment. The Mobile IP protocol supports transparency above the IP layer, including maintenance of active TCP connections and UDP port bindings. However, when a terminal moves to a different type of Layer 1 (L1)/Layer 2 (L2) connection, Mobile IP alone cannot achieve seamless handover, especially for real-time services, because of the latency in setting up the new L1/L2 connection. IEEE 802.21 is a key lower layer enhancement for Mobile IP in heterogeneous environments.

IEEE 802.21 consists of a Media Independent Handover Function (MIHF), shown in Figure I-2, which provides three services to achieve efficient handover decisions.

- The Event Service (ES) notifies upper layer users about dynamic events such as Link Up, Link Down, Link Parameter change, etc.
- The Command Service (CS) enables higher layers to control the L1 and L2 of the terminals. Examples include Get Status of link, Scan for new link, Switch link, etc.
- The Information Service (IS) provides information about surrounding networks such as Neighbour List Technology, Neighbour Operator List, etc.



**Figure I-1: 802.21 MIH and Mobile IP on different access technologies**

Using this architecture, IEEE 802.21 minimizes handover latency to support real-time services by providing the following standardized services to upper layer mobility protocols such as Mobile IP:

- Triggers fast detection (discovery) of neighbouring L2 networks of different technologies;
- Detects current L2 link status;
- Quickly informs upper layers of new L2 network point of attachment;
- Allows setup of multiple L2 links for Make-Before-Break handling;
- Allows quick teardown of unused L2 links; and
- Allows QoS parameter-mapping among different access technologies.

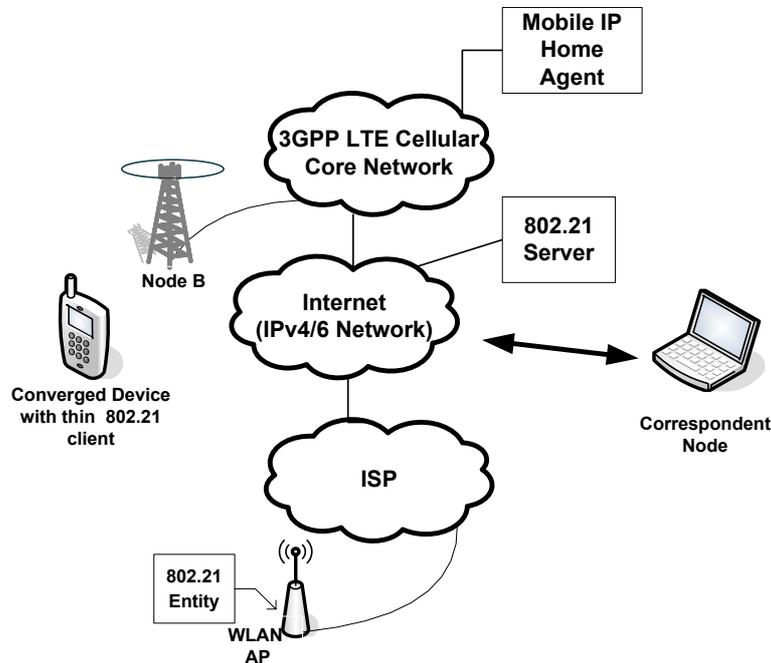
The overall result is faster handovers since the protocol specifically minimizes the time between link layer connection setups and Mobile IP signalling.

Interaction between cellular networks and WLAN technology is one of the important handover scenarios to be considered. 3GPP LTE defines the evolution of 3GPP cellular towards an “All IP” network. LTE will employ new air interface technologies, such as Orthogonal Frequency Division Multiplexing (OFDM) and Multiple-Input Multiple-Output (MIMO) for higher throughput. Both, Mobile IPv4 and Mobile IPv6 are to be supported in LTE. Detailed description of MIH signalling and data flows for WLAN-3GPP handovers can be found in other ITU-T MM Framework Recommendations.

## **1.2 MIP-based Handover based on MIH**

This clause touches two example scenarios involving 3GPP LTE and WLAN network architectural configurations based on the degree of IEEE 802.21 support in different network entities.

In the first scenario, the IEEE 802.21 network Server manages the handover process with support from the 802.21 peer in the terminal. In the second scenario, the handover is accomplished with total control by the 802.21 client in the terminal, and there is no 802.21 support anywhere else in the network.



