A QoS based Vertical Handoff scheme for WiMAX/WLAN Networks

R. Augastiny[*], S. Sarala[**], C. Janani[**]

[*] Electronics & Communication Engineering, Sri Manakula Vinayagar Engineering College

Abstract- Recently, a number of wireless communication technologies are migrating toward heterogeneous overlay networks. The integration of Mobile WiMAX and WLAN seems to be a promising approach due to their homogeneous nature and complementary characteristics. In this paper, we investigate several important issues for the interworking of Mobile WiMAX and WLAN networks. We address a tightly coupled interworking architecture. Further, a seamless and proactive vertical handoff scheme is designed based on the architecture with aims to provide always the best quality of service (QoS) for users. Both the performance of applications and network conditions are considered in the handoff process. Moreover, we derive evaluation algorithms to estimate the conditions of both WiMAX and WLAN networks in terms of available bandwidth and packet delay. A simulation study has demonstrated that the proposed schemes can keep stations always being best connected.

Index Terms- Available bandwidth, packet delay, vertical handoff, WiMAX, WLAN

I. Introduction

Roaming across heterogeneous wireless networks such as wireless wide area network (WWAN) and wireless local area network (WLAN) poses considerable challenges, as it is usually difficult to maintain the existing connections and guarantee the necessary quality of service (QoS).The trend in fourth-generation wireless networks (4G) is the coexistence of heterogeneous technologies. During the past few years, wireless local area networks (WLANs) have been widely deployed due to its low cost and high capacity. On the other hand, mobile worldwide interoperability for microwave access (Mobile WiMAX) networks become a fast growing technology for its promised high bandwidth over long-range transmission with quality of service (QoS) supports. The integration of WiMAX and WLAN has been seen as a promising approach toward 4G.

In the design of heterogeneous overlay systems, one of the most important issue is vertical (intersystem) handoff (VHO) support. Generally, traditional horizontal (intrasystem) handoffs are initiated only by mobility to maintain the connectivity of the station. However, more metrics may be considered in VHOs especially when more than one network is available. These metrics can be classified into two categories. One category is QoS. I f the service provided by the connected network cannot satisfy the requirements, the station may switch to another network for better performance.

The other category is user preference which reflects the user's special requirements on price, power consumption or speed, etc. Therefore, VHO plays a significant role in achieving the main goal of 4G networks— allowing users to profit always best connected (ABC) service.

For VHO schemes, "seamless" and "proactive" are two desirable features. A proactive handoff means that the handoff process (i.e., initiation, decision, and execution) is controlled by the stations. Hence, if QoS metrics such as time, such as bandwidth and packet delay are considered in a VHO scheme, the stations should be able to detect network conditions for a handoff decision. Consequently, the network condition detection algorithms need to be tightly integrated into QoS oriented VHO schemes. On the other hand, a seamless handoff denotes that the handoff execution is transparent to upper layer applications. Indeed, this depends on the interworking architecture of heterogeneous networks. In the existing cellular/WLAN overlay systems, there are two types of interworking architectures: tightly coupled where WLAN works as a radio access network of cellular system, and loosely coupled where different networks are independently deployed but integrated at network layer. Comparably, a more seamless VHO can be expected in the tightly coupled networks, where the handoff execution follows the protocols of cellular network conditions.

We investigate the integration and VHO issues in WiMAX/WLAN overlay networks. The major contributions of our work are threefold: 1) a QoS oriented VHO scheme is proposed for the tightly coupled WiMAX/ WLAN networks to provide the ABC services (i.e connectivity over multiple mobile and fixed users; 2) in order to achieve proactive handoffs, network condition detection algorithms are derived for stations to estimate the available bandwidth and the packet delay of WiMAX and WLAN networks, respectively; and 3) since to our knowledge, there is still no tightly coupled architecture dedicatedly designed in literatures for WiMAX/WLAN systems, we address an architecture to support our VHO scheme

II. Existing System

In existing QoS oriented VHO approaches, for overlay networks, QoS metrics are considered in handoff decisions. However, the handoff procedures are normally initiated when the stations move across the border of WLANs. As a result, both the fixed stations and the mobile stations within overlapped areas cannot benefit from VHOs. This is the biggest disadvantage of the existing system

The main objective of the proposed algorithm is, to provide QoS service to both fixed and mobile networks.

