계층적 Mobile-WiMAX/WLAN 네트워크에서의 트래픽 관리 전략에 관한 연구연구

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Proposal of Traffic Management Strategy between Hierarchical Mobile-WiMAX/ WLAN Networks

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요 약

전국망 규모의 망 설계 및 QoS가 적용된 Mobile-WiMAX 시스템과 54Mbps의 광대역 서비스가 가능한 WLAN 시스템으로 구성된 계층적 네트워크는 VoIP, VOD, 화상전화 등과 같은 실시간 서비스를 포함한 다양한 무선 인터넷 서비스를 제공한다. 그러나 실시간 서비스를 이용하는 사용자가 Mobile-WiMAX/WLAN 계층적 네트워크에서 핸드오프를 수행할 경우, 특히 Mobile-WiMAX 네트워크에서 WLAN 핫스팟 지역으로 핸드오프를 할 경우 핸드오프 지연으로 인해 사용 중인 서비스가 끊기게 된다. 본 연구는 Mobile-WiMAX(IEEE 802.16e) 규격에서 제시된 서비스 종류(ToS) 파라미터를 이용하여 vertical 핸드오프 수행 기준이 되는 vertical 핸드오프 프로세스를 제안한다. 이 프로세스를 이용하면 실시간 서비스를 사용 중인 사용자는 핸드오프 수행을 일정시간 지연하므로 실시간 서비스의 끊기는 불편함을 해소할 수 있다. 본 논문에서 제안한 프로세스를 이용할 경우 Mobile-WiMAX/WLAN 계층적 네트워크에서 vertical 핸드오프 수행 중의 실시간 서비스 이용에 제한이 없어진다. 이는 사용자 편의 중심의 서비스를 실현할 수 있게 될 것이다.

ABSTRACT

A hierarchical network between Mobile-WiMAX and WLAN systems is to make it possible to utilize wireless internet services including time sensitive applications such as VoIP, VOD, visual telephony etc. During the process of vertical handoff decision from Mobile-WiMAX to WLAN hotspot, vertical handoff delay causes user dissatisfaction because it doesn't provide the seamless wireless internet service. We make use of type of service (ToS) parameters in IEEE 802.16e specification as the criterion parameter of vertical handoff decision process in hierarchical Mobile-WiMAX/WLAN networks. In this paper, we propose the process of vertical handoff decision for seamless wireless internet service which is sensitive to time delay. If type of service is time sensitive application, the decision of vertical handoff is withdrawn until the service is terminated. In focus on user satisfaction, if the proposed traffic management strategy in hierarchical Mobile-WiMAX/WLAN networks is used, user will utilize seamless wireless internet services including time sensitive applications.

키워드

Hierarchical network, Handoff, WLAN, Mobile-WiMAX, QoS.

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Ⅰ. Introduction

WLAN technology based on 802.11a/g provides high-speed data service i.e., 54Mbps data rates, and the Mobile-WiMAX technology based on IEEE 802.16e specification provides wide local area wireless internet services including time sensitive applications such as VoIP, VoD, visual telephony etc. A hierarchical network between WLAN and Mobile-WiMAX systems provides high-speed data service in WLAN hotspot and user mobility with quality guaranteed wireless internet service in Mobile-WiMAX network. But it isn't provides seamless service during vertical handoff in hierarchical Mobile- WiMAX/ WLAN networks. Figure 1 shows the configuration of hierarchical Mobile-WiMAX/WLAN networks including in hierarchical Mobile-WiMAX/WLAN networks. Figure 1 shows the configuration of hierarchical Mobile- WiMAX/ WLAN networks including in IMS system. Because WLAN and Mobile-WiMAX systems consists all IP network with AAA(Accounting, Authentication and Authorization) servers, it is more appropriately to construct hierarchically structured network between Mobile-WiMAX /WLAN than CDMA/ WLAN. The user authentication in each network utilizes IEEE 802.1x-EAP(Extensible Authentication Protocol)

