

Gateway Service for Integration of Heterogeneous Networks using Different Interworking Solutions

Hyunho Park*, Hyeong Ho Lee*, H. Anthony Chan**

* Electronics and Telecommunications Research Institute (ETRI), Korea

** Huawei U.S.A . North American Headquarters, U.S.A

hyunhopark@etri.re.kr, holee@etri.re.kr, h.anthony.chan@huawei.com

Abstract— Heterogeneous networks with different radio access technologies such as GSM, UMTS, LTE, WiMAX, and WLAN has been deployed to support various communication services. Network operators want to manage the heterogeneous networks using interworking solutions such as MIH (Media Independent Handover), ANQP (Access Network Query Protocol), and ANDSF (Access Network Discovery and Selection Function). However, the interworking solutions were developed without any compatibility. The network operators have difficulties to manage heterogeneous networks using different interworking solutions. This paper proposes gateway service that supports cost-effective integration of heterogeneous networks using different interworking solutions. The gateway service is provided through gateway function of general network entities by using message encapsulation with MIH protocol header. The gateway service can help network operators manage integration of heterogeneous networks effectively.

Keywords— Gateway service, interworking solutions, MIH, ANQP, ANDSF

I. INTRODUCTION

Heterogeneous networks supporting different radio access technologies gains attention because the radio access technologies can complement each other. For example, while WLANs (Wireless Access Networks) provide high data rate, WWANs (Wireless Wide Area Networks), such as GSM, UMTS, LTE, and WiMAX, covers large area. Moreover, the GSM, UMTS, LTE, and WiMAX provide different types of communication services in data rate, cost, etc. These different characteristics of radio access technologies can complement each other through interworking between heterogeneous networks.

Standard organizations, such as IEEE, WiMAX, and 3GPP, have separately developed interworking solutions for heterogeneous networks. IEEE developed MIH (Media Independent Handover) framework to provide vertical handovers between

different radio access networks, and suggested ANQP (Access Network Query Protocol) to provide information for connecting to WLANs [1, 2]. 3GPP developed ANDSF (Access Network Discovery and Selection Function) for interworking with non 3GPP networks and 3GPP networks, such as GSM, UMTS, and LTE networks [3]. WiMAX also suggested solutions for interworking with other radio access networks [4]. However, these interworking solutions have no compatibility each other, and thus network operators have difficulties to manage heterogeneous networks using different interworking solutions.

Some researchers have studied integration of heterogeneous networks using different interworking solutions. Frei et al [5] and Omar et al [6] introduced cooperation between MIH and ANDSF. In [7], interaction between MIH and ANQP of WLANs was suggested. However, these integrations of different interworking solutions can increase complexity of network entities because network entities need to convert messages for an interworking solution to messages for other interworking solutions.

In this paper, we propose the gateway service as a new MIH service for supporting integration of interworking solutions. The gateway service is provided through gateway function of general network entities. For the gateway function, the network entity with gateway service encapsulates interworking messages with MIH header. If the network entity receives interworking messages, the network entity does not need to translate the messages, but encapsulates the messages with MIH header and then sends to the corresponding network entity. The gateway service is expected to support

integration of heterogeneous networks with low network complexity. We proposed the gateway service for IEEE 802.21c draft [8], and the gateway service is included in IEEE 802.21c draft.

The remainders of the paper are organized as follows. In section II, MIH services are introduced, and the need of a new MIH service is explained. Section III describes the gateway service for integration of heterogeneous networks using different interworking solutions. Section IV shows examples for gateway service. In section V, we will conclude the paper.

II. MIH SERVICES AND NEED FOR A NEW MIH SERVICE

The IEEE 802.21 introduced MIH services for interworking heterogeneous networks [1, 9]. The MIH services consist of three types of services.

- Media Independent Event Services (MIES)
- Media Independent Command Services (MICS)
- Media Independent Information Services (MIIS)

The MIES is used to report information of lower layer, such as link layer and physical layer, to higher layer called MIH user. The reported information includes lower layer state, link parameters events, link transmission events, etc. Based on the MIES, the MIHF (Media Independent Handover Function) can determine whether vertical handover begins or not.

The MICS is used to determine the states of links and to control radio interfaces. Through the MICS, the MIH user can gather from link-layer parameters such as SNR (Signal to Noise Ratio), BER (Bit Error Ratio), and RSSI (Received Signal Strength Indication). Moreover, the MICS helps the lower layer prepare and perform handover.

The MIIS is designed to deliver information of the radio access networks. The MIIS can include information about cost for service or network usage, QoS (Quality of Service), locations, and IP addresses of radio access networks. The MIIS also includes network specific, service specific, and vendor/network specific information.

