Media Independent Handover in Broadband Mobile Networks

Jong-Moon Chung, Jae-Han Seol, Sang-Hyouk Choi
Communication & Networking Laboratory (CNL)
School of Electrical & Electronic Engineering
Yonsei University
Shinchon-Dong 134, Seodaemun-Gu
Seoul 120-749, Republic of Korea.
http://www.yonsei.ac.kr/jmc

Abstract: This paper focuses on Media Independent Handover (MIH) issue for two future mobile communication networks, WiMAX and 3G-LTE/SAE. The IEEE 802.21 MIH protocol structure has been investigated such that the messages and primitives to enable interoperable operations in MIH functions (MIHFs) could be compared to the WiMAX and 3G-LTE/SAE protocol.

Key-Words: 3G-LTE/SAE, WiMAX, IEEE 802.21, MIH, Handover

1 Introduction

Recently, Internet service providers (mostly data based services) have been heading towards the telecommunication service field (mostly voice based services), and telecommunication service providers have been also entering the Internet service field. This crossover situation is a general trend of broadband mobile internetworking protocols, where new emerging standards like IP multimedia subsystem (IMS) are expected to have a large impact. Using these technologies, it is predicted that any type of access network will be able to support any kind of mobile node that has the capability to access to the radio station of the network. Therefore, it is expected that the boundary of the mobile communication network and the Internet service network would disappear in the near future. For this heterogeneous grand network to properly work, enhanced controllable network interoperating functions and specified point of interfaces (i.e., services access points (SAPs)) are required.

Based on this objective, a major issue to consider is how to interoperate the new emerging advanced mobile communication networks and terminals. One of the current emerging advanced mobile communication standards is based on mobile WiMAX networking, which uses the IEEE 802.16 (a/d/e) PHY and MAC standards. Mobile WiMAX is currently being deployed worldwide and is expected to revolutionize mobile networking services. Looking a step further into the future, third generation (3G) long-term evolution (LTE) technology is under rapid standardization. The 3G-LTE standards define the PHY and MAC standards of the protocol, where the system architecture evolution (SAE) standards under development define the networking architecture and specifications.

In this paper, the foundation of IEEE 802.21 Media Independent Handover (MIH) is used as the interoperable interfacing entity. The IEEE 802.21 framework defines MIH functions (MIHFs), which are intended to enable seamless handover across both 802 and non-802 networks.

This paper focuses on the IEEE 802.21 MIH interface specifications in relation to two emerging future mobile communication network technologies, WiMAX and 3G-LTE/SAE.

2 System Model

2.1 WiMAX Architecture

The WiMAX network is divided into the connectivity service network (CSN) and the access service network (ASN). The CSN provides traffic anchoring services (home agent) and authentication, authorization & accounting (AAA) services. The ASN is divided into the ASN gateway and base stations (BSs). The ASN gateway has many functional entities, such as, paging controller, authenticator, dynamic host configurable protocol (DHCP) proxy/relay server, radio resource controller (RRC), handover function, data path function, AAA client, location register, mobile IP foreign agent, and proxy mobile IP client. The base station has handover functions, radio resource agent (RRA), authentication relay, and so on [2].

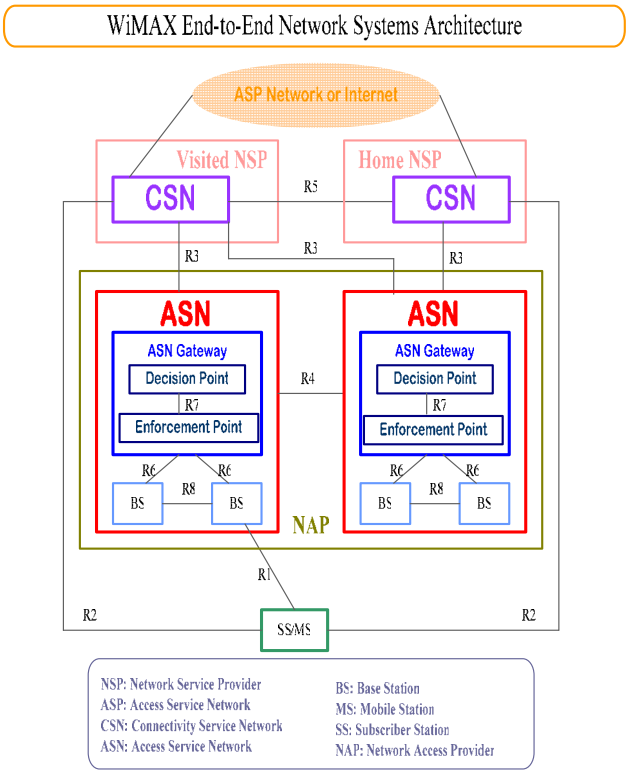

Figure 1. WiMAX system network architecture [2].

