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WiMAX - WLAN 멀티홈드 노드의 시뮬레이션 모델

Simulation model of a multihomed node with WiMAX and WLAN

장효뢰*, 왕야*, 기장근**, 이규대***

Xiao-Lei Zhang, Ye Wang, Jang-Geun Ki, Kyu-Tae Lee

요 약 오늘날 무선 기술의 급속한 발전으로 인해 복수개의 액세스 인터페이스를 갖는 이동단말들이 나타나고 있다. 최근 WLAN이 근거리 통신을 위해 많은 가정과 기업에서 사용되고 있으며, WiMAX 또한 장거리 데이터 전달을 위한 무선 표준으로 부각되고 있다. 따라서 이기종 무선망간에 멀티미디어 데이터를 전달하기 위한 효율적인 접속 방안 연구가 필요하다. 본 논문에서는 WiMAX와 WLAN 인터페이스를 갖고 모바일 IP를 이용해 두 망사이를 이동할 수 있는 멀티홈드 노드의 시뮬레이션 모델과 환경을 개발하였다. 개발된 모델을 검증하기 위해 단방향/양방향 UDP 패킷, FTP 트래픽, SIP 프로토콜을 이용한 음성 전송 등과 같은 다양한 트래픽 환경하에서 여러가지 시뮬레이션 시나리오 즉, WiMAX와 WLAN 망간 이동, 그룹 이동성, MANET, 중첩 모바일 IP 등을 설계하고 구성하였으며, 시뮬레이션 결과를 분석함으로써 개발된 모델이 다양한 무선망 접속 시나리오에서의 이동성 연구에 효율적임을 보였다.

Abstract With the rapid progress of wireless technologies today, mobile terminals with multiple access interfaces are emerging. In recent years, WLAN (Wireless Local Area Networks) has become the premier choice for many homes and enterprises. WiMAX (Worldwide Interoperability for Microwave Access) has also emerged as the wireless standard that aims to deliver data over long distances. Therefore, it is important to explore efficient integration methods for delivering multimedia data between heterogeneous wireless networks. In this paper, we developed the simulation models and environments for the mobile multihomed node that has both WiMAX and WLAN interfaces and can move around in both networks by using mobile IP. In order to verify the developed models, we designed and constructed several simulation scenarios, e.g. movement in WiMAX/WLAN, group mobility, MANET, and nested MIP under the various traffic environments such as oneway or bothway UDP packets, FTP traffic, and voice with SIP protocol. The simulation results show that the developed models are useful for mobility studies in various integrated wireless networks.

Key Words : multihomed, WiMAX, WLAN, SIP, MANET

Ⅰ. Introduction

In recent years, the technology scene as well as user's expectations from communication networks has changed enormously. It is now becoming common for a user to have access to a number of wired or wireless networks simultaneously. Moreover today's user does not want to be restricted within a confined area while availing the communication facility. Users desire to remain connected while on the move. The users of mobile device may move around through various access networks and they may want to take service via the network that is most efficient for that service. Mobility management thus becomes one of the core challenges of future 4G heterogeneous all IP networks.

*준회원, 공주대학교 대학원 정보통신공학과
**종신회원, 교신저자, 공주대 전기전자제어공학부
***종신회원, 공주대학교 정보통신공학부
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In a heterogeneous access network environment, the mobile device may select a proper access network fit for the cost or required degree of service quality. The heterogeneous access network environment has close relation with ubiquitous network. An important characteristic of heterogeneous networks is that the user equipment is multihomed. It is common that modem mobile terminals possess multiple network interfaces e.g. Ethernet, WLAN, Bluetooth and WiMAX network interfaces. Currently, standards lack in efficiently exploiting the existence of these multiple network interfaces[1][2].Therefore, an in-depth research in this area is needed.

