Adaptive Distance Handover Scheme in Mobile WiMax

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***Abstract* – WiMax (Worldwide Interoperability Microwave Access) is a wireless system based on the IEEE 802.16e [1] standard which supports Wireless Metropolitan Area Network (WMAN). In order to meet the requirements of different types of access, two versions of WiMAX have been defined. The first is based on 802.16-2004[2] and is not implemented support of handovers between cells. This version of WiMax allows only fixed and nomadic access [3].The second version is an improvement over the first version and is designed to support portability and mobility based on the IEEE 802.16e amendment to the standard. There is introduced support of soft handover and hard handovers in this version. In the environment of WMAN the mobile client has high mobility as it moves from the coverage area of Serving Base Station (SBS) to Target Base Station (TBS). In order to support mobility, the handover schemes must be adopted in which the hard handover is defined as mandatory. In order to make this handover the existing draft standard considers only the received signal strength when deciding handover initiation. However the distance and velocity factors also have an important influence on handover initiation and cannot be neglected. To deal with these problems, this paper proposes a adaptive distance handover scheme. This scheme proposes a adaptive distance threshold based on the velocity of the vehicle to skip some unnecessary stages, reducing handover delay and to reduce packet loss during the handover.**

***Keywords* – Mobile WiMAX, Handover , Delay, Signal Strength, Distance, Packet, Velocity**

I. INTRODUCTION

Mobile WiMax users have the characteristic of mobility which allows users to move anywhere at any time and be served as long as there is network coverage within the area. There are basically two major types of handover (HO) defined in mobile WiMax: Hard Handover (HHO) and Soft Handover (SHO). HHO is mandatory while SHO is optional**.** HHO is characterized by "break before make". This implies that Mobile station (MS) releases its connection from the SBS before establishing a new connection to the TBS as depicted in Fig 1. During this the MS communicates with only one BS at each time. Handover is executed after the signal strength from neighbor's cell exceeds the signal strength from the current cell. HHO causes HO delay and service interruption which has a negative impact on delay-sensitive applications.

SHO is characterized by "make before break". This implies that Mobile station (MS) establishes a new connection to the TBS before releasing its connection from the SBS. SHO is divided into two types Macro-Diversity Handover (MDHO) and Fast Base Station Switching (FBSS). When MDHO [3] is supported by MS and by base station (BS), the "Diversity Set" is maintained by MS and BS. Diversity set is a list of the BS's, which are involved in the handover procedure. MS communicates with all BS's in the diversity set as depicted in Fig 2. For downlink in MDHO, two or more BS's transmit data to MS such that diversity combining can be performed at the MS. For uplink in MDHO, MS transmission is received by multiple BS's where selection diversity of the received information is performed. The BS, which can receive communication among MS's and other BS's, but the level of signal strength is not sufficient is noted as "Neighbour BS".

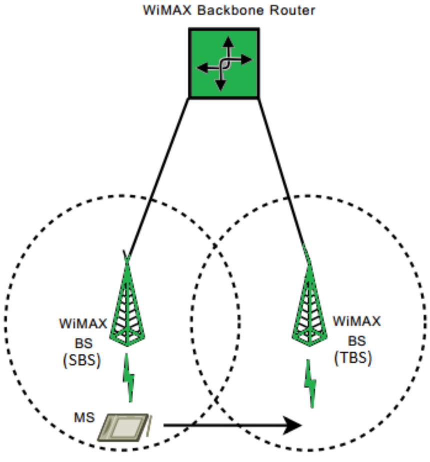

Fig. 1: HHO

In FBSS [3], the MS and BS diversity set is maintained similar as in MDHO. MS continuously monitors the base stations in the diversity set and defines an "Anchor BS". Anchor BS is only one base station of the diversity set that MS communicates with for all uplink and downlink traffic as depicted in Fig 3. This is the BS where MS is registered, synchronized, performs ranging and there is monitored downlink channel for control information. The anchor BS can be changed from frame to frame depending on BS selection scheme. This means every frame can be sent via different BS in diversity set.