The ASN gateway and base station could be combined into one device. The WiMAX radio access system follows the IEEE 802.16 suite of applicable standards [2].

2.2 3G LTE & SAE Architecture

The heart of the SAE network is the evolved packet core (EPC). The SAE network performance is highly dependent to the architecture of the EPC. The main functions of the EPC are: (1) all-IP based mobility support (that enables handover support), and (2) interoperability with other networking systems (e.g., WiMAX, WLAN, WPAN, etc.) [1]. Fundamentally all-IP based mobility support has four considerations. The first one is host based mobility management (e.g., MIPv4, MIPv6). The second one is network based mobility management (e.g., NetLMM, PMIP, etc.). The third one is interworking between IPv4 and IPv6, and the last one is backward handover. Evidently, implementations using combinations are possible.

SAE networks basically include a large portion of voice service based networks (e.g., GSM, UMTS) as well as connections to other networks (e.g., WiMAX, WLAN, etc.) through the 3GPP anchor and the SAE anchor of the EPC.

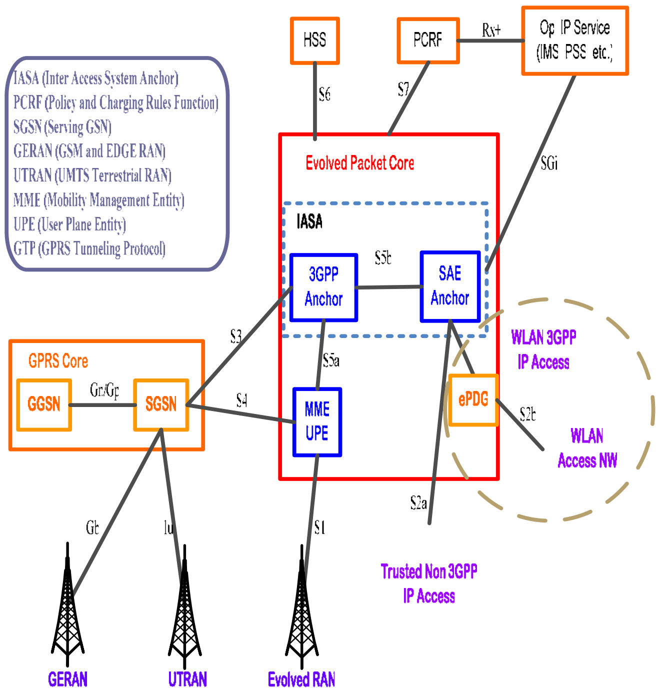

Figure 2. Logical high-level architecture for the 3G-LTE/SAE evolved system [1].

Data services over WiMAX are expected to be (most commonly) heavily multiplexed bursty giga-bit Ethernet traffic. Bursty traffic could result in a bad influence to voice services that are much more stable traffic streams compared to the multiplexed data service traffic. Therefore, at the SAE anchor, scheduling, call admission control (CAC), and various traffic engineering techniques are needed to minimize delay and losses. One of the main objectives of SAE is to support interoperability, where foreign MNs that are not 3GPP subscribers can be connected through the SAE anchor. When foreign MNs try to roam to the SAE network, the first thing done in the SAE network is execute AAA procedures. Resulting from the AAA procedures, the SAE network can apply proper management rules for foreign MNs. The EPC of the SAE network is responsible for all of these processes and should protect the SAE network from unidentified foreign

MNs that could attack. Therefore security and information assurance (IA) are very important issues along with AAA features.

2.3 IEEE 802.21 MIH Architecture

IEEE 802.21 working group is focused on developing a framework that enables Media Independent Handover Functions (MIHFs), which can enable seamless handover across heterogeneous networks, including both 802 and non-802 networks. The MIHF is an abstraction layer for planning the process of handovers among Ethernet, Bluetooth, Wi-Fi, UMTS, GPRS, GSM, 802.16, and various other networks. The objective of IEEE 802.21 is to support a unified common interface for managing events and to control messages exchanged between heterogeneous access networks [4]. The structure of 802.21 helps mobile devices discover, denote, and select networks within their current areas by exchanging information about the available link types, link identifiers, and link qualities of nearby network links.