These days, many researchers prefer a simulation to an experiment because there are many advantages to performing a simulation rather than actually conducting an experiment. In the communication network simulation area, the OPNET is one of most popular software to be used. In this paper, we developed the simulation models and scenarios for a mobile multihomed node that has both WiMAX and WLAN interfaces and can move around by using mobile IP under the OPNET environment. The developed multihomed node model can act as a mobile host as well as a mobile router and can move around both WiMAX and WLAN networks.

There are four scenarios that will be described and simulated in this paper. In the first scenario, the multihomed node is moving around between WiMAX and WLAN access networks under the various traffic conditions such as oneway/bothway UDP traffic, FTP, VoIP with SIP protocol, etc. The second scenario shows a group mobility test by using the developed multihomed node model as a mobile router, while the third scenario will describe the interconnection of WiMAX and MANET networks through the mobile multihomed router as a gateway. The fourth scenario shows the nested mobile IP operation.

The rest of the paper is organized as follows. In the following section, the network technologies in our proposed internetworking architectures are briefly reviewed and discussed. Section III describes the developed simulation models and scenarios to test the interworked heterogeneous networks. Some simulation results and analysis are shown in section IV. Finally, conclusions and some recommendations for future work are given in Section V.

Ⅱ. The Network Technologies

1. WiMAX and WLAN access technology

1) WiMAX technology

WiMAX(Worldwide Interoperability for Microwave Access) is a new technology that is still not very popular but is gaining widespread attention due to the niche it serves. WiMAX equipment provides services that are in between high speed, narrow range WLAN and low speed, wide range 3G and 2G technologies. WiMAX is a high-performance, cost-efficient technology that is set to make wireless broadband widely available and affordable.

IEEE 802.16 WiMAX is the broadband wireless access (BWA) system designed mainly for Wireless Metropolitan Area Network (WMAN). The motivation is to provide last mile broadband wireless access to the general population and implement a single standard for fixed broadband wireless access and mobility with high scalability and a low cost of deployment.

2) WLAN technology

WLANs provide wireless network communication over short distances using radio or infrared signals instead of traditional network cabling. A WLAN typically extends an existing wired local area network. It provides users mobility to move from one location to another without thinking about the wires. It has grown in popularity along with the rise of laptop computers and low cost notebooks that made mobile computing within reach for most people.

The IEEE 802.11 standard group specified the technologies for wireless LANs. 802.11 standards use the Ethernet protocol and CSMA/CA (carrier sense multiple access with collision avoidance) for path sharing and include an encryption method, A Wireless Local Area Network (WLAN) implements a flexible data communication system frequently augmenting rather than replacing a wired LAN within a building or campus. WLANs use radio frequency to transmit and receive data over the air, minimizing the need for wired connections.

표 1. WiMAX와 WLAN 차이점
Table 1. The difference between WiMAX and WLAN

	WiMAX	WLAN
Standardization	IEEE802.16	IEEE802.11x
Primary Application	Broadband Wireless Access	Wireless LAN
Frequency Band:	Licensed/unlicensed 2G to 11 GHz	5GHz(802.11a) 2.4GHz(802.11b,g)
Range	12-15km (LOS) 1-2KM (NLOS)	~100 meters
Peak data rate	70 Mbps	54 Mbps(802.11a,g) 11 Mbps(802.11b)
Number of users:	Thousands	Dozens
Bandwidth	5-6 GHz	20 MHz
Multiple Access	OFDM/OFDMA	CSMA/CA
Coverage	Mid	Small
Mobility	Mobile WiMAX (802.16e)	In development
Environment	Outdoor, NLOS	indoor
Security	Multi-level encryption	limited
Quality Guarantees	Supported by MAC, differentiation by service type	802.11e

Table 1 shows the difference between WiMAX and WLAN. The two technologies differ in the type of Media Access Controller or MAC that they utilize. Wi-Fi uses one that is contention based. This means that all clients who use the same access point are competing for bandwidth with the closest user getting the highest priority. WiMAX uses a MAC with a scheduling algorithm that ensures each client gets assigned a certain time span to communicate with the access point. The time span allocated to each client can be reduced or expanded depending on the needs of the client but it cannot be used by other clients as long as it remains connected.

