Handover Optimization for Real-Time Application in Mobile WiMAX / IEEE 802.16e

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Abstract—The demand for wireless broadband services is growing rapidly. Mobile WiMAX is one of the most promising technologies for broadband wireless communication. It allows users to roam over the network under vehicular speeds. However since IEEE 802.16e standard for Mobile WiMAX defines only hard handover mandatory, Mobile WiMAX cannot transmit or receive packets during handover. Thus real-time packets can be dropped and it may result that service providers cannot guarantee quality of service during handover procedure. The long interruption of handover is horrible for real-time applications like IPTV, VoIP and Sat TV. Our proposed solution solves this latency problem during handover. In our scheme minimum number of Base Stations will be scanned and MS should scan only those BSs which can fulfill the bandwidth requirement of MS. Priority should be given to real time flows in handover. Through the proposed scheme handover will be fast, secure and seamless; and transmission interruption will be so brief that user will not perceive the interruption.

Keywords- Mobile WiMAX, Handover, MDHO, FBSS

I. INTRODUCTION

The demand for higher data rate wireless broadband access is growing rapidly so that user can get wireless services anytime and everywhere. WiMAX as compared to other wireless broadband technologies provides higher bandwidth and larger coverage. WiMAX (Worldwide Interoperability for Microwave Access) is an emerging technology that can provide wireless broadband access at the data rates of multiple Mbps over long distances to both home and business customers. High speed data services can be provided to devices like laptop and PDA by using this technology. WiMAX can also be used for connecting Wi-Fi hotspots with each other and to other parts of the Internet so it can extend WLAN( hot spots) to city wide coverage(hot zones) [1,2,4]. WiMAX can be deployed in disaster recovery scenes very quickly where the wired networks have broken down. In recent years WiMAX networks were successfully deployed in many disaster scenes e.g. recent hurricane disasters.

It is also possible to use WiMAX as backup link in case of broken wired link [4, 5].

The Mobile WiMAX / IEEE 802.16e standard adds mobility to these networks. Mobile WiMAX provides high data rate wireless access under vehicular speed. It enables the users to roam between different WiMAX networks and still keep their session active. Mobile WiMAX provides better quality because it is based on OFDMA, which is multiplexing technique and supports multipath environment so have higher throughput and better coverage [5]. Handover is an essential function for networks which support mobile subscribers i.e. Mobile WiMAX. User receiving mobile services expect handover completed very fast so they do not experience any service degrading. In IEEE 802.16e standard for Mobile WiMAX, three types of handover are supported Hard Handover (HHO), Fast BS Switching (FBSS), and Macro Diversity Handover (MDHO). In IEEE 802.16e standard for Mobile WiMAX only hard handover is mandatory so Mobile WiMAX cannot transmit or receive packets during handover. Handover latency should be not more than 50 ms in VoIP and should be not more than 100 ms in streaming media. Thus real-time packets can be dropped and it may result that service providers cannot guarantee quality of service during handover procedure. The long interruption of hard handover is horrible for real-time applications like IPTV, VoIP and Sat TV. In our proposed scheme we tried to solve this latency problem during handover.

The remainder of this paper is organized as follows. Section II provides technical background of WiMAX Network Architecture and overview of Handover Operation in Mobile WiMAX / IEEE 802.16e networks. In section III an overview of previous work on Handover Operation in Mobile WiMAX / IEEE 802.16e networks is presented. We have described our proposed improvements in handover procedure scheme in section IV. In section V, we discuss the effects of our proposed scheme on handover latency. Conclusion and future work are given in section VI.
II. BACKGROUND

A. WiMAX Network Architecture

In Mobile WiMAX networks, the Mobile Stations are connected to Base Stations through air-interface. The base stations are connected to Access Service Network Gateway (ASN-GW) via routers and ASN-GW is connected to a Connectivity Service Network. The basic architecture of Mobile WiMAX network is shown in figure 1 [3]. Logically WiMAX Network Architecture [6, 7] can be divided into two parts namely Network Service Provider (NSP) and Network Access Provider (NAP). Network Service Provider (NSP) is a business entity and constructs Connectivity Service Provider (CSN), which is responsible for providing IP connectivity and WiMAX bandwidth services to Mobile Station. Connectivity Service Provider (CSN) provides many functions including IP address allocation, internet access, AAA proxy, QoS policy, admission control based on user profile. Network Access Provider (NAP) is a business entity that is responsible for providing WiMAX radio access infrastructure to one or more Network Service Providers (NSPs). Network Access Provider (NAP) consists of one or more Access Service Networks (ASN).