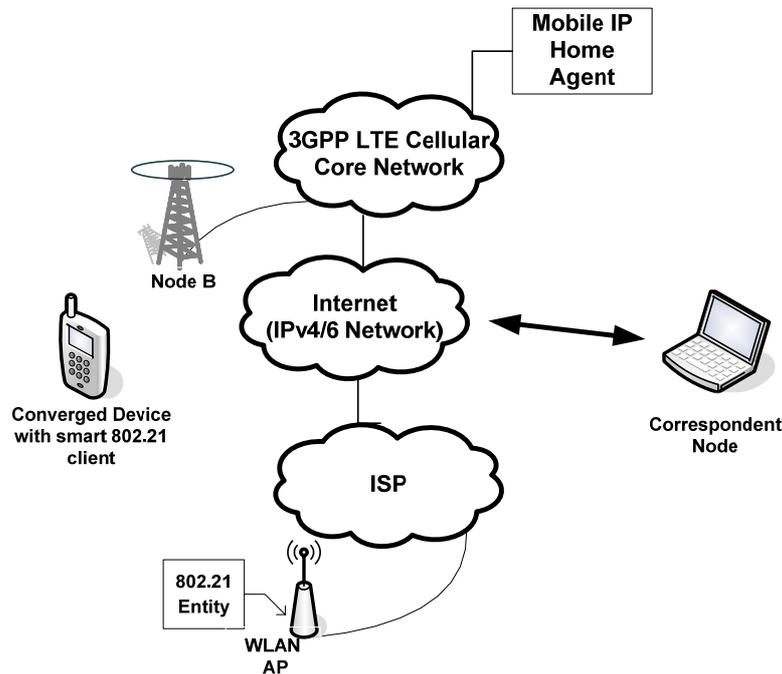
**Figure I-2: Handover between 3GPP and WLAN technologies based on MIH**

In the first scenario or network controlled handover, the inter-system handover is completely controlled by the network. In this architecture, the terminal has a thin 802.21 client. The WLAN access point (AP) also has an 802.21 entity and connects to the Internet, IPv4 or IPv6, through the local Internet Service Provider (ISP). The 3GPP LTE cellular Core Network contains the Mobile IP Home Agent and also connects to the Internet. Finally, also connected to the Internet is an 802.21 Server that is easily accessible by both the WLAN and 3GPP LTE networks via IP. Note that the 802.21 Server only needs IP connectivity to deliver its services. Hence, it could also be connected directly to the 3GPP LTE Core network - for instance as part of the IP Multimedia Subsystem (IMS) platform, or to the ISP. Also all messages between the 802.21 Server and the terminal are carried over IP packets.

From the network 802.21 Server, the terminal client 802.21 can be provided with Information such as the Neighbour List Technology. The terminal client can then be asked by the 802.21 network Server, via Commands Service, to scan the different technologies so as to identify the best possible L1/L2 network. In addition, Event Services, such as Link Going Down or Link Detected, can be used to make efficient handover decisions. Specifically the terminal can be asked to report these Events to the 802.21 network Server as a basis for making handover decisions. Finally, Commands Service such as Switch Link can be sent by the 802.21 network Server to the terminal client to execute the L1/L2 handover.

In the second scenario or terminal controlled handover, the terminal contains a “smart” 802.21 client that fully controls the inter-technology handover process. The WLAN AP, via the ISP, connects to the Internet, IPv4 or IPv6, which also has the 3GPP LTE cellular Core Network

connected to it. The 3GPP LTE network also contains the Mobile IP Home Agent. However, note that there are no 802.21 entities anywhere outside the terminal.



**Figure I-3: Terminal Controlled Handover between 3GPP and WLAN Technologies**

In this architecture, all the 802.21 services are generated locally and are exchanged between the different layers of the terminal. Upper layer Command Services can be used to gather link status using the Get Status Command. Lower layers can report new link detection with the Link\_Detected Event or can relay predictive Events about link degradation with the Link\_Going\_Down Event Service. These services are locally provided within the terminal without any service support from an 802.21 network entity.

In the above two scenarios emphasis is given to “All IP” networks such as 3GPP LTE cellular and WLAN. This type of MM will require the interaction of mobility protocols at different layers to achieve seamless handovers across heterogeneous networks. While Mobile IP supports mobility at the network level, the emerging IEEE 802.21 standard provides standardized L1/L2 enhancements which will enable faster inter-technology handovers. IEEE 802.21 can complement Mobile IP for cellular-WLAN mobility.