WiMAX stands for worldwide interoperability for internet access to areas the WLAN cannot reach.

WLAN is meant for short range applications while WiMAX is meant for long range applications. WLAN can deliver much faster speeds compared to WiMAX. WiMAX provides a much better method of bandwidth distribution compared to WLAN. Both technologies are still susceptible to overloading.

2. IMS and SIP

A clear advantage of using the IMS is its ability for real-time session negotiation and management using the Session Initiation Protocol (SIP). Therefore, a brief overview of the IMS and SIP is presented.

1) IP Multimedia Subsystem (IMS) overview

The IP Multimedia Subsystem (IMS) standard defines a generic architecture for offering Voice over IP (VoIP) and multimedia services. It is comprised of a layered and unified architecture that manages media as it moves through the network and provides the systems integration needed to provide any IP Multimedia services for and between any set of wireline and wireless end-users[3].

The key elements of the IMS framework are the Call State Control Functions (CSCFs) and the Home Subscriber Server (HSS). A CSCF can be loosely defined as a SIP proxy server and the HSS as a master database for user profiles. The CSCFs can be identified as follows; Proxy-CSCF, Interrogating- CSCF, and Serving-CSCF. The P-CSCF is the first SIP proxy receiving a SIP request, which also acts as a SIP Back-to-Back User agent (B2BUA). The P-CSCF forwards session requests to the S-CSCF via the I-CSCF. The task of the I-CSCF is to select the appropriate S-CSCF by checking with the HSS. If the relevant S-CSCF is known, the I-CSCF may be bypassed. The S-CSCF is the actual SIP server that eventually performs the user registration and handles session control for the IMS network. The Media Gateway Control Function (MGCF) interconnects with circuit switched networks via the corresponding IMS Media Gateway (IMS-MGW)[4].

2) Session Initiation Protocol (SIP) overview

SIP is the core protocol chosen by the 3GPP for signaling and session management within the IMS[5]. By and large, SIP can be defined as an application layer based flexible framework used for establishing, maintaining, and tearing down multimedia sessions. SIP is capable of supporting multiple IP media streams and other TCP or UDP based streaming applications. Nevertheless, SIP is not just a single standalone protocol, which is fully capable of call control. It rather behaves as a suite of protocols when it comes to providing a complete solution. For example, a standard VoIP application embeds the Session Description Protocol (SDP) within the SIP messages for negotiating bearer path attributes. Once the parameters of the session are agreed upon, a media session can now be established. The media flow typically uses the Real-Time Protocol (RTP) if it is VoIP traffic. Even though SIP does not play a role in the media session, it is used for terminating or changing the parameters of the session[4].

3. MANET

Ad Hoc networking is a concept in computer communications, which means that users wanting to communicate with each other form a temporary network, without any form of centralized administration. Each node participating in the network acts as both a host and a router and therefore is willing to forward packets for other nodes. For this purpose, a routing protocol is needed.

One of key issues in MANETs (Mobile Ad Hoc Networks) is the necessity that the routing protocols must be able to respond rapidly to topological changes in the network. At the same time, due to the limited bandwidth available through mobile radio interfaces, it is imperative that the amount of control traffic generated by the routing protocols is kept at a minimum.

Ⅲ. Simulation Models and Interworking Scenarios

In this chapter, we describe the developed simulation models and environments for a mobile multihomed node that has both WiMAX and WLAN interfaces and can move around by using mobile IP.

1. Development of multihomed node model

In this section, new multihomed node model is proposed to eliminate the exiting model limitation, which has the only one access technology in one mobile node in OPNET[6]. Fig.1 shows the developed multihomed node model structure for integrating both WiMAX and WLAN access technologies. The developed multihomed node model can act as a mobile router as well as a mobile host and support MIP, MANET, SIP protocols and applications.