III. PROPOSED SYSTEM

VHO could be initiated by two factors: mobility when a station moves out of the coverage of its connected network, and QoS when the connected network cannot satisfy the requirements. The Handoff does not take place immediately when the user enters into the child network. Only when the local connected network is proved to be working in a bad condition handoff decision process can be started. QoS parameters such as bandwidth and packet delay will be analyzed for the other network which is not serving (new child network), When the adequate values are met with handoff takes place.

Therefore, the QoS-triggered handoffs should be designed with an objective to provide ABC services for both mobile and fixed stations .To achieve a proactive handoff, we design a VHO manager (VHOM) to control the whole handoff process, which works on the medium access control (MAC) layers of WiMAX and WLAN interfaces at the station comes the most crucial step for your research publication. Ensure the drafted journal is critically reviewed by your peers or any subject matter experts. Always try to get maximum review comments even if you are well confident about your paper.

A. Service Evaluation and Handoff Initiation

Once an application is established at the station, VHOM will detect each packet of this application. Based on the delay sensitivity characteristics, the applications are classified into real-time applications and nonreal-time applications, respectively. Since a real-time application is sensitive to latency, both the throughput and packet delay of the traffic are measured. For a nonreal-time application, the amount of transmission data is more important, and then only the traffic throughput is measured. Here, the transmission direction of the application should be taken into account. For an uplink (UL) application, VHOM can record the moment that the packet arrives at the MAC layer buffer of the station and the moment that the packet is successfully transmitted by the connected network. Therefore, the calculated UL traffic throughput and packet delay can well reflect the performance of the local connected network (WiMAX or WLAN). If an UL application continually violates the QoS requirements for a given period, the handoff decision process will be started.

For the downlink (DL) traffic, however, the station cannot obtain the time information that the packet arrives at base station (BS) or access point (AP), and then an end-to-end delay will be calculated in this case rather than the delay purely introduced by the local connected network. Meanwhile, if it is the DL traffic throughput or packet delay violates the QoS requirements, the poor performance may be introduced by the local connected network or by other networks on the path between two end nodes of this application. To avoid performing an unnecessary VHO within the local network, VHOM needs to evaluate the conditions of the local connected network first in this case. Only when the local connected network is proved to be working in a bad condition, the following handoff decision process can be started

B. Network Condition Detection and Handoff Decision

In this phase, a decision of whether to perform a VHO will be made by VHOM. The main work is to decide whether the conditions of the other network that is not serving the station can satisfy the QoS requirements. The flowchart is shown in Fig. 1 with the used parameters listed in Table 1. The available bandwidth of the network is evaluated first.If the calculated result is larger than the threshold and a real-time application is running on the station, the average

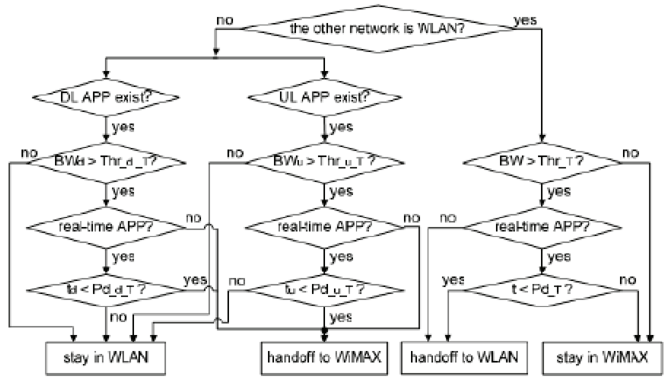


Fig. 1. The QoS-triggered VHO decision algorithm.