Although the MIH services give good solutions for interworking heterogeneous networks, the MIH services have a room to be extended. As shown in Fig.1, SID (Service Identifier) of MIH header is used to indicate media independent services. While the SID consists of four bits, only four SID values are used currently. The reserved SID values can be used for new MIH services.

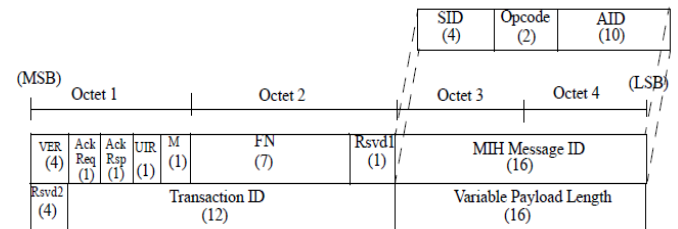


Figure 1. MIH protocol header format

This paper proposes a new service to integrate heterogeneous networks using different interworking solutions such as MIH, ANQP, and ANDSF. The interworking solutions have been developed without any compatibility, and thus network operators have difficulties to integrate heterogeneous networks using different interworking solutions. MIH, as the media independent interworking solution, is the best interworking solution to integrate heterogeneous networks. However, the existing MIH services do not contain integration of heterogeneous networks. Thus, a new service of MIH is needed. The next section will explain the new service called gateway service in detail.

III. GATEWAY SERVICE FOR INTEGRATION OF HETEROGENEOUS NETWORKS USING DIFFERENT INTERWORKING SOLUTIONS

In this section, we will explain gateway service to integrate heterogeneous networks using different interworking solutions. The gateway service focuses on simplification of network entities.

The previous studies such as [5], [6], and [7] proposed integration of interworking solutions such as MIH, ANDSF, and ANQP. However, message translation between different interworking solutions can be a burden for network entity. Figure 2 from [7] explains integration of MIH and

ANQP. For the integration, the WLAN AP (Access Point) of WLANs should translate ANQP message of GAS (Generic Advertisement Service) to MIH message, and vice versa. The translation increases complexity of the WLAN APs, and thus the WLAN APs will be expensive. Network operators have deployment burden with the expensive APs.

The gateway service is designed to reduce the complexity of network entities. The gateway service gives gateway function to the general network entity. The network entity equipped with gateway service behaves like gateway bridging heterogeneous networks using different interworking solutions. The network entity encapsulates interworking messages, such as ANDSF and ANQP messages, with MIH header. For example, if the PoA (Point of Attachment) such as a WLAN AP and a base station of WWANs can perform gateway service, the PoA encapsulates messages for interworking message with MIH header. The gateway service only provides simple encapsulation function, and thus the gateway service can be implemented without significant complexity.

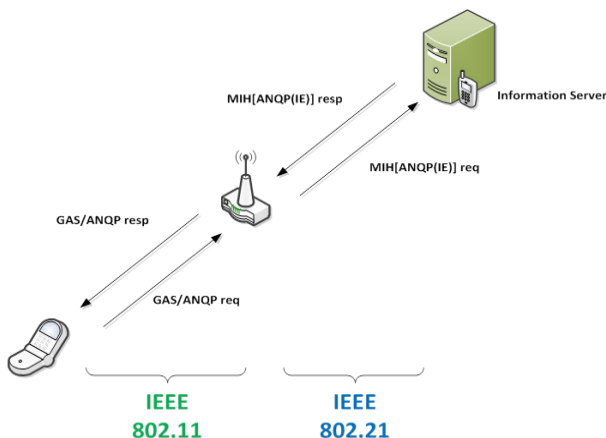
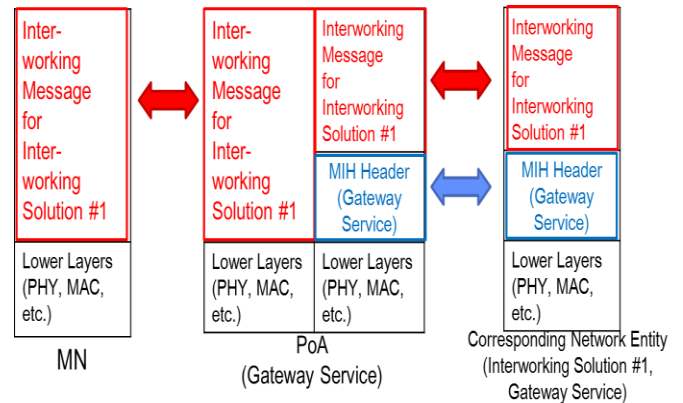