## **Appendix II – Advanced Issues for Handover Control**

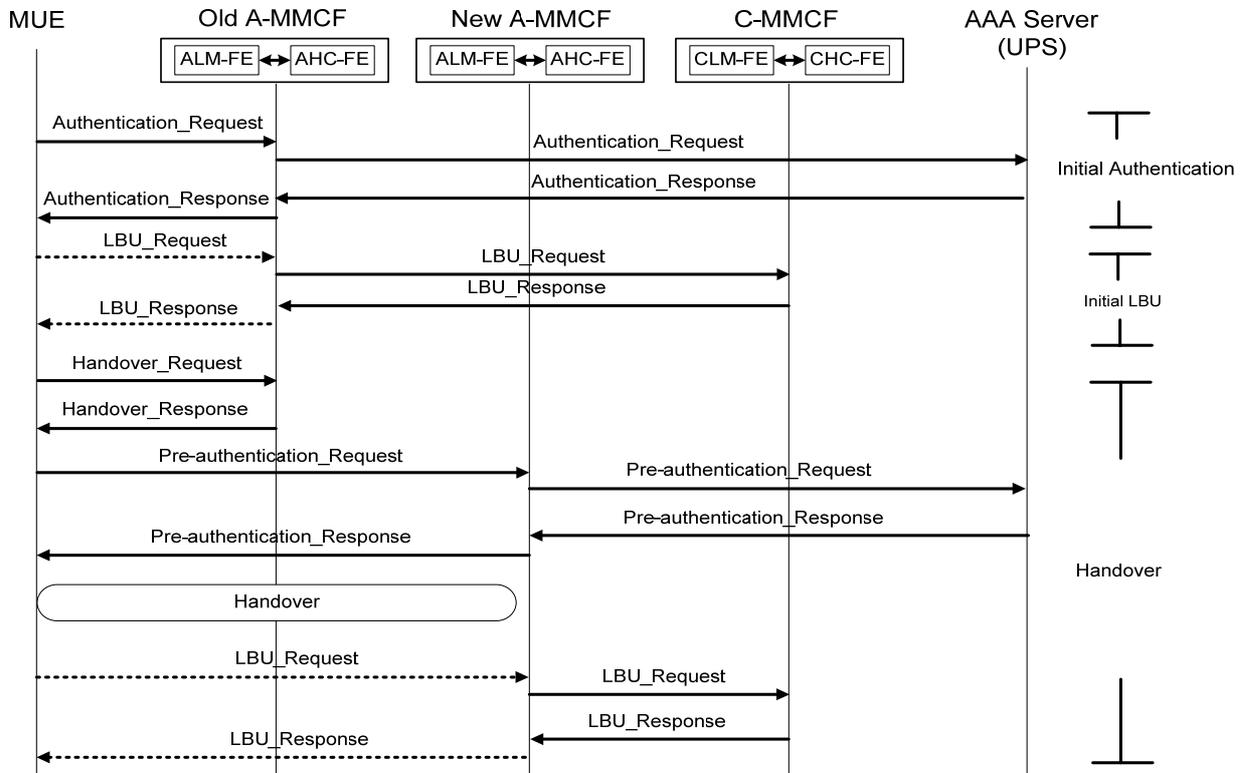
### **II.1 Authentication Procedure for Fast Handover**

Network access authentication and authorization capabilities are needed to mitigate threats associated with unauthorized access by verifying the identities and determining whether access should be granted to Customer Premise Equipment (CPE) and Customer Premise Equipment – Border Element (CPE-BE) requesting network connectivity to NGN.

When an MUE turns on the power and initially connects to an access network, an authentication procedure should be performed. Moreover, when the MUE performs the handover to new access network, the authentication procedure has to be performed. The handover of the MUE between different access networks incurs the delay time including the re-authentication procedure. Here, many discussions have been recently reached with the key issue of the mobility management for the seamless service offer to reduce the delay by the authentication procedure during handover. For reducing the delay, it could have the various methods.

For example, pre-authentication method performs the authentication procedure before the MUE's movement. It is efficient to reduce the delay by the authentication procedure during handover. The MUE requests its pre-authentication to neighboring access functions, and each neighboring access function performs pre-authentication procedure in advance. Pre-authentication method is optional to reduce the delay time of the authentication during handover. There are two approaches in pre-authentication method for handover: a pre-authentication method via AAA server and a pre-authentication method using context transfer otherwise. In Figure II-1 to 3, these consider the network-based MM as well as the host-based MM. In case of the host-based MM, the MM signaling is shown in dotted line from the MUE. And then, in case of the network-based MM, the MM signaling is shown in line from the A-MMCF.

Figure II-1 shows pre-authentication procedure via the AAA server for fast handover. At first, the MUE requests its handover to old A-MMCF in advance, and old A-MMCF responses with candidates of new A-MMCF. Then, the MUE requests pre-authentication to the AAA server via new A-MMCF. The AAA server performs pre-authentication procedure. After the pre-authentication of the MUE, the MUE can move to the new A-MMCF without delay time.