The IEEE 802.21 standards under development have several functional requirements [5]:

- Support for the performance requirements of four application classes, as defined in other standards (c.f. ATM and UMTS).
- Service continuity acceleration, including across service providers or across media types that are not linked at a particular protocol or organization layer.
- Services to help network discovery, supporting a method of pointing if the network does provide the current service above the logical link control (LLC) sublayer.
- Obtaining quality of service (QoS) information about each network involved and comparing them.
- Speed up efficient power use in the scanning process.
- Service to help network selection, which can exchange detailed information about the network (e.g., cost, security mechanisms, provider information) between the attachment point and the mobile node.
- Satisfy the speed capabilities of each media so handover can happen as fast as the media will allow.
- Be agnostic to the handover algorithm or policy.

MIHF is composed of three different services: Media Independent Event Services (MIES), Media Independent Command Services (MICS) and Media Independent Information Service (MIIS).

MIES supply services to the upper layers by informing of both local and remote events. Local events take place within a client, but remote events take place in the network. In the case of local events, information propagates upward from the MAC layer to the MIH layer and then to the upper layers. In the case of remote events, information propagates from the MIH or Layer 3 Mobility Protocol (L3MP) in one stack to the MIH or L3MP in a remote stack [6].

The event model works according to a subscription and notification procedure. An MIH user registers to the lower layers for a specific set of events and gets informed of the occurring events. The Event Services have the Link Events and MIH Events. Link Events are events that originate from event source entities below the MIHF and typically terminate at the MIHF.

In general, MAC and PHY State Change events, Link Parameter events, Predictive events, Link Synchronous events, and Link Transmission events are link events. Entities with occurring link events include Link Up, Link Down, Link Parameter Change, etc. Other sets of MIH events include MIH Link Up, MIH Link Down, MIH Link Parameter Report, MIH Link Handover Complete, etc.

Media Independent Command Services (MICS) are used to assemble information about the status of connected links, and to execute upper layer mobility and connectivity decisions to the lower layer. MICS can be both local and remote. Information provided by MICS is dynamic composing of link parameters, such as, signal strength, link speed, etc. MICS has the following entities: MIH Switch, MIH Configure, MIH Handover Initiate, MIH Handover Prepare, MIH Handover Commit, and MIH Handover Complete, etc.

MIIS provides functions by which both the mobile node and the network can discover and obtain network information inside a physical region to execute vertical handovers. MIIS defines information elements (IEs) and correspondent query-response mechanisms which permit an MIHF entity to discover and obtain information with respect to close by networks. MIIS provides access to both static and dynamic information, including names of providers of neighbouring networks in addition to channel information, MAC addresses, security information, and other information about upper layer services useful to handover decisions. MIIS specifies a general method of characterizing information by using standard formats, such as, type-length-value (TLV) and eXternal Markup Language (XML) [6]. The IEs are divided into several groups. First, General Access Network Information gives a total overview of heterogeneous networks providing reports inside a specific area. These elements form a list of available networks, related operators, roaming accord, cost, network security, and quality of security ability. Second, information about points of attachment (PoA) has addressing information, PoA location, data rates and channel parameters. In addition, several information service elements can be vendor specific information and IEs.

Information given by MIIS is less dynamic compared to the information provided by MICS and is composed of parameters, such as, network operators, upper layer service information, etc. MICS and MIIS information could be used in composite by the network or/and mobile node to accelerate the handover [3].

Figure 3 shows a high-level interface illustration of a heterogeneous mobile station and network MIH reference model. Since the MIHF is located in a mobile node or access network, this model is divided into two parts: mobile station view and network view.

MIHF can correspond with the lower layer and the upper layer entities using an 802.21 primitive. This primitive is defined as a service access point (SAP). There are three types of SAPs: (1) Media Dependent SAP, (2) Media Independent SAP, and (3) Network Management SAP.

