Performance Analysis Handover in Mobile WiMAX Systems

Hazzuan Mohd Noor
Faculty of Electrical Engineering
Universiti Teknologi Mara (UiTM), Shah Alam
Selangor, Malaysia
hazzuannoor@gmail.com

***Abstract*—Mobile WiMAX/IEEE 802.16e standard is designed to support for both stationary and mobile transmission. With excess to supports high data rate and covering large areas it becomes the demands for consumers. Mobile WiMAX systems must have an efficient handover scheme in order to provide a good service for mobile subscriber. On the other hand to succeed an efficient handover the process must in minimum amount of packet loss. The probability of this packet loss might lead link handover start delay and degrade the data transferred from one BS to another BS. In this this paper the performance of handover in term of delay and throughput has been analyzed using the streaming video application with speed of pedestrian. OPNET Modeler 14.5 software was used as a tool for simulation.**

***Index Terms*—Mobile WiMAX, IEEE 802.16e, handover delay, throughput**

I. Introduction

Nowadays new and emerging high quality multimedia service has become imperative in telecommunication services. Thus, the mobile WiMAX was developed from IEEE 802.16 standard which has been designed for the high speed wireless internet access to support various multimedia services to the user [1]. The mobile WiMAX technology has provide a promising features in terms of high bandwidth, extended coverage area and low cost compared with existing Wireless Local Area Network (WLAN) and third generation (3G) technologies have such constraints of low bandwidth and high cost of installation. Despite of the fast growth of mobile WiMAX technology, there are two factors been concern in WiMAX systems which is the location management and handover (HO) management. The location management helps the system to recognize and establish a connection with the user [2].

On HO management there are a few phases that must be taken into account to provide a stable HO. That is first was network topology acquisition phase, the subscriber (SS) obtains the physical information of neighbor BSs from the Mobile Neighbor Advertisement Control(MOB_NBR_ADV) message broadcasted by the serving bas station (BS). After moving to another place the SS select the suitable BSs analyzing this information and scans all the BSs to determine the target BS it will associates with. Then when the BS has been selected, the initiation and ranging process was conducted. In this phase mobile subscriber (MS) will disconnects all communications with the serving BS and synchronizes it with the new BS. When all the parameters have been adjusted successfully, then the MS starts the last phase's network re-entry. In this phase authorization and registration are completed [3].

While all this phase was done the HO process might cause system suffer packet loss. The probability of packet loss is related to link handover start delay and the IP configuration completion time. The real time applications such as video streaming and video conferencing are very sensitive when handover delay happens. The speed of MS from one place to another, also contribute to the time taken of handover process to be done.

In this paper the performance of handover has been analyzed by deploying the streaming video file traces and video conferencing which was set as the application for MS. This service are managed by Quality of Service (QoS) as the parameter for traffic priority, maximum sustained traffic rate, maximum burst rate, scheduling type, automatic repeat request (ARQ) type, maximum delay and tolerated jitter. The speed of MS has been set to pedestrian. The main objective of this project is to measure the handover delay and throughput of the mobile WiMAX systems.

The paper is organized as follows. Section II is an overview of WiMAX technologies and the handover process. This is followed in section III by a brief discussion about the flow chart of the project on how to simulate the project. In the section IV the result and discussion of simulation were described and for the last sections, Section V a conclusion of this project was been concluded.

II. Background

An overview of Mobile WiMAX systems and handover process are discussed in this section.

a) Mobile WiMAX

Mobile WiMAX is developed from IEEE 802.16e standard and introduced in 2005. The 802.16-2004 standard versions allow only fixed and nomadic access, which the handover service is not provided for this standard [4]. The development of the network supporting mobility requires the ability of a device to change the serving BS based on the movement of the user. The IEEE 802.16e can support both fixed and mobile broadband wireless access. Network technology will tracks and maintains the link of wireless on cases where they need to powered-on or power-off or even on the move. Then the active transfer of wireless terminals from the control of a BS is from one cell to another BS in a different cell [5].

b) Handover in Wimax

Handover is a procedure that provides continuous connection when a MS migrate from one BS to another BS without disturbing the existing connection [6]. There is two main phases in handover process network topology acquisition and handover execution. Network acquisition phase is where the parameter values at the MS updating periodically for handover decision purposes.

