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SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS AND NEXT-GENERATION NETWORKS

Next Generation Networks – Generalized mobility

Mobility management for interworking between WiMAX and UMTS

Recommendation ITU-T Y.2812

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Recommendation ITU-T Y.2812

Mobility management for interworking between WiMAX and UMTS

Summary

Recommendation ITU-T Y.2812 describes the mobility management framework for interworking between WiMAX and UMTS networks. The mobility management framework in this Recommendation focuses on vertical handover control in the transport stratum of next generation networks (NGNs) when a user equipment with multiple interfaces moves across those two different wireless access networks. The requirements, functional architecture and procedural information flows are given to specify the vertical handover control functionality.

History

Edition	Recommendation	Approval	Study Group
1.0	ITU-T Y.2812	2012-07-29	13

Keywords

Mobility management, NGN, UMTS, vertical handover, WiMAX.

FOREWORD

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Introduction

This Recommendation describes the mobility management (MM) architecture between WiMAX and UMTS technologies in next generation networks (NGNs). This work has been motivated from the observation that NGN continues to evolve toward the accommodation of various wireless access technologies. Accordingly, it is required to specify the detailed architecture and procedures to practically apply the NGN MM framework to the environment accommodating those various access technologies.

The MM architecture in this Recommendation is designed on the basis of the MM framework for NGN, which is described in the following Recommendations:

- ITU-T Q.1707/Y.2804: Generic framework of mobility management for next generation networks [ITU-T Q.1707];
- ITU-T Q.1708/Y.2805: Framework of location management for NGN [ITU-T Q.1708];
- ITU-T Q.1709/Y.2806: Framework of handover control for NGN [ITU-T Q.1709];
- ITU-T Y.2018: Mobility management and control framework and architecture within the NGN transport stratum [ITU-T Y.2018].

Recommendation ITU-T Y.2812

Mobility management for interworking between WiMAX and UMTS

1 Scope

This Recommendation describes the mobility management (MM) framework for interworking between WiMAX and UMTS networks where each access network would be operated by different service providers or different network management systems. In this Recommendation, the functional architecture focuses on IP mobility support for user equipment (UE) moving between those two different access networks. The functional architecture described in this Recommendation may be referred as a building block to be used to extend toward the other wireless access networks in next generation networks (NGNs).

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.

[ITU-T G.1000] Recommendation ITU-T G.1000 (2001), *Communications quality of service: A framework and definitions*.

[ITU-T Q.1706] Recommendation ITU-T Q.1706/Y.2801 (2006), *Mobility management requirements for NGN*.

[ITU-T Q.1707] Recommendation ITU-T Q.1707/Y.2804 (2008), *Generic framework of mobility management for next generation networks*.

[ITU-T Q.1708] Recommendation ITU-T Q.1708/Y.2805 (2008), *Framework of location management for NGN*.

[ITU-T Q.1709] Recommendation ITU-T Q.1709/Y.2806 (2008), *Framework of handover control for NGN*.

[ITU-T Y.2001] Recommendation ITU-T Y.2001 (2004), *General overview of NGN*.

[ITU-T Y.2011] Recommendation ITU-T Y.2011 (2004), *General principles and general reference model for Next Generation Networks*.

[ITU-T Y.2012] Recommendation ITU-T Y.2012 (2010), *Functional requirements and architecture of next generation networks*.

[ITU-T Y.2018] Recommendation ITU-T Y.2018 (2009), *Mobility management and control framework and architecture within the NGN transport stratum*.

[ITU-T Y.2701] Recommendation ITU-T Y.2701 (2007), *Security requirements for NGN release 1*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 functional architecture [ITU-T Y.2012]: A set of functional entities and the reference points between them used to describe the structure of an NGN. These functional entities are separated by reference points, and thus, they define the distribution of functions.

NOTE – The functional entities can be used to describe a set of reference configurations. These reference configurations identify which reference points are visible at the boundaries of equipment implementations and between administrative domains.

3.1.2 functional entity [ITU-T Y.2012]: An entity that comprises an indivisible set of specific functions. Functional entities are logical concepts, while groupings of functional entities are used to describe practical, physical implementations.

3.1.3 host-based mobility management [ITU-T Q.1707]: A mobility management scheme in which the MM signalling is performed based on (or controlled by) the user equipment (UE).

3.1.4 network-based mobility management [ITU-T Q.1707]: A mobility management scheme in which the MM signalling is performed (or controlled) by the network entities, on behalf of the UE.

3.1.5 next generation network [ITU-T Y.2001]: A packet-based network able to provide telecommunication services and able to make use of multiple broadband, QoS-enabled transport technologies and in which service-related functions are independent from underlying transport-related technologies. It enables unfettered access for users to networks and to competing service providers and/or services of their choice. It supports generalized mobility which will allow consistent and ubiquitous provision of services to users.

3.1.6 mobility [ITU-T Q.1706]: The ability for the user or other mobile entities to communicate and access services irrespective of changes of the location or technical environment.

3.1.7 mobility management [ITU-T Q.1706]: The set of functions used to provide mobility. These functions include authentication, authorization, location updating, paging, download of user information and more.

3.1.8 quality of service [ITU-T G.1000]: The collective effect of service performances, which determine the degree of satisfaction of a user of the service.

3.1.9 transport stratum [ITU-T Y.2011]: That part of the NGN which provides the user functions that transfer data and the functions that control and manage transport resources to carry such data between terminating entities (see also clause 7.1 of [ITU-T Y.2011]).

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AAA	Authentication, Authorization and Accounting
ABG-FE	Access Border Gateway Functional Entity
AN	Access Network
AN-FE	Access Node Functional Entity
AP	Access Point

AR-FE	Access Relay Functional Entity
ASN	Access Service Network
BBM	Break-Before-Make
BCE	Binding Cache Entry
BS	Base Station
CCoA	Co-located CoA
CMIP	Client Mobile IP
CN	Correspondent Node
CoA	Care-of-Address
DHCP	Dynamic Host Configuration Protocol
GGSN	Gateway GPRS Supporting Node
GPRS	General Packet Radio Service
HA	Home Agent
HDC-FE	Handover Decision and Control Functional Entity
HoA	Home Address
IBG-FE	Interconnection Border Gateway Functional Entity
IMSI	International Mobile Subscriber Identity
IP	Internet Protocol
L2HE-FE	Layer 2 Handover Execution Functional Entity
L3HEF	Layer 3 Handover Execution Function
LMA	Local Mobility Anchor
MAG	Mobile Access Gateway
MBB	Make-Before-Break
MIH	Media Independent Handover
MIIS	MIH Information Server
MIP	Mobile IP
MLM-FE	Mobility Location Management Functional Entity
MM	Mobility Management
MMCF	Mobility Management and Control Function
MUE	Mobile UE
NACF	Network Attachment Control Function
NAC-FE	Network Access Configuration Functional Entity
NGN	Next Generation Network
NID-FE	Network Information Distribution Functional Entity
PDN	Packet Data Network
PDP	Packet Data Protocol
PMA	Proxy Mobile Agent

PMIP	Proxy MIP
PRRP	Proxy RRP
PRRQ	Proxy RRQ
QoS	Quality of Service
RNC	Radio Network Controller
RRP	Registration Reply
RRQ	Registration Request
SAE	System Architecture Evolution
SGSN	Serving GPRS Supporting Node
TUP-FE	Transport User Profile Functional Entity
UE	User Equipment
UMTS	Universal Mobile Telecommunications System
WiMAX	Worldwide Interoperability for Microwave Access

5 Conventions

None.

6 Requirements for WiMAX and UMTS interworking

6.1 Harmonization with IP-based core networks

The NGN is envisaged to be IP-based. Accordingly, the mobility management (MM) protocols for NGN should be IP-based or, at least, well-harmonized with IP technology for its efficient and integrated operation in such future networks [ITU-T Q.1706].

In the NGN environment, various access networks could be interconnected to each other through the IP-based core network. Therefore, the MM architecture between WiMAX and UMTS networks also should be designed to be easily applied to IP-based networks and services.

6.2 Service continuity

The MM architecture for WiMAX-UMTS interworking should support seamless handover control functions to maintain session continuity of a user equipment (UE) moving between different access networks (ANs). Furthermore, those handover control mechanisms should provide fast handovers to support non-real time and real time service continuity (e.g., file downloading, VoIP and video streaming).

To support service continuity during a handover, a UE's attachment change between different ANs should be hidden to the service/application layer by IP-based MM mechanisms. It is also required to reduce the communication service disruption due to a handover into the range that does not terminate ongoing services.

6.3 QoS support

The MM mechanisms for WiMAX-UMTS interworking could support QoS-guaranteed handovers to provide seamless real time multimedia services such as VoIP and IPTV, as well as conventional best-effort services. However, the required level of QoS could be different according to the types of ANs, service characteristics, user requirements and handover policy of operators.

Occasionally, after detecting the presence of both WiMAX and UMTS networks, it should be possible for a user to choose to connect to one of the networks based on the QoS policies driven by service characteristics and user requirements. That is, a UE should be able to dynamically change its connection from one attachable AN to another according to the QoS level needed for a particular service (e.g., bandwidth availability, time delay, packet loss ratio, etc.).

6.4 Service compatibility

To support a UE's mobility within a single AN, the operators are likely to use their own MM mechanisms designed for a specific access technology. Thus the MM mechanism for NGN must be able to effectively harmonize with those existing MM protocols for various ANs. Especially, the MM mechanism for WiMAX-UMTS interworking should be well harmonized with the existing intra-AN MM architectures for WiMAX and UMTS networks which were developed by other SDOs (e.g., 3GPP/3GPP2, WiMAX Forum, etc.).

6.5 Service context transfer

When a UE moves across different ANs, the context information of ongoing sessions, including QoS level, security method, AAA mechanism and data compression type in use, might be helpful in performing a vertical handover. The information can be used to minimize the latency involved in handing the session over to new serving entities. The proper use of context transfer mechanism could substantially reduce the amount of overhead in the servers required to support QoS, security, AAA, and so on.

6.6 Interworking with the established AAA and security schemes

The MM protocols for NGN must specify how a user (or UE) is authenticated, authorized, accounted and secured for services using the standard authentication, authorization and accounting (AAA) and security mechanisms. [ITU-T Q.1706].

Because the operators generally have their own AAA and security schemes for their access networks, the MM architecture for interworking between different access technologies in NGN should carefully consider the compatibility with those existing AAA and security schemes.

6.7 Policy-based and dynamic network selection

The NGN could support a user to choose to connect to one of the attachable ANs based on QoS level, cost, security level, etc. When a UE moves between WiMAX and UMTS networks, the MM architecture for interworking between those networks should allow the UE to choose a target AN for handover according to the pre-defined user/operator policy or by the dynamic selection procedure.

7 Functional architecture for interworking between WiMAX and UMTS

This clause describes the functional architecture for interworking between WiMAX and UMTS networks, which is harmonized with the NGN architecture. Figure 7-1 shows the high-level functional architecture to accommodate WiMAX and UMTS network components into the NGN MM architecture. The general NGN architecture shown has been simplified in order to better focus on the objectives of this Recommendation.

