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VLC에서 이동망간 연동성 성능분석

Performance of an Interworking on the VLC

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요 약 본 논문에서는 이동망에서 통신노드가 다이나믹하게 이동하는 경우, VLC 음성품질을 위지하기 위한 상호연동 구조를 다룬다. 연동구조에서 체계적인 품질 분석은 OPENT 시뮬레이터를 사용하였으며, 패킷지연율과 성능분석으로 결과를 제시하였다. 실험결과에 따라 이동노드의 수가 작을 때, PDR은 상대적으로 데이터 프래픽이 증가함에 따라 안정을 유지하며, 성능은 이동노드의 수에 영향을 받는다. 특히 MANET 노드 밀도가 크게 증가하면, 성능은 높아지지만 이동속도에 영향을 받지 않았다. 또한 FTP 업다운 응답시간은 이동속도와 노드의 수에 크게 영향을 주지 않음을 확인하였다.

Abstract This paper represents an interworking architecture for keeping the VLC audio quality between Worldwide Interoperability for Microwave Access (WiMAX) and IEEE 802.11 Mobile Ad hoc Network (MANET) where both mobile routers and mobile nodes are moving dynamically. Systematic performance analysis on the interworking architecture has been conducted by using OPNET simulator to show the results such as Packet Delivery Ratio (PDR) and throughput. Based on simulation results, when the number of MANET nodes is small, PDR remains relatively stable even though data packets increase. However, with the many MANET nodes, PDR decreases as data traffic increases. Throughput is affected by the number of MANET nodes. Especially when the MANET node density has increased further, throughput is much higher, but it is not affected by the mobility speed. However, FTP download and upload response time is not affected much by both the number of MANET nodes and the mobility speed.

Key Words : VLC, MANET, OPNET, QoS, performance, WiMAX

Ⅰ. INTRODUCTION

With the exponential growth of wireless communications, it is well accepted that next generation wireless networks will be heterogeneous, providing users of multi-interface devices the ability to roam

between different access networks, in which different technologies are adopted for different application environments to achieve the enhanced performance. The attractive and complementary characteristics presented by cellular networks (such as mobile WiMAX, 3G/UMTS) and Wireless Local Area Networks (WLANs) make them promising candidates for next generation wireless networks.

As a new wireless network, there has been increased interest in visible light communication systems. The research of the VLC is motivated by an

increasing need of indoor communication and the development of light emitting diode technologies (LEDs). High power LEDs are already used for several applications on light lamp and it is foreseen that they will also replace conventional lighting sources in the next decade. And the bandwidth of optical communication systems using LED has the advantages in comparison to radio frequency based solutions. This widespread use provides the necessary infrastructure for the internetworking and removes one of the major hurdles faced by new communication schemes for keeping a voice quality.

WiMAX Forum[1] believes that Mobile WiMAX (IEEE 802.16e-2005) services will complement existing and future broadband technologies such as WiFi, because both of WLAN and WiMAX aim to providing ubiquitous low cost broadband wireless internet access. The 4G[2] recommends the integration of wireless standards like WLAN, WiMAX and 3G cellular. WLAN offers high data rates of 54 Mbps within a 100m range mostly used within buildings whereas WiMAX offers high bandwidth 70 Mbps wireless back haul in a 5 km range generally covering a large outdoor environment.

Currently, the IEEE 802.11 (WLAN) also provides ad hoc mode of operation in addition to the infrastructure mode, which named Mobile Ad hoc Network (MANET)[3]. It is characterized by infrastructure-less configuration and on-demand routing. Users can access to the internet anywhere at anytime through their neighbors in MANET.

New wireless communication technologies are also expected to significantly influence the design and implementation of MANETs in the military environment. Since the future technology combing wireless local networks and cellular networks is more and more being referred to, it is critical to understand of WiMAX network and its potential in influencing wireless networks, particularly MANET since we should assume low infrastructure of mobile ad hoc networks in the hostile military environment. However, the implementation of interworking of WiMAX and MANET networks may be significantly more complicated than in the civil environment due to the unique specification and requirement of the military environment. Aim to understand this situation for better cooperating together, the further study of that kind of interworking network should be key challenge.