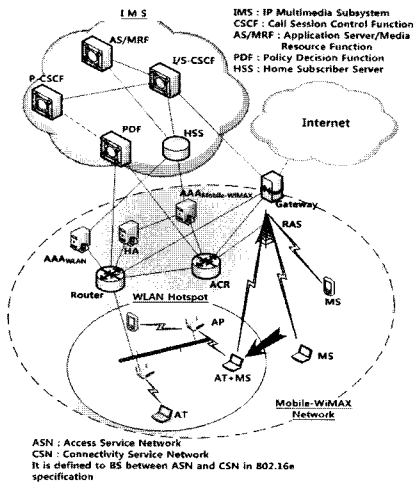


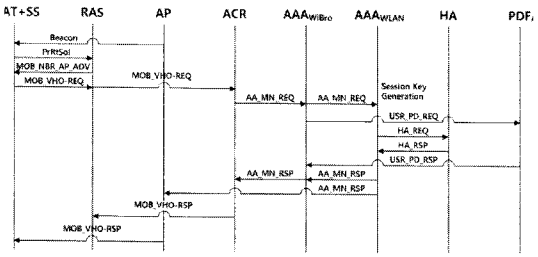
그림 1. 계층적 Mobile-WiMAX/WLAN 네트워크의 구성도
Figure 1. The configuration of hierarchical Mobile-WiMAX/WLAN networks

with AAA and if hierarchical Mobile-WiMAX/WLAN networks are constructed, it is no problem to the integration of WLAN and Mobile-WiMAX networks because these are using in the authentication of user roaming between AAAMobile-WiMAX and AAAWLAN. In the transportation of user data, it is consisting of MIP (Mobile IP) with AAA which takes a role in local authority in the foreign domain AAA (AAAF) server and external authority in the home domain AAA (AAAH) sever to each other [1, 2].

IMS (IP Multimedia Subsystem) should eventually take part in many services related to communications, content s and data, not only as the host of some of these services, but also as a mediator and an added-value contributor to services delivered by 3rd parties possibly located in the Internet. IMS brings many potential benefits for service providers, as it defines an access network agnostic architecture for delivering real-time multimedia services (including voice services) over an IP-based network, with built in support for inter-networking, roaming, access control and online/offline charging. The construction of IMS in hierarchical Mobile-WiMAX/WLAN networks supports the on-demand service to user according to the individual profile by employing policy decision function[3 ,4].

The vertical handoff procedure of hierarchical Mobile-WiMAX/WLAN networks with IMS is shown in Figure 2. This procedure generates vertical handoff delay cause of the processing time of procedures which define user authentication with AAA, mobile IPv6 transportation and service policy in user service profile different network respectively. This vertical handoff doesn't provide the seamless real time service because of no guaranteed quality due to the vertical handoff delay. This vertical handoff delay causes user dissatisfaction because of the disconnection of wireless Internet service. If MS moving from Mobile-WiMAX to WLAN hotspotuses time sensitive application services, it is required to postpone the vertical handoff until the termination of service. Therefore, we design and propose the process of automatic vertical handoff in hierarchically structured Mobile-WiMAX/WLANs to maximize user satisfaction according to the type of service. On the scheme of vertical handoff decision, the decision is made according

to the criterion parameter, Radio Signal Strength (RSS) only.



PrRtSol : Proxy Router Solicitation
MOB_NBR_AP_ADV : AP neighbor Advertisement message for Vertical handoff
MOB_VHO-REQ/RSP : Registration Request/Answer message for Vertical Handoff
AA_MN_REQ/RSP : AA-Mobile-Node Request/Answer message
HA_REQ/RSP : Home-Agent-MIP Request/Answer message
USR_PD_REQ/RSP : User Policy Decision Function Request/Answer message

그림 2. IMS를 사용하는 계층적 Mobile-WiMAX /WLAN 네트워크에서의 vertical 핸드오프 절차
Figure 2. The vertical handoff procedure of hierarchical Mobile-WiMAX/WLAN networks with IMS

In this paper, it makes use of type of service (ToS) parameters in IEEE 802.16e specification as the criterion parameter of vertical handoff decision process over hierarchical Mobile- WiMAX/WLAN networks. Also, it defines MAC field and proposes the scheme of vertical handoff decision based on IEEE 802.16e specification in hierarchical Mobile-WiMAX/ WLAN networks. The proposed traffic management strategy between WLAN and Mobile-WiMAX system will maximize the characteristics of WLAN and Mobile-WiMAX technologies because of vertical handoff scheme depending on Mobile-WiMAX QoS procedure.

