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WLAN과 WiMAX에서의 연동 서비스 품질 비교 연구

Comparative study of an integrated QoS in WLAN and WiMAX

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요 약 본 논문에서는 OPNET 시뮬레이터를 사용하여 IEEE 802.16e(모바일 WiMAX)와 IEEE 802.11e(WLAN) 무선망 상호접속 구조에서의 서비스품질에 대한 체계적 성능분석을 수행하였다. OPNET 시뮬레이터를 이용해 4가지 이동 시나리오에서 음성 트래픽을 인가하는 경우에 대한 시뮬레이션이 수행되었으며, MOS값, 종단간 지연시간, 패킷 전달률 등과 같은 다양한 성능지표들이 분석되었다. 시뮬레이션 결과 MOS 값의 경우 단말이 정지/이동하는 두 경우 모두 WiMAX-> WiMAX 이동 시나리오가 가장 좋은 결과를 보였다. 반면에 종단간 지연시간은 4가지 이동 시나리오 모두 단말의 이동에 의해 크게 영향을 받지 않았다. 그러나 특히 WLAN->WLAN 이동 시나리오의 경우 단말의 이동성은 MOS값과 패킷 전달률에 많은 영향을 미치는 것으로 나타났다.

Abstract This paper addressed the implementation of the systematic performance analysis of Quality of Service (QoS) by using OPNET simulator in the interworking architecture of IEEE 802.16e (mobile WiMAX) and IEEE 802.11e (WLAN) wireless network. Four simulation cases were provided in OPNET simulator and a voice traffic was simulated with various performance metrics, such as Mean Opinion Score (MOS), end-to-end delay and packet transmission ratio. Based on the simulation results, the MOS value presented better in WiMAX to WiMAX case compared to others in both static and mobility case. Meanwhile, end-to-end delay was not greatly affected by mobility in four cases. However, mobility was affected much in MOS value and packet transmission ratio in WLAN to WLAN case than in others.

Key Words : IEEE 802.11e, IEEE 802.16e, MOS, OPNET, QoS, WiMAX, WLAN

Ⅰ. INTRODUCTION

Due to significant developments in the last few years in various wireless access technologies (e.g. IEEE 802.11 (WLAN), IEEE 802.16e (mobile WiMAX), Universal Mobile Telecommunication System (UMTS), etc.), the future heterogeneous wireless environments will be characterized the coexistence of a large variety of wireless access technologies, with various protocol stacks and also providing the different Quality of Service (QoS) requirements for each applications and services[1], which will be mixing of real-time traffic such as voice, multimedia teleconferencing games, and data traffic such as web browsing, messaging, and file transfers. Therefore, the ability of QoS is most important in today's network than it ever was especially in the interworking wireless network. Providing QoS continuity in such an integrated wireless network is challenging research issue.

Some researches already have been provided QoS in the interworking architectures of heterogeneous

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wireless networks. In H. Haffajee and H. Chan (2006) [2], the author analyzed interactions between different layers and network entities which are necessary to provide QoS when interworking WLAN and WiMAX. However, the paper did not provide any implementation details or performance analysis. Lars Berlemann and Christian Hoymann (2006)[3] described restrictions and requirements of each protocol to have enabled QoS support under the coexistence, but the QoS performance was not shown in that paper. A proposed mechanism for simulates QoS to send real-time and non-real-time traffic over the integrated network was explained in G. Arul Prasath and K.R. Raghu (2008)[4], the work of which is to use CBR traffic to emulate UGS flows and Poisson traffic to emulate rtPS and nrtPS flows arriving from the WLAN nodes. The work of Hui-Tang Lin and Ying-You Lin (2009)[5] depicted the performance of QoS management capability across the WLAN and WiMAX by using WiMAX/WiFi AP (W^2-AP) module to evaluate in QualNet simulator. The results confirmed that the integrated architecture reduced the end-to-end delay of high priority traffic.