This paper proposed a design to achieve the interworking between 802.11 Mobile Ad hoc Network (MANET) and WiMAX network. A mobile node equipped with two interfaces – a WiMAX interface and a MANET interface, is assumed and developed by using OPNET Modeler for the OPNET University Program[4].

Some researches already have been provided interworking architectures of WiMAX and MANET. In Hsien-Chou Liao and Cheng-Jung Lin (2008)[5], a revolutionary connectionless approach called OHLAR (one-hop location-aided routing) is proposed and a WiMAX base station is assumed available for interchanging locations of mobile nodes. Matthew Sherman etc. (2006)[6] described an approach, based on 802.16, that extends the standard hub-and spoke modes (802.16 PMP) with both ad-hoc and mesh capabilities, which is called Mesh Enabled Tactical Adaptive -MANET META-MANET), and no performances were introduced in that paper.

This paper presented generic interworking network architecture between WiMAX and MANET, and also the systematic performances analysis was done in OPNET simulator by analyzing the different performance metrics, such as Packet Delivery Ratio (PDR) and throughput.

II. Materials and Methods

A. VLC wireless

White light-emitting diodes (LEDs) are known as be a good energy saving and long life material. However, white LEDs also have the potential used as an indoor

optical wireless broadband communication system. VLC using LEDs is emerging as a coming technology for ubiquitous communication systems, because LED has the advantages of fast switching and safety for the human. WiFi is now the technology which is used in most wireless networks in homes and businesses. But WiFi is a radio frequency-based technology and its bandwidth is limited. On the other hand, visible –frequency wireless, LED does not have the bandwidth limitation problem. The signal would be generated in a room by slightly flickering all the lights without our notice. Because the rate of modulation would be millions of times faster than a human eye can see. Since visible light cannot penetrate walls like radio, there would be no interference from stray signals and reduced opportunity for outside peepers by making the system more secure.

B. IEEE 802.16e Mobile WiMAX

The IEEE 802.16e standard[1] is a technology proposed to offer wireless access to network stations in a metropolitan area environment. These networks are designed to operate at high data rates and to deal with several applications, resulting in different types of traffic profiles and demands. The motivation is to one day provide last mile broadband wireless access to the general population, It is seeking to implement a single standard for fixed broadband wireless access and mobility with high scalability and a low cost of deployment.

WiMAX is a protocol that provides fixed and mobile internet access. The IEEE 802.16e mobile WiMAX can provide up to 40 Mbit/s with the update expected to offer up to 1 Gbit/s fixed speeds. The WiMAX forum describes WiMAX as "a standards-based technology enabling the delivery of wireless broadband access as an alternative to cable and DSL.

C. IEEE 802.11 Mobile Ad hoc Network

A Mobile Ad hoc Network (MANET) is a kind of wireless ad hoc network, which has mobile devices with self-configuring capability and is a network of mobile routers and associated hosts connected by wireless links. The terminals may be free to move randomly and organize themselves arbitrarily. As a result, the network topology may change rapidly, unpredictably and consequently[7].

One of important and popular MANET routing protocol, Ad hoc On-Demand Distance Vector (AODV), is run in this paper. AODV is a reactive routing protocol and constructs the route when the route is needed. In ad hoc network, AODV offers quick adaptation to the dynamic link conditions, self-starting and multi-hop routing, low processing and memory overhead, low network utilization, and determines the unicast routes to destination within the ad hoc network[7].
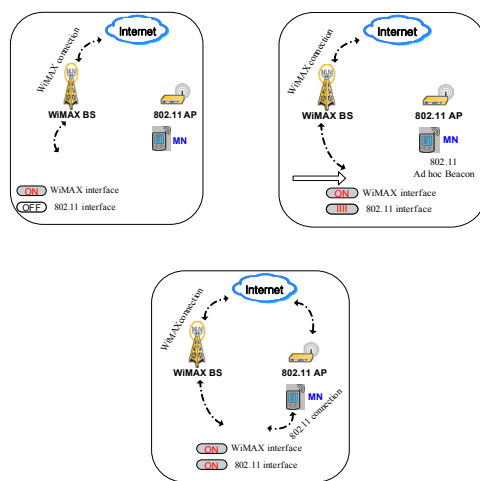