TABLE 1
Parameters Used in VHO Decision Algorithm

APP	current application
$BW_d/BW_u/BW$	estimated available bandwidth of DL WiMAX/UL WiMAX/WLAN
$Thr_{\_d\_T}/ Thr_{\_u\_T}/ Thr_{\_T}$	threshold for the available bandwidth of DL WiMAX/UL WiMAX/WLAN
$t_d/t_u/t$	estimated average packet delay of DL WiMAX/UL WiMAX/WLAN
$Pd_{\_d\_T}/ Pd_{\_u\_T}/ Pd_{\_T}$	threshold for the average packet delay of DL WiMAX/UL WiMAX/WLAN

packet delay of the network will be further estimated. If the other network is WLAN, the network conditions are estimated based on the total radio resource since the medium of WLAN is contended by all stations including AP. But in WiMAX networks, the radio resource has been allocated into a DL portion and an UL portion, which allows the network conditions be evaluated for DL and UL, separately. Therefore, only when both the DL and UL network conditions satisfy the requirements, a decision of handoff to WiMAX can be made.

To make an effective handoff, it is required that the conditions of the target network must be good enough. This is guaranteed by accurately estimating the network conditions and setting suitable thresholds. We have designed novel algorithms for both WiMAX and WLAN networks to detect the network conditions in terms of the available bandwidth and the packet delay, By the proposed scheme, it is required that the thresholds for evaluating the available bandwidth (i.e., Thr_d_T;Thr_u_T and Thr_T) should not be less than the total throughput of the corresponding applications. Meanwhile, the thresholds for the packet delay (i.e., Pd_d_T;Pd_u_T and Pd_T) should not be larger than the required lowest packet delay for the corresponding applications.

C. Handoff Execution

Once a decision of handoff to the other network is made, VHOM needs to transfer current connections at the station to the target network. Under the tightly coupled architecture, AP connects to the central gateway called ASNGW in the access service network (ASN) of WiMAX, just as its overlay BS. Therefore, AP belongs to the same sub network at IP layer with its overlay BS. As a result, the IP address of the station needs not to be changed after a VHO, which makes a MAC layer handoff possible. Based on this consideration, we deploy an address resolution protocol (ARP) method to execute VHOs.

When a handoff decision is made, VHOM issues a gratuitous ARP message which will be transmitted by the target interface at the station. The message conveys the IP address of the station and the MAC address of the target interface. The AP or BS in the target network relays the message to ASN GW, which then updates its ARP cache by binding the IP address with the MAC address contained in the message. Then, ASN GW issues an ARP reply message to the station. Hereafter, the data packets destined to the station will be transferred by ASN GW via the newly selected network.

IV. PROPOSED ESTIMATION ALGORITHMS

The available bandwidth of a link equals to the difference between total capacity and the traffic load over the link. Usually, when the modulation and coding methods are known, the total capacity can be calculated. Therefore, the key idea of estimation is to find the utilization information of the link.

A. *Estimation in WiMAX*

Mobile WiMAX is specified by IEEE 802.16e standard which uses orthogonal frequency division multiple access (OFDMA) technique. Both the time division duplexing (TDD) and frequency division duplexing (FDD) are supported by IEEE 802.16e.In the standard, an adaptive split between DL and UL subframes are allowed. But it is usually fixed or remained unchanged for a long period inpractical applications. Hence, we take the fixed split case as an example for analysis

1) Available Bandwidth Estimation

By the OFDMA technique, the bandwidth is allocated in the form of data bursts where an integer number of slots are included. The BS determines the number of DL and UL slots that a station obtains in one frame, and then broadcasts the resource allocation results through DL-MAP and UL-MAP messages at the beginning of each DL subframe.

