New Authentication Mechanism for Vertical Handovers between IEEE 802.16e and 3G Wireless Networks

Pyung-Soo Kim[1] and Yong-Jin Kim[2]
[1]Department of Electronics Engineering, Korea Polytechnic University,
Siheung-City, Kyonggi-Do, 429-793, Korea

[2]MODACOM Co. Ltd.
Seoch-Gu, Seoul, 137-073, Korea

Summary
This paper proposes a new authentication mechanism for vertical handover between IEEE 802.16e and 3G wireless networks. Firstly, functions of main components in the proposed mechanism are defined newly. Secondly, operation procedures of the proposed mechanism are described for two configuration cases, respectively. According to the proposed mechanism, an inter-base station protocol (IBSP) message can be transmitted between two heterogeneous access networks. Thus, authorization, authentication, accounting (AAA) processes are only performed at an early stage of connecting the MS to the Internet. Therefore, the MS can change its heterogeneous access networks without re-authentication, which can reduce the handover latency of the MS. In addition, the location of the MS can, at any time, be managed by using a single agent server regardless of the MS's current access network, which can make the management of the MS's location easy. Accordingly, the proposed mechanism can provide the ongoing session for service continuity of the MS between two heterogeneous access networks..

Key words:
Authentication, Vertical handover, IEEE 802.16e, 3G.

1. Introduction

Recently, the IEEE approved the 802.16e standards effort with the avowed intent of increasing the use of broadband wireless access (BWA) by taking advantage of the inherent mobility of wireless media. The amendment to IEEE 802.16, which is also called the wireless metropolitan area network (MAN) standard, will enable a single base station to support both fixed and mobile BWA. It aims to fill the gap between high data rate wireless local area networks (LAN) and high mobility cellular wide area networks (WAN) [1]-[4].

For successful deployment of IEEE 802.16e networks worldwide, it is required to integrate them with widely deployed third-generation (3G) wireless networks, such as WCDMA, GPRS, UMTS, cdma2000, etc., to provide ubiquitous wireless communications at high data rates and a large variety of services with variable bandwidth and QoS requirements, across a wide range of propagation environments and mobility conditions, using dual mode terminals [5]-[8]. This interworking of IEEE 802.16e and 3G networks will be linked with many technical challenges including vertical handover, security, common authentication, unified accounting/billing, consistent QoS and service provisioning, etc..

Among them, the authentication within the handover execution of the mobile station (MS) between IEEE 802.16e and 3G networks is considered in this paper. There are some Internet services that require the MS to be properly authenticated. Thus, when the MS moves from the IEEE 802.16e network to the 3G network or vice versa, the MS should perform authorization, authentication, accounting (AAA) processes that it has already performed when entering a new heterogeneous access network in order to maintain a session for the Internet service. That is, whenever the MS moves from one access network to another heterogeneous access network, the MS has to perform the AAA processes all over again, which results in an overload on the AAA server. Therefore, the handover latency between two heterogeneous networks can increase because the MS performs the complicated AAA processes whenever it encounters a new heterogeneous access network, which results in a decrease in the efficiency of a network and may cause discontinuity in an Internet service.

As there is no research effort on the common authentication mechanism within the handover execution of the mobile station (MS) between IEEE 802.16e and 3G wireless networks, this paper proposes a new authentication mechanism for vertical handover between two wireless networks. Firstly, functions of main components in the proposed mechanism are defined newly for base station (BS) of the IEEE 802.16e network, 3G base station of the 3G network, and inter-base station protocol (IBSP) mobility agent server of Internet, etc. Especially, the 3G base station has three functions such as

a virtual BS, a Node-B (NB), and a virtual BS-to-NB (VBS2NB) communication controller. Secondly, operation procedures of the proposed mechanism are described when moving from the IEEE 802.16e network to the 3G network or vice versa, for both cases where the virtual BS for the 3G network is installed in the 3G base station and in the serving GPRS support node (SGSN).