This phases is conducted by the process of network topology advertisement, neighbor BSs scanning and the process of association. Current BS periodically transmits the advertisement message to MSs in order to provide the information of neighboring BS which is a channel information of the neighboring base stations that been provided by each BS's Downlink and Uplink Channel Descriptor (DCD and UCD) message transmission. On the handover execution phases there is two different sub-phases which handover preparation and handover action.

For the handover preparation the expected QoS level is negotiated through backbone message for pre-handover notification. When the neighboring BS signal measure by carrier-to-interference and noise ratio (CINR) exceeds the threshold to meet the criterion, then the handover process will start a scanning request message to the serving BS and also with the CINR value of the neighboring BS. Current BS will refer to the neighboring BS for the information to request resources and the expected QoS level for the MS. Then the appropriate target for new BS can be provide with a best QoS after the current BS receives the QoS value that neighboring BS can be support and transfer it to MS.

The handover action phase was the final decision of the handover process, where MS disconnect the link to the current BS or canceling the handover [7]. Figure 1 shows a combination of network entry and handover process:

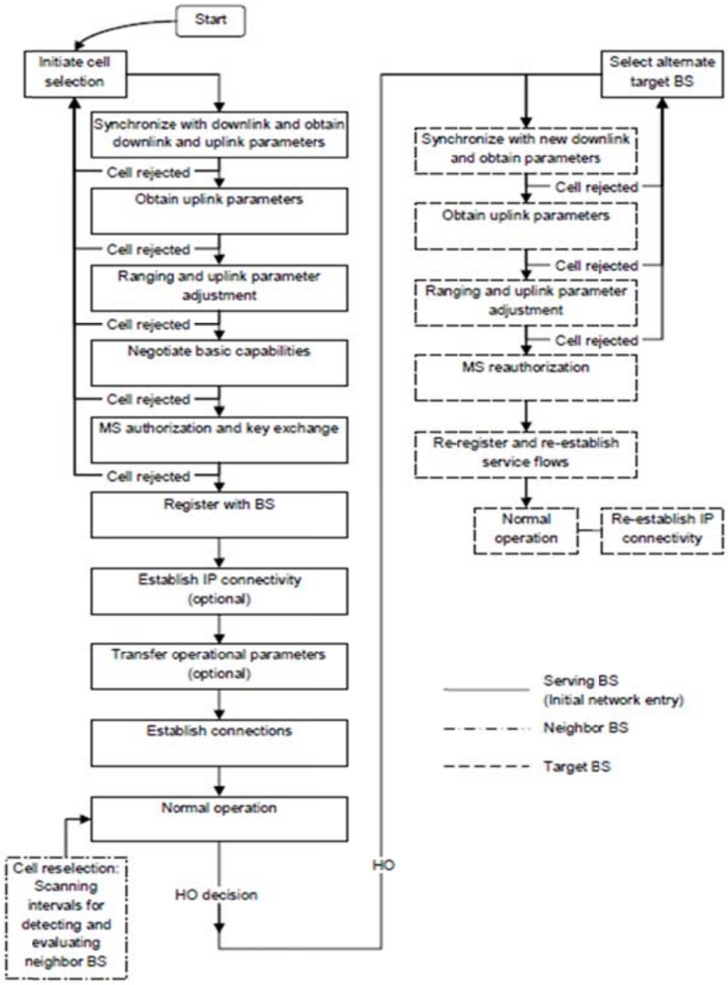


Figure 1: Initial Network Entry and Handoff [7]

Mobile WiMAX has two different types of handover techniques:

i. Hard Handover

When the communication channel is released first and the new channel is acquired later from the neighboring cell that's hard handover or it means a short disconnection of communication. Also can called it break before make.