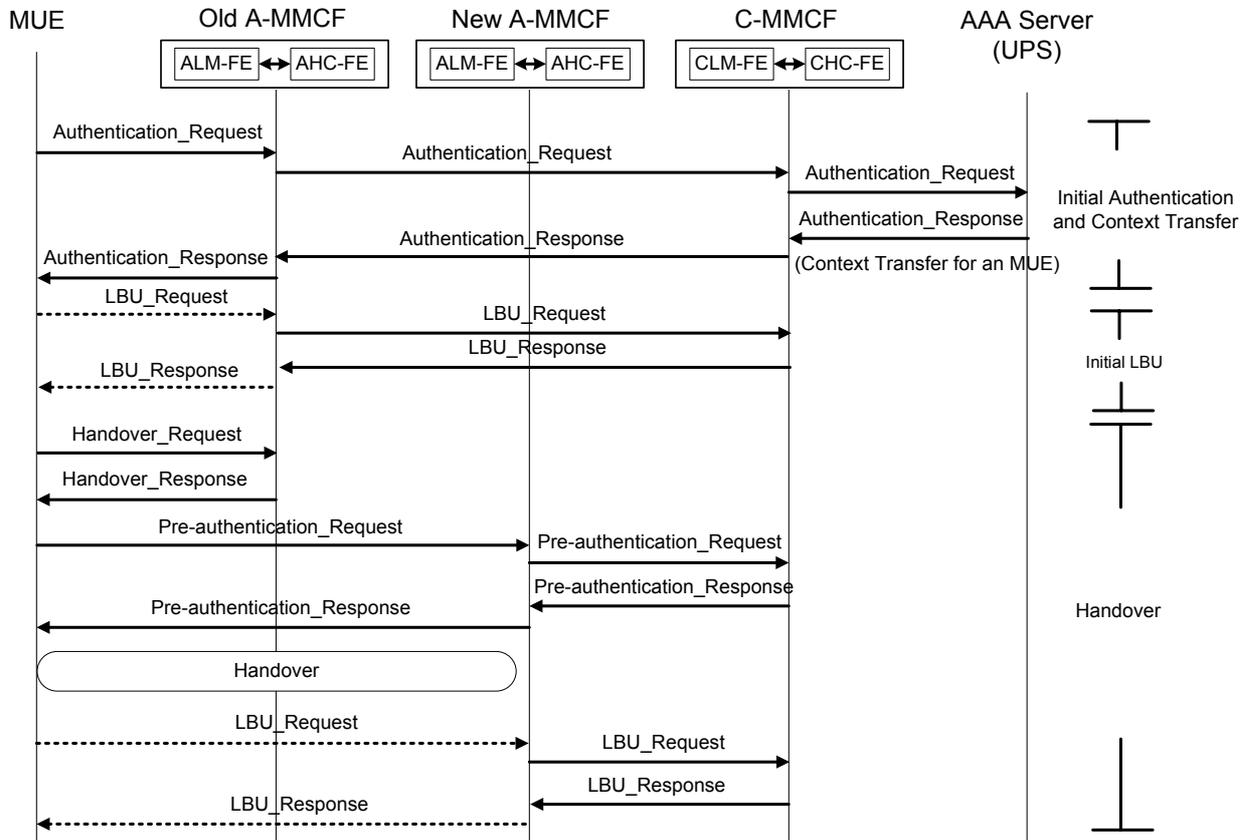


**Figure II-1: Pre-authentication Procedure**

The context transfer method can be considered as the alternative method for fast authentication. The authentication contexts of a MUE may be transferred from the AAA server to relevant MMCFs. Thereafter, the authentication process for the MUE can be performed by the MMCFs using the authentication contexts received from either the AAA server or neighbor MMCFs.

Pre-authentication method using context transfer is divided into two cases (Case 1 and Case 2) as follows. These are considered in case that the handover of the MUE occurs within the same core network.

Figure II-2 shows one of the pre-authentication procedures using context transfer for fast handover. In this case, the CHC-FE in C-MMCF substitutes for the function of AAA server. The authentication contexts of the MUE may be transferred from the AAA server to the C-MMCF during initial authentication procedure. Thereafter, the CHC-FE in the C-MMCF helps the authentication process for the MUE by using the received contexts in case that the MUE moves to another network region within the same core network. For this, the C-MMCF needs to have the function that stores the information about the MUE received from the AAA server.



**Figure II-2: Pre-authentication procedure using Context Transfer (Case 1)**

Figure II-3 shows another pre-authentication procedure using context transfer for fast handover. In this case, the AHC-FE in A-MMCF substitutes for the function of AAA server. The authentication contexts of the MUE may be transferred from the AAA server to the C-MMCF during initial LBU procedure. If the information of new A-MMCF can be informed to C-MMCF in the process where the MUE starts the handover through the old A-MMCF, the authentication context of the MUE may be transferred from the C-MMCF to the new A-MMCF. Thereafter, the AHC-FE in new A-MMCF

helps the authentication process for the MUE by using the received contexts in case that the MUE moves to another network region within the same core network. For this, the A-MMCF needs to have the function that stores the information about the MUE received from the C-MMCF. This accelerates the authentication process for the MUE's handover by reducing the signaling latency between the MUE and the AAA server.