Therefore, the station can easily obtain the utilization of WiMAX link by aggregating the number of allocated slots stated in DLMAP/UL-MAP messages. Let AASd and AASu denote the number of allocated DL/UL slots in one frame, which are averaged from n frames.Tf; Tdf , and Tuf denote the duration of a frame, a DL subframe, and an UL subframe, respectively. Then, the available bandwidth in DL and UL can be calculated by

$$\begin{cases} B_d = \left(1 - \dfrac{AAS_d}{s_d}\right)\dfrac{\delta_d s_d}{T_f} \\ B_u = \left(1 - \dfrac{AAS_u}{s_u}\right)\dfrac{\delta_u s_u}{T_f} \end{cases},$$

Where $s_d(s_u)$ denotes the total slots in a DL(UL) subframe.

2)Packet Delay Estimation

We define the packet delay as the latency from the time that the packet arrives at the MAC layer buffer to the time that the packet is successfully transmitted. We divide the total delay into four components for analysis

$$t = t_s + t_q + t_m + t_t$$

The scheduling delay **ts** is taken from the moment the packet arrives at the MAC layer buffer, to the moment this arrival information is obtained by BS. The queuing delay **tq** is the time to be waited for the beginning of the frame allocated for transmitting the packet. The mapping delay **tm** is taken from the beginning of the allocated frame to the first time slot appointed to the station.The transmission delay **tt** is the time required to transmit the packet.

B. *Evaluation of proposed VHO scheme*

On the proposed VHO scheme, we have conducted simulations in an interworking system which consists of one WiMAX network and two overlapped WLANs, as shown in Fig 2.

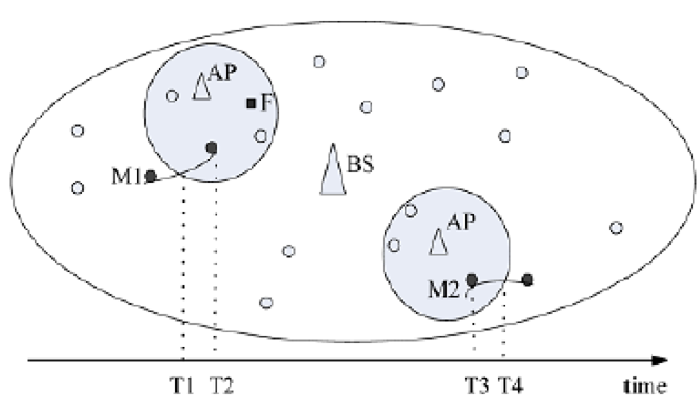


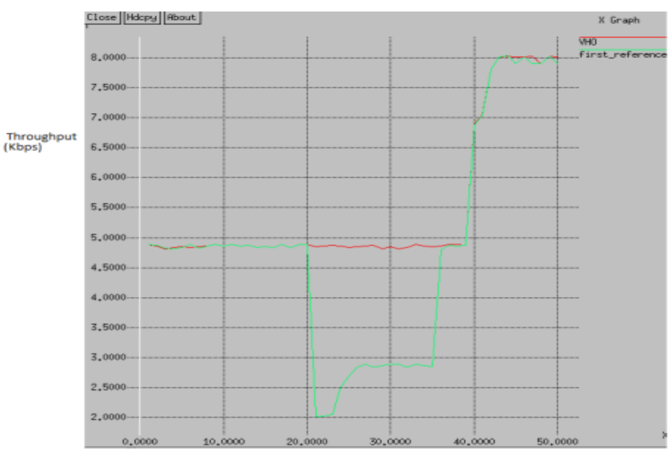
Fig.2. Simulation topology forWiMAX/WLAN interworking system

We have compared our proposed VHOM scheme with one reference scheme that is based on mobility factor.when the mobile node detects the presence of other network handoff takes place.

1)For Mobile Stations

We have performed simulation study for mobile station. In that scenario, a mobile station M1 moved toward an overlapped region as shown in Fig. 2. There was an UL connection running at M1 which was a nonreal-time variable bit rate (VBR) application with an expected throughput of 800 kbps. Initially, the VHO found that the average throughput of the application fell below the accepted 600 kbps.