그림 1. 기본 구조 개념도
Fig. 1. Basic concept of architecture

D. Simulation Environment

The main objective in this paper is to simulate and analyze the performance in an interworking of WiMAX and MANET. Figure 1 depicts a scenario that illustrates the basic concepts of this architecture.

However, this basic concept architecture is not our concern in this paper, in which there is another situation that we are thinking about. A Dual-Mode

Mobile Node (DMMN) is considered to be mobile router between WiMAX BS_1 and WiMAX BS_2 and MANET gateway between WiMAX network and MANET networks. Whenever DMMN is moving from one WiMAX BS to another WiMAX BS, MANET mobile nodes can join the WiMAX network through the DMMN at any time by using the MANET routing protocol in order to send packets to their destination. As can be seen, the simulation scenarios in OPNET simulator is proposed and illustrated in Figure 2.
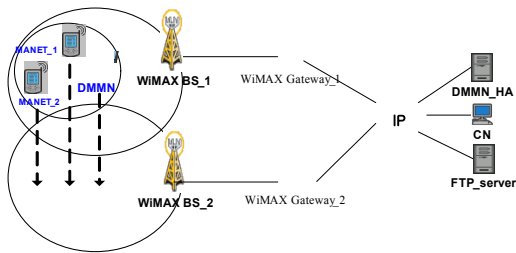

그림 2. OPNET 시뮬레이션 네트워크 구조
Fig. 2. Simulation network architecture in OPNET

표 1. 기본 시뮬레이션 변수
Table 1. The Common Simulation Parameters

Parameters	Value
Distance between BSs and BSs	2 km
No. of MANET nodes	2, 4, 6, 8, ,10
Max Hop Count in MANET	5
Node Mobility Speed (m/s)	5, 10, 15, 20, 25, 30
Simulation Time	2000 sec

표 2. CBR과 FTP 응용 변수
Table 2. The CBR and FTP Application Parameters

Type	Attribute	Value
CBR	Request Packet size (bytes)	1024
	Inter-Request Time (sec)	Constant (0)
	Packets per Request	Constant (1)
	Packet Arrival Rate (pkts/sec)	1,3,5,7,10,12,15
	Type of Service	Best Effort (0)
FTP	Command Mix (Get/Total)	50%
	Inter-Request Time (sec)	Constant(36000000)
	File Size (bytes)	Constant (15000)
	Type of Service	Best Effort (0)

E. Simulation Parameters

The common simulation parameters are shown in Table 1. In MANET network, the number of MANET mobile node also is changed from 2 to 10. Both of mobile router and mobile nodes are moving in 5 m/s to 30 m/s mobility speed.

Table 2 describes CBR and FTP application parameters. As can be seen from Table 2, the packet arrival rate of CBR traffic is changed from 1 to 15 packets/sec. The Packet delivery ratio is measured by using CBR traffic, while FTP traffic is utilized to measure throughput performance.

F. Performance Metrics

The major two metrics used for evaluation of the relative performance is described as follows:

1) Packet Delivery Ratio: It is the ratio between the number of packets delivered to the receiver and the number of packets sent by the source.

2) Throughput: It is a measure of how much actual data can be sent per unit of time across a network, channel or interface. In other words, it is the total of all bits (or packets) successfully delivered to individual destinations over total-time.