ii. Soft Handover

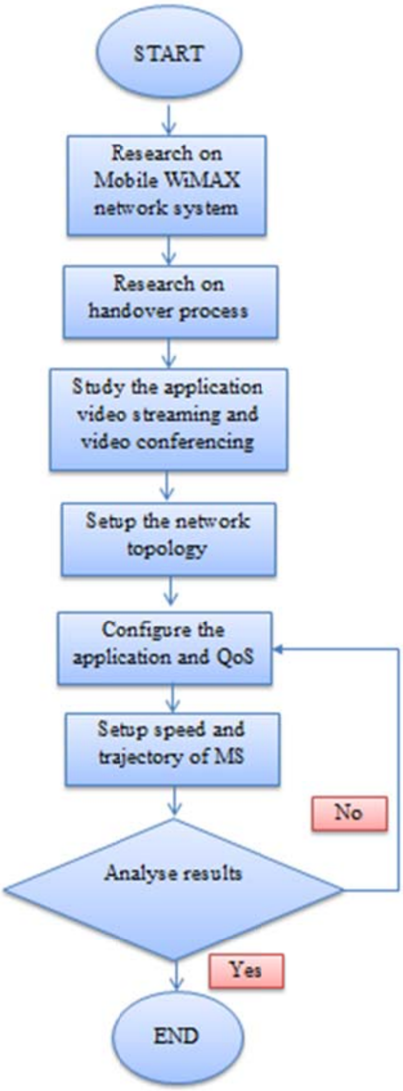
Used by the code division multiple access (CDMA) system where the cells use same frequency band using different code words. It establishes multiple connections with neighboring cells. There are several techniques that used in soft handover which is Macro Diversity Handover (MDHO) and Fast Base Station Switching (FBSS). A MDHO technique is supported by MS and BS, the diversity set is maintained by MS and BS. Diversity set is a list of the BSs and been updated by medium access control (MAC) management messages. The MS will continuously monitor the BS in the Diversity Set.

Once it detects the target, the new BS than perform handover. Fast Base station Switching (FBSS) is a method where a diversity set is maintained for each MS. The serving BS and MS monitor the neighboring BS that can be added in diversity set and be maintained for both MS and BS. FBSS Diversity Set is a collection of BS and can be chosen as target BS for a handover [6].

III. METHODOLOGY

a) Flowchart of project development

Opnet Modeler 14.5 was used to analysed and designed the network topology, protocols and applications. With different applications used in a single MS, handover delay and throughput has been simulated.



b) Network Topology

By using OPNET 14.5 software the handover delay and throughput has been analyzed for the WiMAX mobility. The simulations involved on examining a single MS moving across the BS with pedestrian speed. The movement path travels from a starting point at BS 1 to BS2, BS3 and BS4. The speed of 5 km/h has been set as the normal pedestrian speed for the average human walking with a distance of 5 km. The application of video streaming and video conferencing has been evaluated, for the handover delay and throughput. The QoS of the video streaming used the Best Effort (BE) while for video conferencing is matched to the real-time Polling service (rtPS). Figure shows the network topology of mobile WiMAX system.

The setup used to evaluate handover delay and throughput by supplied a two application in single MS with a constant volume of traffic to local video client that access video on demand (VoD) service and video conferencing services.

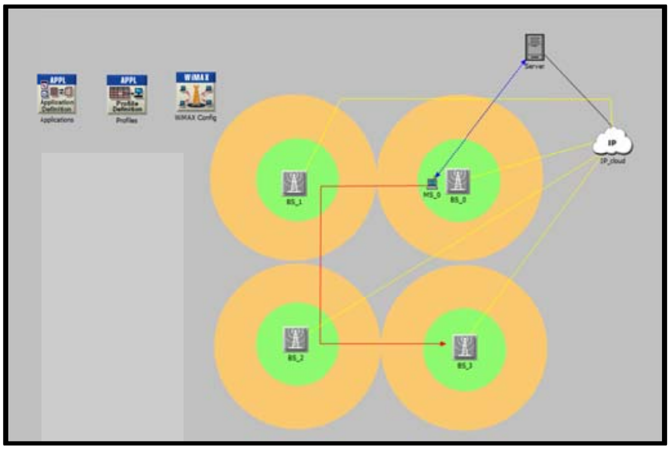


Figure2.Network topology for mobile WiMAX system

c) WiMAX configuration

To configure the WiMAX parameters in OPNET modeler 14.5 there are several steps need to be implemented such as [8]:-