II. The Consideration of Vertical Handoff in Hierarchical Mobile-WiMAX/WLAN Networks

Mobile-WiMAX handoff and traffic management was defined in the specification of IEEE 802.16e [5]. The study of hierarchical network architecture has been based on MIPv6 with AAA and has been studied on the procedure of vertical handoff using the user authentication [5, 6]. Like 802.16e specification, as the execution of vertical handoff starts, it performed user authentication using MIP with AAA between AAAMobile-WiMAX and AAAWLAN. After user authentication, vertical handoff is terminated. In order to carry out this process, it is necessary to define appropriate MAC management message on vertical handoff. A set of MAC management message has already defined BS-BS handoff in IEEE 802.16e specification, but vertical handoff process for traffic management in hierarchical Mobile-WiMAX/WLAN networks hasn't defined. We define a set of proposed MAC management message for traffic management in hierarchical Mobile-WiMAX/WLAN networks. By using these MAC management messages, the vertical process in hierarchical Mobile-WiMAX/WLAN networks could be simpler than that of any other studies [7, 8]. We define a set of proposed MAC management message on vertical handoff process in hierarchical Mobile-WiMAX/ WLAN network as shown in Table 1.

MOB_NBR_AP_ADV message is referred to neighbor AP advertisement information at WLAN hotspot as followed:

- Neighbor_AP_Index: AP in WLAN hotspot index corresponds to position of hotspot in MOB_NBR_AP_ADV
- Neighbor SSID: SSID parameter in WLAN hotspot
- Time Interval T: vertical handoff is postponed interval time. T is variable time based on statistical analysis data of service provider

MS may transmit an MOB_VHO-REQ message to RAS in Mobile-WiMAX network when vertical handoff occurs. And then MS may receive MOB_VHO-RSP from AP as the completion of vertical handoff.

표 1. Vertical 핸드오프를 위한 제안된 MAC 관리 메시지
Table 1. Proposed MAC management message on vertical handoff

Type	Message name	Message description
70	MOB_VHO-REQ	MS vertical handoff request message
71	MOB_VHO-RSP	BS vertical handoff response message
72	MOB_NBR_AP_ADV	AP neighbor advertisement message for vertical handoff

The proposed MAC management message on vertical handoff is defined in detail as follows in Table 2. According to the reported metric that MS indicates, MOB_ VHO-REQ message includes the following parameters:

- AP RSSI mean: AP RSSI mean parameter indicates the Received Signal Strength measured by MS from AP at WLAN hotspot
- Service level prediction: service level prediction value indicates the level of service which MS can expect from serving BS. The following encodings apply:
- 0; No service possible for this MS

표 2. 제안된 MOB_VHO-REQ 메시지 포맷
Table 2. Proposed MOB_VHO-REQ message format

Syntax	Size	Notes
Management Message Type=70		
Report metric	8bits	
N_New_AP_Index	8bits	Bitmap indicating presence of metric in message Bit #0: AP RSSI mean Bit #1-2: Service level prediction Bit #3-7: Reserved.
If(N_New_AP_Index!=0){	8bits	Number of new recommended APs which are included in MOB_NBR_AP_ADV message.
Configuration change count for MOB_NBR_AP_ADV}		
For(j=0; j<N_New_AP_Index; j++){	8bits	Neighbor_AP_Index Neighbor SSID
Neighbor_AP_Index		
If(Report metric[Bit#0]==1	8bits	

- 1; Some services are available for one or several service flows authorized for MS
- 2; For each authorized service flow, a MAC connection can be established with QoS specified by the Authorized QoS ParamSet
- 3; No service level prediction available

A Service Level Prediction may be accompanied by a number of services flow encodings shown in Table 3. If Service Level Prediction encoding value is 2, RAS doesn't transmit MOB_HHO-RSP message because of time sensitive application services. Otherwise, RAS transmits MOB_HHO-RSP message because it is possible for MS to execute the vertical handoff. In addition, the process of vertical handoff in which an MS migrates from the air-interface provided by RAS to AP in WLAN hotspot is not necessary because it doesn't need synchronization or scanning to each other on account of different frequency band and heterogeneous networks.

표 3. 데이터 delivery 서비스 종류 (IEEE 802.16e 규격내용)
Table 3. Type of data delivery services (IEEE 802.16e specification)

Type	Symbolic name	Meaning
0	UGS	Unsolicited Grant Service : to support real-time applications generating fixed-rate data
1	RT-VR	Real Time Variable Rate Service : to support real-time data applications with variable bit rates which require guaranteed data rate and delay
2	NRT-VR	Non-Real Time-Variable Rate Service : tosupport applications that require a guaranteed data rate but are insensitive to delays.
3	BE	Best Efforts Service : no rate or delay requirements
4	ERT-VR	Extended Real-Time Variable Rate Service : to support real-time applications with variable data-rates, which require guaranteed data and delay, for example VoIP with silence suppression

As depicted in Figure 3, the block diagram of dual mode terminal which perform vertical handoff in hierarchical Mobile-WiMAX/WLAN network consists of Mobile-WiMAX module including of architecture to provide type of service and WLAN module. This terminal concludes vertical handoff process to be the information of Grant Allocator[9].