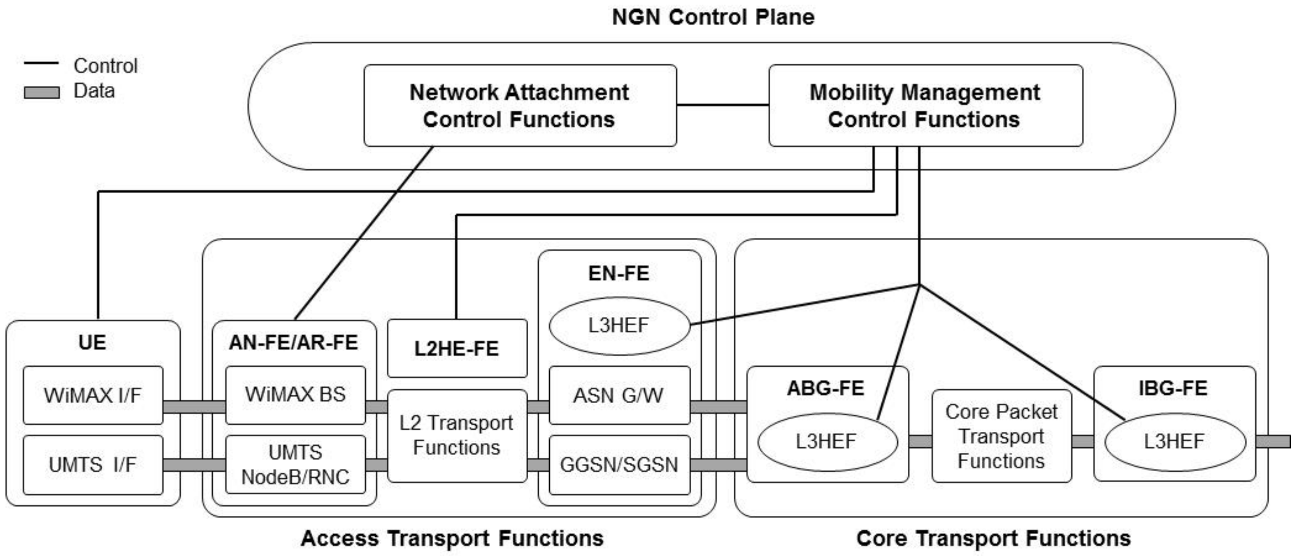

Figure 7-1 – Functional architecture for interworking between WiMAX and UMTS

7.1 Access transport function

The access transport functions manage a UE's attachment to each access network as well as collect and aggregate traffic from various access networks, and then merge them into the core transport network. These functions typically interact with the network attachment control functions (NACFs) and the mobility management and control function (MMCF) to support IP mobility in the transport stratum in NGN.

7.1.1 Access node functional entity (AN-FE)

The access node functional entity (AN-FE) in the access network directly connects to UEs and terminates the first/last hop wireless link signals at the network side. Generally, it is located at layer 2 devices such as WiMAX base station (BS) or UMTS Node B/RNC.

7.1.2 Layer 2 handover execution functional entity (L2HE-FE)

The layer 2 handover execution functional entity (L2HE-FE) takes access technology specific actions as required in order to preserve flow continuity during handover. The L2HE-FE completes handover execution in the direction toward a UE when it has determined that the UE has executed a handover. The L2HE-FE resides in the access transport functional block as specified in [ITU-T Y.2018].

7.1.3 Edge node functional entity (EN-FE)

The edge node functional entity (EN-FE) in the access transport functional block connects to core packet transport functions and terminates the layer 2 access sessions with the end-user functions. To connect the layer 2 sessions to IP-based core transport functions, it shall be a layer 3 device with IP forwarding capabilities such as the ASN gateway in WiMAX network or GGSN/SGSN in UMTS network. The EN-FE can optionally support media independent handover (MIH) functions to increase the efficiency of handover control.

7.2 Core transport function

The core transport functions are responsible for ensuring data transport throughout the core network. They can provide a means to differentiate the quality of data transport in the core network. These functions can also provide QoS support mechanisms dealing directly with user traffic, including buffer management, queuing and scheduling, packet filtering, traffic classification, marking, policing, shaping, gate control and firewall capability.

7.2.1 Interconnection border gateway functional entity (IBG-FE)

The interconnection border gateway functional entity (IBG-FE) is a packet gateway used to interconnect an operator's core transport network with another operator's core transport network that supports the packet-based services. There may be one or multiple IBG-FEs in a single core transport network according to its interconnection topology.

7.2.2 Access border gateway functional entity (ABG-FE)

The access border gateway functional entity (ABG-FE) is a packet gateway between an access network and a core transport network. It is used to mask a service provider's network from access networks through which end-user functions are accessing packet-based services. For example, the PDN gateway in 3GPP SAE architecture can be located at the ABG-FE's position in NGN.

7.3 Interworking for handover support

For MM in NGN, the layer 3 handover execution function (L3HEF) resides in the access transport and core transport functional blocks. It performs the commands from the MMCF to:

- execute tunnel set up, modification and takedown during handover;
- buffer user packets as required to preserve flow continuity during handover;
- following handover, encapsulate user packets received from the UE (at the tunnel lower end in the case of network-based mobility) or from correspondent nodes (at the tunnel upper end) and forward them through the tunnel; similarly, decapsulate packets received from the tunnel and forward them to the UE (at the tunnel lower end in the case of network-based mobility) or to the correspondent node (at the tunnel upper end) [ITU-T Y.2018].

7.4 Seamless handover support

The handover control scenarios can be classified into two methods according to the order of a release of the existing connection to the old network and an establishment of a new connection to the target network. The 'break-before-make (BBM)' scenario represents a handover procedure that a UE first releases its current connection and then makes a new connection with the target network of a handover. On the other hand, the 'make-before-break (MBB)' scenario establishes a new connection first before releasing the current one. The MBB scenario is typically used to achieve relatively faster and seamless handovers which may not suffer from service disruption.

For seamless handover support in the BBM handover scenario, the packet buffering and forwarding scheme can be applied between two L3HEFs residing in the old and target networks. By forwarding packets from the old L3HEF to the target L3HEF, the UE may not experience packet loss after a handover. How to implement the packet buffering and forwarding scheme is not covered in this Recommendation.

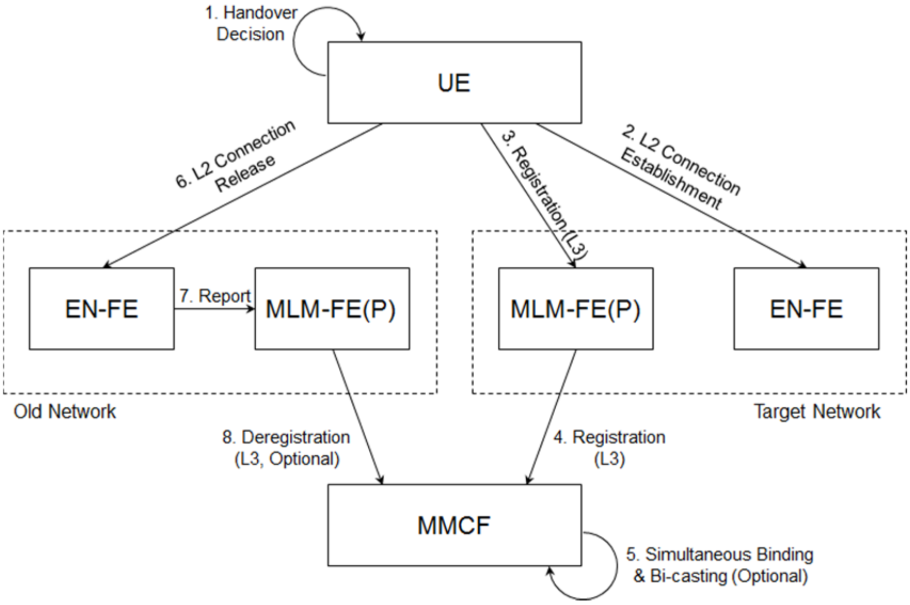

Figure 7-2 – Host-based seamless handover control architecture

Figure 7-2 illustrates the handover control architecture employing the MBB handover scenario in the host-based MM for interworking between WiMAX and UMTS networks. In this case, the UE establishes an L2 connection with the EN-FE in the target network while maintaining the existing L2 connection to the EN-FE in the old network. Therefore, the UE temporarily has two L2 connections at the same time. In the host-based MM architecture, the L3 registration for vertical handover control is initiated by the UE and handled by MLM-FE Proxy (MLM-FE(P)) in the target network. This L3 registration process is also performed while the existing L3 mobility location binding in the old network is being maintained by MMCF.

To achieve better handover performance, the simultaneous binding and bi-casting schemes can be applied with a support of the MMCF (optional). Those schemes allow the UE to temporarily receive packets both through the old and target networks so that packet losses during a handover are considerably reduced. How to implement those schemes is not within the scope of this Recommendation.

Another option to enhance the handover control procedure is an explicit deregistration of the useless L3 mobility location binding for the old network after the UE releases the existing L2 connection to the old network. Deletion of the useless binding information can be implicitly performed by the timeout/refresh mechanism. Otherwise, if the timeout/refresh mechanism is not applied to the simultaneous binding information's lifetime, the explicit deregistration may be needed to reduce the waste of network resources due to unnecessary packet bi-casing after completion of the handover procedure.

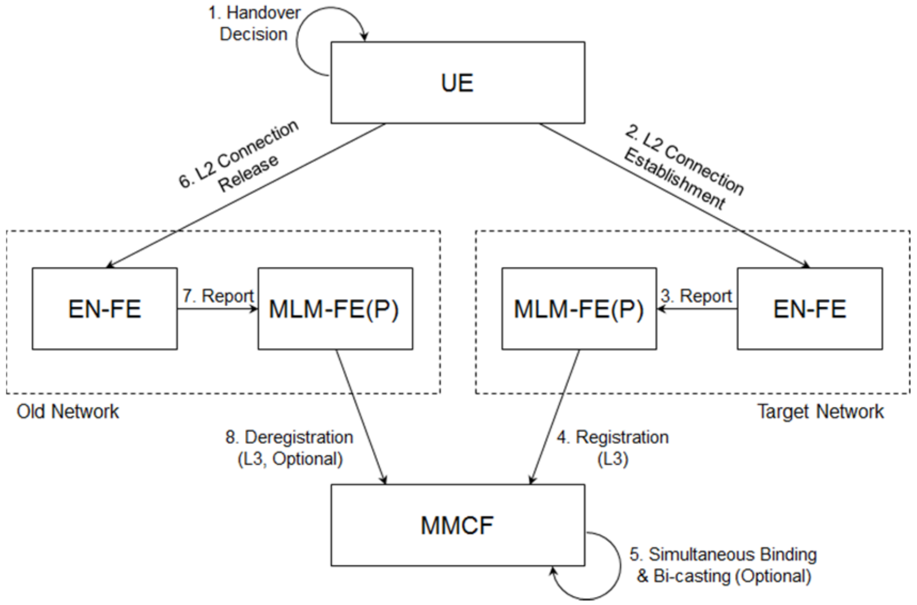

Figure 7-3 – Network-based seamless handover control architecture

Figure 7-3 depicts the handover control architecture employing the MBB handover scenario in the network-based MM for interworking between WiMAX and UMTS networks. The architecture is quite similar to that of the host-based MM case shown in Figure 7-2. The only difference is that the L3 mobility location binding registration for the target network is initiated by the MLM-FE(P). To do this, the EN-FE in the target network sends the MLM-FE(P) a report triggering an L3 handover procedure when the UE establishes a new L2 connection.

8 Signal flow for interworking between WiMAX and UMTS

8.1 Access network detection and selection

How a multi-mode mobile UE (MUE) detects various attachable networks (i.e., WiMAX and UMTS networks) is not specified here. It may depend on the specific wireless access technology or the manufacturer's implementation of the terminal device. However, in frequent situations, a multi-mode MUE may have to decide which will be the target network for a new L2 connection establishment or imminent vertical handover.

[ITU-T Y.2018] specifies that the network discovery and decision procedure must be performed before a MUE's handover to a new access point (AP) or network. The network discovery can be triggered by multiple reasons such as link deterioration, user request, network provider's intervention, etc. The network discovery procedure is generally performed by the MUE when it detects alternative APs to which it may move.

The decision for initial attachment or handover decision may be based on information such as radio signal strength, resource availability in candidate networks and the applicable MUE-specific policy specified in the user mobility service profile. Such decision must consider three cases:

- the network makes the handover decision with input from the MUE;
- the MUE makes the handover decision with the assistance of information from the network;
- the MUE makes the handover decision without assistance from the network.