i. Define Service Classes.
ii. Configure Efficiency Mode.
iii. Configure Physical Layer (PHY) Profiles.
iv. Associate Subscriber Stations with Base Stations.
v. Define service flows.
vi. Assign traffic to service classes.
vii. Configuring physical layer parameters
viii. Configure mobility

WiMAX MAC layer is designed to support QoS. When an application is to be offered, a connection has to be created between the BS and MS. This is done by a unidirectional logical link between the peer MACs. The service flow has certain QoS parameter that gives the scheduler a chance to do decision for transmission priorities [9].

On this project mobility and ranging is used to create the mobility mode. All WiMAX model features are enabled when set to this mode.

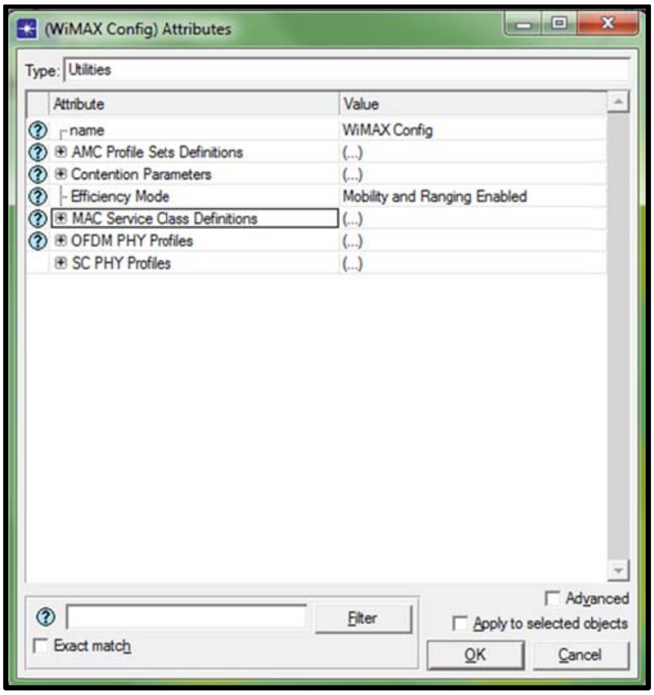


Figure 3: WiMAX efficiency mode configuration

For the MAC service class definition Row 0 the sustained traffic rate is set from 10 Mbps to 1 Mbps for BE, while the rtPS is set between 5 Mbps to 0.5 Mbps at Row 1 as state in figure 4.

BE was chosen to use in video conferencing application because it supports data streams with no throughput or delay guarantee. BE connection are never polled but they can only receive resources through contention. The video streaming application is mapped to the rtPS as it provides variable bit rate real-time service. The BS periodically polls the MS by granting one slot for sending a bandwidth request/transmission policy are the same mandatory service flow parameters that are defined in rtPS [10]. However it is sensitive to delay.