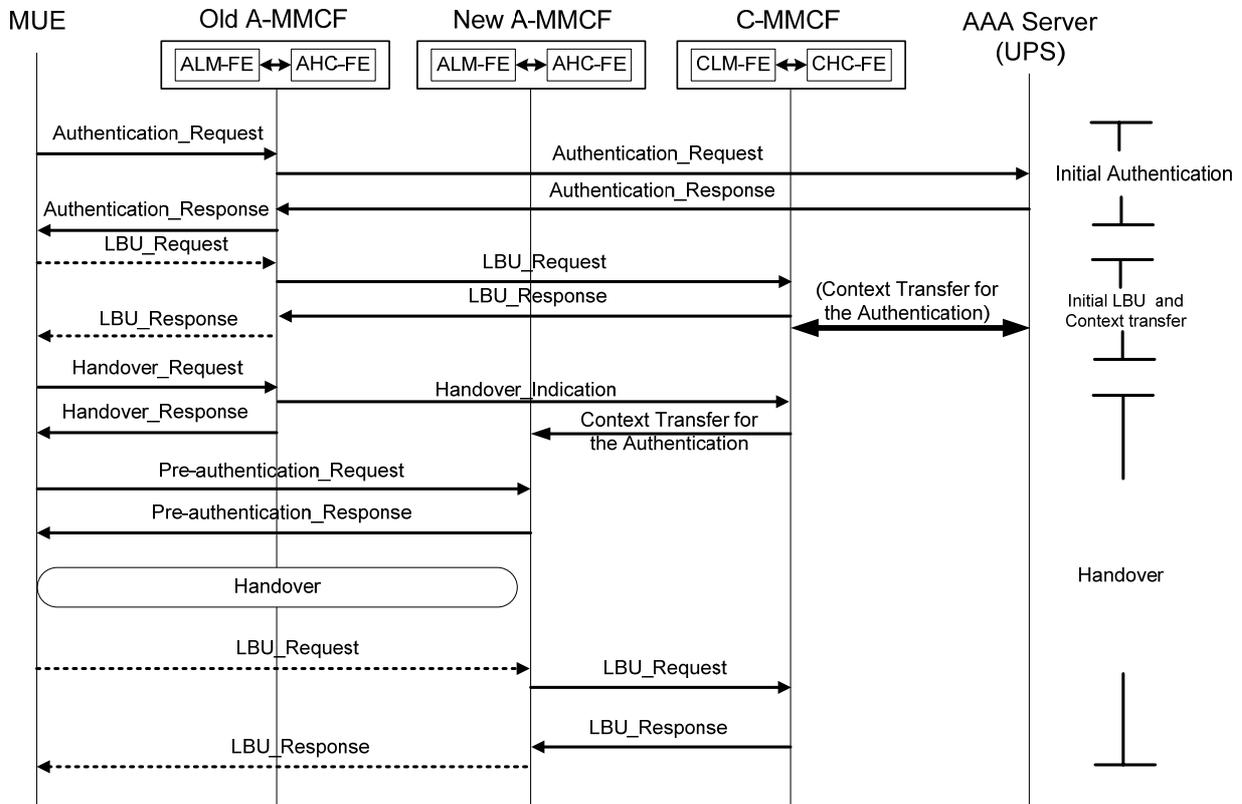


Figure II-3: Pre-authentication procedure using Context Transfer (Case 2)

## II.2 Policy-based Handover Control

The NGN has many access networks and an MUE wants to access the best network for service. The policy-based HC relates to network selection and handover decision. The network selection and handover decision could be controlled by a user/operator policy. The core network in NGN has a kind of policy entity. ITU-T Y.2111 defines Policy Decision Functional entity (PD-FE) and Policy Enforcement Functional entity (PE-FE) for support QoS but it could be extended for mobility management policy.

The PD-FE, which is placed at the Service/Transport Control Function in the core, decides policy rules, it handles network selection for the UE and triggers handover. The PE-FE, which is placed at the MUE, it triggers handover and performs handover according to received policy rules.

The HC procedure is divided into two cases: host-based and network-based handovers. In the former, the host-based handover, the MUE triggers a handover based on received signal strength or QoS level required for a particular service. In the case of the later, the network based-handover, the network (i.e., A-MMCF) triggers a handover based on current network states such as traffic load or operator's policies. The details of policy-based handover are for further study.