When the MUE is acting together with the network, the handover decision process begins when the MUE reports a list of alternative APs (i.e., node B/RNC in UMTS network and WiMAX BS) to the handover decision and control functional entity (HDC-FE) in the MMCF. Based on the information from the MUE, the HDC-FE requests the resource admission and control function (RACF) to check network resource availability on the potential path through each candidate network and receives the check result from the RACF. The HDC-FE then responds to the MUE, indicating its choice of deciding entity and triggering entity. If it has chosen the MUE to make the decision, it returns a candidate AP list which is based on the MN's input but reflects the results of the resource check and perhaps of local policy. If it has chosen to make the decision itself, its response includes no candidates.

The next step depends on which entity the HDC-FE has nominated to make the handover decision. If it is the HDC-FE, then the HDC-FE retrieves static network information for the candidate APs from the network information distribution functional entity (NID-FE). Based on the information, it makes a final decision on the identity of the target AP. Then it informs the MUE of its decision. The MUE responds when it is ready for the handover. Otherwise, if the MUE is the one to make the decision, the MUE retrieves static network information about the target networks from the NID-FE. It makes its selection, and then informs the HDC-FE of the decision.

After the MUE or the HDC-FE decides the target network for a handover, it may establish a proactive resource reservation through the target network by interworking with the RACF. The MM architecture in [ITU-T Y.2018] supports proactive resource reservation to provide seamless QoS after the MUE's handover. The resource check result from the RACF includes the information of resource availability in each candidate AP. With this information, the MUE or the HDC-FE requests the RACF to proactively reserve resources in the target network. Thereafter, the MN may activate the proactive resource reservation immediately after a handover in order to utilize a QoS-guaranteed path. This will significantly reduce the QoS degradation incurred by a handover when compared to the case of establishing a reactive resource reservation after completing the handover control procedure.

8.2 Connection establishment

8.2.1 Initial connection establishment to UMTS network

As shown in Figure 8-1, the initial L2 connection establishment procedure of a dual-mode MUE in the UMTS network is not different from that of a single-mode MUE moving within the UMTS network. On the network side, however, the MLM-FE proxy (MLM-FE(P)) initiates the MM procedure to support the dual-mode MUE's inter-AN mobility. The MLM-FE is a logical functional entity in MMCF which is defined in [ITU-T Y.2018]. A central instance of the MLM-FE (MLM-FE(C)) is generally located in the NGN core network while a proxy instance of the MLM-FE (MLM-FE(P)) could be typically co-located with a gateway node of each access network (e.g., GGSN/SGSN in UMTS network and ASN gateway in WiMAX network).

1. To initiate the L3 MM procedure, the MLM-FE should be triggered differently depending on whether the network employs a host-based or network-based MM procedure.
   - In the network-based MM (Case 1), after a request to create a PDP context for the MUE (including the MUE's persistent IP address allocation) is accepted, the NACF sends an indication message to the MLM-FE(P) to notify the need of network-based initial registration procedure with the MMCF.
   - In the host-based MM (Case 2), the MUE first sends a Mobility Location Binding Update message to the MLM-FE(P) to trigger the initial registration procedure with the MMCF.

2. To perform the MUE's L3 registration, as described in [ITU-T Y.2018], the MLM-FE(P) sends a Mobility Location Binding Registration/Update Request message to the MLM-FE(C) of the MMCF in the NGN control plane. The message needs to include a user/UE identifier authenticated for mobility services. To do this, the MLM-FE(P) may retrieve an L2 identifier, for example, an international mobile subscriber identity (IMSI) number of the MUE from Access Request and Access Accept messages exchanged between the GGSN and the NACF. In the network-based MM (Case 1), the MUE's L2 identifier can be delivered by an indication message from the NACF, which initiates the network-based MM procedure.

3. Upon receiving a Mobility Location Binding Registration/Update Request message from the MLM-FE(P), the MLM-FE(C) allocates the MUE's temporary IP address as specified in [ITU-T Y.2018]. Subsequently, MLM-FE(C) records the binding information of the MUE (i.e., mapping among the MUE's L2 identifier, persistent and temporary IP addresses) and responds to the MLM-FE(P) with a Mobility Location Binding Registration/Update Response message.

4. After the initial registration procedure is completed, the MUE can send and receive IP packets through the UMTS network.

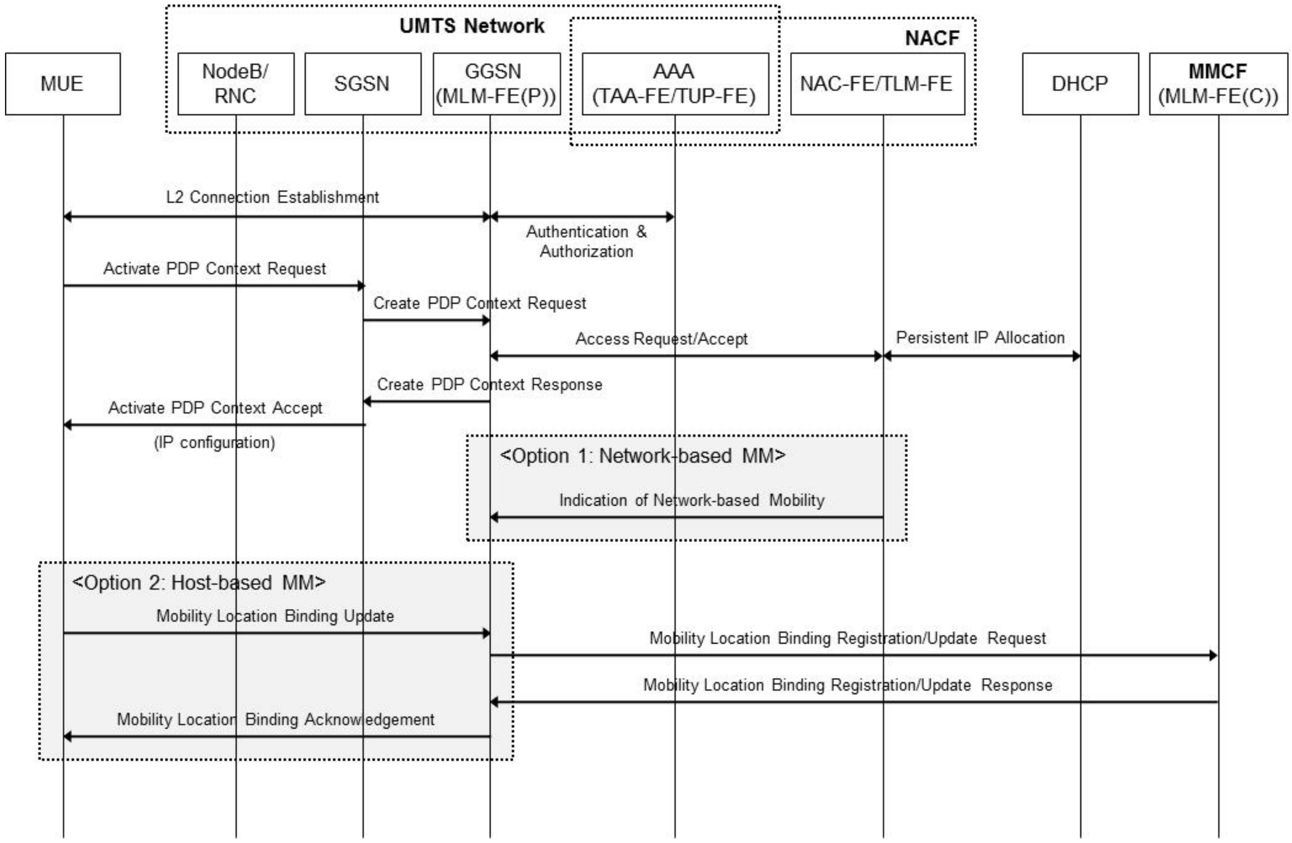

Figure 8-1 – Initial connection establishment procedure to UMTS network

8.2.2 Initial connection establishment to WiMAX network

As shown in Figure 8-2, the initial L2 connection establishment procedure of a dual-mode MUE in the WiMAX network is not different from that of a single-mode MUE. During the initial connection establishment procedure, the NACF assigns the MUE's persistent IP address using dynamic host configuration protocol (DHCP). When a DHCP discover message from the MUE is arrived at the ASN gateway, it relays the message to the NACF.

1. After completion of the DHCP transaction, the MLM-FE(P), which is co-located with the ASN gateway, sends a Mobility Location Binding Registration/Update Request message to the MLM-FE(C)) of the MMCF in the NGN control plane. As mentioned in clause 8.2.1, this message transmission can be triggered with either network-based (Case 1) or host-based (Case 2) MM procedure.
2. The Mobility Location Binding Registration/Update message includes an MUE's L2 identifier (for example, an L2 address used in the WiMAX network) to be authenticated for mobility services. The L2 address may be retrieved by MLM-FE(P) through the L2 connection establishment procedure. In the network-based MM (Case 1), it can be delivered by an indication message from the NACF, which notifies the need of network-based MM procedure for the MUE.
3. The MLM-FE(C) allocates the MUE's temporary IP address and then records its binding information (i.e., mapping between the MN's L2 identifier, persistent and temporary IP addresses). After that, the MLM-FE(C) responds to the MLM-FE(P) with a Mobility Location Binding Registration/Update Response message.
4. After the initial registration procedure is completed, the MUE can send and receive IP packets through the ASN gateway.