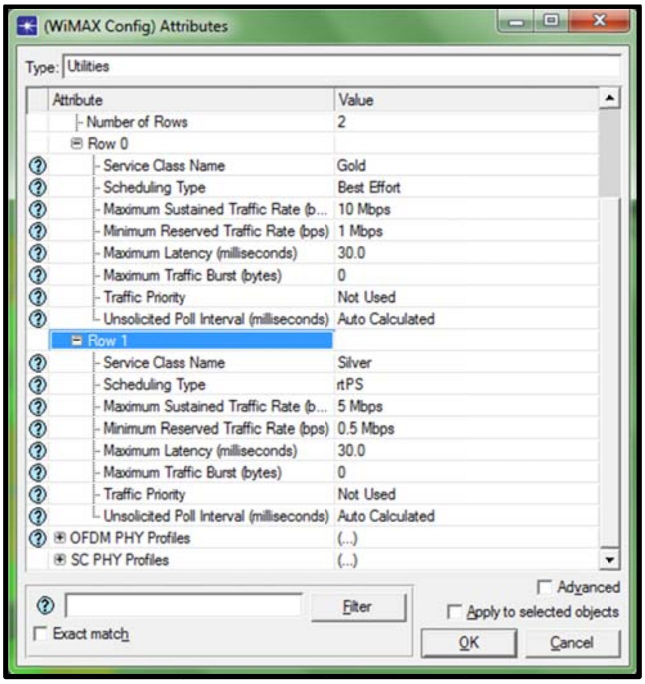


Figure 4: WiMAX service class configuration

The operation of frequency band is 2.3 GHz and Bandwidth of 10 MHz with 512 subcarriers has been set at the OFDM PHY profiles. Time division Duplex (TDD) technique was used. TDD is inherently better suited to more advance antenna techniques than Frequency Division Duplex (FDD) as it capable adjusting downlink and uplink ratio based on their service needs in the networks [7]. Figure below show the configuration of OFDM physical profiles.

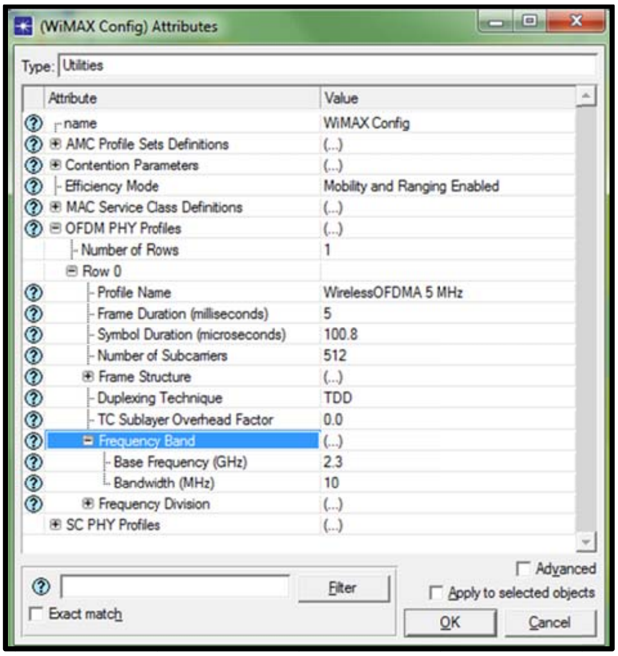


Figure 5: WiMAX physical layer profiles configuration

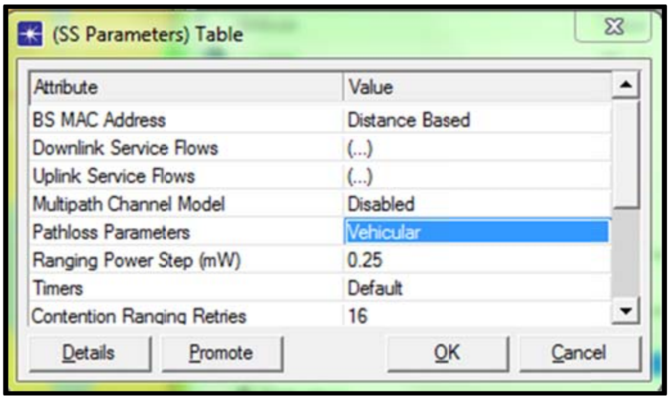


Figure 6: MS parameter configuration

On figure 6 show the MS used a vehicular path loss parameter as to create mobility for MS while travelling across four BS with terrain C that corresponds to mostly flat terrain with light tree densities. For both downlink and uplink service class flows the modulation is set to 64-QAM ¾ which is used by the rtPS service class and QPSK ¾ for BE. The modulation technique is chosen because of the distance of the MS from the BS.