Figure 2. Previous approach for integration between MIH and ANQP [7]

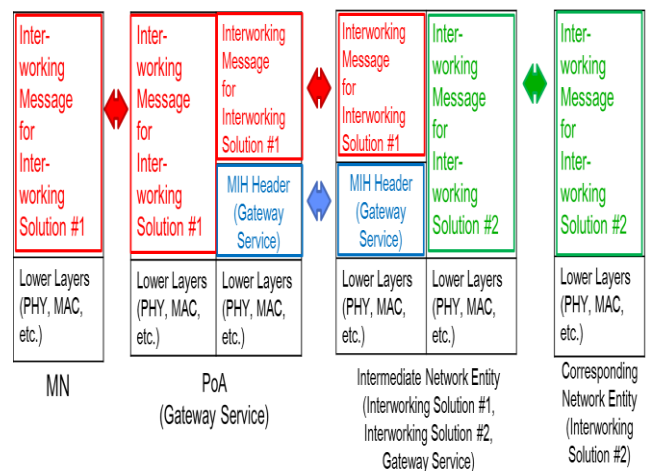
Figure 3 explains the application of gateway service with protocol stacks of network entities. We assume that the MN (Mobile Node) uses interworking solution #1, and the interworking solution #1 can be ANQP, ANDSF, etc.

The case 1 of Fig. 3 (a) shows delivery process of messages for interworking solutions when the corresponding network entity supports gateway

service and interworking solution #1. The PoA equipped with gateway service encapsulates messages from the MN with MIH header and transfers the encapsulated messages to the corresponding network entity. The corresponding network entity send messages encapsulated with MIH header to the PoA. The PoA decapsulates messages from the corresponding network entity and then send the messages to the MN.



(a) Case 1: Corresponding network entity supports gateway service and interworking solution #1.



(b) Case 2: Corresponding network entity supports interworking solution #2 but does not support interworking solution #1 and gateway service.

Figure 3. Delivery of messages for interworking solutions using gateway service

The case 2 of Fig. 3 (b) shows delivery process of interworking messages when the corresponding network entity supports other interworking solution (interworking solution #2), but does not support interworking solution #1 and gateway service. For this case, intermediate network entity should

support interworking solution #1, interworking solution #2, and gateway service. The intermediate network entity can be a gateway for WLANs, WiMAX networks, and 3GPP networks. The PoA encapsulates and decapsulates interworking messages for the MN and intermediate network entity. The intermediate network entity translates messages for interworking solution #1 into messages for interworking solution #2, or vice versa.

For the gateway service, the MIH header as shown in Fig. 1 should identify the gateway service. A new SID value and new AID (Action Identifier) values in MIH message identifier are used to identify gateway service. The new SID value for gateway service is five, and AID values are defined in Table 1. The AID value, 2, is for delivering ANQP messages. The AIDs from 3 to 500 are reserved for interworking solutions such as Rx, Ry, and R9 of WiMAX, and ANDSF of 3GPP. To determine the value for messages of other interworking solutions, cooperation between IEEE 802 and other standard organizations such as WiMAX and 3GPP is needed. AID values from 501 to 1023 can be used for vendors to implement the gateway service.

TABLE 1. AIDs WHEN THE SID IS FIVE (GATEWAY SERVICE)

AIDs	Description of Behaviour
2	Delivery of ANQP messages
3~500	Reserved for messages for interworking solutions
501~1023	Reserved for vendor specific area

IV. EXAMPLES OF GATEWAY SERVICE

In this section, we will show the examples of gateway service. The examples will also deal with integration between MIH and ANQP such as Fig. 1. This section explains the simplification of network entity through gateway service in detail.

Figure 4, as an example of the case 1 in Fig. 3, shows integration between MIH and ANQP using gateway service when the Media Independent Information Server can process ANQP messages. When the MN wants to receive ANQP messages from the Media Independent Information Server,

the WLAN AP can bridge between the MN and Media Independent Information Server as shown in Fig. 4 (a). The WLAN AP only encapsulates or decapsulates messages from the MN and the Media Independent Information Server as shown in Fig. 4 (b).