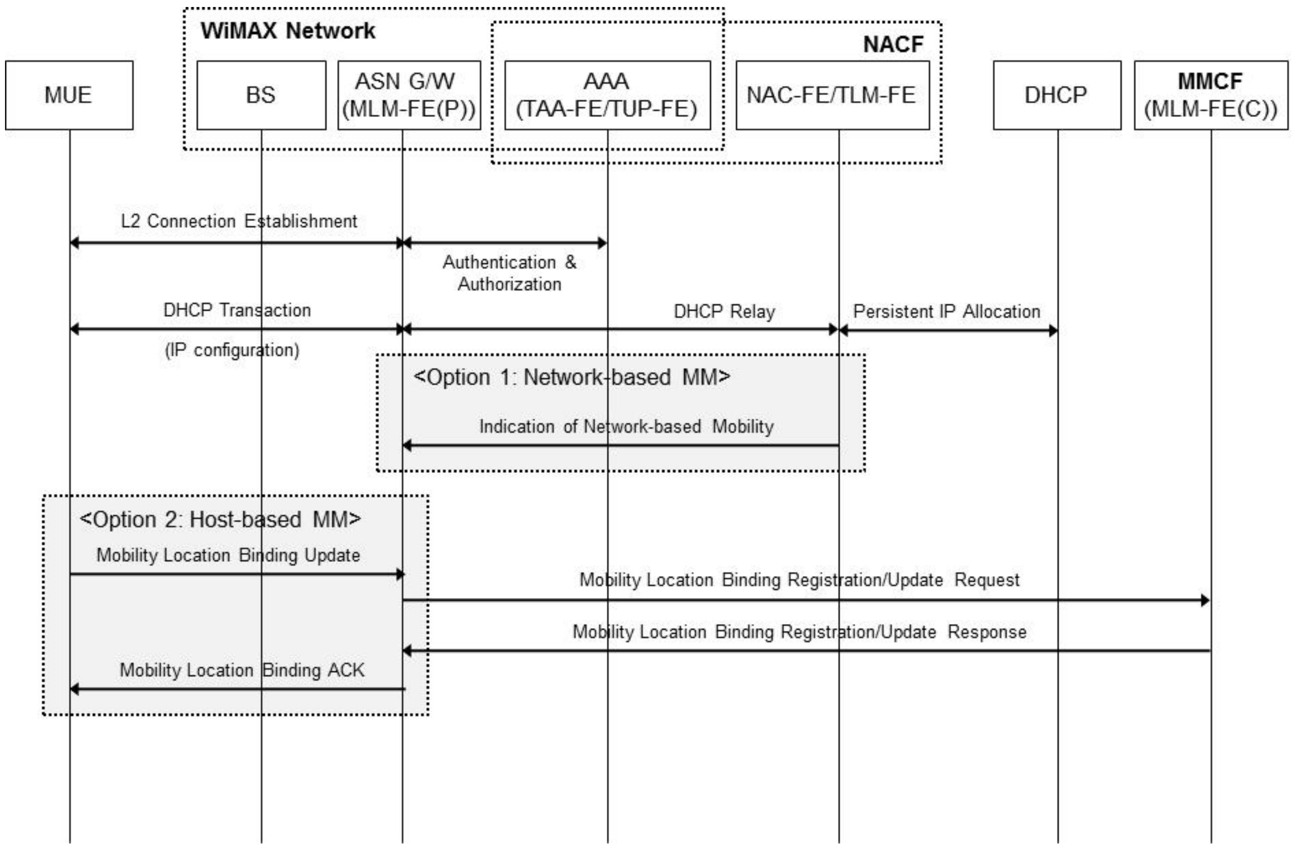

Figure 8-2 – Initial connection establishment procedure to WiMAX network

8.3 Vertical handover

8.3.1 Handover from UMTS to WiMAX (make-before-break scenario)

1. While an MUE is connected to the UMTS network, the MUE may send and receive IP packets through GGSN/SGSN. If the MN detects a radio signal from WiMAX base station (BS) and the signal strength from the WiMAX BS is strong enough to support the required QoS, a vertical handover to the WiMAX network may occur according to the predefined inter-AN handover policy.
2. The network discovery and decision procedure specified in [ITU-T Y.2018] will be applied with the predefined policy. How to make a handover decision would be based on signal strength, network topology and handover policy. The decision needs to be made so as to minimize the transmission cost and the MUE's battery power consumption while maintaining the required QoS.
3. Once the handover decision has been made, the MUE sends a Handover Commit Request message to GGSN/SGSN, and the message is relayed to the target ASN gateway in the WiMAX network. The Handover Commit message is used in this Recommendation to inform the MLM-FE(P) that is co-located with the ASN gateway of the MUE's imminent handover. Those message exchanges would be implemented with the MIH protocol specified in [b-IEEE 802.21] (for example, MIH_MN_HO_Commit and MIH_N2N_HO_Commit messages).
4. After the MUE receives a Handover Commit Request message, it starts an L2 connection establishment procedure to the WiMAX network. Until the new connection establishment is completed, the MUE may continue to send and receive IP packets through GGSN/SGSN in the UMTS network.
5. In the view point of MUE, the L2 connection establishment procedure for an inter-AN handover to WiMAX network is not much different from that of a single-mode MUE's intra-AN handover. The only difference is in the network-side where the MLM-FE(P) in the ASN gateway performs the L3 handover control procedure by exchanging the Mobility Location Binding Registration/Update Request and Response messages with the MLM-FE(C) in the MMCF.
6. This L3 handover control procedure can be triggered by either host-based or network-based manner.
   - In the network-based MM, the MLM-FE(P) initiates the L3 handover control procedure when the L2 connection establishment procedure of the MUE has been completed (possibly notified through an MIH event). At this time, the MLM-FE(P) in the WiMAX network may not know the MUE's persistent IP address. In this case, to identify the MUE, the Mobility Location Binding Registration/Update Request message from the MLM-FE(P) to the MMCF needs to include the MUE's temporary IP address and L2 address which are used in the WiMAX network.
   - On the contrary, in the host-based MM (optional), the MUE is required to send the Mobility Location Binding Update message to the MLM-FE(P) to initiate the L3 handover control procedure. The message should contain the MUE's WiMAX L2 address, temporary IP address (used in the WiMAX network) and persistent IP address (used for identification of the MUE by the MMCF).
7. When receiving a Mobility Location Binding Registration/Update Request message from the MLM-FE(P) in the WiMAX network, the MMCF updates the MUE's mobility binding information with a new temporary IP address assigned in the WiMAX network. In the network-based MM, because the Mobility Location Binding Registration/Update Request message does not contain the MUE's persistent IP address, the MMCF only knows the MUE's L2 address and temporary address. In this case, the MMCF may need to retrieve the

MUE's persistent address by sending a query (including the MUE's L2 address) to the AAA server (i.e., TUP-FE). After updating the mobility binding information, the MMCF replies the MLM-FE(P) with a Mobility Location Binding Registration/Update Response message.

8. To reduce the handover latency, the MLM-FE(P) may request the MMCF to temporarily keep simultaneous mobility binding information for the MUE. If the simultaneous binding is invoked, the core transport functions can temporarily bi-cast IP packets destined to the MUE via both GGSN/SGSN in the UMTS network and the ASN gateway in the WiMAX network to reduce packet loss during the handover.

9. After the MUE completes the L2 connection establishment and L3 registration procedures to the WiMAX network, the MUE exchanges Handover Complete Request/Response messages with the ASN gateway. Then the MUE releases a UMTS connection. The Handover Complete Request/Response messages are used in this Recommendation to inform the old network of the MUE's L3 registration completion to the target network. Those message exchanges would be implemented with the MIH protocol (for example, MIH_MN_HO_Complete-REQ/RSP messages).

10. The old MLM-FE(P) in GGSN/SGSN optionally can perform an explicit de-registration procedure with the MMCF if a timeout/refresh mechanism is not applied to the simultaneous binding information's lifetime. Then the MUE's binding information for the UMTS network is deleted. Thereafter, IP packets destined to the MUE are delivered solely by a unicast through the WiMAX network.

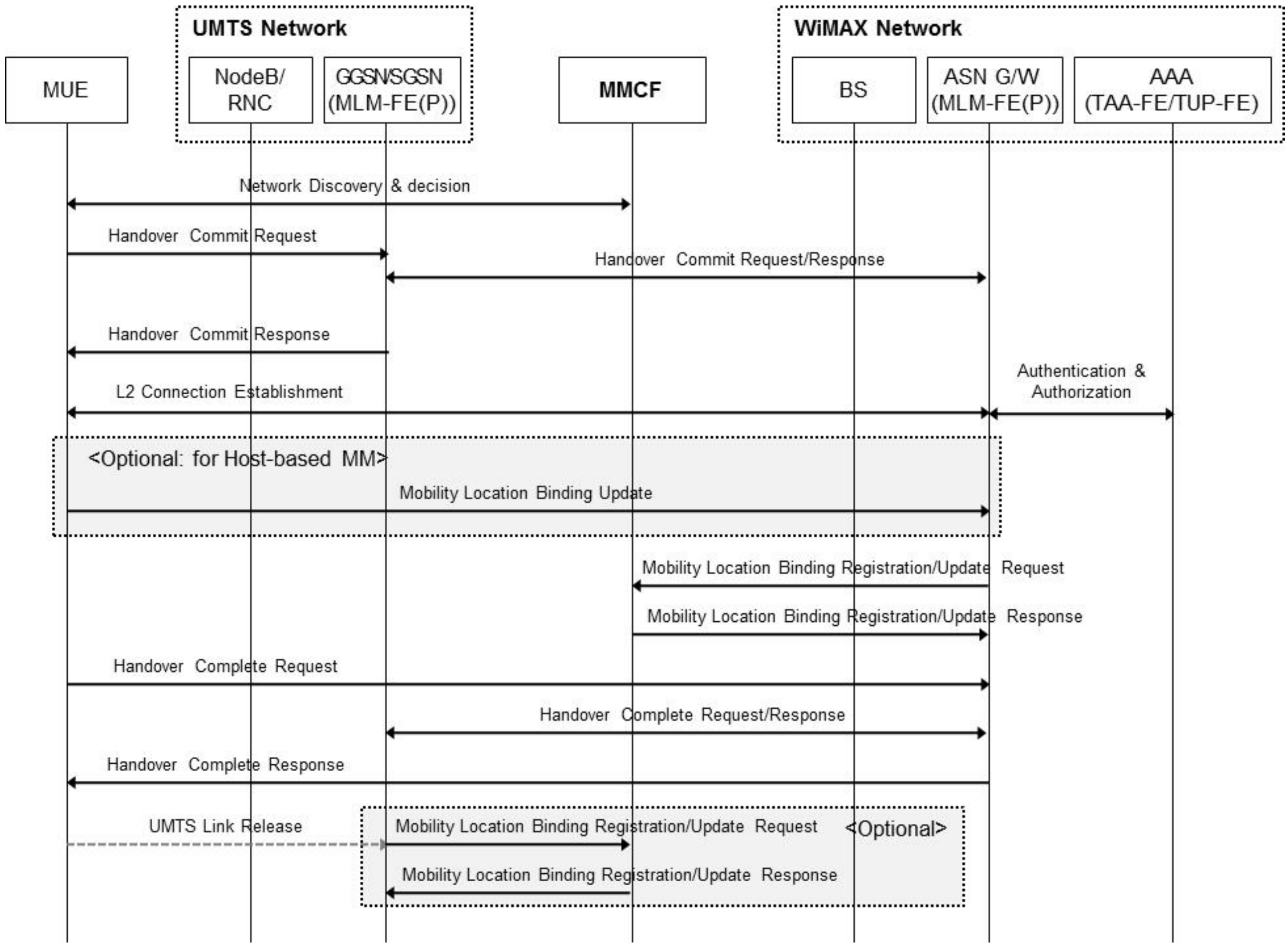

Figure 8-3 – Vertical handover procedure from UMTS to WiMAX (MBB)

8.3.2 Handover from UMTS to WiMAX (break-before-make scenario)

There is little difference between the MBB and BBM handover scenarios in terms of handover detection, target network decision, and handover initiation. However, in the BBM handover scenario, the MUE first releases its current connection with the UMTS network before making a new connection to WiMAX network.

1. Once the handover decision has been made, the MUE sends a Handover Commit Request message to GGSN/SGSN, and the message is relayed to the target ASN gateway in the WiMAX network. When the MUE receives a Handover Commit Response message from GGSN/SGSN, it immediately starts an L2 handover by releasing the current link with the UMTS network.
2. The MUE's L2 handover may trigger the MLM-FE(P) in GGSN/SGSN to initiate a de-registration procedure of the MUE, which sends a Mobility Location Binding Registration/Update Request message to the MMCF. When the MMCF receives this message from the MLM-FE(P) in GGSN/SGSN, the MUE's binding information for the UMTS network is deleted. If a timeout/refresh mechanism is applied to the MUE's binding information management, this explicit de-registration procedure can be omitted.
3. Subsequently, the MUE establishes a new L2 connection with the WiMAX network by exchanging some control messages with the target BS and the ASN gateway in the WiMAX network. Those control messages to make an L2 connection in the WiMAX network are simplified in Figure 8-4 because they are not in the scope of this Recommendation. After the connection establishment, the MUE exchanges Handover Complete Request/Response messages with the ASN gateway to complete the L2 handover procedure.