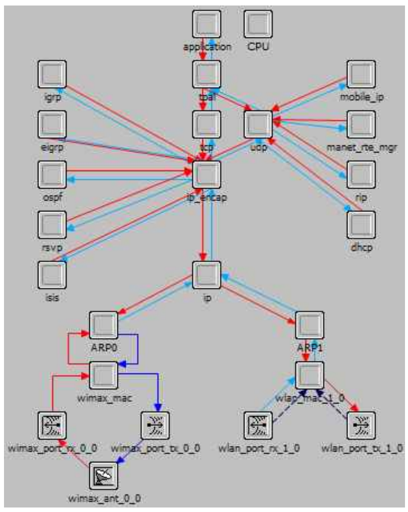


그림 1. 멀티홈드 노드 모델
Fig. 1. Multihomed node model

2. WiMAX-WLAN interworking scenarios

In order to verify the usefulness of the developed multihomed node simulation model, various interworking scenarios between WiMAX and WLAN are designed like below.

1) Scenario 1: movement in WiMAX/WLAN networks

In this scenario, the multihomed node operates as a mobile multihomed host and is moving among WiMAX Base Stations (BSs) and WLAN Foreign Agents (FAs) by using mobile IP. During the simulation, the various types of traffic including UDP, FTP, and VoIP are generated at the multihomed node and the correspondent node (CN) in order to test the proposed scenario. For FTP traffic, CN node (workstation model) is replaced with server model. For VoIP with SIP protocol, P/S/I-CSCF nodes are added for SIP signaling.

Fig.2 shows the network model of the scenario with UDP traffic. From this scenario, various performance indices related to the horizontal/vertical handoff in/between WiMAX and WLAN can be obtained.

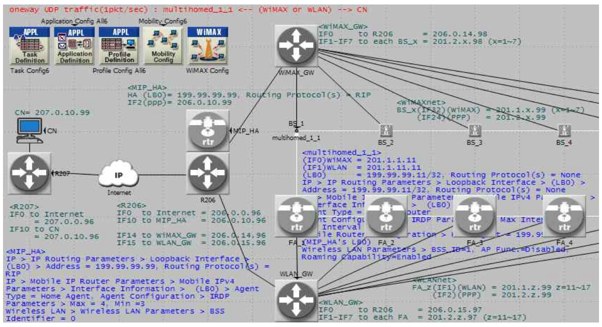


그림 2. WiMAX와 WLAN 사이의 이동
Fig. 2. Movement between WiMAX and WLAN

2) Scenario 2: group mobility by using mobile multihomed router

In this scenario, a group mobility test is made by using a mobile multihomed node as a mobile router, which is the gateway of a wireless network. Within this wireless network, if mobile wireless nodes want to connect to the Correspondent Node (CN), it should connect the mobile multihomed router by using WLAN access technology, and then the data packets will go through the each WiMAX BSs to the CN whenever the wireless network is moving from one WiMAX BS to another WiMAX BS.

Fig.3 shows the network model of this group mobility scenario and in fact this scenario covers the NEMO(Network Mobility) of the IETF.

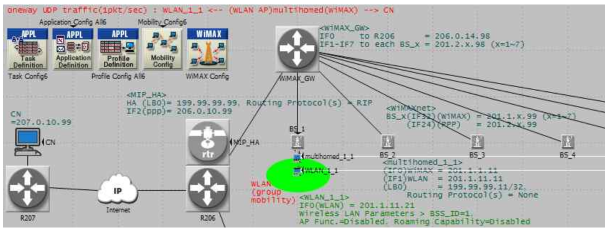


그림 3. 멀티홈드 라우터를 이용한 그룹 이동성
Fig. 3. Group mobility with the multihomed router

3) Scenario 3: MANET interconnection to WiMAX netwrok

In the previous scenario 2, the group mobility wireless network utilizes WLAN access technology. However, in this scenario, the group mobility wireless network uses Mobile Ad hoc network (MANET), where the MANET routing protocols is run among the various wireless mobile nodes. It is worth mentioning that the mobile multihomed node also is used as a mobile router as well as a gateway of MANET.