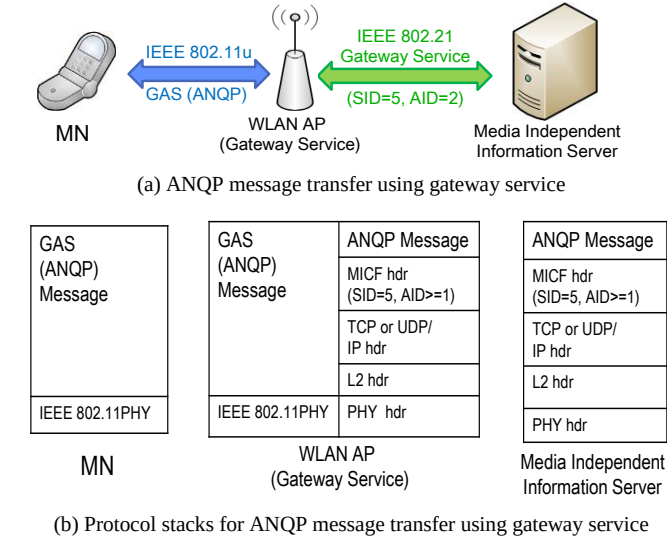


Figure 4. Example of case 1 in Fig. 3: Integration between MIH and ANQP using gateway service when the Media Independent Information Server that support ANQP messages and gateway service

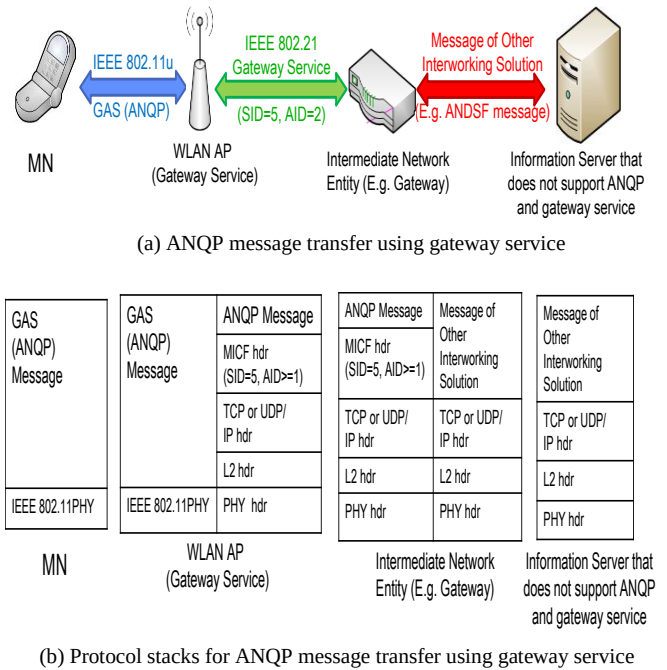


Figure 5. Example of case 2 in Fig. 3: Integration between ANQP and other interworking solution using gateway service when the Information Server that does not ANQP messages and gateway service

Figure 5, as an example of case 2 in Fig. 3, shows integration between ANQP and other interworking solution when the Information Server does not support ANQP and gateway service. For integration between ANQP and other interworking solutions such as ANDSF, the intermediate network entity such as a gateway should convert ANQP messages into other interworking message or vice versa as shown in Fig. 5 (a). In Fig. 5 (b), the WLAN AP only encapsulates or decapsulates messages from the MN and intermediate the network entity. Thus, even though the Information Server does not support ANQP and gateway service, the MN can interwork with the Information Server.

As shown in these examples, the WLAN AP with gateway service can be simpler than the WLAN AP of Fig.2. The WLAN AP will be implemented with low-cost because of its simplicity, and thus can gather interest of network operators.

V. CONCLUSIONS

This paper proposed gateway service for cost-effective integration of heterogeneous networks using different interworking solutions. The gateway service is provided through gateway function of general network entities by using message encapsulation with MIH protocol header. The gateway service helps simplification of network entities, and thus the cost of the network entities can be reduced. This gateway service has been proposed to be included in the draft of IEEE 802.21c.

As further study area to enhance the gateway service, it is needed to support efficient discovery of target networks and delivery of various kinds of interworking messages as well as ANQP message. Through the enhanced gateway service, interworking between heterogeneous networks will be realized cost-effectively.