If Grant Allocator value is UGS or rtPS(RT-VR or ERT-VR), MS doesn't transmit MOB_VHO-REQ message to RAS because of the time sensitive application services. Otherwise, MS transmits MOB_HHO-REQ message because it is possible for MS to execute the vertical handoff.

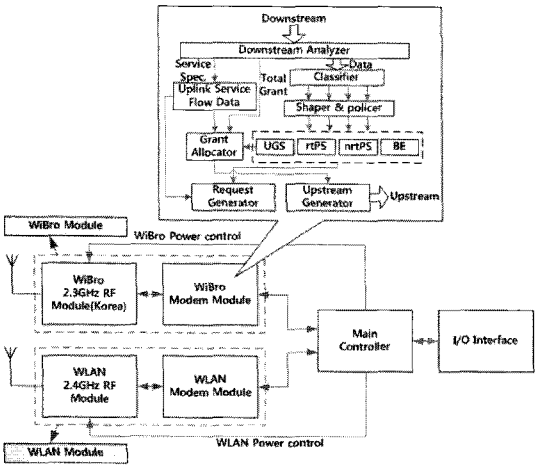


그림 3. 계층적 Mobile-WiMAX/WLAN 네트워크에서 사용되는 듀얼 모드 단말기의 구조

Figure 3. The block diagram of dual mode terminal used in hierarchical Mobile-WiMAX/WLAN network

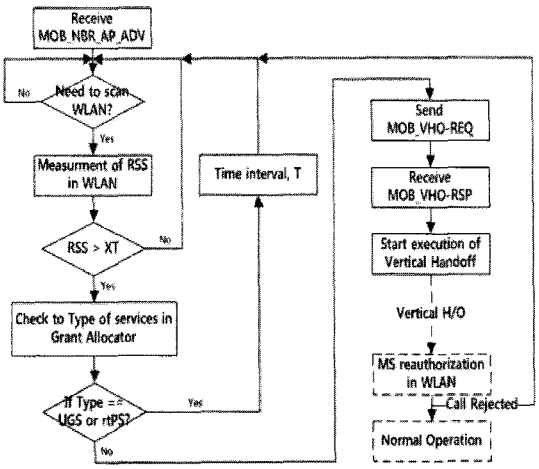


그림 4. Mobile-WiMAX에서 WLAN 핫스팟으로의 vertical 핸드오프 절차

Figure 4. The vertical handoff process from Mobile-WiMAX network to WLAN hotspot

III. The Proposed Process of Vertical Handoff Decision between the hierarchical Mobile-WiMAX/WLAN networks

We propose the process of vertical handoff decision between hierarchical Mobile-WiMAX/ WLAN networks. When Mobile-WiMAX to WLAN vertical handoff is executed, type of service should be considered because of the handoff delay time. If type of service is UGS service or rtPS (real time Polling Service), the decision of vertical handoff is withdrawn until termination of service. In Figure 4, the vertical handoff process from Mobile-WiMAX network to WLAN hotspot is shown when Mobile-WiMAX to WLAN vertical handoff is executed.

When signal from WLAN is strong, MS tries to seek SSID in WLAN hotspot referring MOB_NBR_AP_ADV. When received SSID in WLAN hotspot is correct, MS checks the type of service in Grant Allocator. If type of service is USG or rtPS (RT-VR or ERT-VR), vertical handoff is postponed by interval T, the time for termination of service. Otherwise, MS sends MOB_VHO-REQ message to RAS. WLAN AP sends MOB_VHO-RSP message to MS, vertical handoff is terminated to success.

The vertical handoff process execution will be restarted after Time interval, T which is based on statistical analysis data of service provider. MS, to success in receiving MOB_VHO-RSP on vertical handoff, attempts to user authentication through $AAA_{Mobile\text{-}WiMAX}$ to AAA_{WLAN}. A proven user for roaming network starts transportation of wireless internet data. If the user authentication is not succeeded, MS restarts this process. As shown in Figure 5, the improved vertical handoff procedure of hierarchical Mobile-WiMAX/WLAN networks with IMS.