In MANET network, all mobile nodes participate in the delivery of others traffic. Fig.4 shows the example MANET network where MANET_1_1 traffic is sent to the multihomed node through the MANET_1_2 node and then this traffic will be delivered to the CN through WiMAX network.

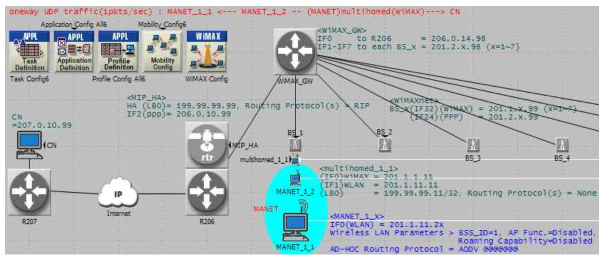


그림 4. MANET망의 WiMAX 망 접속
Fig. 4. Interconnection of MANET to WiMAX network

4) Scenario 4: nested MIP

In this nested MIP scenario, the multihomed nodes behave as foreign agents for other WLAN MIP hosts. In Fig.5, the multihomed node and the mobile IP host have their own Home Agent for nested mobile IP operations.

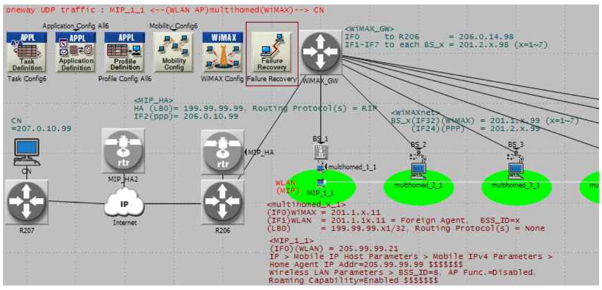


그림 5. 중첩 모바일 IP
Fig. 5. Nested mobile IP

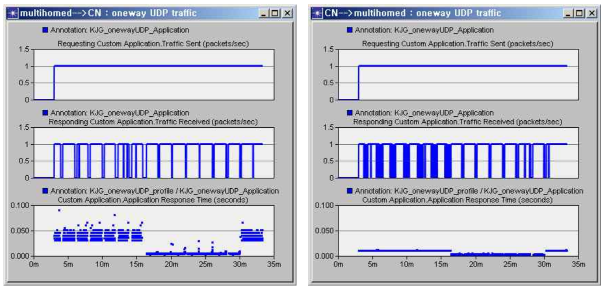
IV. Simulation and Analysis

The main purpose of our simulation in this paper is to verify the operations of the developed multihomed node model in the various network technologies. In-depth performance evaluation will be dealt in another paper.

In order to verify the developed multihomed node model, the proposed WiMAX/WLAN interworking scenarios have been simulated by using the OPNET simulator with some modification of the exiting simulator code, in order to support the simulation of dual interface mobile nodes and vertical handoffs between the different heterogeneous networks.

After simulating the whole scenarios and analyzing the results, we conclude that the developed simulation models are logically correct and very useful for studying mobility between WiMAX and WLAN networks.

Fig.6 and Fig.7 are the simulation results of the scenario 1. Fig.6 (a) shows the traffic transmitted from the multihomed node and the traffic received by the correspondent node and the end-to-end transmission delay from the multihomed to the correspondent. Fig.6 (b) shows the results of the vice versa. From the figure, it can be seen that traffic from the multihomed node to the correspondent node and vice versa is transmitted successfully except the handoff period.