This paper presented generic interworking network architecture between different access technologies to evaluate the performance of QoS by using integration node model introduced in Ye Wang (2009)[6]. The systematic performance analysis was done in OPNET simulator[7] by analyzing the different performance metrics, such as Mean Opinion Score (MOS), packet end-to-end delay and packet transmission ratio.

Ⅱ. MATERIALS AND METHODS

1. IEEE 802.16e Mobile WiMAX QoS

The IEEE 802.16e standard[8] is a technology proposed to offer wireless access to network stations in a metropolitan area environment. IEEE 802.16e defines five scheduling services to support various types of real-time and non-real-time services. The five scheduling service classes are Unsolicited Grant Scheme (UGS), Extended Real Time Polling Service (ertPS), Real Time Polling Service (rtPS), Non Real Time Polling Service (nrtPS) and Best Effort (BE), respectively.

2. IEEE 802.11e WLAN QoS

IEEE 802.11e draft[9] specification specifies new enhanced mechanisms to provide the guaranteed QoS. IEEE 802.11e adopts two channel access mechanisms to cater for applications with different QoS requirements based on Hybrid Coordination Function (HCF), namely the: (i) Enhanced Distributed Channel Access (EDCA) and (ii) HCF Controlled Channel Access (HCCA).

IEEE 802.11e defines four Access Categories (ACs) in EDCA and also provides eight different priorities.

3. QoS Mapping in WiMAX and WLAN

Since most access technologies differ significantly in terms of QoS support, it is very hard to keep the same QoS metric and QoS class for all types of applications. Therefore, QoS mapping strategies is important in providing efficient access managements and connection strategies in a heterogeneous wireless network[10].

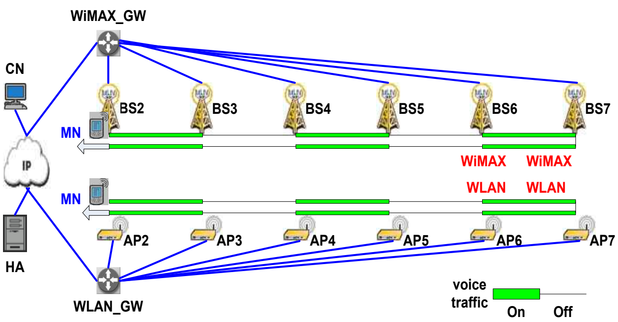
Table 1 describes the QoS classes mapping policy between WiMAX and WLAN[11].

표 1. WiMAX와 WLAN 사이의 QoS 매핑
Table 1. QoS Mapping between WiMAX and WLAN

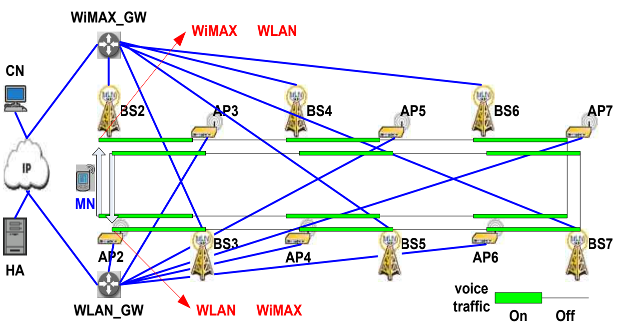
Priority	WiMAX	WLAN	Services
0	BE	AC_BK	E-mail
1	BE	AC_BK	Web Browsing
2	nrtPS	AC_BE	FTP (low quality)
3	nrtPS	AC_BE	FTP (high quality)
4	rtPS	AC_VI	VoD
5	ertPS	AC_VI	Real-time Streaming
6	UGS	AC_VO	VoIP (low quality)
7	UGS	AC_VO	VoIP (high quality)

4. Simulation Environment

The main objective is to simulate the performance of QoS in an integrated WiMAX and WLAN architecture. The simulation scenarios in OPNET simulator is proposed and illustrated in Figure 1, from which four cases were simulated to analyze the evaluation of QoS in OPNET, each of which was WiMAX to WiMAX, WLAN to WLAN, WiMAX to WLAN, WLAN to WiMAX, respectively.