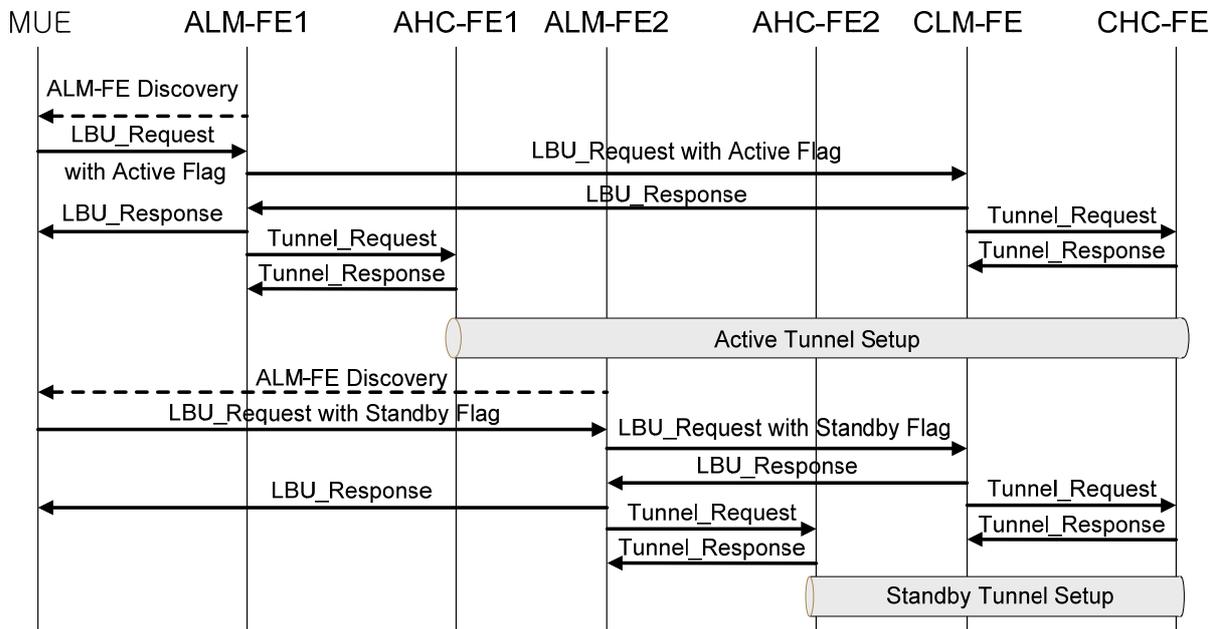
### II.3 Fast Handover Control for Multi-interfaced MUE

An MUE may have multiple interfaces to maintain durable and wide area network connectivity. Depending on the user preference or network environment, only one interface or multiple interfaces can be used at one time. The multiple interfaces in an MUE can be utilized efficiently to minimize the handover delay. ‘Make-before-break’ handover can be achieved by activating a new interface before breaking the current active interface.

If multiple interfaces are active and simultaneously used for data traffic delivery, the data traffic from an interface can be handed over to another active interface(s). However, if only one interface is active at one time, at least one of the other interfaces can be prepared to receive the data traffic seamlessly as fast as possible after detecting the current active interface is about to go down. The preparation in this context may include TLID (IP address) allocation, LID binding update, and data tunnel creation, which allow a fast handover by just switching one data tunnel to the other one.

This clause presents an example scenario for an MUE with two interfaces. In the example, one interface (active) is used to deliver the data traffic while the other one (standby) is just prepared to deliver the data traffic when the active interface is about to go down. As shown in the generic handover procedures in Clause 7.1 of this Recommendation, there are two possible cases depending on the location of two tunnel endpoints.