III. Results and Discussion

A. Packet Delivery Ratio (PDR)

In this section, in order to better understand how much effect in number of MANET nodes and data traffic ratio, the packet delivery ratio in WiMAX_MANET network should be studied and illustrated in Figure 3. Meanwhile, the DMMN mobile router and MANET mobile nodes are kept at 60 km/hr in mobility speed.

Figure 3 shows the trend that the PDR decreases when the packet arrival rate increases. In the Figure, at less packet arrival rate, there is not much performance difference even though the number of MANET mobile nodes is increasing from 2 to 10. But at higher packet

rate, the PDR of the network with more MANET nodes presents much more decrease trend. In WiMAX_MANET, with the increases of the number of MANET nodes and the packet arrival rate, the much more data traffics are generated and the DMMN becomes the bottleneck, which caused limited capacity.

Figure 4 and Figure 5 illustrate the packet sent/received in 1 pkt/sec and 10 pkts/sec in MANET_2 and MANET_8 during simulation time 7m to 9m respectively. From the Figure 4a and Figure 4b, even though the number of MANET nodes increases, the packets are not lost much. However, while the much more data traffic is generated in Figure 5a and Figure 5b, the loss of packets is nearly in half value, especially in MANET_8 case.
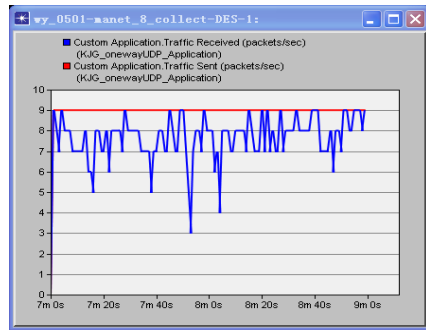
B. Throughput
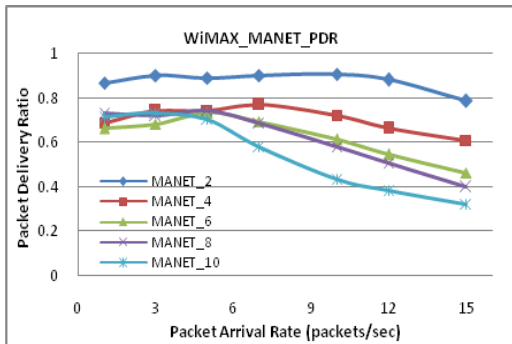
그림 3. 패킷 지연 비율
Fig. 3. Packet Delivery Ratio in WiMAX_MANET
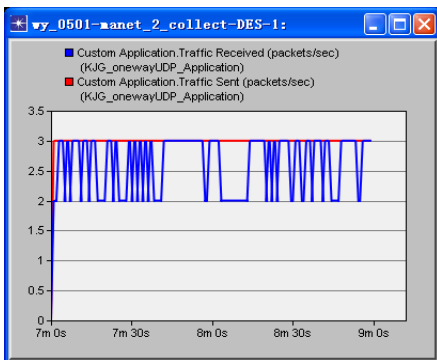
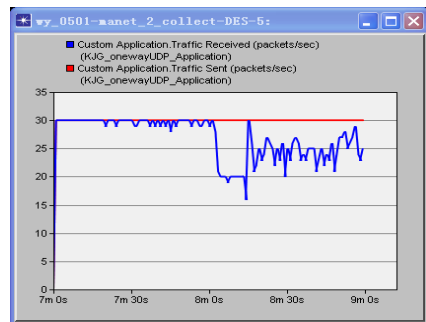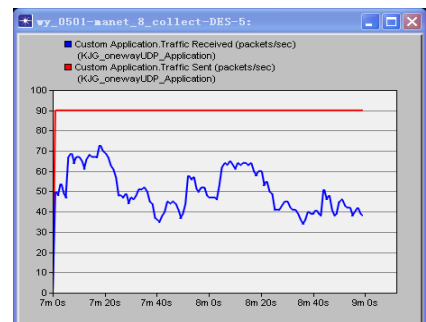(a) Packet sent/received in 1 pkt/sec in MANET_2