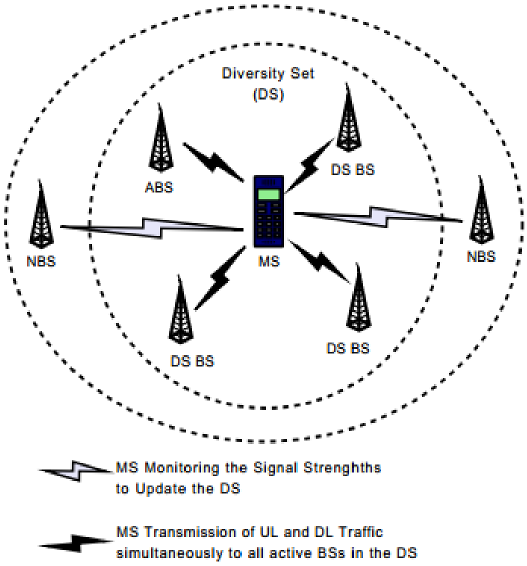

Fig 2: MDHO

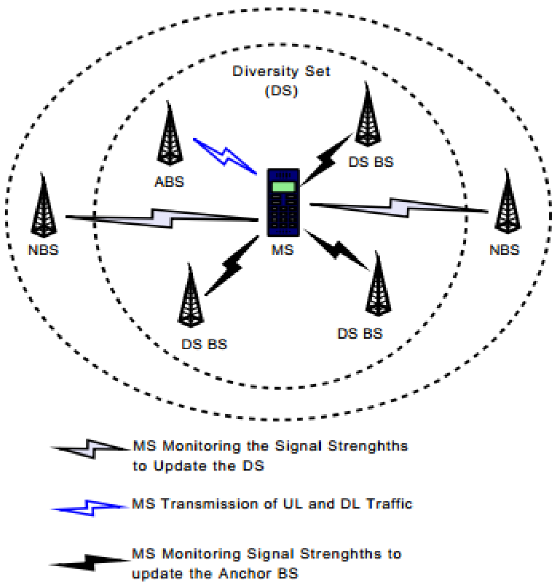

Fig. 3: FBSS

Basically in WiMAX, the Received Signal Strength Indicator (RSSI) is used to measure the signal strength of each BS. When the RSSI of the Serving Base Station (SBS) is lower than the signal strength of the Target Base Station (TBS) by a certain threshold, HO is executed. The MS scans the multiple BSs and selects the most suitable BS as the TBS. The TBS selected is the most appropriate because of its stronger signal strength when compared to other adjacent BSs. The proposed scheme considers both signal strength received by the MS and depending on the adaptive distance threshold which is set based on the velocity of the vehicle the HO is executed.

The remainder of this paper is organized as follows:

Section II describes the related work that is being carried out. Section III explains the HO process in IEEE 802.16e. Section IV describes the handover initiation schemes used for the handover activity. Proposed scheme for the velocity adaptive handover is provided in section V and Section VI concludes the paper..

II. RELATED WORK

Many of the algorithms have been proposed in past. The initiation of handover takes place depending on the RSSI signals of the base stations i.e. the handover takes place when the signal strength of neighboring base station exceeds that of the current SBS. Recently Mary Alatise, Mjumo Mzyece and Anish Kurien have proposed a combined method of signal strength and distance to initiate fast handover. In this scheme they have considered the distance as a parameter in initiating the potential handover i.e. depending on the distance between the base stations and MS the handover takes place. In this scheme if the distance between the mobile station and neighbouring base station exceeds the distance between the MS and current SBS then the handover will be initiated from the current SBS to the neighbouring base station that is set as Target Base Station (TBS). But this handover does not depend on the velocity of the vehicle and hence for fast mobile stations it would not be so convenient since it may overrun the boundary of neighbouring base station to much extent in terms of distance and then the initiation of handover will be done. In this paper we are setting the distance parameter depending on the velocity [5] of the vehicle which will decrease the handover delay occurring in case of fast moving MS as well as reduce the packet loss incurred in the existing handover scheme.

III. Handover Process

A. *Stages Of Handover Process in HHO*

Handover (HO) in mobile WiMAX can be divided into two major phases: the Network Topology Acquisition phase and the actual HO process [3]. The Network Topology phase precedes the actual HO process which includes handover decision and initiation, synchronization and ranging process, cell reselection and termination context. The breakdown is shown in Fig 4.