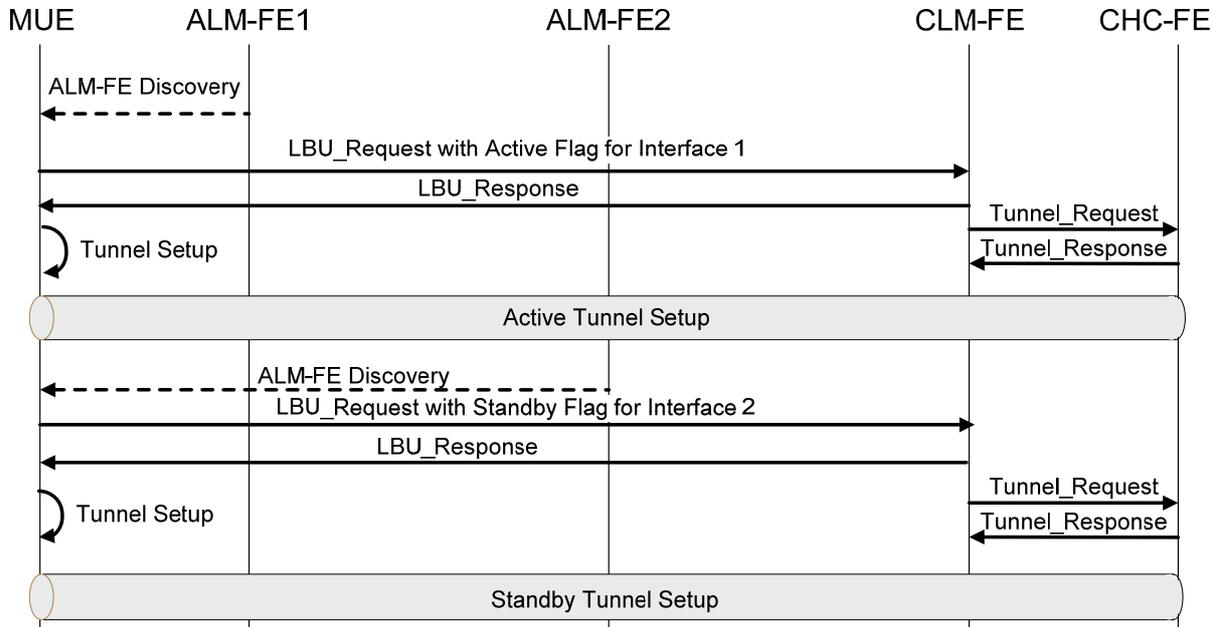
The flow in Figure II-4 shows the case that a data tunnel for an MUE is established between two endpoints controlled by the CHC-FE and AHC-FE (Case 1). For each interface, the procedure is the same as in Figure 7-2. The difference from Figure 7-2 is that the LBU procedure and tunnel setup are done for each interface.



**Figure II-4: Initial Connection Establishment for a MUE with Multiple Network Interfaces (Case 1)**

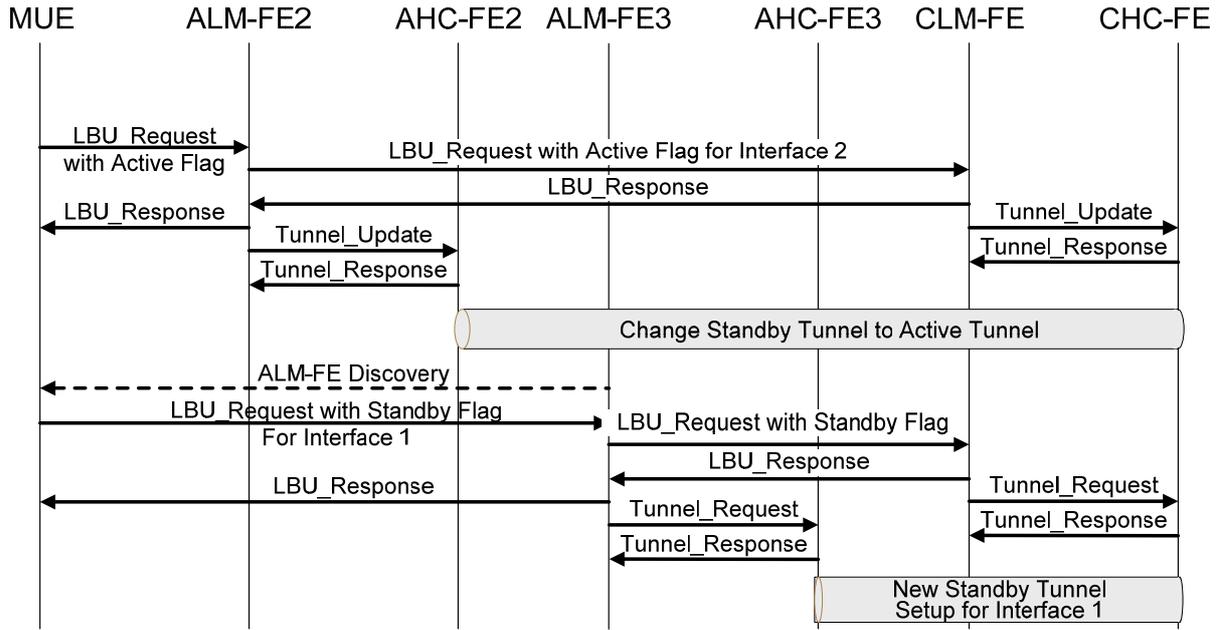
To simplify the description, the tunnel endpoints are illustrated as HC-FEs in Figure II-4. However, it is noted that the real endpoints of a tunnel are NGN transport functions controlled by those HC-FEs. This simplification will be applied to all the figures presented in this clause.