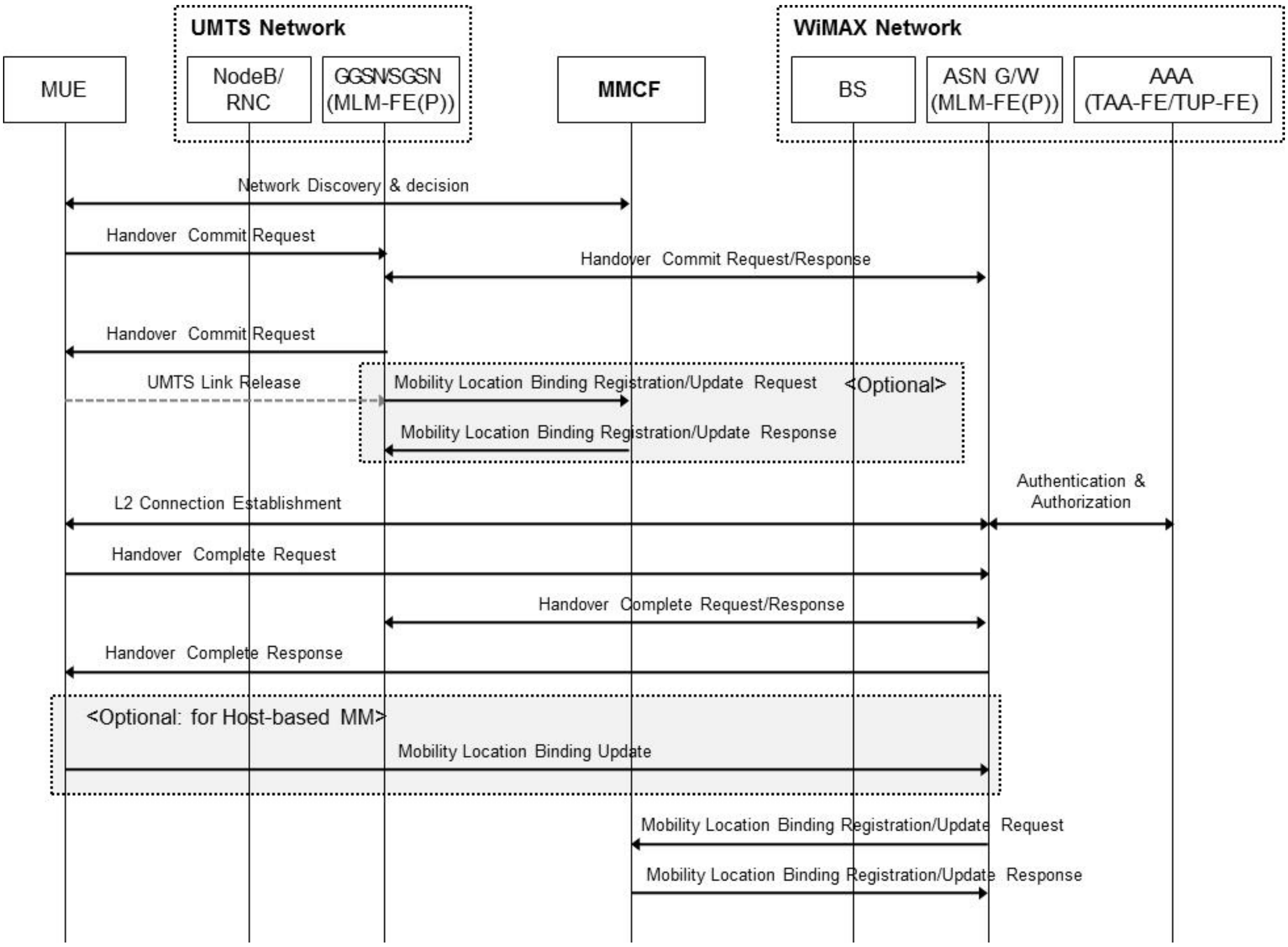

Figure 8-4 – Vertical handover procedure from UMTS to WiMAX (BBM)

4. In the network-based MM, the completion of L2 handover procedure triggers the MLM-FE(P) that is co-located with the ASN gateway to initiate the L3 handover control procedure. The MLM-FE(P) exchanges the Mobility Location Binding Registration/Update Request and Response messages with the MLM-FE(C) in the MMCF. At this time, the MLM-FE(P) in the WiMAX network may not know the MUE's persistent IP address. Therefore, to identify the MUE, the Mobility Location Binding Registration/Update Request message from the MLM-FE(P) to the MMCF needs to include the MUE's temporary IP address and L2 address which will be used in the WiMAX network.
5. However, in the host-based MM (optional), the MUE is required to initiate the L3 handover control procedure by sending the Mobility Location Binding Update message to the MLM-FE(P) which is co-located with the ASN gateway. The message should contain the MUE's WiMAX L2 address, temporary IP address (used in the WiMAX network) and persistent IP address (used for identification of the MUE by the MMCF). It triggers the MLM-FE(P) to send a Mobility Location Binding Registration/Update Request message to the MLM-FE(C) in the MMCF.
6. When receiving a Mobility Location Binding Registration/Update message from the MLM-FE(P) in the WiMAX network, the MMCF updates the MUE's mobility binding information by the same procedure described in the MBB handover scenario. After completion of the L3 handover control procedure, IP packets destined to the MUE are delivered via the ASN gateway in the WiMAX network.

8.3.3 Handover from WiMAX to UMTS (make-before-break scenario)

While an MUE is connected to the WiMAX network, the MUE may send and receive IP packets through the ASN gateway. If the strength of radio signals received from WiMAX BS deteriorates and an attachable UMTS network is detected, a vertical handover to the UMTS network may occur. How to make a handover decision would be based on signal strength, the network topology and handover policy. The network discovery and decision procedure specified in [ITU-T Y.2018] will be applied with the predefined policy. The decision needs to be made so as to minimize the transmission cost and the MUE's battery power consumption while maintaining the required QoS.

1. Once the handover decision has been made, the MUE sends a Handover Commit Request message to the ASN gateway in the WiMAX network. Then the ASN gateway exchanges Handover Commit Request/Response messages with the target GGSN/SGSN in the UMTS network. Those Handover Commit Request/Response messages are used in this Recommendation to notify the MUE's imminent vertical handover.
2. After receiving a Handover Commit Response message, the MUE starts establishing a UMTS connection. Until the new connection establishment is completed, the MUE may continue to send and receive IP packets through the WiMAX network if the radio signal quality allows. In the viewpoint of MUE, the L2 connection establishment procedure for a vertical handover to the UMTS network is equivalent with that of a single-mode MUE's intra-AN handover.
3. After completing the L2 connection establishment to the UMTS network, the MLM-FE(P) in the target GGSN/SGSN performs the L3 handover control procedure for the MUE by exchanging the Mobility Location Binding Registration/Update Request and Response messages with the MLM-FE(C) in the MMCF.
4. This L3 handover control procedure can be triggered either by the network-based or host-based MM (optional) procedure.

- In the network-based MM, the MLM-FE(P) that is co-located with GGSN/SGSN retrieves the MUE's L2 address, such as IMSI number from Access Request and Access Accept messages, and sends the Mobility Location Binding Registration/Update Request message to the MLM-FE(C). At this time, the MLM-FE(P) in the UMTS network may not know the MUE's persistent IP address. Thus, to identify the MUE, the Mobility Location Binding Registration/Update Request message from the MLM-FE(P) to the MMCF needs to include the MUE's temporary IP address and L2 address which are used in the UMTS network.
- However, in the host-based MM (optional), the MUE is required to send the Mobility Location Binding Update message to the MLM-FE(P) to initiate the L3 handover control procedure. The message should contain the MUE's L2 address, temporary IP address (used in the UMTS network) and persistent IP address (used for identification of the MUE by the MMCF).

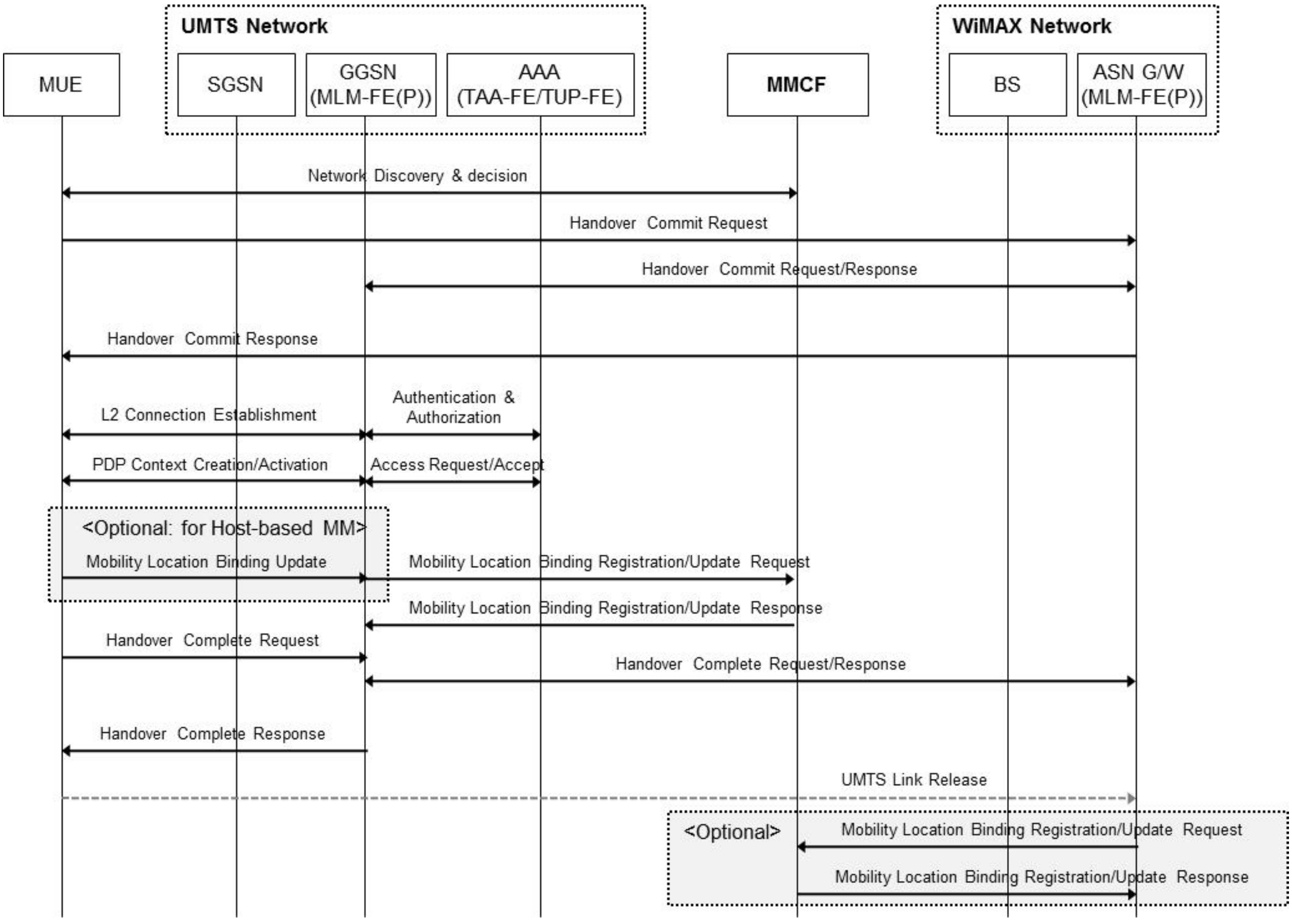

Figure 8-5 – Vertical handover procedure from WiMAX to UMTS (MBB)

5. When receiving a Mobility Location Binding Registration/Update Request message from the MLM-FE(P) in the UMTS network, the MMCF updates the MUE's mobility binding information with a new temporary IP address assigned in the UMTS network. In the network-based MM, because the Mobility Location Binding Registration/Update Request message does not contain the MUE's persistent IP address, the MMCF only knows the MUE's L2 address and temporary IP address. In this case, the MMCF may need to retrieve the MUE's persistent IP address by sending a query (including the MUE's L2 address) to the AAA server (i.e., TUP-FE). After updating the mobility binding information, the MMCF replies the MLM-FE(P) in the UMTS network with a Mobility Location Binding Registration/Update Response message.

6. During the handover procedure, if the simultaneous binding is invoked, the core transport functions can temporarily bi-cast packets destined to the MUE via both GGSN/SGSN in the UMTS network and the ASN gateway in the WiMAX network simultaneously to reduce packet loss during the handover.
7. After the MUE completes the L3 handover control procedure, it exchanges Handover Complete Request/Response messages with GGSN/SGSN and releases the L2 connection to the WiMAX network. This may trigger the MLM-FE that is co-located with the ASN gateway to send the Mobility Location Binding Registration/Update Request message to the MLM-FE(C) in the MMCF to de-register the MUE's old binding information in the WiMAX network. If a timeout/refresh mechanism is applied to the MUE's binding information, this de-registration procedure can be omitted.
8. After the MUE's old binding information is deleted, IP packets destined to the MUE are delivered solely by a unicast through the UMTS network.

