Analysis of Handover Performance in Mobile WiMAX Networks

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***Abstract* – Mobile terminals allow users to access service while on the move. This unique feature has driven the rapid growth in the mobile network industry, changing it from a new technology into a massive industry in less than two decades. The handover performance in mobile network is the most important factor that can influence the Quality of Service (QoS). Nowadays, many countries in the world have move to more advance mobile communication system such as IEEE 802.16e Mobile WiMAX standard. The parameters such as handover time, throughput and packet delay are the main factors which affect the mobile WiMAX network performance. OPNET 14.5 is used to simulate the mobileWiMAX handover process.**

***Keywords*—Mobile WiMAX, Handover, Delay**

I. INTRODUCTION

Data and voice over IP (VoIP) is the transports of voice using the Internet Protocol (IP) are the main traffic from users around the world. The demand for high speed transmission data rate is growing every day. This phenomenon will continuously happen and never one knows the end. Therefore, the introduction to WiMAX system is one the solution at this moment [13].

Mobile WiMAX has supports mobility in the standard. It is the first mobile broadband wireless-access solution based on the IEEE 802.16e standard [14] was started in December 2005. The range of frequency in license band from 2GHz to 6GHz and in unlicensed band, from 2GHz to 11GHz [15]. This service enables roaming for portable client using smart phone, laptop or personal computer within the service area.

The objectives of this research are to study the QoS of the network which contain of Unsolicited Grant Scheme (UGS), Non- Real-time Polling Service (nrtPS), and Best Effort (BE); over the mobile WiMAX applications and analyze the handover performance in terms of delay and throughput in different scenarios. In this project, the OPNET simulation software is used to obtain the results.

The outline of the paper is as follows. In Section II, description of Mobile WiMAX and handover technologies were provided and the network design was described. The methodology was in section III. Follow by the simulation results were described in Section IV and the conclusion in Section V.

II. BACKGROUND

In this Section, an overview of Mobile WiMAX and handover in mobile WiMAX technologies and the content are presented. The network configurations that were simulated in this project were also described briefly.

A. Mobile WiMAX Overview

The great demand for multimedia applications for voice and video transfer and fast Internet access, combined with the global proliferation of the wireless devices has given sprouting for broadband wireless access networks [7]. Mobile WiMAX has received a great deal of interest in the industry. It is the first mobile broadband wireless-access solution based on the IEEE 802.16e standard [8] was started in December 2005. The standard was originally meant to specify a fixed wireless broadband access technique for point-to-point and point-to-multipoint links. During its development, however, it was decided that mobility support should also be considered. The standard enables roaming for portable client using smart phone, laptop or personal computer within the service area.

The mobile system profile include mandatory optional of PHY and MAC layer features that required to all WiMAX product. The WiMAX Forum established the *Network Working Group* (NWG) with the aim of developing an end-to-end network reference model architecture based on IP supporting both fixed and mobile WiMAX refer to [3] and [4].

A WiMAX network is partitioned into three independent architectural components: the user equipment (also referred to as *Customer Premises Equipment* [CPE]), the *Radio Access Network* (RAN, based on IEEE 802.16e), and the network providing IP connectivity with the rest of the Internet. Clearly, this model allows a single operator to freely mix and match offerings from

different manufacturers for these three parts, at least after interoperable equipment becomes readily available.

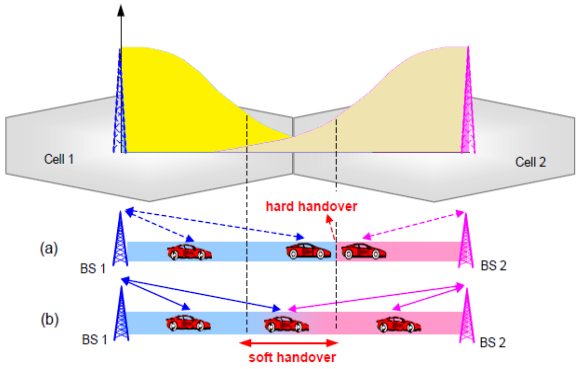

Figure 1 : Handover Process

B. Handover Mobile WiMAX

A special requirement of a mobile device is the ability to change its serving base station(BS) if there exists another BS with better signal strength in the reach of mobile station (MS). Handover is a procedure that provides continuous connection when a MS migrates from the air-interface of one BS to another air-interface provided by another BS without disturbing the existing connections as in Figure 1. Handovers are needed to support mobility of the system. If the signal strength is not enough for maintaining proper connection. Behaviour of the MS changes, for example in case of fast moving MS suddenly stopping; the large cell size can be adjusted by a small size cell with better capacity[16].