(b) Packet sent/received in 1 pkt/sec in MANET_8
그림 4. 1개의 패킷 송수신 변화
Fig. 4. Packet sent/received in 1 pkt/sec during 7 – 9 m

(a) Packet sent/received in 10 pkts/sec in MANET_2

(b) Packet sent/received in 10 pkts/sec in MANET_8
그림 5. 10개의 패킷 송수신 변화
Fig. 5. Packet sent/received in 10 pkts/sec during 7– 9 m

In this section, the simulation result of throughput in WiMAX_MANET has been collected while changing the number of MANET mobile nodes and nodes mobility speed. In our architecture, both DMMN mobile router and MANET mobile nodes are kept from 0 m/s

to 30 m/s in mobility speed while moving from one BS to another BS.

The trend of graph in throughput was illustrated in Figure 6. From the figure can be seen the throughput in WiMAX_MANET network with more MANET nodes is higher than in the network with less node. Meanwhile, it is obvious that the throughput is not affected much by the node mobility speed. In MANET network, this is because the data packets will be stored in a buffer while a router discovery is conducted by using AODV routing protocol.

In our interworking scenario, DMMN performance also should be considered for better understanding throughput, because DMMN has two functions as introduced in Section C, one is a mobile router to connect WiMAX network and the other is a MANET gateway to connect MANET mobile nodes. The results of traffic sent (pkts/sec) on both MANET interface and WiMAX interface of DMMN have been collected and showed in Figure 7.

Figure 7a describes routing traffic sent in the DMMN MANET interface while Figure 7b shows data traffic sent in the WiMAX interface. From the Figure 7a, it can be seen that MANET routing traffic is proportional to the number of MANET nodes. In Figure 7b, because DMMN WiMAX interface should perform the better connection with WiMAX BS in WiMAX network especially in more MANET nodes case, the data traffic should be transmitted as the number of MANET nodes changed.
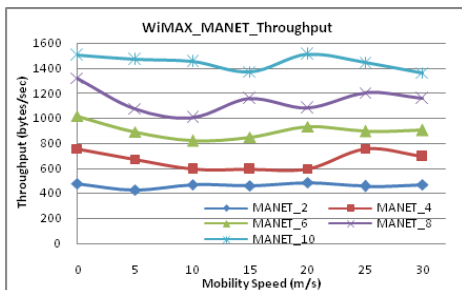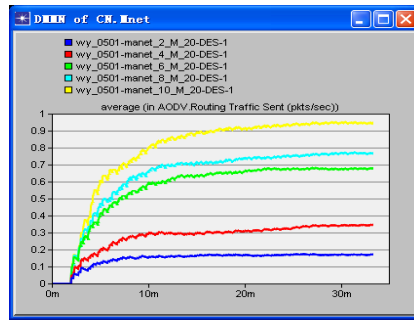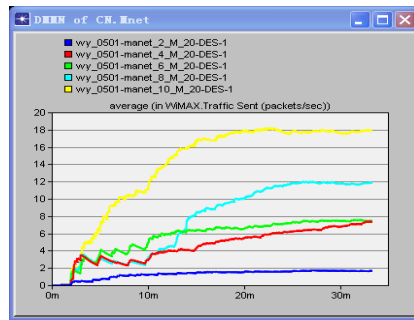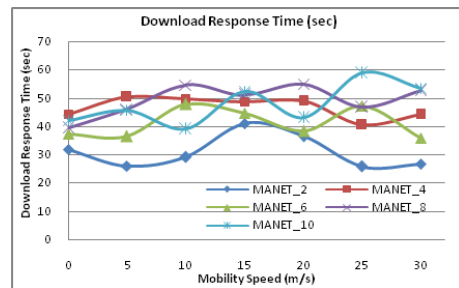