According to the proposed mechanism, an IBSP message can be transmitted between IEEE 802.16e and 3G wireless networks. Thus, AAA processes are only performed at an early stage of connecting the MS to the Internet. Therefore, the MS can change its access networks without re-authentication, which can reduce the handover latency of the MS. In addition, the location of the MS can, at any time, be managed by using the single IBSP mobility agent server regardless of the MS's current access network, which can make the management of the MS's location easy. Moreover, a single Internet service provider (ISP) enables two heterogeneous access networks to share and use authentication information on the MS. Accordingly, the proposed mechanism can provide the ongoing session for service continuity of the MS between the two heterogeneous access networks.

This paper is organized as follows. In Section 2, a new authentication mechanism for vertical handover between IEEE 802.16e and 3G wireless networks. In Section 3, operation procedure of the proposed mechanism are described for two cases. In Section 4, advantages of the proposed mechanism are discussed over existing mechanisms. Finally, the conclusion is made in Section 5.

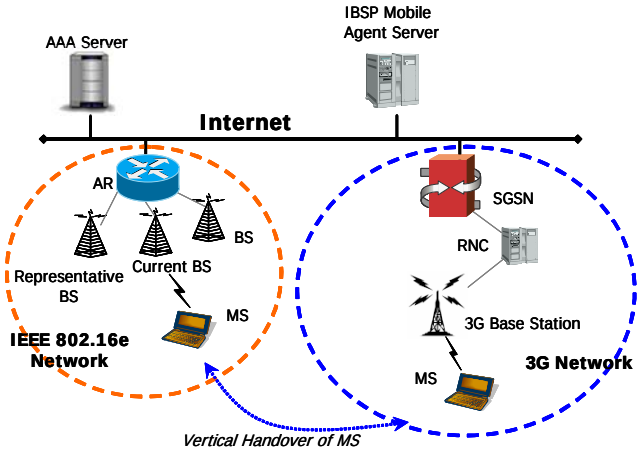

Figure 1. Exemplary Network Environment

2. Proposed Mechanism

2.1 Functions of Main Components

Figure 1 is a diagram illustrating an exemplary network environment where the MS moves between IEEE 802.16e and 3G wireless networks. As shown in Figure 1, the exemplary network consists of IEEE 802.16e network, 3G network, AAA server, IBSP mobility agent server. The 3G wireless network consists of SGSN, and radio network controller (RNC), 3G base station, etc. The IEEE 802.16e network consists several BSs and an access router (AR) which manages wireless areas of several BSs.

□ Base Station and Access Router

The base station (BS) and access router (AR) manage the IEEE 802.16e network. If the MS attempts to access the Internet from the IEEE 802.16e network via the BS, the MS's current BS accesses the AAA server via the AR and then performs AAA processes for the MS. Once the AAA processes are completed, the MS's current BS performs appropriate operations so that the MS can be connected to the Internet, and thus can be provided Internet services by an Internet service provider (ISP). Once the MS is connected to the Internet, the MS's current BS multicasts an IBSP message, which contains information on the MS obtained by performing the AAA processes in its IEEE 802.16e network. Then, other BSs in the IEEE 802.16e network can share the information on the MS by receiving the IBSP message multicasted from the MS's current BS. The information on the MS includes an authentication key of the MS, a base station identifier (BSID) information that specifies an identifier of the MS's current BS, and accounting information. If the ISP designates the particular BS as a representative BS of the IEEE 802.16e network, the representative BS unicasts a packet containing the IBSP message to the IBSP mobility agent server. In order to transmit/receive the IBSP message to/from the IBSP mobility agent server, the representative BS utilizes a user datagram protocol (UDP) processing function. The UDP processing function consists of a UDP encapsulation module, a UDP decapsulation module, and a control module, which controls the UDP encapsulation and decapsulation modules. If the MS changes its BS in the same IEEE 802.16e network, the MS's new BS multicasts the UDP packet with IBSP message containing the information on the MS throughout the entire IEEE 802.16e network and updates the location information of the MS shared with the other BSs. In this case, the representative BS does not need to unicast the UDP packet with IBSP message to the IBSP mobility agent server.