An Access Service Networks (ASN) is responsible for providing layer 2 connectivity functions to WiMAX Mobile Stations. It consists of one or more Base Stations and one ASN gateway (ASN-GW). A Base Station provides MS wireless access and it can be connected to one or several ASN gateways (ASN-GW). An ASN gateway (ASN-GW) is responsible for connections with CSN.

B. Overview of Mobile WiMAX Handover

Handover [2, 5] is an important function in Mobile WiMAX. In WiMAX Network Mobile Station (MS) has the ability to perform handover function to support its mobility. In Handover a Mobile Station (MS) switches from air-interface of one Base Station (BS) to air-interface of another Base Station (BS) without losing its current sessions and data. It is also important that when Mobile Station (MS) moves from one Base Station (BS) to another Base Station (BS) then there should be minimum delay in communication. Mobile Station (MS) performs handover due to different situations which include the following:

1. In case the strength of signal weakens because of movement of Mobile Station (MS) or level of interference then the Mobile Station (MS) performs handover to other Base Station (BS) which can provide better signal quality.
2. In case Mobile Station (MS) can get better quality of Service (QoS) at other Base Station (BS).

Hard Handover (HHO) is mandatory in IEEE 802.16e but other two techniques i.e. Micro Diversity handover (MDHO) and Fast BS Switching (FBSS) are optional. The last two are called Soft Handover techniques and these are able to provide more seamless and faster Handover (HO). The description of these handover types is given below [2, 5]. Handover Procedure in Mobile WiMAX is described in Fig. 2 [5].

1) Hard Handover (HHO)

In this type of handover Mobile Station only communicates with only on Base Station at any time. Hard handover is uses the break-before-make strategy as Mobile Station (MS) has to disconnect from serving Base Station (BS) before connecting to target Base Station (BS). The Hard Handover is simplest of all three types of handovers but it has high latency time which is not suitable for real-time application. The serving Base Station periodically broadcasts neighbour advertisement message MOB_NBR-ADV. The Mobile Station received information through this message about characteristic of neighbouring Base Stations such that number of neighbour Base Stations and their BSIDs. After this the Mobile Station can select appropriate target Base Station for handover. It also performs ranging; association procedures, authentication and registers with target Base Station.
2) Macro Diversity Handover (MDHO):

This is an optional scheme so it must be supported by both Mobile Station and Base Station. In this scheme Mobile Station and Base Station keeps a list of Base stations which are capable to the MDHO on MS’s coverage area. This group of Base Stations is called diversity set or active set. One Base Station among these is defined as anchor Base Station. The Mobile Station can communicate with any Base Station in diversity set for UL and DL traffic. The Base Stations involved in MDHO must share or transfer MAC context including current encryption and authentication keys. MDHO is described in Fig.3 [12].

3) Fast base Station Switching (FBSS)

This scheme is similar to MDHO. Both Mobile Station and Base Station have to support FBSS. The Mobile Station and Base Station manage the diversity set but Mobile Station can only communicate with one Base Station i.e. anchor Base Station for all type of traffic. The switching from one anchor BS to other anchor BS is performed without invoking normal HO procedure. As in MDHO, it is required that BSs involved in FBSS share or transfer MAC context. FBSS is described in Fig. 4[12].

III. RELATED WORK

Researchers have been working on Handover of IEEE 802.16e broadband wireless network for years and several fast handover schemes
had been proposed. In [8] a new fast handover algorithm was proposed which reduces the waste of the wireless channel resources and handover delay. This scheme tries to reduce unnecessary neighbour Base Station scanning & association process. The proposed scheme performs Target Base Station estimation using mean CINR and arrival time differences. In [9], authors proposed an enhanced link-layer HO scheme called Passport Handover with a new Transport CID mapping strategy for real-time applications. With the help of this CID assignment strategy confliction of CIDs of handing over services with that of ongoing services in the target Base Station can be avoided. But this scheme can be complex when deployed.

In [10], the authors proposed two efficient schemes to enhance the performance of authentication during handover in Mobile WiMAX. The proposed schemes help to avoid the device re-authentication. In the first scheme, whenever Mobile Station first enters the network it is authenticated by AAA through EAP authentication. After that whenever Mobile Station needs to be authenticated by AAA server then instead of standard EAP method used in handover authentication, an efficient shared key-based EAP method is used. In the second scheme, the standard EAP method is skipped and the device authentication is done by SA-TEK three-way handshake in PKMv2 process. This scheme is not suitable for implementation because it avoids the standard procedures. In [11], the authors proposed a secure pre-authentication that follows the least privilege principle to solve the domino effect and handover protocol guarantees the backward and forward secrecy. But this pre-authentication scheme is not efficient and secure.