8.3.4 Handover from WiMAX to UMTS (break-before-make scenario)

In case of vertical handover from the WiMAX network to the UMTS network, the procedures of handover detection, target network decision and handover initiation are similar between the MBB and BBM handover scenarios. The only difference is that the MUE first releases its current connection with the WiMAX network before making a new connection to the UMTS network.

1. Once the handover decision has been made, the MUE sends a Handover Commit Request message to the ASN gateway, and the message is relayed to the target GGSN/SGSN in the UMTS network.
2. When the MUE receives a Handover Commit Response message from the ASN gateway, it immediately starts a L2 handover by releasing the current L2 connection with the WiMAX network. This may trigger the MLM-FE(P) that is co-located with the ASN gateway to initiate an optional de-registration procedure for the MUE (i.e., the MLM-FE(P) sends a Mobility Location Binding Registration/Update Request message to the MMCF).
3. When the MMCF receives the Mobility Location Binding Registration/Update Request message from the ASN gateway, the MUE's binding information for the WiMAX network is deleted. If a timeout/refresh mechanism is applied to the MN's binding information management, the explicit de-registration procedure can be omitted.
4. Subsequently, an L2 handover procedure is initiated by the MUE to release the current connection to the WiMAX network and to establish a new L2 connection to the target UMTS network. This L2 handover shall be performed according to the standard signalling procedures of the WiMAX and UMTS networks.
5. After the MUE establishes an L2 connection to the UMTS network, it exchanges Handover Complete Request/Response messages with GGSN/SGSN to complete the L2 handover procedure.
    - In the network-based MM, the L2 handover completion triggers the MLM-FE(P) which is co-located with GGSN/SGSN to initiate the L3 handover control procedure by exchanging the Mobility Location Binding Registration/Update Request and Response messages with the MLM-FE(C) in the MMCF. At this time, the MLM-FE(P) in the UMTS network may not know the MN's persistent IP address. Therefore, to identify the MUE, the Mobility Location Binding Registration/Update Request message needs to include the MUE's L2 address and temporary IP address which will be used in the UMTS network.

- However, in this host-based MM (optional), the MUE is required to initiate the L3 handover control procedure by sending the Mobility Location Binding Update message to the MLM-FE(P), which is co-located with GGSN/SGSN. In this case, the message should contain the MUE's L2 address, temporary IP address (used in the UMTS network) and persistent IP address (used for identification of the MUE by the MMCF). It triggers the MLM-FE(P) that is co-located with GGSN/SGSN to send a Mobility Location Binding Registration/Update Request message to the MLM-FE(C) in the MMCF.

6. When receiving a Mobility Location Binding Registration/Update message from the MLM-FE(P) in the UMTS network, the MMCF updates the MUE's mobility binding information through the same procedure described in the MBB handover scenario. After completion of the L3 handover control procedure, IP packets destined to the MUE are delivered via GGSN/SGSN in the UMTS network.

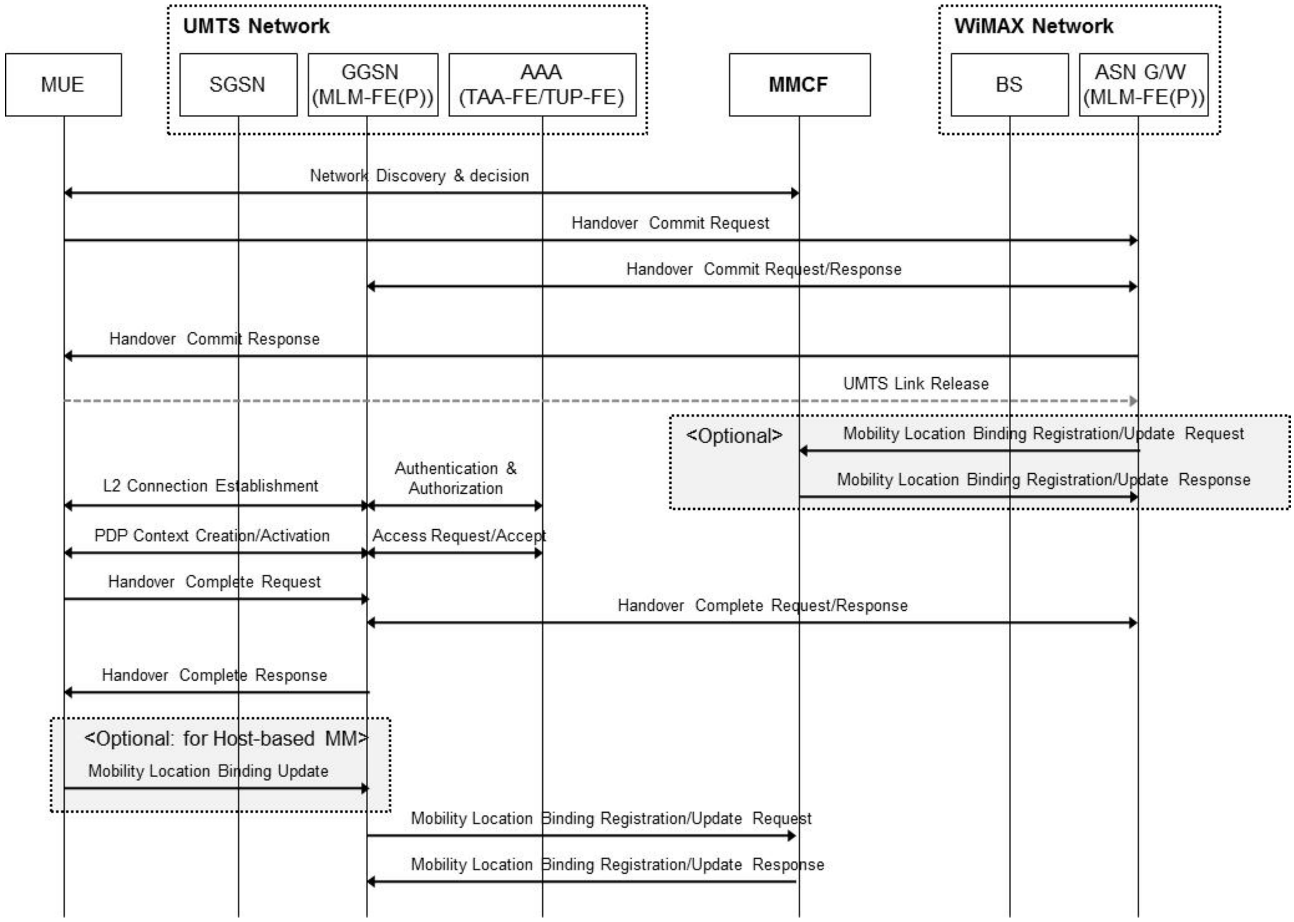

Figure 8-6 – Vertical handover procedure from WiMAX to UMTS (BBM)

9 Security considerations

This Recommendation requires no specific security considerations and aligns with the security requirements in [ITU-T Y.2701].

Appendix I

Use cases of hybrid MIP-based MM between WiMAX and UMTS

(This appendix does not form an integral part of this Recommendation.)

I.1 Introduction to hybrid mobile IP

Figure I.1 depicts the hybrid mobile IP (MIP) operation for handover between the WiMAX and UMTS networks. It is assumed that proxy mobile IPv4 (PMIPv4) function, namely proxy mobile agent (PMA), is implemented in GGSN while the ASN gateway does not have PMIP function. When a UE is attached to the WiMAX network, IP mobility is supported by client MIP (CMIP) operating in co-located care-of-address (CCoA) mode, and the UE registers its IP address with HA using CMIP. A correspondent node (CN) communicating with the UE sends and receives user traffic through the home agent (HA). If a UE is handed over to the UMTS network, GGSN detects the MUE's attachment, and the PMA function in GGSN registers the UE's IP address with the HA. While the UE is attached to the UMTS network, the UE operates in a simple IP mode, in which the MIP client function in the UE ceases to operate. (How the UE determines the employed IP mobility protocol in each access network is not specified here.) When the UE is handed over from the UMTS network to the WiMAX network, the MIP client function in the UE resumes its operation, and user traffic is exchanged through the tunnel between the UE and the HA.

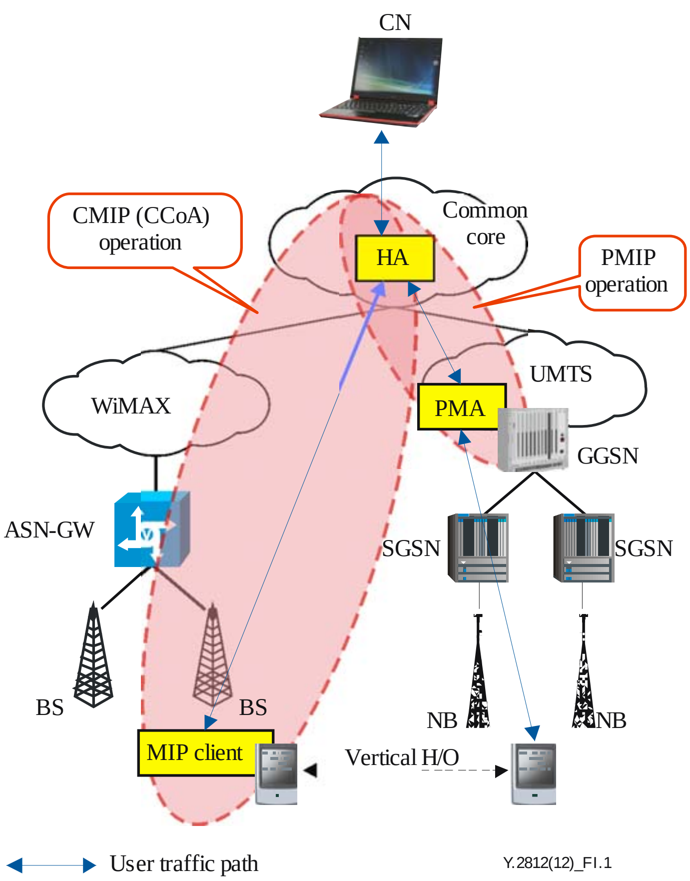

Figure I.1 – Hybrid mobile IP operation

I.2 Initial connection establishment procedure in the UMTS network

A UE's initial connection establishment procedure to the UMTS network is defined in the 3GPP specifications. The additional signalling needed for PMIP operation is performed by the Proxy Registration Request (PRRQ) and Proxy Registration Reply (PRRP) messages exchanged between the PMA function in GGSN and the HA. Upon receiving a PRRQ message from GGSN, the HA allocates home address (HoA) for the UE and sends GGSN a PRRP message containing the HoA. GGSN informs the UE of the allocated HoA using PDP Context messages. After the HoA is assigned to the UE, it registers with the MIH information server (MIIS), and downloads inter-system handover policy and the network topology information to be utilized during the handover decision procedure.