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REFERENCES

- [1] IEEE Standard for Local and Metropolitan Area Networks – Media Independent Handover Services, IEEE 802.21, January 2009.
- [2] IEEE standard 802.11n, Part 11: Wireless LAN medium access control (MAC) and physical layer (PHY) specifications – amendment 5: Enhancements for higher throughput, 2009
- [3] 3GPP. Access Network Discovery and Selection Function (ANDSF) Management Object (MO), V9.1.0. TS 24.312, 3rd Generation Partnership Project (3GPP), Mar. 2010.
- [4] WiMAX Forum Network Architecture - Architecture, detailed Protocols and Procedures Single Radio Interworking between Non-WiMAX® and WiMAX® Access Networks, Nov. 2010.
- [5] S. Frei, W. Fuhrmann, A. Rinkel, and B. Ghita, "Improvements to Inter System Handover in the EPC Environment," in Proc. NTMS'2011, pp.1-5, Feb. 2011.
- [6] O. Khattab and O. Alani, Ed., "Improvements to Seamless Vertical Handover between Mobile WiMAX, Wi-Fi and 3GPP through MIH," in Proc. PGNet 2012.
- [7] P. Feder et al, "802.11/21 Network Discovery and Selection Architecture (DCN: 21-12-0025-00-0000)," in IEEE 802.21 WG, March 2012.
- [8] IEEE P802.21c™/D01 Draft Standard for Local and metropolitan area networks- Part 21: Media Independent Handover Services Amendment 3: Optimized Single Radio Handovers, Oct., 2012
- [9] A. Oliva et al, "An Overview of IEEE 802.21: Media-Independent Handover Services," *IEEE Wireless Communications*, vol. 15, no. 4, pp. 96-103, Aug. 2008.



Hyunho Park received the B.S. degree in electrical engineering and computer science from Kyungpook National University, Daegu, Rep. of Korea, in 2005, and the M.S. degree in information and communications from the Gwangju Institute of Science and Technology, Gwangju, Rep. of Korea, in 2007. He is currently working towards his PhD degree in mobile communication & digital broadcasting engineering at the University of Science and Technology, Rep. of Korea.

From 2008 he has been working for ETRI (Electronics and Telecommunications Research Institute) and engaged in the research and standardization on vertical handover technologies for heterogeneous networks. He is serving as a secretary of IEEE Standard 802.21c Task Group on Single Radio Handover Optimization. His research interests include vertical handover and interworking between heterogeneous networks.



Hyeong Ho Lee received B.S. degree from Seoul National University, Seoul, Korea in 1977, and the M.S. and Ph.D. degrees from KAIST (Korea Advanced Institute of Science and Technology), Daejeon, Korea all in Electrical Engineering in 1979 and 1983, respectively. From 1983 he has been working for ETRI (Electronics and Telecommunications Research Institute) and engaged in the research and development of digital switching systems, LAN equipment, routers,

optical access systems, and IT standardization. From 1984 to 1986, he was a visiting engineer in AT&T Bell Laboratories, Naperville, U.S.A., where he was involved in the development of the No.5 ESS digital switching system. From 1997 to 2007, he was the director of Switching System, Router Technology, Optical Access Network Technology Departments, and Protocol Engineering Center (PEC) in ETRI. Since 2008, he is serving as a Special Fellow in ETRI, and works in the area of standardization researches for the next generation IT environment. He was the chairman of KOREF (Korea Ethernet Forum) from 2000 to 2004, the President of IPv6 Forum Korea from 2005 to 2008, and a Vice President of IEEK (Institute of Electronics Engineers of Korea) from 2004 to 2011. Also, From 2005 to 2012, He served as a Vice Chairman of ITU-T SG11 (Study Group on signalling requirements, protocols and test specifications). Currently, he is an Editor of the ETRI Journal, a Council member of IEEK, a Council member of KICS (Korea Information and Communications Society), and a Senior member of IEEE (Institute of Electrical and Electronics Engineers).

H. Anthony Chan received his PhD in physics at University of Maryland, College Park in 1982 and then continued post-doctorate research there in basic science. After joining the former AT&T Bell Labs in 1986, his work moved to industry-oriented research in areas of interconnection, electronic



packaging, reliability, and assembly in manufacturing, and then moved again to network management, network architecture and standards for both wireless and wireline networks. He was the AT&T delegate in several standards work groups under 3GPP. He moved to academia as professor at University of Cape Town in 2004, and moved again to industry research as he joined Huawei Technologies in 2007. His current research is in emerging broadband wireless network technologies. He contributed to mobility standards in both IETF and IEEE and is the editor of an IETF DMM Working Group draft on the requirements on distributed mobility management

Dr. Chan is a Fellow of IEEE, chair of IEEE Standard 802.21c Task Group on Single Radio Handover Optimization, Vice-chair of IEEE standard 802.21 Working Group on Media Independent Handover, honorary professor at The University of Hong Kong, and adjunct professor at Hong Kong Polytechnic University. He has authored/co-authored over 200 conference and journal papers, a research handbook, several book chapters, and 16 patents. He is a Distinguished Lecturer of IEEE ComSoc, a distinguished Speaker of IEEE CPMT Society and a Distinguished Speaker of IEEE Reliability Society, and had delivered 40 conference tutorials / short courses and 6 invited speech / keynotes.