Modulation	Coding	Information Bits/symbol/Hz	Required SNR (dB)
QPSK	1/2	1	9.4
	3/4	1.5	11.2
16-QAM	1/2	2	16.4
	3/4	3	18.2
64-QAM	2/3	4	22.7
	3/4	4.5	24.4

Table 1: Modulation techniques in IEEE 802.16e

WiMAX BS transmit power is configured to 3 (W) and at the MS is set to 0.5 (W). Traffic was the main characteristic for this project. Video streaming is a Variable Rate Traffic (VBR). The VBR frame stream encoded Terminator 2 movie was used as the data traffic. The trace file is generated by using this information, where trace files contains information of time and packet size.

For video conferencing, the traffic application parameter is tabulated in the table 2.

Video Traffic Application			
Frame size	Inter-arrival time	Throughput (bps)	Throughput (packet/sec)
Lognormal distribution Average = 4.9 bytes $\sigma^2 = 0.75$ bytes	Normal distribution Mean = 33 msec $\sigma^2 = 10$ msec	8000	30.30

Table 2: Video conferencing traffic application parameters

IV. Simulation Results

This project was simulated for 1 hour while the MS walked from BS1 until BS4 with a speed of pedestrian while streaming the Terminator 2 movies and simultaneously deploying the video conferencing. The handover process of the MS has been analyzed, which to observe the throughput, delay and handover delay.

a) Throughput

Figure 7 shows that the throughput for the video streaming is higher than video conferencing. For video conferencing show that the throughput value is approximately 8000 bps and video streaming is between 0.9 Mbps to 3.3 Mbps. Based on the graph below shoe video streaming has a soft handover while the MS travel from BS1 until BS4. Where data is send from serving BS to new BS before it reached to new BS. The graph show throughput not drastically dropped and continuously transfer data from serving BS to new BS softly.

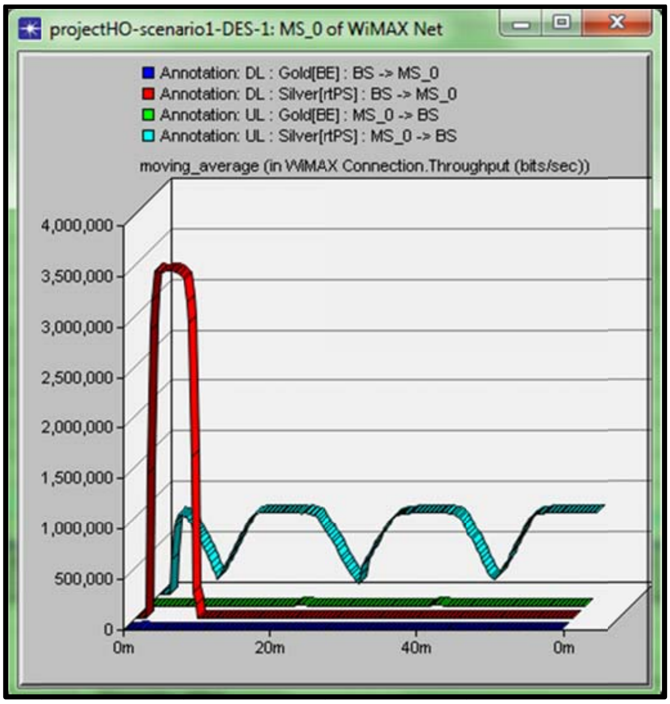


Figure 7: Throughput of the network model

b) Delay

In this project the delay has been analyzed from the time taken for packets to be transmitted from source to destination. Figure 8 shows that while MS is moving, video streaming having a delay of 2.4 ms and video conferencing of 0.8 ms.