(a) multihomed→CN (b) CN→multihomed

그림 6. 시나리오 1에서의 UDP 트래픽
Fig. 6. UDP traffic in the first scenario

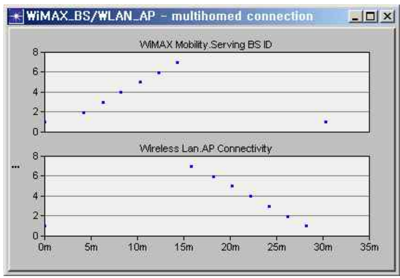


그림 7. WiMAX BS ID와 WLAN AP ID
Fig. 7. WiMAX BS IDs and WLAN AP IDs

Fig.7 shows the WiMAX serving BS IDs and the WLAN AP IDs to which the mobile multihomed node is connected during the simulation. As Fig.7 depicts, while the multihomed node is moving from WiMAX to WLAN networks, serving BS ID is changed from BS1 to BS7 and after detecting WLAN access technology, the WLAN connected AP ID is changed from FA7 to FA1 in order.

The simulation results of the scenario 2 and 3 can be seen in Fig.8, Fig.9 and Fig.10.

From Figure 8 and Figure 10, it can be known that WLAN node and MANET node can transmit/receive the data packet to/from CN through mobile multihomed router, even though some packets are lost during the handoff. And also mobile multihomed router can receive the data traffic in WiMAX interface when it is moving among WiMAX BSs.

Fig.9 shows the mobile IP related statistics of the multihomed node in the scenario 2. In the case of both scenario 2 and 3, the multihomed node behaves as a mobile router and manages WLAN or MANET nodes as a group while they are moving together. In other words, the multihomed node acts as a mobility manager of a group of WLAN or MANET nodes.

Fig.11 shows the tunneled traffic statistics of the nested MIP in the scenario 4. More specifically, Fig.11(a) depicts the tunneled traffic sent from each Home Agent and Fig.11(b) show the tunneled traffic received by each multihomed node that act as a foreign agent of the MIP host.

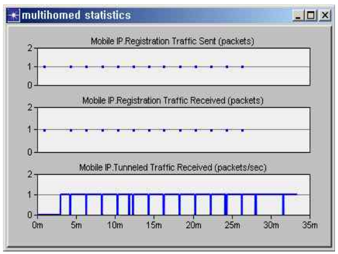
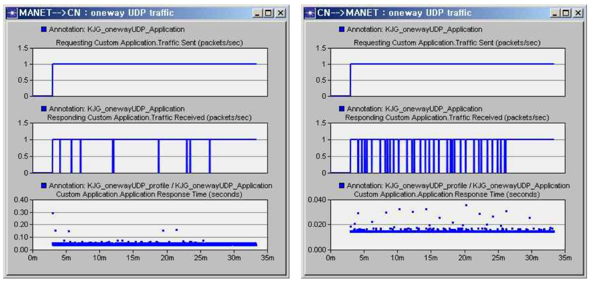
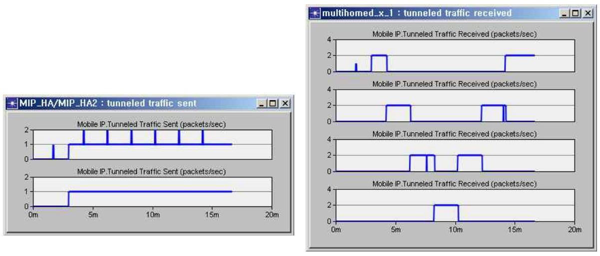