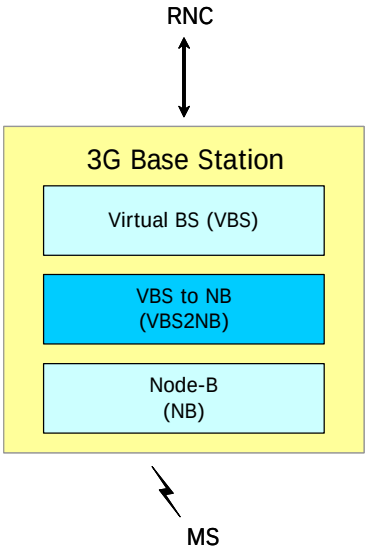

Figure 2. 3G Base Station

☐ 3G Base Station

The 3G base station manages the 3G network. As shown in Figure 2, the 3G base station consists of a virtual BS, a Node-B(NB), and a virtual BS-to-NB (VBS2NB) communication controller. The virtual BS in the 3G base station can play a role of the representative BS of the 3G network. The 3G base station can be connected to the Internet via the SGSN using the point-to-point protocol (PPP). When the UDP packet with IBSP message is received from the SGSN via the RNC, the virtual BS performs an IBSP operation by removing a PPP header from the UDP packet, parsing resulting UDP packet data, and then storing the parsed UDP packet data. Accordingly, the 3G network and the IEEE 802.16e network can share the same information on the MS. The NB provides a path, along which the 3G base station can wirelessly communicate with the MS. The NB operates by using a protocol exclusive for the 3G network. The VBS2NB communication controller is a module for enabling the NB to communicate with the virtual BS. The VBS2NB communication controller is necessary because the virtual BS, unlike the NB, which operates by using the protocol exclusive for a 3G network, operates using an IP. Note that, as an alternative configuration, the virtual BS can be installed in the SGSN rather than in the 3G base station unlike in Figure 2.

☐ IBSP Mobility Agent Server

Within an IEEE 802.16e network, the MS may handover between different BSs as shown in [1]-[4]. In order to ensure all relevant information is delivered to the correct BS to which the station is associated, an Inter-Base Station Protocol (IBSP) should be required. This protocol should be designed for the enforcement of unique association for secure exchange of station's security context between the current BS and the new BS during the handover period. The IBSP mobility agent server mediates IEEE 802.16e and 3G wireless networks. Using this IBSP mobility agent server, the information on the MS can be shared across BSs in each of the IEEE 802.16e network and the 3G network. As shown in Figure 3, the IBSP mobility agent server consists of an IBSP processing module, a representative BS list, and a MS database. The IBSP processing module performs a predetermined operation so that an IBSP message can be shared between BSs in IEEE 802.16e and 3G wireless networks connected to each other by an ISP. Therefore, when the UDP packet with IBSP message is received from the representative BS of the IEEE 802.16e network or the 3G network, the IBSP processing module parses an IBSP message contained in the received UDP packet, thereby obtaining information on the MS. Then, the IBSP processing module stores the information in the MS database and forwards this UDP packet to the representative BS. This UDP packet also includes the IBSP message, which contains the information on the MS. The representative BS list stores IP addresses of representative BSs in all access networks including IEEE 802.16e and 3G networks that can be connected to one another by the ISP. The MS database stores the information on the MS contained in the IBSP message, such as an authentication key, BSID information, and accounting information of the MS, and is updated whenever the MS is associated with a new access network.

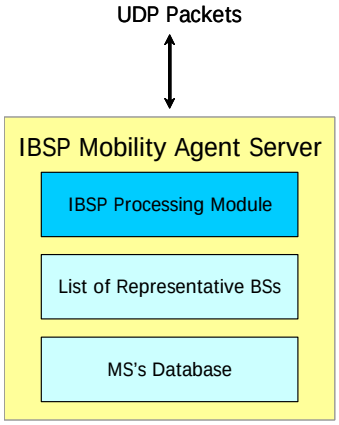

Figure 3. IBSP Mobility Agent Server

3. Operation Procedure

Figure 4 illustrates an exemplary network including only one IEEE 802.16e network and one 3G network. However, the proposed mechanism can also be applied to an expanded version of the network, i.e., a network

comprising a plurality of IEEE 802.16e and 3G networks. It is assumed that the MS initialize the communication on the IEEE 802.16e network.