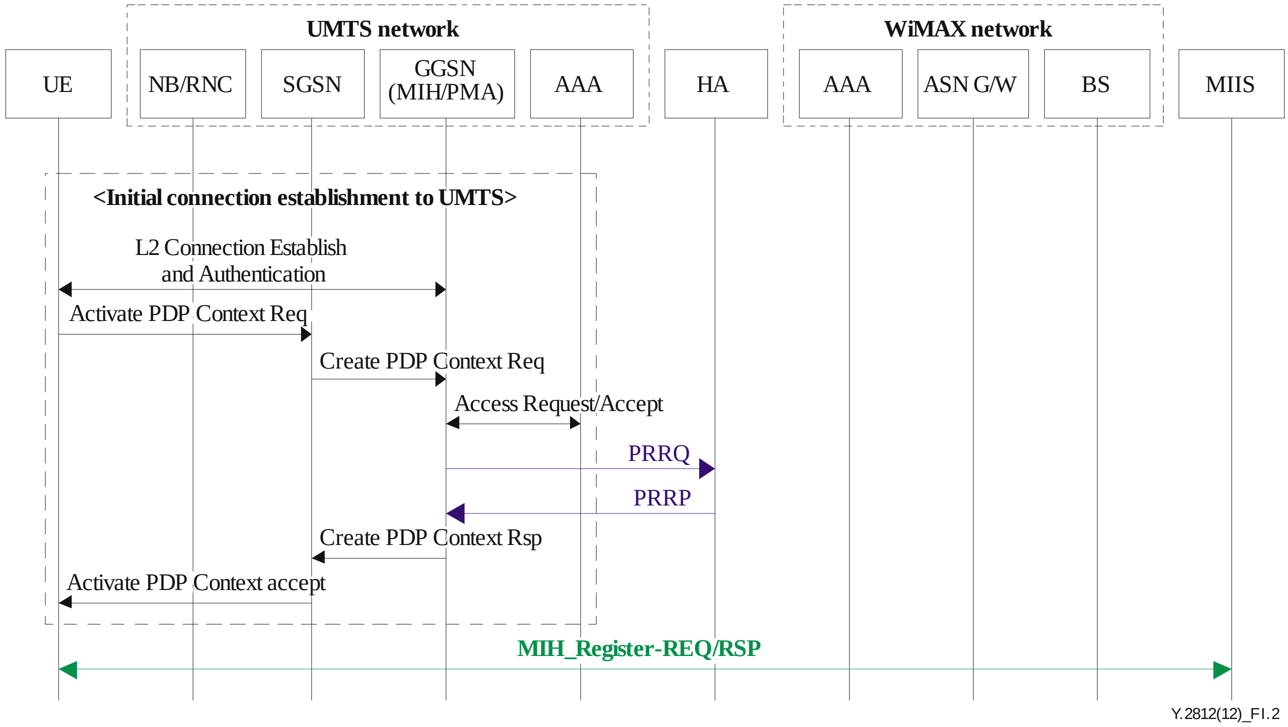

Figure I.2 – Initial connection establishment procedure for UMTS

I.3 Handover procedure from UMTS to WiMAX (make-before-break scenario)

After a UE establishes a connection with the UMTS network, the UE may send and receive user traffic through GGSN. If the UE detects a reachable WiMAX BS and the received signal strength is strong enough, a handover from UMTS to WiMAX may occur. (How to make the handover decision based on the received signal strength, the network topology information and the handover policy is not specified here.) Once the handover decision is made, the UE sends Handover Commit message to GGSN. Upon receiving the Handover Commit response message from GGSN, the UE starts establishing a connection with the WiMAX network. The UE may send and receive user traffic through the UMTS network until it establishes a new WiMAX connection, and UE sends a Registration Request (RRQ) message to the HA when a WiMAX connection is established. By setting the S-bit of RRQ message header, the HA may allow simultaneous binding for both UMTS and WiMAX networks. If the simultaneous binding is invoked, the HA can bi-cast user traffic to the UMTS network and the WiMAX network. After the UE receives Registration Reply (RRP) message from the HA, the UE exchanges Handover Complete messages with the MIIS and releases the old UMTS connection. When GGSN detects the connection release, GGSN sends the HA a PRRQ message with life time of zero. Upon receiving the PRRQ message from GGSN, the HA disconnects the PMIP tunnel between the HA and GGSN.

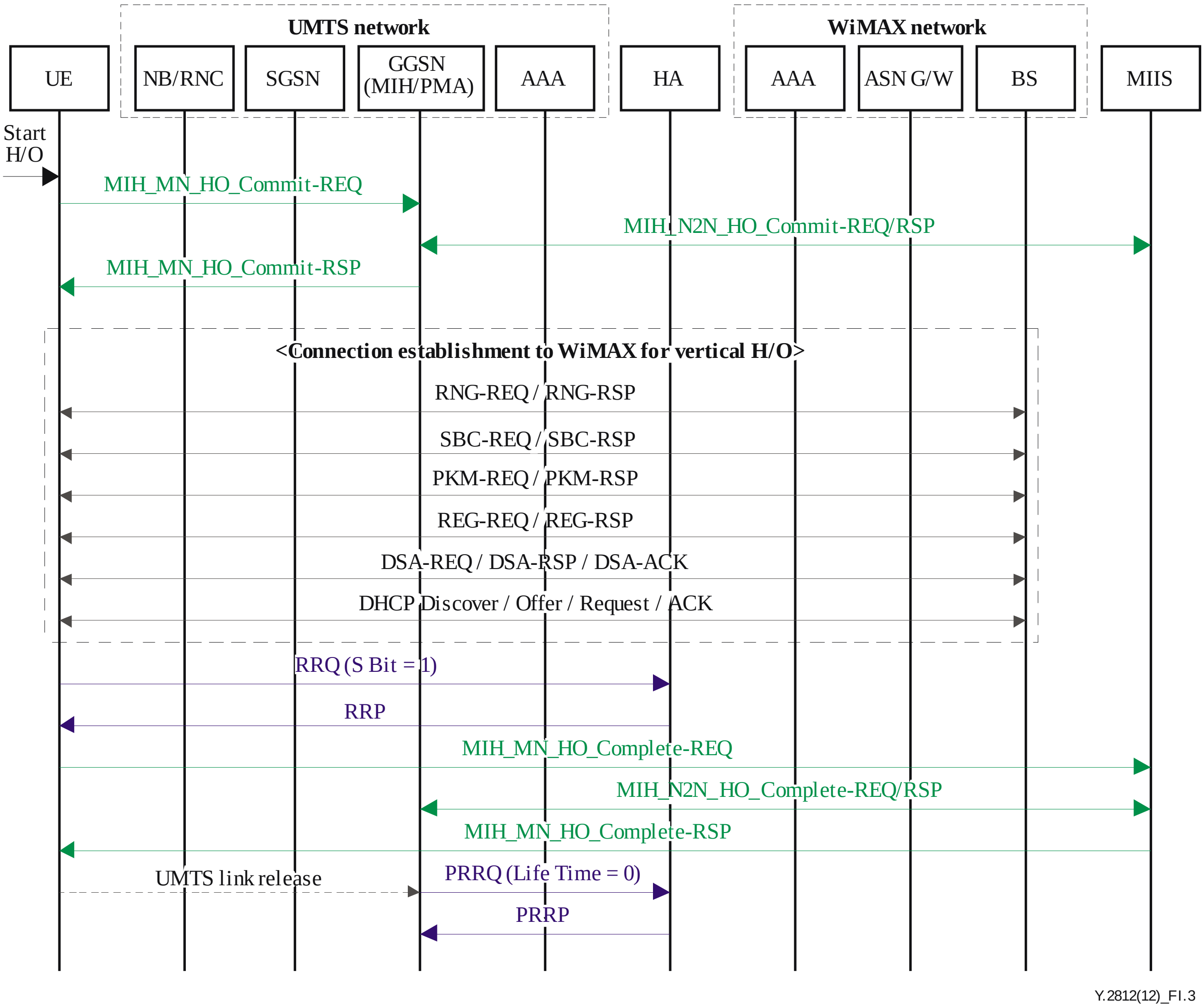

Figure I.3 – Signalling procedure for handover from UMTS to WiMAX

I.4 Initial connection establishment procedure in the WiMAX network

A UE's initial connection establishment procedure for the WiMAX network is described in [b-IEEE 802.16e]. The additional signalling needed for CMIP operation is done by the RRQ and RRP messages exchanged between the UE and the HA. After the ASN gateway allocates an IP address to be used as care-of-address (CoA) and assigns the CoA to the UE, the UE sends an RRQ message to the HA. Upon receiving the RRQ message, the HA allocates a HoA and informs the UE of the HoA by sending a RRP message. After the HoA is assigned to the UE, it registers with the MIIS and downloads inter-system handover policy and the network topology information to be utilized during the handover decision procedure.

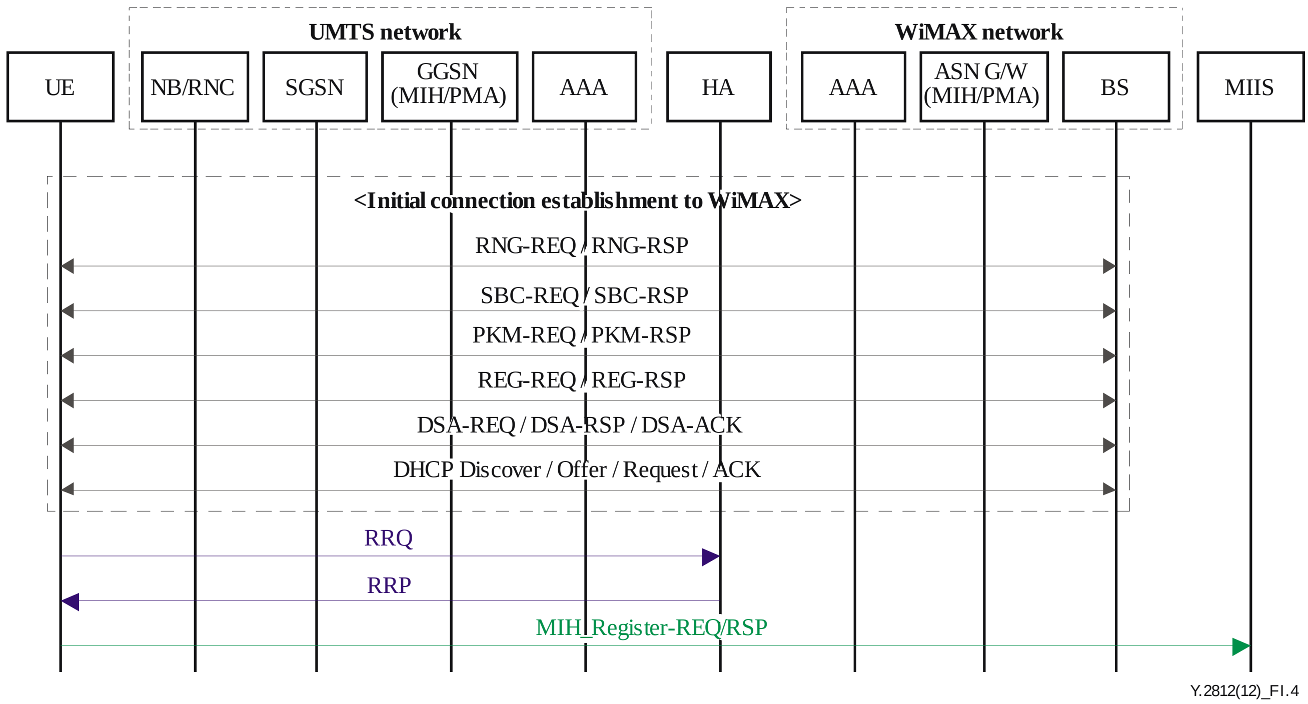

Figure I.4 – Initial connection establishment procedure for WiMAX

I.5 Handover procedure from WiMAX to UMTS

After a UE establishes a connection with the WiMAX network, the UE may send and receive user traffic through the WiMAX network. If the received signal strength from the WiMAX BS deteriorates, a handover from WiMAX to UMTS may occur. (How to make the handover decision based on the signal strength, the network topology information and the handover policy is not specified here.) Once the handover decision is made, the UE sends a Handover Commit message to the MIIS, and the MIIS sends a Handover Commit message to the target GGSN in the UMTS network. Upon receiving the Handover Commit message, GGSN performs the PMIP registration procedure. If the S-bit in the PRRQ message header is set to one, the HA allows simultaneous binding for both UMTS and WiMAX networks. When the UE receives Handover Commit response message, the UE starts establishing a connection with the UMTS network. The UE may send and receive user traffic through the WiMAX network until it establishes a new UMTS connection. After the UE establishes a UMTS connection, the UE exchanges Handover Complete messages with GGSN and sends the HA a RRQ message with lifetime of zero. Upon receiving the RRQ message, the HA severs the CMIP tunnel between the UE and the HA.