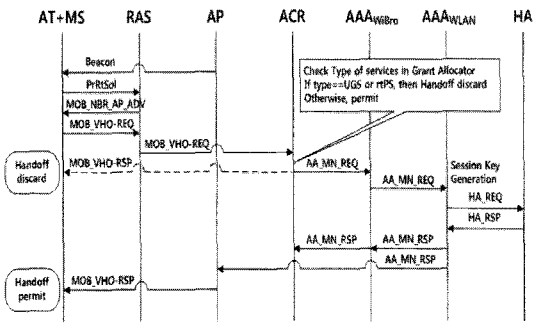


그림 5. MS를 사용하는 계층적 Mobile-WiMAX/WLAN 네트워크에서의 향상된 vertical 핸드오프 절차

Figure 5. The improved vertical handoff procedure of hierarchical Mobile-WiMAX/WLAN networks with IMS

On the other hand, vertical handoff from WLAN to Mobile-WiMAX network is not concerned about the criterion parameter of QoS because WLAN hotspot covers small area. It has to take a vertical handoff from WLAN to Mobile-WiMAX network because WLAN terminal doesn't have a resource to communicate when MS moves from WLAN hotspot zone to Mobile-WiMAX network. The vertical handoff process in the hierarchical Mobile-WiMAX/WLAN networks is shown in Figure 6 when Mobile-WiMAX to WLAN vertical handoff is executed. This vertical handoff process is simpler because vertical handoff from WLAN to Mobile-WiMAX network is not concerned about criterion parameter of QoS.

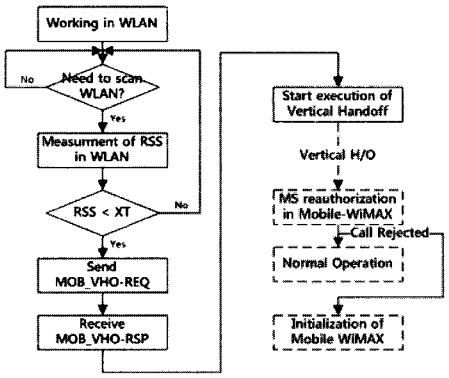


그림 6. WLAN 핫스팟에서 Mobile-WiMAX로의 vertical 핸드오프 절차

Figure 6. The vertical handoff process from WLAN hotspot to Mobile-WiMAX network

Ⅳ. Performance Evaluation

We use numerical analysis to verify the performance of proposed vertical handoff process. The analysis is performed in terms of throughput and delay during handoff process. Regarding the process time between AAAMobile-WiMAX and AAAWLAN and the process time of both MIP with AAA and PDF, we define the time parameters used in the numerical analysis on Table 4. It is assumed that the round-trip time between MS and AP/ACR is 8ms, which between AAAMobile-WiMAX and AAAWLAN caused by the user authentication is 74ms, that of MIP is 15ms, and that of PDF determining the service policy is 22ms [10].

As shown at Figure 2, the legacy vertical handoff procedure use a variety of messages such as PRRtSol, MOB_VHO_REQ, MOB_ VHO_RSP, MOB_NBR_AP_ ADV, AA_MN_ REQ, AA_MN_ RSP, HA_REQ, HA_RSP, USR_PD_REQ, and USR_PD_RSP. So it takes pretty much time for sending those messages and the handoff delay is given by

표 4. 수치분석에 사용된 시뮬레이션 파라메터

Table 4. Time duration parameters used in the numerical analysis

Parameters	Messages	Time Duration (ms)
T_{PRS}	PRRtSol	4
T_{VHO_REQ}	MOB_VHO_REQ	4
T_{VHO_RSP}	MOB_VHO_RSP	4
T_{AP_ADV}	MOB_NBR_AP_ADV	4
T_{AA_REQ}	AA_MN_REQ	37
T_{AA_RSP}	AA_MN_RSP	37
T_{HA_REQ}	HA_REQ	15
T_{HA_RSP}	HA_RSP	15
T_{PD_REQ}	USR_PD_REQ	11
T_{PD_RSP}	USR_PD_RSP	11

Delay for legacy VHO

$$= T_{PRS} + T_{AP\_ADV} + T_{VHO\_REQ} + T_{AA\_REQ} + T_{HA\_REQ} + T_{VHO\_RSP} + T_{AA\_RSP} + T_{HA\_RSP} \quad (1)$$

Note that the time duration of USR_PD_REQ/RSP is much smaller than which of AA_MN_REQ/ RSP, it thus is excepted from the equation (1).