C. Type of handover

There are two types of handovers been considered in the network system: hard handover and soft handover.

I. Hard Handover (HHO)

The hard handover is used when the communication channel is released first and the new channel is acquired later from the neighbouring cell. For real-time users it means a short disconnection of communication. Thus, there is a service interruption when the handover occurs reducing the quality of service. Hard handover is used by other systems which use time division multiple access (TDMA) and frequency division multiple access (FDMA) such as GSM and General Packet Radio Service (GPRS) [16].

II. Soft handover

The soft handover is contrast to the hard handover, established multiple connection with neighbouring cells. Soft handover is used by the code division multiple access (CDMA) systems where the cell use the same frequency band and using different code words. This method can be classified into two methods: Fast Base Station Switching (FBSS) and Macro Diversity Handover (MDHO).

a. *Fast Base Station Switching (FBSS)*

The FBSS is supported when the MS and base BS keep up a list of BSs that are involved in FBSS with the mobile station (Active set). The process happens when only the MS defines an anchor BS and communicate only with it. The FBSS also support when a decision by an MS to receive or transmit data from the anchor BS that may change within the active set as describe in figure 2. The important requirement of FBSS is the data is simultaneously transmitted to all members in active set of BSs that are able to serve the MS.

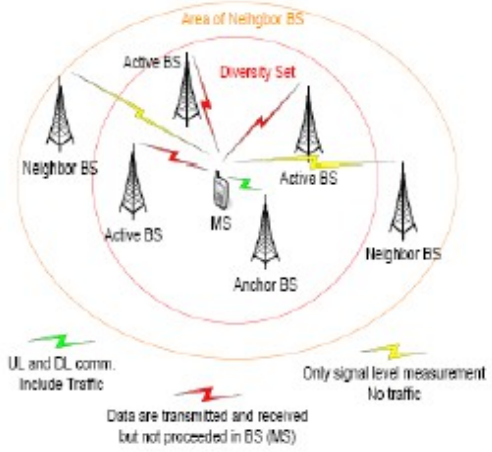

Figure 2 : Fast Base Station Switching Handover

b. *Macro Diversity Handover (MDHO)*

The Macro Diversity Handover (MDHO) is supported when the MS and BS maintain in active set of BSs that are involve in MDHO with the mobile station (MS). The MS communicates with all BSs in active set of uplink and downlink uni-cast message and traffic. It can be illustrate as in figure 3 below.

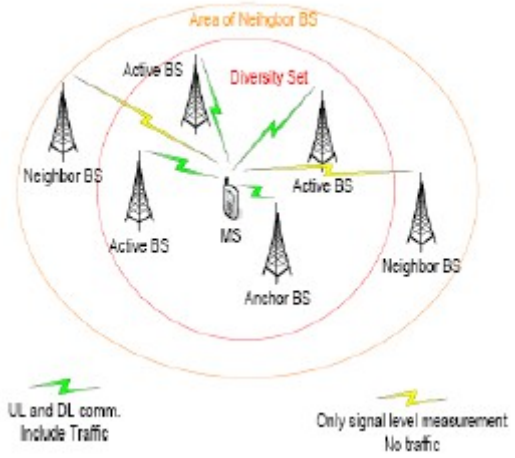

Figure 3: Macro Diversity handover

III. METHODOLOGY

This project is carry out by designing the network scenarios. In order to evaluate the handover scenarios and QoS mapping, a network is simulated by using OPNET simulation software. OPNET is a software package that provides network simulation and analysis tools. OPNET Modeler is used to design and study the communication networks, devices, protocols and applications.

A. *Network Topology Design*

This project are modelled and analyzed by using OPNET simulation software. The study on Mobile WiMAX handover, delay and QoS applications is performed before defining the network topology. The next step is to setup the profile configuration for each user type. Each MS has its own profile application consistent with the user's main role. Once applications and profile is defined, the traffic and QoS for each type of mobile station applications is assigned. Type of service (ToS) of each application need to be determined and mapped to traffic priority. The ToS would later being mapped to a service flow. The service flow can be classified into different classes which are Gold, Silver and Bronze.