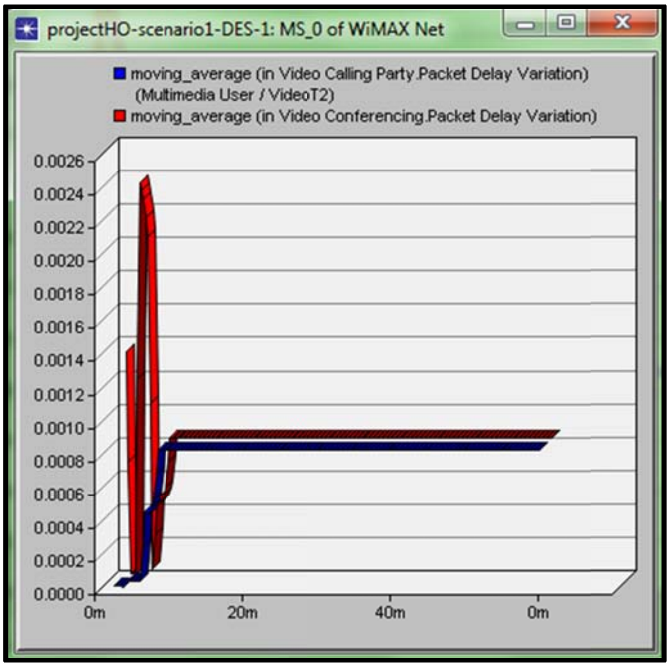


Figure 8: Packet delay variation transmitted from source to MS

c) *Handover Delay*

The result of Figure 9 shows that the average of handover delay in this network is 20 ms when the MS travel from BS1 toBS4 with a speed of 5 km/h and the value is acceptable for real time applications, because to meet delay requirement the delay must be less than 400 ms.

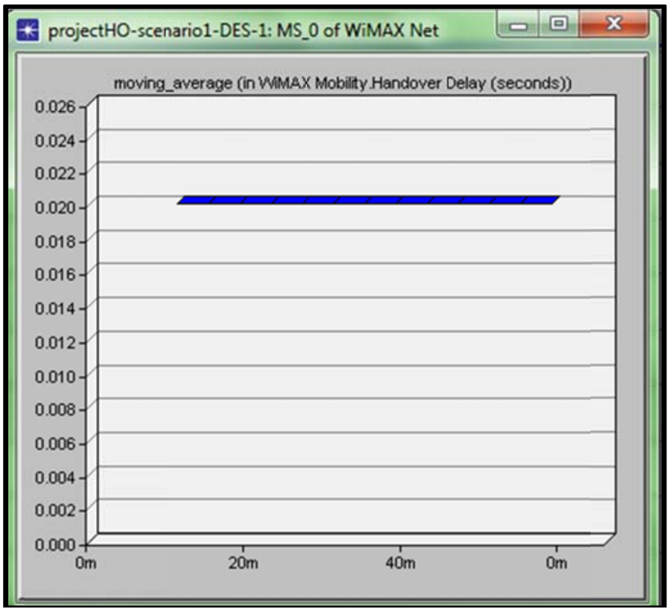


Figure 9: Handover delay from BS to another BS

d) *Packet loss*

For video conferencing MS having packet drop 980 packet/sec, while for video streaming is 1490 packet/sec. Packet loss can caused by a number of factors, including signal degradation, channel congestion or corrupted packets rejected in-transit, which also cause handover start to delay. In this graph rtPS show high packet loss compared to BE.