그림 9. 시나리오 2에서의 모바일 IP 통계치
Fig. 9. Mobile IP statistics in the second scenario



(a) MANET→CN (b) CN→MANET

그림 10. 시나리오 3에서의 UDP 트래픽
Fig. 10. UDP traffic in the third scenario



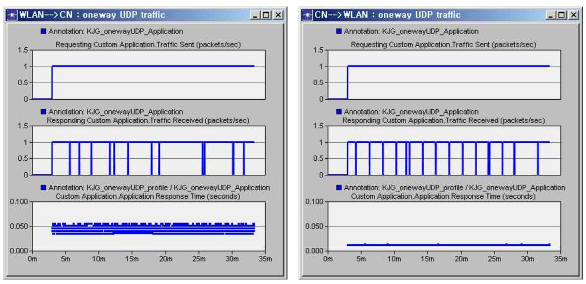
(a) Tx traffic (b) Rx traffic

그림 11. 중첩 모바일 IP의 터널통과 트래픽
Fig. 11. Tunneled traffic of the nested MIP

V. Conclusion

With the dramatic progress in wireless technology, it is getting more important to explore efficient integration methods for delivering multimedia data between heterogeneous wireless networks.

In this paper, we developed the simulation models and environments for a mobile multihomed node that has both WiMAX and WLAN interfaces and can move around by using mobile IP. The developed multihomed node model can act as a mobile router as well as a mobile host and support MIP, MANET, SIP protocols and applications. And also many different interworking architectures with WiMAX and WLAN are proposed and simulated by using the developed multihomed node model for studying and evaluating the mobility management mechanisms. Simulated scenarios include the movement in WiMAX/WLAN, group mobility, MANET, and nested MIP under the various traffic environments such as oneway or bothway UDP packets, FTP traffic, and voice with SIP protocol. The simulation results show that the developed models are useful for mobility studies in various integrated wireless networks. In-depth performance evaluation will be conducted by using the developed multihomed node model in the next work.



(a) WLAN→CN (b) CN→WLAN

그림 8. 시나리오 2에서의 UDP 트래픽
Fig. 8. UDP traffic in the second scenario

Further studies are necessary in order to integrate more wireless access technologies such as UMTS and CDMA as well as WLAN and WiMAX in a multihomed node and QoS(Quality of Service) support is an interesting topic in mobility studies among those wireless access technologies.

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저자 소개

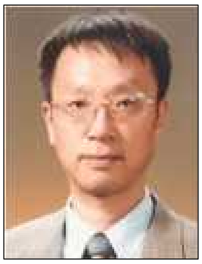
장 효 뢰(준회원)

Zhang Xiaolei received B.S. degree in the automation from Beihua University, China, in 2007, and received her M.S. in Information and Communication Engineering from Kongju National University in Kongju, Korea in 2009. She holds a Ph.D. from the department of Information and Communication Engineering of Kongju National University of Korea. Her main research interests include MANET, MIPv6 and Internet protocol suite.

왕 야(준회원)

Wang ye received the B.S. in Electrical Engineering and Automation from Beihua University, China in 2003. He has been worked for 3 years in Zhuhai Wanlida Electric Co., LTD., and also received his M.S. in Information and Communication Engineering from Kongju National University in Kongju, Korea in 2009. He holds a Ph.D. from the department of Information and Communication Engineering of Kongju National University of Korea. His main research interests include Mobile ad hoc networks, wireless communication networks, NGN mobility.

기 장 근(종신회원)



Jang-Geun Ki received the B.S., M.S., Ph.D. in electronics from Korea university, Korea in 1986, 1988, 1992 respectively. Since then, he has been a professor in Kongju National University. His main research interests include telecommunication protocols and network architectures.

이 규 대(종신회원)

Kyu-Tae Lee received his B.S. in Electronics Engineering from Korea University, Korea, 1984 and M.S. degree in Electronics Engineering from Korea University, Korea, 1986 and Ph.D. degree in Computer and Electronics Engineering from Korea University in 1991. He joined the faculty of Kongju National University, Korea where he is currently a professor in Division of Information and Communication Engineering. His research interests include DSP programming, Reconfigurable open architecture, Software Defined Radio system and Circuit and System. He is a member of Webcasting, Internet and Telecommunication.