In this paper we propose some improvements for handover procedure in Mobile WiMAX. Our proposed solution will reduce the latency so handover will be seamless and user will experience no or minimum interruption in service. As compared to above mentioned schemes ours is more practical as it require only few changes in the standard.

IV. PROPOSED IMPROVEMENTS IN HANDOVER

An efficient Handover scheme is very important in WiMAX to complete the handover procedure and to satisfy QoS requirements. Many Handover schemes have been proposed for reducing the handover latency and ensuring QoS requirements of various service flows. Some of these have been discussed in last section of this paper. Any fast handover scheme should satisfy some features and criteria for optimizing handover performance e.g. minimum scanning time, handover latency time, mobility, and QoS requirements etc. In this section we will describe our proposed scheme. Scanning of neighbour Base Stations is very time consuming process. More the number of Base Stations a Mobile Station have to scan the greater latency time will be. We propose following improvements for the efficiency of handover procedure in Mobile WiMAX.

A. Neighbor Advertisement message (MOB_NBR-ADV) improvement

In the current standard Neighbor Advertisement message (MOB_NBR-ADV) contain the information like number of neighbouring Base Station and only this information is not very helpful in selection of target Base Station. We propose that MOB_NBR-ADV should also contain some information that can be helpful for selecting Target Base Station i.e. list of neighbouring Base Station, number of real-time flows each of these have and free bandwidth of each neighbouring Base Station etc. As all neighbouring Base Stations are connected to the serving Base Station through backhaul network. So there are many important parameters related to neighbour Base Stations e.g. PHY information and channel information can be sent to serving BS through backbone and then transmitted to Mobile Station via MOB_NBR-ADV message. In this way Mobile Station do not have to monitor transmission of neighbour Base Station and overall efficiency of handover procedure will be improved.

B. Scanning of neighbour Base Stations (BS)

We propose that not all neighbour Base Stations should be scanned because scanning is very time consuming process. And if Mobile Station has to scan more Base Stations then latency will much increased. Only those Base Station will be scanned which can fulfil quality of service requirement of Mobile Station. This will avoid the frequent handovers which can cause wastage of resources. Information acquired from improved MOB_NBR-ADV message will be used to decide which of the neighbouring Base Stations are suitable for scanning. The serving Base Station assign scanning interval to Mobile Station for scanning of neighbouring Base Stations and as fewer number of neighbouring Base Stations are selected so scan intervals will be significantly reduced. As scan intervals will be reduced so handover procedure will be more efficient.

C. Selection of Target Base Station

We propose few improvements for selection of target Base Station. We recommend that Base Station which has largest free bandwidth is suitable as target Base Station. On the other hand
number of real-time flows Base Station already has will also effect the selection of target Base Station because Base Station with minimum number of real-time flows is good candidate to be target Base Station. When selecting new TBS, consideration will be given to avoid of unnecessary ping pong handovers in overlapping areas.

V. DISCUSSION

In this paper we explained handover process in WiMAX along with different handover techniques. In this section we will discuss how our scheme is more efficient as compared to previously proposed schemes. First we proposed some improvements in Neighbor Advertisement message (MOB_NBR-ADV). Mobile Station will extract the information from this message to decide which of the neighbouring Base Stations should be scanned to find target Base Station. In our proposed scheme it is not necessary to scan all neighbouring Base Stations. As scanning is very time consuming procedure so latency time during handover procedure will be greatly reduced due to less number of Base Station are scanned. Also in our proposed scheme for the selection of target Base Station the preference will be given to Base Station which has largest remaining bandwidth and lowest number of real-time flows. This will avoid unnecessary frequent handovers. Hence our proposed scheme is efficient and will greatly reduce the handover latency.

VI. CONCLUSION AND FUTURE WORK

Secure and seamless handover is very important for real-time application in Mobile WiMAX. In this paper, we have proposed some improvements in handover procedure in Mobile WiMAX to make this procedure more efficient. In our proposed approach less target Base Stations will be scanned. So handover latency is reduced greatly. Also our proposed scheme avoids frequent handovers so wastage of resources can be prevented. In the future we will demonstrate our proposed improvements with the help of simulation.

REFERENCES