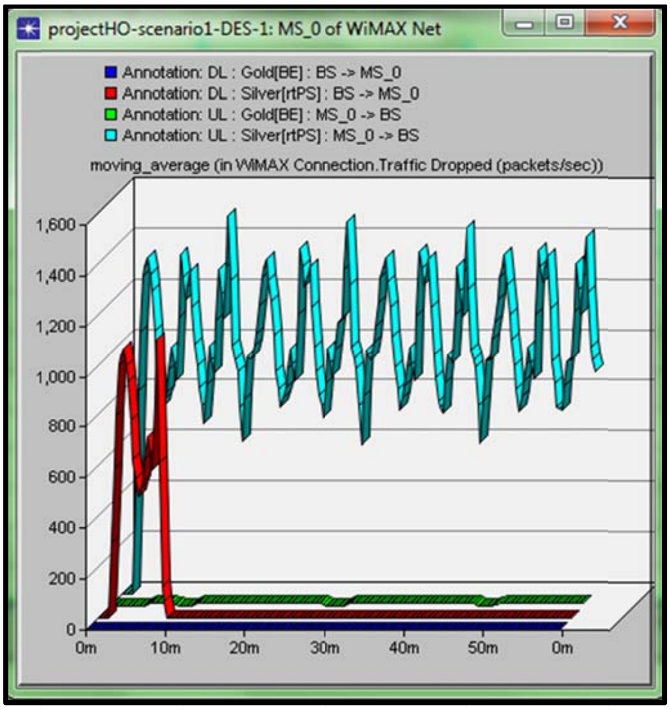


Figure 10: Packet dropped between MS and BS

V. Conclusion

In this project the performance analysis of handover in Mobile WiMAX system is presented. The MS is set with a two applications, video streaming and video conferencing while moving from one BS to another with a speed of pedestrian. By using OPNET Modeler 14.5 simulation software the technical details and the objective to analyze the handover in terms of throughput and delay has succeeded. Handover delay is the key parameter to optimize the effectiveness of the mobile WiMAX, with a minimum delay the packet loss also can be decrease.

For future recommendation to recover the packet loss which contribute handover process to delay, suggest that each BS has a network coding system which to broadcast the packet lost due to the data transferred time from MS to BS and provide recovery process.

REFERENCES

[1] NafizImtiaz and Adnan Mahmud, “Optimizing the Handover Procedure in IEEE 802.16e Mobile WiMAX Network,” in *National Conference on Communication and Information Security*, Feb, 2009.

[2] BhaskarAshoka, David Eyers and Zhiyi Huang, “Handover Delay in Mobile WiMAX: A Simulation Study” in *International Conference on Parallel and Distributed Computing, Applications and Technologies*, New Zealand, 2011.

[3] Zhenxia Zhang, Richard W. Pazzi and Azzedine Boukerche, “Reducing Handoff Latency for WiMAX Networks Using Mobility Patterns” in *IEEE Communication Society subject matter experts for publication in the WCNC*, Canada, 2010.

[4] ZdenekBecvar and Jen Zelenka, “Handover in the Mobile Wimax,” in *Proc. IEEE Malaysia International Conference on Communications (MICC)*, Malaysia, Dec, 2009.

[5] R. Q. Hu, “On the Evolution of Handoff Management and Network Architecture in WiMAX”, in *Proc. of IEEE Mobile WiMAX Symposium*, pages 144-149, Florida, USA, 25-29 March 2007.

[6] RambirJoon, Sandeep and Manveen Singh Chadha,”Analysis of WiMAX Handover,” in *International Journal of Soft Computing and Engineering*, July, 2012.

[7] June H. Park, Jung J. Son, and Chung G. Kang, “Improvement of Handover Break Time Performance for Wireless Broadband Access System”, in *Wireless Broadband World Forum (WBWF)*, October, 2007.

[8] OPNET Modeler [Online]. Available: file:///C:/Program%20Files/OPNET/14.5.A/doc/modeler/wwhelp/wwhimpl/js/html/wwhelp.htm?tab=contents.

[9] B. Kaarthick, V.J Yeshwenth, N. Nagarajan and Rajeev, “Performance analysis of Video Confrencing and Multimedia application Services over WiMIMAX, “ in *International Advance Computing Conference,*March,2009.

[10] Hung-Hui Juan; Hsiang-Chun Huang, "Cross-layer System Designs for Scalable Video Streaming over Mobile WiMAX", in *IEEE Wireless traffic Communications and Networking Conference* , Page(s) 1860-1864, 11-15 March, 2007.