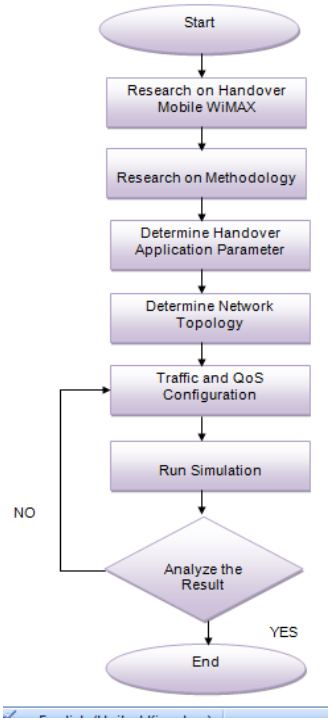

Figure 4 : Design Flowchart

B. *Network Model*

In order to analyze the performance of the handover scenario and QoS mapping issues, a simulation model was designed by using OPNET modeler. Table 1 shows the Mobile WiMAX parameter used in the simulation process. The parameters are commonly used in the previous studies.

Table 1 : WiMAX simulation parameters

Parameters		**Value**
Duplex Mode		TDD
Frequency		2.3GHz
Bandwidth		10MHz
Frame length		10ms
Modulation/coding		Adaptive
BS	Antenna Gain	15dBi
	Tx Power	3.162W
MS	Antenna Gain	-1dBi
	Tx Power	0.501W
Pathloss		Vehicular

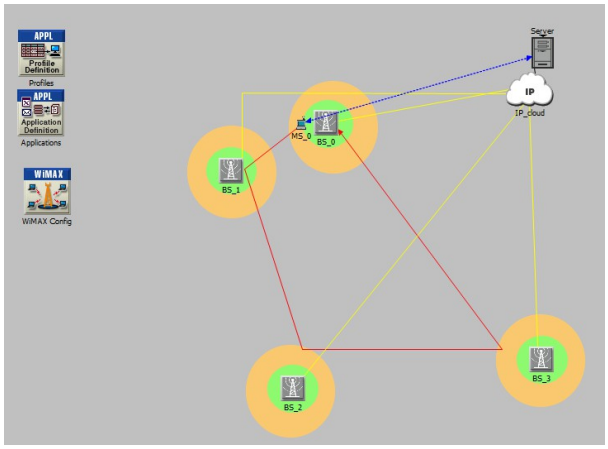

Figure 5 : WiMAX simulation network for both scenario

There are two scenarios that have been evaluated for this project which is scenario1: one MS with one application and scenario2: one MS with two applications. Scenario1 consist of application VoIP while in scenario2 consist of File Transfer Protocol (FTP) and Web browsing (HTTP). The simulation is done by observing and analyzing the delay, QoS, and throughput when the vehicular speed is increased.

In order to simulate scenario1, the VoIP application is transmitted by setting the voice into PCM quality speech of G.711 encoder. For scenario2, the FTP and HTTP was set up to 450000 bits with a frame rate of 10 frames/sec. Table 2 shows the ToS which is configured and mapped to the corresponding applications.

Table 2 : Simulation configuration

Types of service	Application Configured
Best Effort	Web browsing (HTTP)
Excellent Effort	FTP
Interactive Voice	VoIP

IV. Result and Discussion

The MS is moving vehicular and the project was simulated for 30 minutes. The handover can be determined when the MS moving from one BS to another BS. In this simulation, the speed of vehicular was to various speeds to measure and analyzed the QoS of the network. For scenario1, MS is delivering the VoIP application while in the scenario2 the users are connected to two applications, which are FTP and HTTP simultaneously.