On the other side, the proposed vertical handoff scheme reduces handoff delay as illustrated at Figure 4. In case of rtPS, the total delay time is given by

Delay for improved VHO (RTPS)

$$= T_{PRS} + T_{AP\_ADV} + T_{VHO\_REQ} + T_{VHO\_RSP} \quad (2).$$

The equation (2) explains that the proposed scheme uses fewer messages than legacy scheme in order to decrease vertical handoff delay.

In Figure 7 and 8, the delay time and the packet loss during vertical handoff process is evaluated in terms of the delivery time of MOB_VHO_REQ and the number of packets dropped, respectively. In the evaluation, we assume the simulation topology to consist of a Wibro network, a WLAN network, and a core Internet as shown at Figure 1. The radius of Wibro is considered as 50m and that of WLAN is considered as 5m. The packet generation rate of Wibro is 100 packets/sec, while which of WLAN is 200 packets/sec. It is also assumed that the terminal velocity is 10 m/sec.

In the evaluation, we assume that the data rate of Mobile-WiMax is 5Mbps and which of WLAN is 10Mbps. As illustrated in Figure 7, the improved scheme significantly reduces VHO latency by terminating needless handover in case of RTPS. As shown at Figure 8, the legacy process has many VHO control messages to send so that critical packet loss is occurred during handoff. It also causes the deterioration of throughput performance during handoff. However, it is verified that the proposed vertical handoff process diminishes handoff delays, thus the throughput performance and the packet loss problem is improved. Especially, the proposed process denies vertical hanoff during rtPS data is in air so that the critical packet loss is suppressed and seamless service is guaranteed.

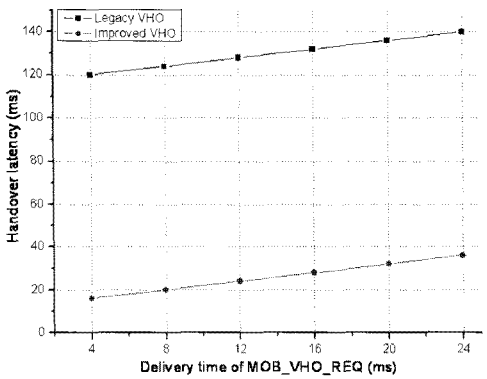


그림 7. vertical 핸드오프 실행 중의 throughput 성능 비교
Figure 7. The comparison of throughput performance during vertical handoff process

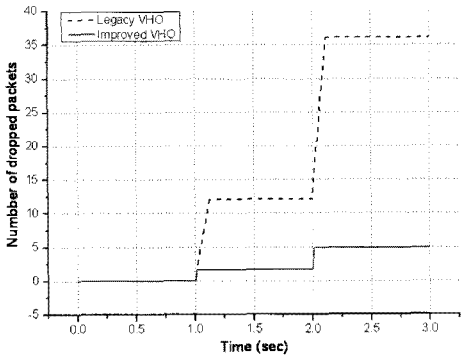


그림 8. vertical 핸드오프 실행 중의 패킷 손실 비교
Figure 8. The comparison of packet loss during vertical handoff process

V. Conclusions

In this paper, we considered the vertical handoff process between the hierarchical Mobile-WiMAX/WLAN networks. We defined MAC management messages on vertical handoff process in order to improve handoff performance. The criterion parameter of RSS is not sufficient to provide seamless service, i.e. VoIP, visual telephony, and etc, because the vertical handoff delay did not guarantee quality of service. Therefore, we propose the novel vertical handoff decision scheme for seamless service which is sensitive to time delay. The type of services should be considered because of handoff delay time. If type of service is UGS or rtPS service, the decision of vertical handoff is withdrawn until the service finishes. If these proposed strategy and scheme are adopted, the user satisfaction'll be improved. The MAC management messages, such as the type of service based on 802.16e specification, are used for quality of service which is seamless wireless internet service. In focus on user satisfaction, if the proposed traffic management strategy in hierarchical Mobile-WiMAX/WLAN networks is used, user will utilize seamless wireless internet services including time sensitive applications. As the future work, we will focus on Media Independent Handover (MIH), Voice Call Continuity (VCC), and Multimedia Session Continuity (MMSC) in order to enhance vertical handover and QoS.

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