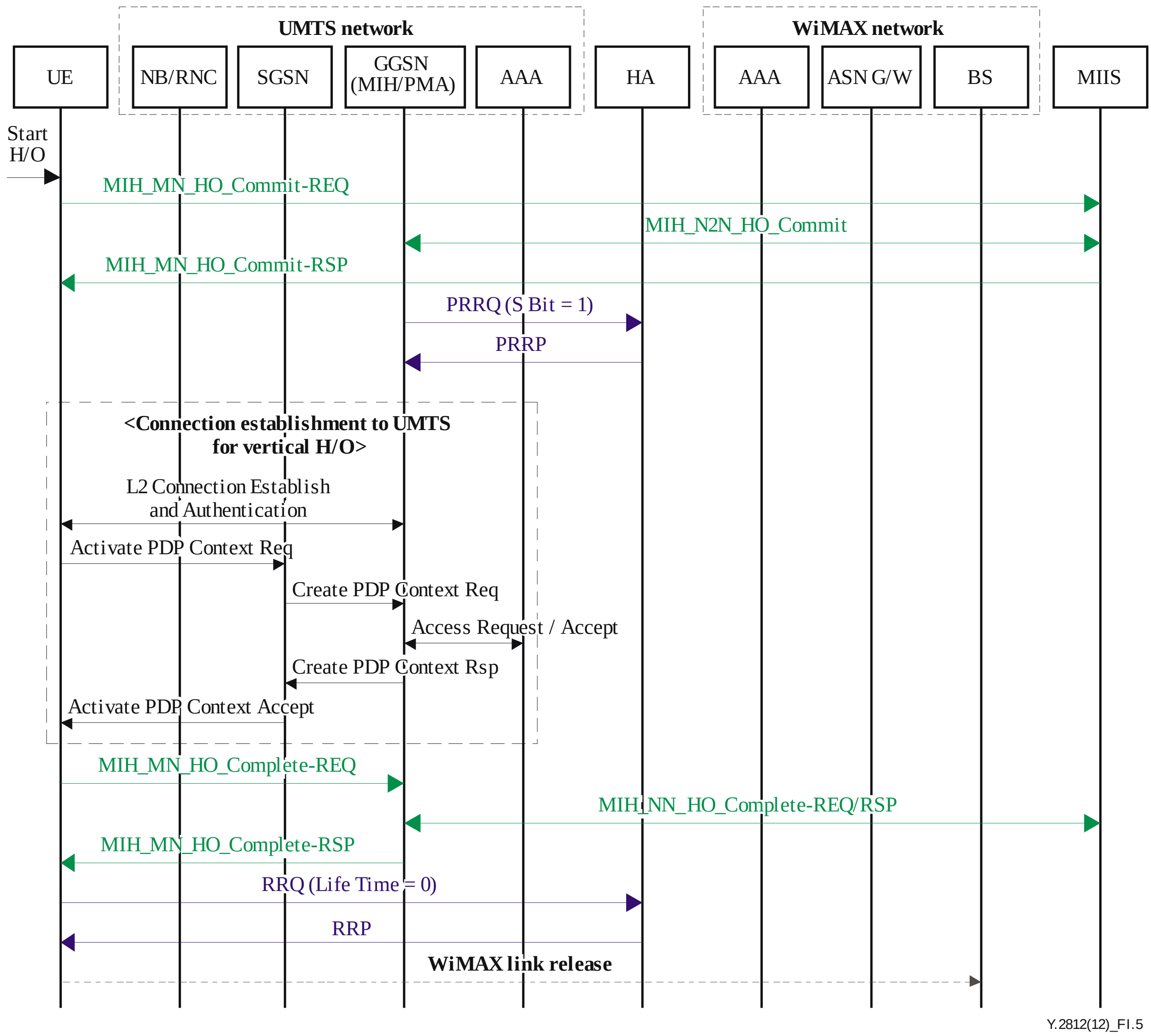

Figure I.5 – Signalling procedure for handover from WiMAX to UMTS

Appendix II

Use cases of PMIPv6 with bicasting for vertical handovers

(This appendix does not form an integral part of this Recommendation.)

This appendix describes an extensional scheme using multiple bindings of proxy mobile IPv6 (PMIPv6) to support seamless and soft vertical handover against the movement of mobile users between the UMTS and WiMAX networks. For a multi-homing UE residing in the overlapping region between the UMTS and WIMAX networks, this multiple binding scheme of PMIPv6 can be used to reduce the packet loss and handover delay during the handover.

Figure II.1 shows the reference network configuration for multiple bindings of PMIPv6 to support a vertical handover, in which the UE moves across UMTS and WiMAX networks.

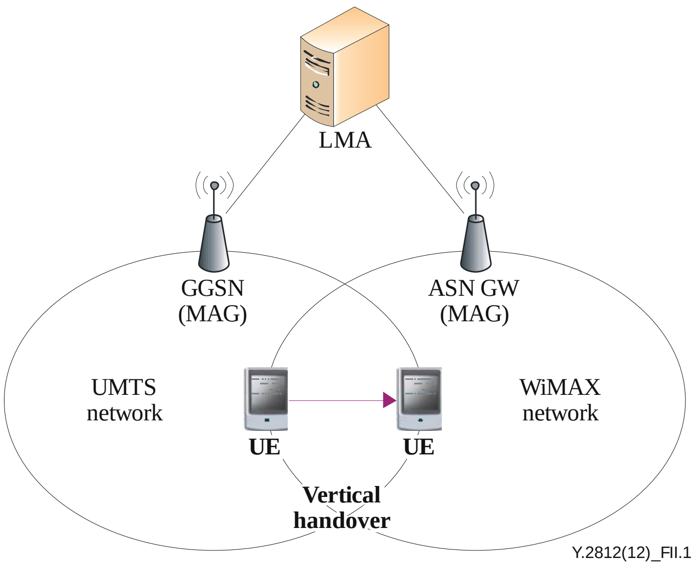

Figure II.1 – Reference network model of multiple bindings of PMIPv6

In the figure, a UE moves from the UMTS network toward the WiMAX network. It is assumed that GGSN in the UMTS network and the ASN gateway in the WiMAX network are equipped with the PMIPv6 mobile access gateways (MAG) functions, respectively. During a vertical handover, the UE will go into the overlapping region, in which the UE is dual-homed to both of the UMTS and WiMAX networks. In this time, two PMIPv6 tunnels, called 'multiple bindings', can be established from the PMIPv6 local mobility anchor (LMA) to the MAGs in the UMTS and WiMAX networks.

Figure II.2 shows the detailed operations of the multiple binding scheme of PMIPv6 to support vertical handovers between the UMTS and WiMAX networks. In the figure, it is assumed that the UE is initially connected to the UMTS network by using the PMIPv6 protocol. However, this scheme can also be applied to the opposite case (i.e., the UE is initially connected to the WiMAX network).

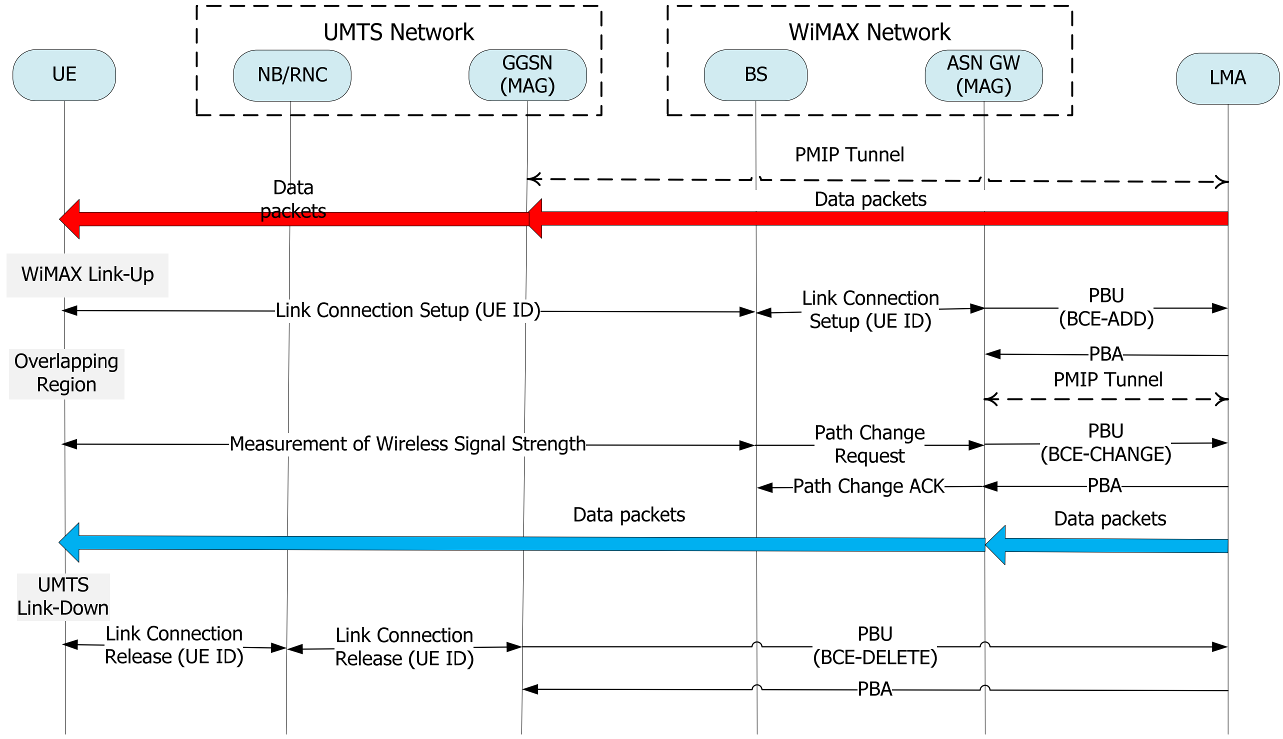

Figure II.2 – Handover operations of PMIPv6 with multiple bindings

When the UE begins to move into the overlapping region with a link-up event for the WiMAX network, it can establish an L2 connection to the BS and the ASN gateway in the WiMAX network. Then, the MAG that is co-located with the ASN gateway will add the corresponding binding cache entry (BCE) to the LMA by exchanging the PMIP Proxy Binding Update (PBU) and the Proxy Binding Acknowledgement (PBA) messages. Then, a PMIPv6 tunnel is established between the LMA and the MAG in the WiMAX network. However, this will not be used for data transport yet.

While the UE remains in the overlapping region, the signal strengths of the two wireless link channels (for WiMAX and UMTS) are measured and compared. If the signal strength of the WiMAX link is greater than that of UMTS, the WiMAX BS may request the 'path change' to the MAG in the WiMAX network. In turn, the MAG in the WiMAX network will request the LMA to change the PMIPv6 tunnel by exchanging the PMIPv6 PBU and PBA messages. Then the LMA will deliver the data packets to the MAG in the WiMAX network as shown in Figure II.2.

By further movement of the UE toward the WiMAX network, the old PMIPv6 tunnel for the UMTS network may be released, as described in the figure. The above procedure can also be performed for the vertical handover from the WiMAX network to the UMTS network.

This multiple binding scheme of PMIPv6 can be effectively applied to support the vertical handover, especially, in which the UE may frequently move across the UMTS and WiMAX networks, as known as the 'ping-pong' movement pattern. In this movement scenario, the frequent operations for PMIPv6 binding update to the LMA may be needed (i.e., establishment and release of the PMIPv6 tunnels from the LMA to the UMTS or WiMAX networks), which may incur unnecessary control operations and considerable handover delay. These drawbacks may be alleviated by using the multiple binding scheme of PMIPv6.

Bibliography

[b-ITU-T Y.2091]	Recommendation ITU-T Y.2091 (2007), *Terms and definitions for Next Generation Networks*.
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