3.1 MS's Initialization in IEEE 802.16e network

When the MS is initialized in the IEEE 802.16e network, the MS issues firstly an association request to the its current BS on the IEEE 802.16e network and then the BS performs an authentication process on the MS by communicating with the AAA server. Once the authentication process is completed such that the MS can be provided an Internet service, the MS's current BS multicasts an IBSP message, which contains information on the MS obtained by performing the AAA process. If the ISP designates the particular BS as a representative BS of the IEEE 802.16e network as shown in Figure 1, the representative BS makes the UDP packet with IBSP message multicasted from the MS's current BS and unicasts this UDP packet to the IBSP mobility agent server. When the IBSP mobility agent server receives the UDP packet with IBSP message, it forwards this message to a representative BS of the 3G network by referring to the representative BS list of Figure 3. As shown in Figure 2, the virtual BS plays a role of the representative BS in the 3G network. The SGSN, the RNC, and the 3G base station are connected to each other and communicate with each other via the 3G protocol defined by the ISP. Therefore, in order to forward an IBSP message to a virtual BS installed in the 3G base station, a PPP session is opened on the 3G protocol, which operates between the SGSN and the virtual BS, so that the SGSN and the virtual BS can be connected with PPP to each other. Accordingly, the SGSN can forward the UDP packet with IBSP message to the virtual BS in the 3G base station by using its PPP connection to the virtual BS. Then, the virtual BS parses the UDP packet with IBSP message and stores authentication information on the MS.

3.2 MS's Moving to 3G Network

As mentioned before, the virtual BS can be installed in the 3G base station or in the SGSN. Thus, when the MS moves to the 3G network, operation procedures are described for two cases, respectively.

The first case is that the virtual BS for the 3G network is installed in the 3G base station. As shown in Figure 4, when moving from the IEEE 802.16e network to the 3G network, the MS issues an association request to the 3G base station. The NB in the 3G base station issues a request for authentication information on the MS to the VBS2NB communication controller by using the intrinsic information of the MS, such as terminal identification information. Then, the VBS2NB communication controller issues a request for the authentication information to the virtual BS. And then, the virtual BS determines whether it possesses the requested authentication information. If the virtual BS possesses the requested authentication information on the MS, it provides the requested authentication information to the VBS2NB communication controller. Otherwise, the virtual BS provides information indicating that it has failed to search for the requested authentication information to the VBS2NB communication controller. Then, the VBS2NB communication controller transmits information received from the virtual BS to the NB. The NB determines whether to perform an authentication process on the MS based on the information received from the VBS2NB communication controller. If the NB receives the requested authentication information from the VBS2NB communication controller, it performs an authentication process by using the requested authentication information on the MS. Thereafter, the NB issues a request for PPP connecting the MS to the SGSN via the RNC without the need to further issue a request for authenticating the MS to the SGSN. However, if the NB does not receive the requested authentication information from the VBS2NB communication controller, the NB issues the request for authenticating the MS as well as the request for PPP connecting the MS to the SGSN to the RNC. Accordingly, the SGSN communicates with the AAA server, thereby performing AAA processes on the MS. Eventually, the SGSN and the MS are connected with PPP to each other.