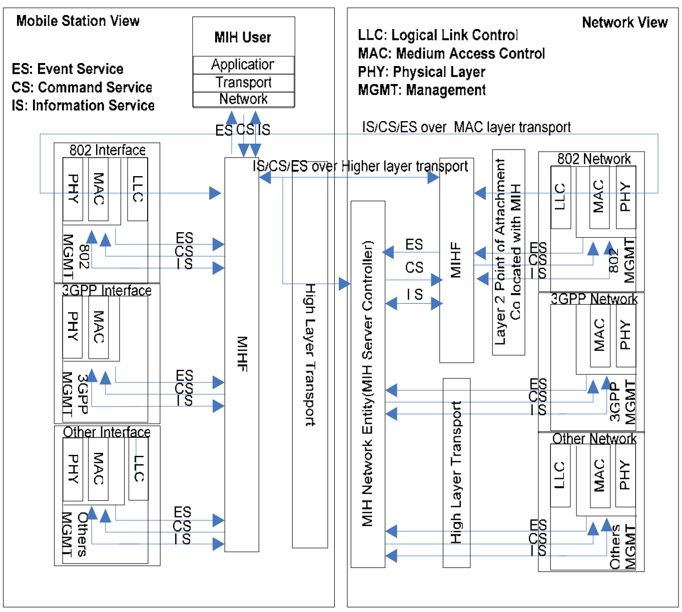

Figure 3. Example of a MIH high-layer interfacing model of the MS and network view [3].

The MLME_SAP provides the interface between MIH and the 802.11 management plane. The M_SAP and C_SAP characterize the interface between MIHF and the 802.16 control/management plane entities. The MIH_3GLINK_SAP defines the interaction between the MIHF and 3GPP system. MIH does not require 3GPP systems to have new primitives or SAPs. The Media Independent SAPs (MIH_SAP) are used to interface between the MIHF and MIH user, such as, to serve a higher layer mobility protocol. In addition, MIH_SAP has a handover function that can exist at the upper layer transport entity. The MIH_NMS_SAP is a Network Management SAPs for interaction between the MIHF and the Network Management Entity (NME) or the Network Management System (NMS) [3].

3 Interoperating MIHF & MIH SAPs

Figure 4 shows an MIH reference model for mobile stations with two protocol stacks, IEEE 802.16 (for WiMAX) and 3G-LTE (assumed model). The MIH_SAP is a media-independent interface for the IP layer (or higher mobility protocols), handover policy, transport, and applications. The PHY SAP is the interface for transmission of the PHY control, data, and statistics. The MAC SAP provides an interface for connection establishment and maintenance, MAC functionality, scheduling of users for both down-link (DL) and up-link (UL) for the MAC common part sublayer (CPS). The CS SAP is an interface for data transmission, includes signalling control for data transmission support, and access of the mapping of external network data into MAC SDUs via the CS SAP. The CS SAP defines the classification of foreign network service data units (SDUs), association SDUs to the appropriate connection identifier (CID) and MAC service flow, as well as the suppression and compression of the packet header [7], etc.

The M_SAP and C_SAP characterize the interface between the MIHF and the management and control plane of each network. The M_SAP primarily serves system configuration, monitoring statistics, notifications, and triggers. The C_SAP serves handover notification, idle mode mobility management, subscriber and session management, radio resource management, and AAA server signalling [3].

Due to the fact that the layered architecture and SAPs of 3G-LTE and 3G-SAE have not been defined yet in the 3GPP working groups, in this paper an assumed model is used, which is illustrated in Figure 4. In the assumed model, the 3G-LTE/SAE reference model is shown to have a MIH_3GLINK_SAP and SEC SAP, where the SEC SAP is a characterized interface for encryption, authentication, and secure key exchange.

The MIH_3GLINK_SAP serves the interaction between the MIHF and protocol elements of 3GPP.

Through the defined SAPs, the messages to execute the MIHFs are described. When the mobile node needs to perform handover, the network triggers handover preparation by sending a MIH_Handover_ Preparation.request message. This message could be mapped to the Handover Preparation Request message of 3G-LTE/SAE. In WiMAX the M_MACHandover.request/response message, which indicates the network decision to initiate handover to target network, could be mapped to the MIH_ Handover_Initiation.request/response message of IEEE 802.21.

The wireless link of the target network could be set up when the handover preparation is completed. In order to indicate the completion of the handover preparation procedure, the MIH_Handover_ Preparation.response message in 802.21 should be sent from the target network to the serving network. This message could be mapped to the Handover Preparation Confirm message of 3G-LTE/SAE. The serving network sends the MIH_Handover_ Commit.request message to the UE/MS when the network receives the MIH_Handover_ Preparation.response message in order to command the UE/MS to set up a wireless link in a foreign target network. This message could be mapped to the Handover Command message of 3G-LTE/SAE and M_HOIND.request message of WiMAX.