(a) WiMAX→WiMAX, WLAN→WLAN movements



(b) WiMAX→WLAN, WLAN→WiMAX movements

그림 1. OPNET 시뮬레이션 네트워크 구조
Fig. 1. Simulation network architecture in OPNET

5. Simulation Parameters

The voice traffic was generated and transmitted at 180 sec, and the packet interval of VoIP was assumed to 120 sec. More details about the common simulation parameters for four cases presented in Table 2.

In terms of QoS classes of each access technologies described in section 1 and 2, the default MAC Access parameters defined in IEEE 802.16e[8] and IEEE 802.11e[9] were listed in Table 3 and Table 4 respectively.

표 2. 공통 시뮬레이션 파라미터
Table 2. The Common Simulation Parameters

Parameters	Value
Distance between BSs and APs	1.5 km
Voice Traffic	G.711 (silence)
Packet Data Rate	64 kbps
Voice Traffic Generation	3m,7m,11m,15m,…
Mobility Speed	45 km/h
Simulation Time	2000 sec

표 3. IEEE 802.16e MAC 액세스 파라미터
Table 3. IEEE 802.16e MAC Access Parameters

	VoIP
Type	ertPS with silence
Maximum Sustained Traffic Rate	96000 (bps)
Minimum Reserved Traffic Rate	96000 (bps)
Maximum Latency (miliseconds)	10
Maximum Traffic Burst (bytes)	0

표 4. IEEE 802.11e MAC 액세스 파라미터
Table 4. IEEE 802.11e MAC Access Parameters

	VoIP
Type	AC_VO
CWmin	(PHY CWmin + 1) / 4 - 1
CWmax	(PHY CWmin + 1) / 2 - 1
AIFSN	2

6. Performance Metrics

The major three metrics used for evaluation of the relative performance of QoS in VoIP is described as follows:

1) Packet end-to-end delay: It is the differing time intervals between time on receiving the packet in receiving host and time on transmitting the packet by the sending host.
2) Packet transmission ratio: It is ratio between the number of packets received by the receiver and the number of packets sent by the sending host.
3) MOS value: Mean Opinion Score (MOS) is a subjective measurement method, which provides a numerical indication of the perceived quality of received media after compression and/or transmission.

III. RESULTS AND DISCUSSION

1. BS/AP connectivity and MIP registration

The mobility connection and MIP operating process analysis between BSs and APs are more significant to better understand how WiMAX Base Station (BS) or WLAN Access Point (AP) affect the performance of QoS in interworking network architecture.

Figure 2 shows the mobility connectivity and MIP registration in WiMAX and WLAN network. It was found that in Figure 2a and Figure 2b, the continuity of the connectivity was changed, but it overlapped in Figure 2c and Figure 2d.