A. Throughput

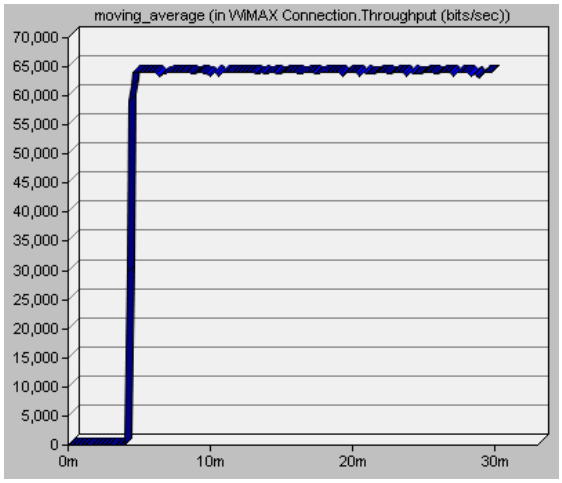

Figure 6 : Throughput of scenario1

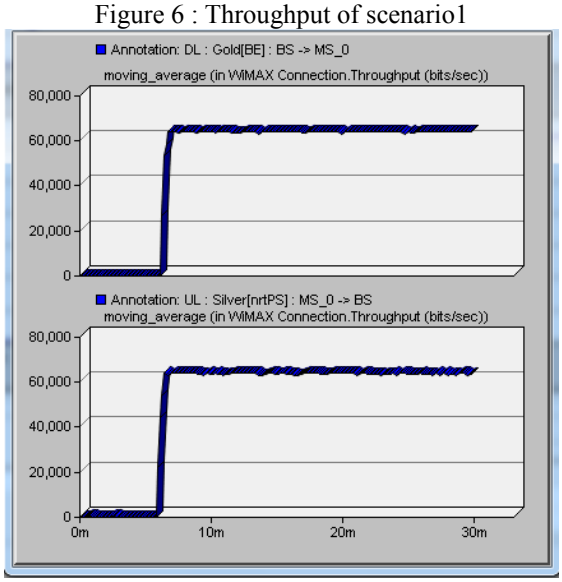

Figure 7 : Throughput of scenario2

Figure 6 show the throughput for the scenario1. The result of VoIP applications started when the vehicular start to move. The throughput was increased to 65 Kbits/sec and maintain until the end of the simulation. The throughput for scenario 2 is shown in figure 7. The result of FTP and HTTP applications started when the vehicular start to move. The throughput was increased to 60 Kbits/sec and maintain until the end of the simulation. It is observed that the MS for both scenarios were connected to the BS.

B. Delay

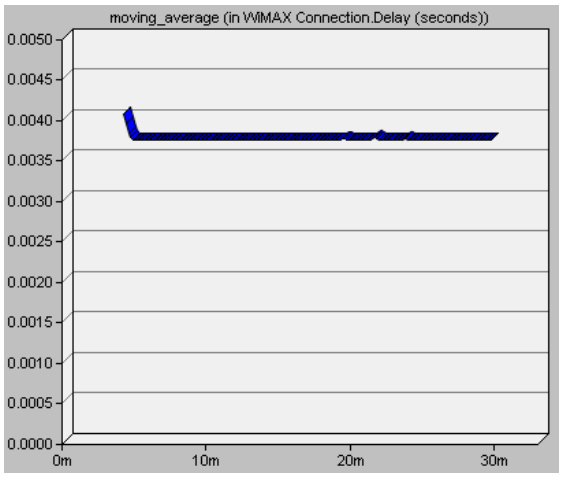

Figure 8 : Time delay for scenario1

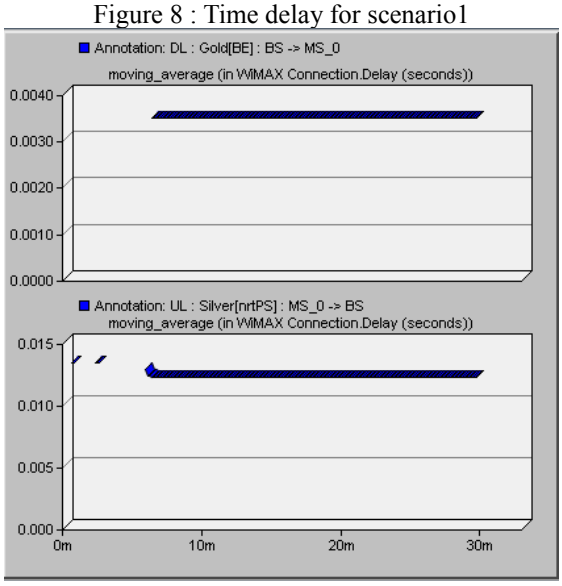

Figure 9 : Time delay for scenario2

Delay can be defined as the time taken for packet to be transmitted from source to destination. Figure 8 shows that while MS is moving, VoIP is having a delay of 3.7 ms. Figure 9 shows that while MS is moving, FTP is having a delay of 3.6 ms and HTTP is 1.4ms. Uploading a file and transferring voices may increase the delay in the connection.