But there was no other network available at that time. At the moment of T1, a WLAN network was found, and then a handoff was executed by the reference scheme immediately. But By our scheme, VHOM initiated the available bandwidth estimation process first. To guarantee the conditions of WLAN sufficiently good, Thr T was set to be 900 kbps. The estimated available bandwidth could not satisfy this requirement until T2, and then a handoff was performed at T2 as shown in Fig. 3a.



T1 T2

Fig 3.a Throughput comparison in the movement scenario.

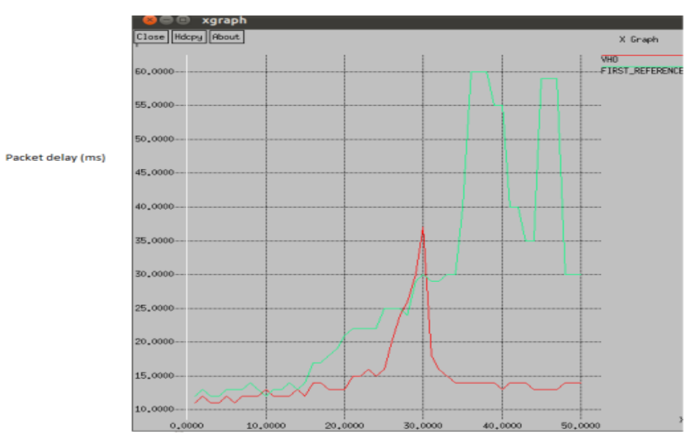


Fig 3.b Packet delay comparison in the fixed scenario

4.2.2For Fixed Stations

In the simulation, a station F located in an overlapped region without movements, which worked with a real-time constant bit rate (CBR) application. The expected throughput was 500 kbps with a threshold of 450 kbps. The accepted end-to-end packet delay is 20 ms. Initially, the station was served by the WLAN. At around 27 ms, the average end-to-end delay detected by VHOM could not fulfill the requirement for three times although the throughput was fairly well. By the VHOM scheme, the condition of the WLAN was evaluated first.

The result showed that the latency introduced by the WLAN operations exceeded the 8 ms, which is the threshold. Then, the VHOM began to estimate the status of the WiMAX network. At about 30 ms, a decision of handoff was made based on the fact that conditions of the WiMAX network could satisfy the requirements. The and end-to-end packet delay obtained by the schemes have been compared and shown in Fig. 3. The reference scheme could not initiate handoffs for the fixed stations. The results show that a much lower packet delay and more stable throughput can be obtained by the proposed VHOM scheme.

V. CONCLUSION

In this paper, we investigate several important issues for the interworking of WiMAX and WLAN networks. We address a tightly coupled interworking architecture as the platform of our scheme. Based on the tightly coupled architecture, we propose a novel seamless and proactive VHOM scheme for stations to control the vertical handoff operations in the interworking networks, which aims to provide ABC service for both mobile users and fixed users. In order to make stations be able to proactively evaluate network conditions for making handoff decisions, we develop algorithms to estimate the available bandwidth and packet delay in WiMAX and WLAN, respectively. By the simulation experiments, we have proven the feasibility and effectiveness of our proposed schemes.

ACKNOWLEDGMENT

The preferred spelling of the word “acknowledgment” in American English is without an “e” after the “g.” Use the singular heading even if you have many acknowledgments.

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AUTHORS

First Author –R. Augastiny, M.Tech II yr, Sri Manakula Vinayagar Engineering college,sweetaugas@gmail.com.

Second Author – S.Sarala, M.Tech, Sri Manakula Vinayagar Engineering college, er_sarala@yahoo.co.in
Third Author – C.Janani, M.Tech II yr, Sri Manakula Vinayagar Engineering college, c.jananichandhru@gmail.com

Correspondence Author– R.Augastiny, sweetaugas@gmail.com,sweet_augas@yahoo.co.in, 8870584922
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