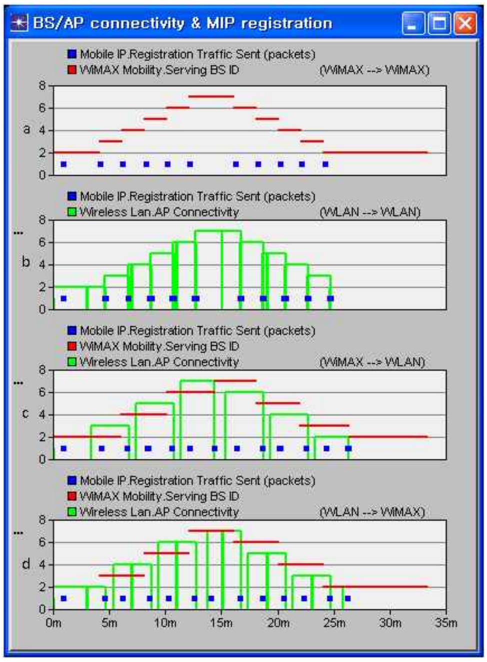


그림 2. WiMAX와 WLAN에서의 이동 접속
Fig. 2. Mobility connectivity in WiMAX and WLAN

For the simulation network architecture had the mobility Serving ID was changed from number 2 to number 7 as presented in Figure 2, and then it changed back to number 2. The MIP registration sent happened exactly during the changing of service BS ID. It meant that MN can support the best connection with BSs, when MN was moving in WiMAX network.

However, in Figure 2b the WLAN AP connectivity was not inerratic. As mentioned in wireless LAN access technology, the MN can support long distance wireless signal, and it can change its point of attachment until its wireless signal lost completely in WLAN network.

Figure 2c and Figure 2d explained the connection ID and MIP registration in WiMAX to WLAN and WLAN to WiMAX cases, from which the MIP registration traffic sent did not match with changing point. Because MN does not operate MIP process until it loses its signal completely.

2. MOS value evaluation during one period

In voice and video communication, quality usually dictates whether the experience is a good or bad one. Aside from the qualitative description usually heard, like 'quite good' or 'very bad'. Even though MOS value is a subjective measurement that is derived entirely by people listening to the calls and scoring the results from 1 to 5, but MOS value is also a numerical method of expressing voice and video quality.

Figure 3 explained the MOS value for four situations during one voice period, which collected statistics around 7m to 9m. It can be seen that the MOS value performed well during WiMAX network in Figure 3a compared to others, even during handoff period. MN can support well connection to the backhaul in WiMAX network.

Figure 3b showed much more floating points than in other cases, especially during handoff period where no MOS value was presented. The co-interference problem between APs and handoff implementation caused the packet to be completely lost, which directly affected the MOS value.

Comparing Figure 3c with Figure 3d, it was apparent that Figure 3d performed better than in Figure 3c in MOS value. Even though the MOS value decreased in Figure 3d during handoff period, the voice traffic connection was continuous. However, in Figure 3c there were part of packet lost, which caused MOS value was missed.

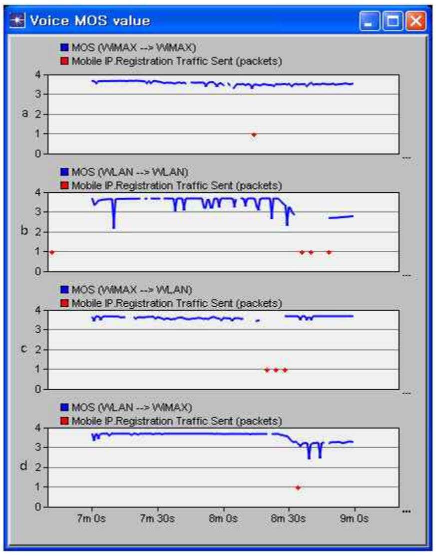


그림 3. WLAN과 WiMAX에서의 한주기 MOS 값
Fig. 3. MOS value during one period in WLAN and WiMAX

3. Voice traffic analysis during one period

In this section, the voice traffic was collected during 7m to 9m. With QoS, the voice traffic should not be delayed considerably, like normal stations are when they need to send data.

In Figure 4, it can been seen that the voice traffic presented perfect matching between traffic sent and receive during 7m to 9m in WiMAX to WiMAX network. WiMAX network provided a data-oriented MAC function, and also WiMAX technology supported Request/Grant access mechanism, which can eliminate inbound collisions and support consistent-delay voice and always-on data transmission. WiMAX also featured Layer 2 error correction using automatic retransmission in the event of errors.