Network Topology Acquisition Phase: -

During the NTAP [4], the MS and serving BS (SBS), together with the help of the backhaul network, gather information about the underlying network topology before the actual handover decision is made. This is done to identify lists of potential Neighboring Base Stations (NBSs), out of which one particular TBS may be chosen for the handover activity. The major tasks involved in this phase are described briefly as follows:-

- *Network Topology Advertisements*: - Using MOB_NBR-ADV (Mobile Neighbor Advertisement) message, the SBS periodically broadcasts information about the state of the NBSs, preparing for potential handover activities. The SBS keeps on gathering these channel information of the NBSs with the help of the backbone network.
- *Scanning of advertised neighboring BSs by MS:* - The MS scans the advertised BSs within specific time frames, to select suitable candidate BSs for the handover. A list of potential candidate TBSs is thus maintained. This procedure is carried out with the help of Scanning Interval Allocation request and response messages (MOB SCN-REQ and MOB SCN-RSP), respectively, sent by the MS and the SBS. In the end, Scanning Result Report (MOB SCN-REP) summarizes all the scanning activities.
- *Cell Reselection:* - The scanning is followed by contention/non-contention ranging activities through which the MS gathers further information about the PHY channel related to the selected TBSs. Ranging Request (RNG REQ) and Ranging Response (RNG RSP) messages are used for this purpose. Ranging may be followed by optional association activities through which the MS gets associated with the potential target BS candidates.

Actual Handover Phase: -

During the AHOP [5], the MS switches location from the SBS to the selected TBS. The major tasks involved are briefly described as follows:

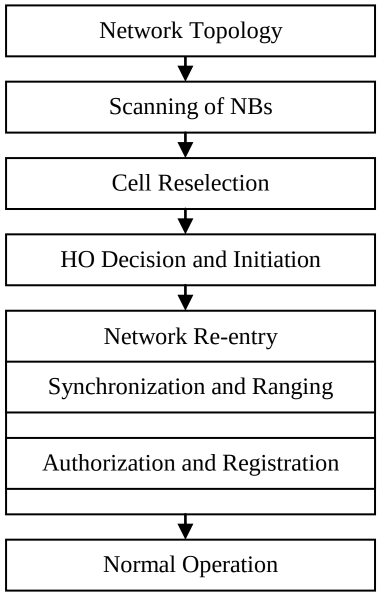

Fig. 4: IEEE 802.16e HO Stages

- *Deciding on the TBS:* - Here the MS chooses the final TBS for handover, out of the multiple TBSs selected from the scanning activities. The decision or initialization of a handover process may arise at the MS, the SBS or at the network associated. If the decision arises at the MS, it communicates the MOB_MSHO-REQ message containing the list of selected TBSs to the SBS and the SBS replies back with the MOB_BSHO-RSP message. On the other hand, if the decision arises at the SBS, the MOB_BSHO-REQ message is used. However, handover decision and initiation messages from the MS are always given preference.
- *Initiating the Handover:*-Depending on the above mentioned messages, once a particular TBS is selected from the list of the suitable candidate TBSs, the MS informs the current SBS about the beginning of the HO activity by sending a MOB_HO-IND (Mobile Handover Indication) message.
- *TBS synchronization and Ranging Process:* - Appropriate synchronization and ranging activities take place once again with the TBS, to resume DL/UL retransmissions.
- *Authorization and Registration Phases:* - Lengthy authorization and registration processes of the MS with the TBS follow next. It marks the onset of the network re-entry phase of this MS, after which it becomes fully functional with the new SBS.

B. Macro Diversity Handover and Fast Base Station Switching

The important concepts in the MDHO and FBSS approaches are:

- *Diversity Set Updating:* Update of the Diversity set (DS) at any time depends on two different thresholds, the H_Add threshold and the H_Delete threshold, contained in the Downlink Channel Descriptors (DCD) that are broadcasted by the BSs. Based on a given MS's scanning of the BSs, those active BSs in its current DS with signal lower than the H_Delete Threshold value are deleted from the current DS and new active BSs with signal more than the H_Add Threshold value are inserted in the current DS.

- *Updating and Selecting the new ABS*: Update and selection of the new ABS for the modified DS is done by its MS and the BSs based on the signal strength measurements performed. For doing this, 802.16e uses the traditional MAC Management mechanism [8].

IV. Handover Initiation Schemes

The HO process is initiated based on receiving the Relative Signal Strength (RSS) of the SBS and TBS, measured and reported by the Mobile Station (MS). This section outlines a number of conventional HO decision and initiation algorithms proposed for various wireless communication standards.

- *Relative signal strength:*- In this algorithm, the HO decision is based on the average measurement of the received signals.