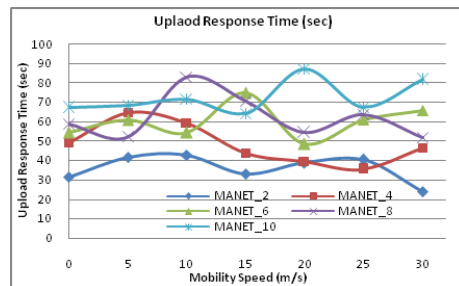(a) Routing traffic sent (pkts/sec) via DMMN MANET interface

(b) Data traffic sent (pkts/sec) via DMMN WiMAX interface

그림 7. DMMN 에서의 송신 traffic
Fig. 7. Traffic sent in DMMN (mobility=20 m/s)

(a) Download Response Time (sec)

(b) Upload Response Time (sec)

그림 8. FTP 응답시간
Fig. 8. FTP response time in WiMAX_MANET

그림 6. WiMAX 에서의 throughtput
Fig. 6. Throughput in WiMAX_MANET

Figures 8 represents the FTP average download and upload response time when the mobile nodes are moving at the speed of 0 m/s to 30 m/s. Figure 8a shows the ftp average download response time and Figure 8b depicts the average upload response time in WiMAX_MANET network. From the figure has been seen that FTP average download and upload response time is not affected much by mobility speed even though in high mobility case. In MANET network, although the MANET nodes are increased from 2 to 10, the FTP averaged download and upload time is also not affected much by the number of MANET nodes.

IV. CONCLUSIONS

In this paper, we have tried to address the implementation mobility performance in interworking of WiMAX and MANET for preserving VLC audio quality. Because successful and safe implementations of next generation wireless technology into the MANET in military environment might be future trend and most significant meaning for our study.

It has been found that Packet Delivery Ratio in WiMAX_MANET network with small number of MANET nodes performed more stably no matter how much data traffic is generated in MANET. However, PDR showed much down trend in more MANET nodes and much data traffic case in WiMAX_MANET because of bottleneck of DMMN which connected to the WiMAX network. By analyzing throughput in WiMAX_MANET, the number of MANET nodes can affect throughput performance, especially in much more MANET nodes. However, the throughput is not affected by node mobility speed. Meanwhile, FTP download and upload response time are not affected much by the number of MANET nodes and mobility speed.

Future research is necessary to analyze the interworking of 3G/UMTS and MANET, or 4G/LTE with MANET, which could be key challenge issue in future military environment. And also the real-time application (such as VoIP) should be tested in that interworking network.

ACKNOWLEDGEMENT

REFERENCES

[1] 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.

[2] Dave Wisely, "IP for 4G", John Wiley & Sons, Ltd. ISBN: 978-0-470-51016-2, 2009

[3] Mobile Ad hoc Network (MANET) Charter. http://datatracker.ietf.org/wg/manet/charter/

[4] OPNET Simulator, http://www.opnet.com, 2011.

[5] Hsien-Chou Liao, Cheng-Jung Lin "A position -Based Connectionless Routing Algorithm for MANET and WiMAX under High Mobility and Various Node Densities", Information Technology Journal, ISSN 1812-5638, 2008

[6] Matthew Sherman, Kevin M. McNeill, Keith Conner, Phong Khuu and Tim Mcnevin, "A PMP-FRIENDLY MANET NETWORKING APPOACH FOR WIMAX/IEEE 802.16 TM ",IEEE conferenceon Military communications, pages 1586-1592, ISBN1-4244-0618-8, 2006.

[7] Ye Wang, Xiao-Lei Zhang, Jang-Geun Ki, Kyu-Tae Lee, " Performance Comparison of OLSR and AODV Routing Protocols using OPNET". The Journal of The Institute of Webcasting, Internet Television and Telecommunication, pages 9-17, ISSN 1738-4281, June, 2009.

[8] T.Komine and M.Nakagawa, "Fundamental analysis for visible-light communication system using LED lights," IEEE Trans. Comsumer Electron., vol.50, no.1, pp.100-107, Feb. 2004.

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