Figure 5 illustrated voice traffic sent/receive in WLAN to WLAN case. From the Figure a lot of voice packets were lost during handoff period. As explained in section II, even though IEEE 802.11e adopted new mechanism (HCF) to provide QoS, the possibility of collisions can only be reduced, but not eliminated. The incidence of collisions increased as MN cannot hear each other. Because the wireless signal was completely lost while changing the point in WLAN communication, more voice traffics were lost.

As can be seen from Figure 6, the voice traffic was processed between WiMAX and WLAN network. When handoff occurred, it was just part of voice packets that lost completely, while it performed better than in Figure 5, which showed all voice traffic received.

The voice traffic sent/receive was illustrated in Figure 7, in which the voice traffic was received continuously even though much voice traffics were lost. In WLAN network, once MN finds the wireless signal to be weak, it always tries to connect with WLAN AP until the wireless signal is completely lost.

Comparing Figure 4 to 7, it was found that Figure 4 had the better voice receiving performance than others, and Figure 5 presented lower situation. Even though lots of voice packets were lost in Figure 5 to 7. Figure 7 performed well because the voice traffic was continuously received. Some voice traffic receiving was lost in Figure 6 and full voice traffic receiving was missed in Figure 5.

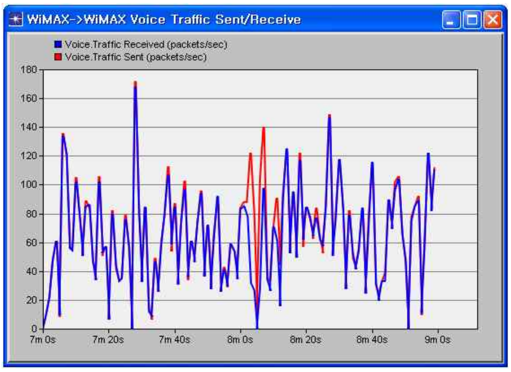


그림 4. WiMAX→WiMAX 음성 트래픽
Fig. 4. WiMAX→WiMAX voice traffic

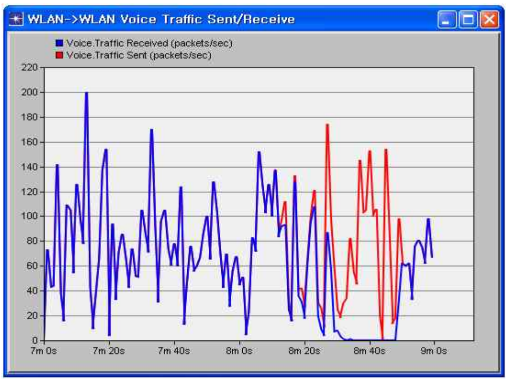


그림 5. WLAN→WLAN 음성 트래픽
Fig. 5. WLAN→WLAN voice traffic

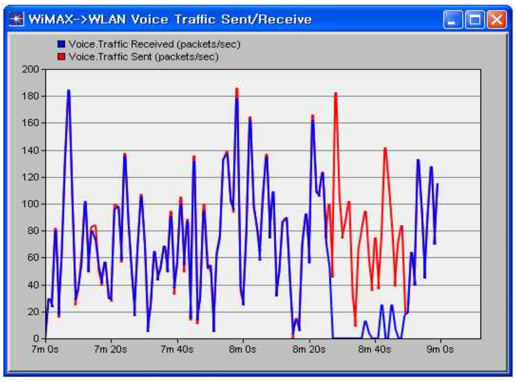


그림 6. WiMAX→WLAN 음성 트래픽
Fig. 6. WiMAX→WLAN voice traffic

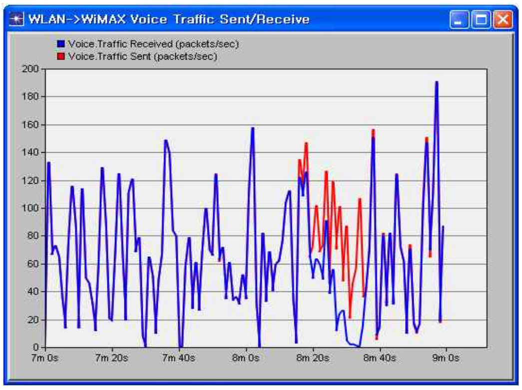


그림 7. WLAN→WiMAX 음성 트래픽
Fig. 7. WLAN→WiMAX voice traffic

4. Performance Metrics in static / mobility case

The following Figures demonstrated the comparison of MOS value, end-to-end delay and packet transmission ratio in static and mobility case, and each performance metrics was collected in average value in all simulation time.