The second case is that the virtual BS for the 3G

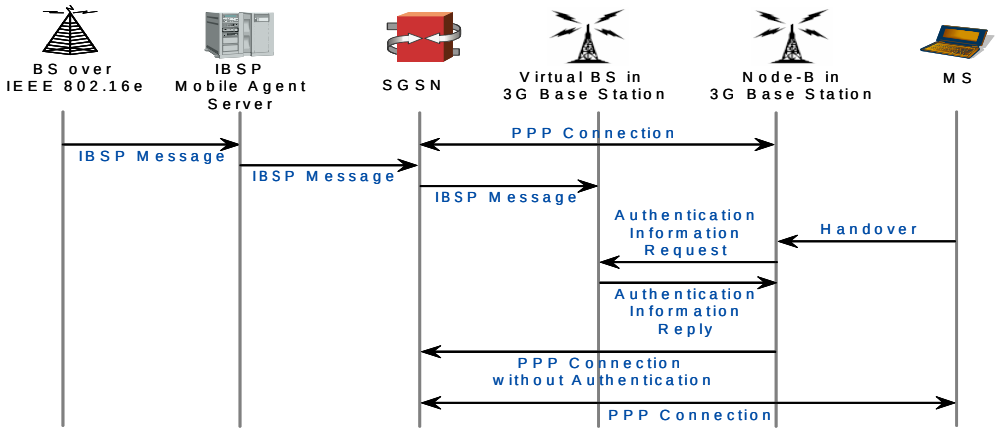

Figure 1. Exemplary Network Environment

network is installed in the SGSN rather than in the 3G base station unlike in Figure 2. Thus, the representative BS list in the IBSP mobility agent server includes an IP address of the SGSN for the 3G network. Thereafter, the IBSP mobility agent server unicasts the UDP packet with IBSP message to the SGSN. Accordingly, an IBSP message forwarded from the IBSP mobility agent server is stored in the virtual BS in the SGSN without the need to forward the IBSP message to the NB. When moving from the IEEE 802.16e network to the 3G network managed by the NB, the MS issues an association request to the NB. Then, the NB issues a request for authentication information on the MS to the virtual BS in the SGSN via its PPP connection to the SGSN. If the NB receives the requested authentication information on the MS from the virtual BS in the SGSN, it performs an authentication process on the MS by using the authentication information on the MS and issues a request for PPP connecting the MS to the SGSN without further issuing a request for authenticating the MS.

3.3 MS's Return to IEEE 802.16e network

9When the MS returns from the 3G network to the IEEE 802.16e network, two wireless networks are enabled to share the information on the MS by performing the IBSP processes in the inverse order of their presentation above.

4. Advantages

In this section, several advantages of the proposed mechanism are discussed. In the proposed mechanism, AAA processes are only performed at an early stage of connecting the MS to the Internet. That is, whenever the MS moves from one access network to another heterogeneous access network, the MS do not need to perform the complicated AAA processes all over again, which can reduce the overload on the AAA server. Therefore, the handover latency of the MS can be reduced since the MS can change its access networks without re-authentication. In addition, the location of the MS can, at any time, be managed by using a single IBSP mobility agent server regardless of the MS's current access network, which can maximize the ease with which the location of the MS is managed. Moreover, a single ISP enables two heterogeneous access networks to share and use authentication information on the MS. Accordingly, the proposed mechanism can provide the ongoing session for service continuity of the MS between the two heterogeneous access networks.

5. Conclusions

This paper has proposed the new authentication mechanism for vertical handover between IEEE 802.16e and 3G wireless networks. Firstly, functions of main components in the proposed mechanism are defined newly. Secondly, operation procedures of the proposed mechanism are described for two configuration cases, respectively. According to the proposed mechanism, an IBSP message can be transmitted between two heterogeneous access networks. Thus, AAA processes are only performed at an early stage of connecting the MS to the Internet. Therefore, the MS can change its heterogeneous access networks without re-authentication, which can reduce the handover latency of the MS. In addition, the location of the MS can, at any time, be managed by using a single agent server regardless of the MS's current access network, which can make the management of the MS's location easy. Accordingly, the proposed mechanism can provide the ongoing session for service continuity of the MS between two heterogeneous access networks.

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Pyung-Soo Kim He received the B.S. degree in Electrical Engineering from Inha University in 1994. He received the M.S. degree in Control and Instrumentation Engineering and the Ph.D. degree at the School of Electrical Engineering and Computer Science from Seoul National University in 1996 and 2001, respectively. From 2001 to 2005, he was a senior researcher at the Digital Media R&D Center of Samsung Electronics Co. Ltd. Since 2005, he has been with the Department of Electronics Engineering at Korea Polytechnic University. His main research interests are in the areas of system software solutions, wireless mobile networks, next generation network system design, statistical signal processing, and various industrial applications.

Yong-Jin Kim He received the B.S. degree in Electronics Engineering from Yonsei University in 1883. He received the M.S. and the Ph.D. degrees in Electric and Electronics Engineering from KAIST in 1889 and 1997, respectively. From 1983 to 2002, he was a principal member of researcher at ETRI. Since 2003, he has worked for Modacom. His main research interests are in the areas of fixed and mobile convergence technologies, embedded system, next generation network system, and Internet multimedia subsystem applications