  MS is allowed to handover if the RSS of a TBS exceeds that of SBS. The scheme can be expressed as:

  $$RSS_{TBS} > RSS_{SBS}$$

- *Relative signal strength with threshold:*- The MS is allowed to handover only if the RSS of the TBS exceeds that of the SBS and the signal strength of the SBS is below a threshold, TH. The performance of this method is dependent on the value of threshold chosen. The scheme can be expressed as:

  $RSS_{TBS} > RSS_{SBS}$ and $RSS_{SBS} < TH$ or $RSS_{TBS} > RSS_{SBS}$ and $RSS_{TBS} > TH$

- *Relative signal strength with hysteresis:*- The MS is allowed to handover if the RSS of the TBS is stronger than that of the SBS by a hysteresis margin, HYS. The scheme can be expressed as:

  $$RSS_{TBS} > RSS_{SBS} \text{ and } RSS_{SBS} + HYS$$

- *Relative signal strength with hysteresis and threshold:*- The MS is allowed to handover to the TBS, except if the current signal level of the SBS drops below a threshold and the signal level of the TBS is capable of supporting the current BS by a given hysteresis margin. The scheme can be expressed as:

  $RSS_{TBS} > RSS_{SBS} + HYS$ and $RSS_{SBS} < TH$ or $RSS_{TBS} > RSS_{SBS} + HYS$ and $RSS_{SBS} > TH$

The relative signal strength with hysteresis and threshold scheme is considered the best algorithm to initiate the HO process because it incorporates the advantages of the other algorithms.

V. Proposed scheme

In this section, the Adaptive Distance handover scheme is proposed to initiate handover. The distance parameter is set depending on the velocity of the vehicle. The existing standard takes only RSSI into consideration when deciding handover. In the signal strength algorithm, the MS handover is done from one BS to another BS if signal strength of a SBS exceeds that of NBS by a hysteresis margin. Distance needs to be also considered in deciding for the handover. To minimize the handover delay, a control measure scheme called distance is introduced. Distance is a factor that improves the process of handover delay. But the distance for the handover should be dependent on the velocity of the vehicle on when exactly to handover which reduces the delay and packet loss incurred in deciding handover. The distance between the MS and BS can be calculated by

$$D_{MS\text{-}BS} = V_{MS} \times T_{MS}$$

Where $D_{MS\text{-}BS}$ is the distance between the MS and the BS, V_{MS} and T_{MS} are the speed and the travel time of the MS, respectively. In order to reflect the adaptive distance threshold th_{d} is calculated as

$$th_d = \log_2(v+1)/10$$

Where v is the velocity of the vehicle. Through this we can see for slow moving vehicle the value of threshold distance will be set low and as the vehicle speed will increase so does the distance threshold will increase.

The proposed scheme follows the conditions given below:-

If the calculated distance of the MS from the SBS exceeds that of the TBS by reducing the threshold distance, the handover will be decided which can be given by:

$$D_{MS\text{-}SBS} \geq D_{MS\text{-}TBS} - 2\times th_d$$

So the handover will be decided depending on the velocity of the vehicle i.e. if the vehicle is moving at very low speed then the decision of the handover will be made just before entering into the new cell region, so by the time the vehicle reaches into the new cell the handover process would be completed. Even in the case of high vehicular speed the handover decision would be made much before entering into the new cell region, so by the time the vehicle reaches into the new cell the handover process would be completed. This adaptive distance threshold used takes into count the velocity of the vehicle because in high speed vehicles the distance covered is much faster than that of the slow moving vehicles and does not require much time in entering the new cell region. So in order to make the handover decision before the MS enters into NBS cell the adaptive distance threshold is used. The adaptive distance threshold scheme thus will help in reducing the handover delay involved and as well as the rate of packet loss will be reduced in this handover.

VI. CONCLUSION

In this paper, an Adaptive distance handover scheme is proposed. According to the existing draft version of 802.16e standard, the HO initiation should be performed if the RSSI of the serving BS is lower than the threshold However, it does not consider the distance between the MS and BS in the HO process, so there is a handover delay involved as well as there is packet loss. To cope with this problem, our scheme proposes; the use of adaptive distance threshold which allows handover between the two BSs depending on the velocity of the vehicle and establishes the connection before the MS overruns the boundary of NBS to a much extent in terms of distance thereby decreasing the handover delay involved as well as the rate of Packet loss.

VII. ACKNOWLEDGMENT

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