Figure 8 showed that the MOS value was almost the same in static case around 3.6. However, the MOS value was affected in mobility case and all presented lower MOS value than in static case. WiMAX to WiMAX case performed better MOS value compared with other cases. Because MN supports better the backhaul connectivity in WiMAX network compared to other networks, even though MN is at 45 km/h mobility speed. It was stated that much more packets will be lost during handoff period in WLAN to WLAN case, which causes the MOS value reduction.

In Figure 9, the end-to-end delay was seen in four cases. Even though MN was moving at 45 km/h mobility speed, the simulation result showed that end-to-end delay was not affected too much in both static and mobility cases. In voice traffic, end-to-end delay was affected only by number of packets and distance, not in other situations, such as four cases in our simulation and mobility speed.

It can be seen that WiMAX to WiMAX case presented higher packet transmission ratio than others in mobility case in Figure 10. Because of handoff, WLAN to WLAN case reduced a lot voice traffics comparing with others. That is why it affected greatly in mobility case.

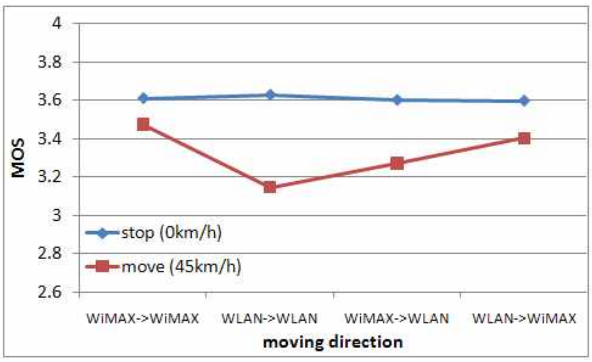


그림 8. WLAN과 WiMAX에서의 MOS 값
Fig. 8. MOS value in WLAN and WiMAX

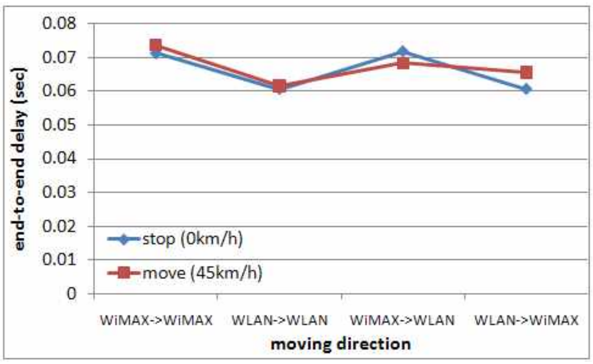


그림 9. WLAN과 WiMAX에서의 종단간 지연
Fig. 9. End-to-End delay in WLAN and WiMAX

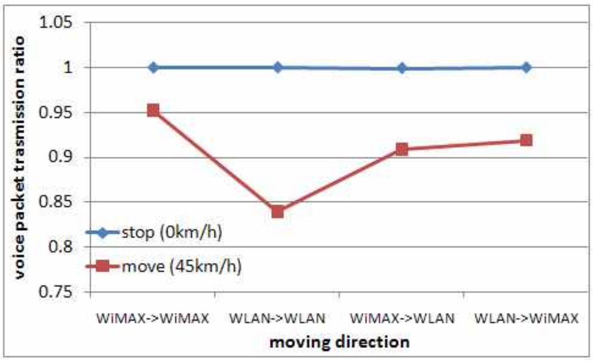


그림 10. WLAN과 WiMAX에서의 패킷 전달율
Fig. 10. Packet transmission ratio in WLAN and WiMAX