After the wireless link is setup, the UE/MS sends the MIH_Handover_Commit.response message to the serving network. This message could be mapped to the Handover Complete message of 3G-LTE/SAE and the M_HOIND.response message of WiMAX. Then, the serving network could release the network resources and the target network could provide the connectivity service to the UE/MS. In order to check this condition, the source network sends a MIH_Handover_ Complete.request message. Nevertheless 3G-LTE/ SAE and WiMAX do not have messages that have this exact meaning. After the UE/MS releases the radio resource of the source network, the UE/MS sends the MIH_Handover_Complete.response message. This message does not directly match to a message of 3G-LTE/SAE or WiMAX either, but the Handover Complete ACK message of 3G-LTE/SAE and the M_Registration.response message of WiMAX are similar.

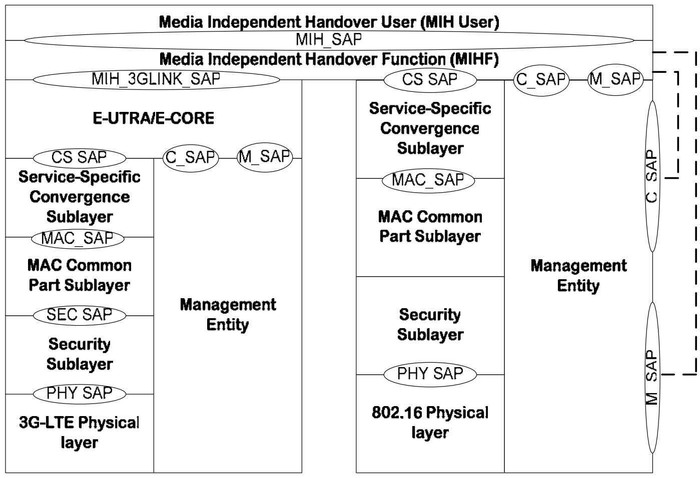

Figure 4. MIH protocol stack relationship of 3G-LTE/SAE (assumed layered model) and IEEE 802.16 [3].

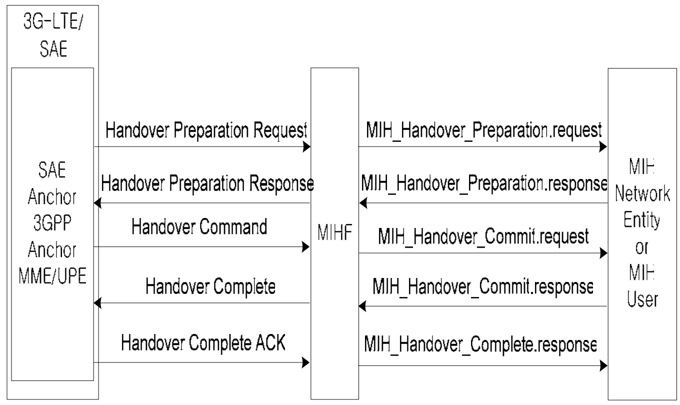

Figure 5. Message mapping between 3G-LTE/SAE and IEEE 802.21.

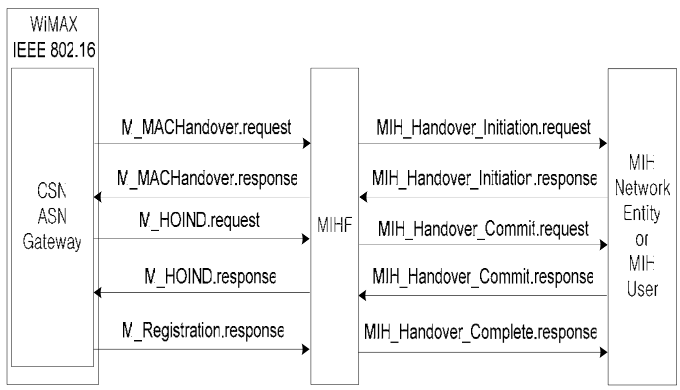

Figure 6. Message mapping between WiMAX and IEEE 802.21.

The relation of the MIHF messages described in Chapter 3 is summarized in Figures 5 and 6.

4 Conclusion

The IEEE 802.21 working group is developing a framework to enable media independent handover to support seamless handover across heterogeneous networks, including both 802 and non-802 networks. This paper investigates the MIH interface issues of two emerging future mobile communication networks, WiMAX and 3G-LTE/SAE. The IEEE 802.21 MIH protocol structure is based on MIHFs and MIH SAPs. SAPs, messages, and functions of the WiMAX and 3G-LTE/SAE protocol have been compared to MIH Functions (MIHFs) to enable interoperable interface operations. However, it is shown that numerous operations and features still need to be developed to enable full interoperable functionalities. In the future, it is expected that new messages will be made (or more features will be added to existing messages) to better support the interoperating functionalities of 3G-LTE/SAE and WiMAX via MIH.

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