Figure II-5 shows the case that a data tunnel for an MUE is established between an MUE and an endpoint controlled by the CHC-FE (Case 2). For each interface, the procedure is the same as in Figure 7-3. The difference from Figure 7-3 is that the LBU procedure and tunnel setup are done for each interface.



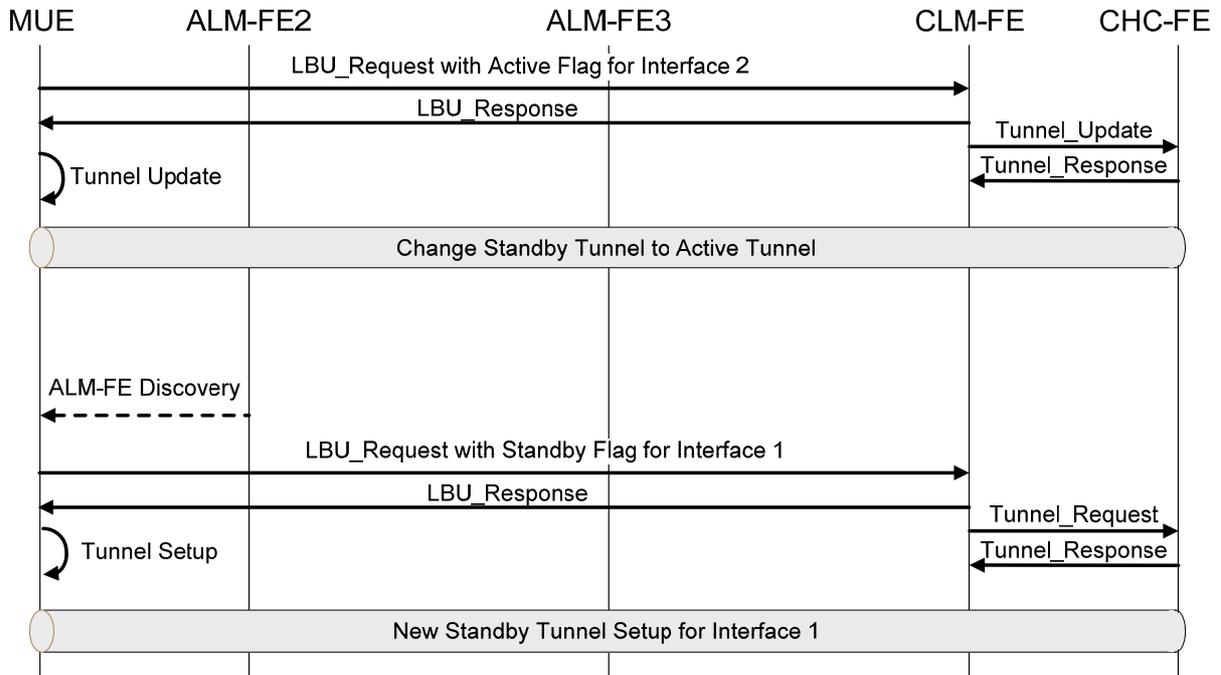
**Figure II-5: Initial Connection Establishment for a MUE with Multiple Network Interfaces (Case 2)**

Figure II-6 illustrates an information flow to control an MUE's handover between two A-MMCFs' regions for the MUEs with multiple interfaces. It describes the case that two data tunnels for an MUE are established between an endpoint controlled by the CHC-FE and AHC-FE1 and also between an endpoint controlled by the CHC-FE and AHC-FE2 (Case 1). If an active interface (interface 1 in the example) goes down, one of standby interface (interface 2 in the example) goes up to be an active interface. Then, if the previous active interface (interface 1) attached to the other access network (ALM-FE3), the MUE will proceed with LBU procedure to setup a tunnel between the endpoints controlled by AHC-FE3 and CHC-FE.



**Figure II-6: HC Procedure for a MUE with Multiple Network Interfaces (Case 1)**

Figure II-7 shows another information flow for the MUEs with multiple interfaces. It represents the case that two data tunnels for an MUE are established through each interface between an MUE and an endpoint controlled by the CHC-FE (Case 2). If an active interface (interface 1 in the example) goes down, one of standby interface (interface 2 in the example) goes up to be an active interface. Then, if the previous active interface (interface 1) attached to the other access network (ALM-FE3), the MUE will proceed with LBU procedure to setup a new tunnel between MUE and CHC-FE.



**Figure II-7: HC Procedure for an MUE with Multiple Network Interfaces (Case 2)**

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