IV. CONCLUSIONS

In this paper, IEEE 802.11e (WLAN) and 802.16e (mobile WiMAX) were presented to provide QoS guarantees, QoS mapping mechanism was also illustrated to understanding how QoS in WiMAX and WLAN is mapped to each other. Furthermore, the integrated architecture was provided for evaluating the performance of QoS in OPNET simulator by using voice (real-time) traffic.

It was found that during WiMAX network in three performance metrics, MN performed better evaluation in four cases due to the best connectivity in static and mobility cases. However, in WLAN to WLAN network, lower performance was always showed while comparing with other cases, especially in mobility case, it affected greatly in MOS value and packet transmission ratio. In WiMAX to WLAN and WLAN to WiMAX cases, it was not affected too much in both static and mobility cases.

Further research is necessary to analyze the performance of QoS in interworking network of WiMAX and 3G (UMTS), or 3G (UMTS) and WLAN with different traffic types, such as VoIP (real-time) with BE, video (real-time) traffic and FTP (non-real-time) traffic.

REFERENCES

[1] J. Perez-Romero, O. Sallent, R. Agusti, "A Novel Metric for Context-Aware RAT Selection in Wireless Multi-Access Systems", IEEE, ICC, 2007.

[2] H. Haffajee and H. Chan,"Low-cost QoS-enabled Wireless Network with Interworked WLAN and WiMAX", Proc. Of the First IEEE Intl. Conf. on Wireless Broadband and Ultra Wideband Communications (AusWireless 2006), Sydney, March, 2006.

[3] Lars Berlemann, Christian Hoymann, Guido R. Hiertz and Stefan Mangold, "Coexistence and Interworking of IEEE 802.16 and IEEE 802.11(e)", IEEE 63rd Vehicular Technology Conference (VTC 2006-Spring), vol.1, Melbourne, Australia, 2006.

[4] G. Arul Prasath, K.R. Raghu and Maode Ma, Senior, "Integration of WLAN and WiMAX with Base Station Assisted QoS", IEEE 978-1-4244-1980-7/08, 2008.

[5] Hui-Tang Lin, Ying-You Lin, Wang-Rong Chang and Rung-Shiang Cheng, "An Integrated WiMAX/WiFi Archtecture with QoS Consistency over Broadband Wireless Networks", IEEE 978-1-4244-2309-5/09, 2009.

[6] Ye Wang, Xiao-Lei Zhang, Jang-Geun Ki, "Simulation models for mobility in WLAN and WiMAX", the 11th Conference on Electronics and Information Communications in korea, pp101-pp105, Nov. 2009.

[7] OPNET Simulator, http://www.opnet.com, 2010.

[8] IEEE 802.16e-2005, IEEE standard for local and Metropolitan Area Network- Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Amendment 2: Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands, February, 2005.

[9] IEEE Standard 802.11e/D13.0, \Draft supplement

to standard for telecommunications and information exchange between systems-LAN/MAN specific requirements. Part 11: Wireless medium access control (MAC) and physical layer (PHY) specifications: Medium access control (MAC) enhancements for quality of service (QoS)," Apr.2005.

[10] Dusit Niyato and Ekram Hossain, "Call Admission control for QoS Provisioning in 4G Wireless Networks", WiMAX Forum, "WiMAX System Evaluation Methodology V2.1", 230 pp, July 2008.

[11] Jongmin Lee, S.H. Shah Newaz, Jun Kyun Choi, Gyu Myung Lee and Noel Grespi, "QoS Mapping over hybrid Optical and Wireless Access Networks", Internal Conference on Evolving Internet, IEEE 978-0-7695-3748-1/09, Oct. 2009.

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