As for VoIP application, the most important parameter in the delay time is the traffic dropped. Figure 10 shows that the simulation has zero traffic dropped. The transmission of VoIP satisfied the requirement because there is no traffic drop occurred during the transmission.

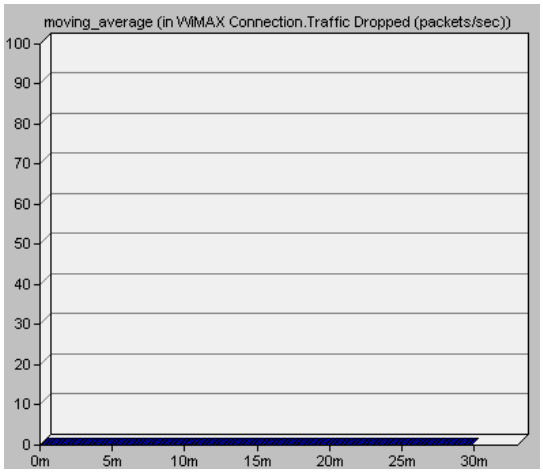

Figure 10 : Traffic Dropped for scenario1

C. Handover Delay

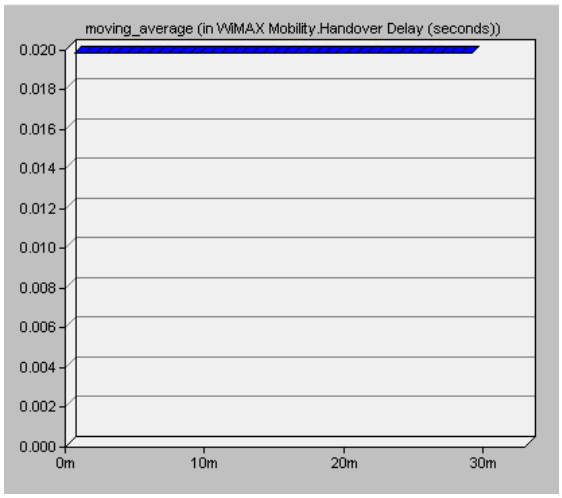

Figure 11 : Handover Delay for scenario1

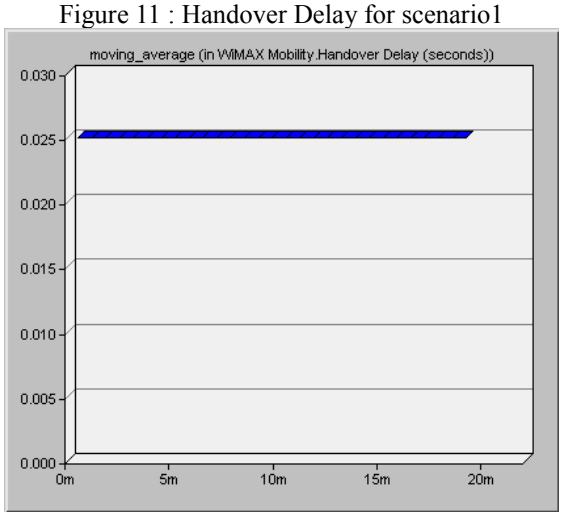

Figure 12 : Handover Delay for scenario2

The result on Figure 11 and 12 show the average of handover delay for each scenario. The results on figure 11 shows that the average delay taken is 20 ms while the result of Figure 12 shows that the

average of handover delay in this network is 25 ms. The handover delay occurs when the MS travel from BS1 to BS4 with a speed of vehicular from 70 km/h to 100 km/h with an interval of 10 km/h increased.

V. Conclusion

This study concentrated technically details about the performance of mobile WiMAX technology and the concept of handover. The aim of this study to ensure that continuity of the network without any packet loss could be provide comparable to the other network. The OPNET Modeler was used to design and characterize the performance of handover in two different scenario using three performance metrics. Two scenarios were simulated to analyze the effect of the QoS and delay in mobile WiMAX system. The validation scenario confirms the overall design of the study that was implemented using OPNET Modeler.
Simulation results demonstrated that the more application were using simultaneously at one time may considerable to have a more delay time. It shows that the performance of MS user with one application would have low delay as it perform the soft handover. Small queues reduce delay, which is essential for real-time traffic. Such queues are required for file transfer that are sensitive to delay and coverage network.

For future studies, the performance of the delay network can be conducted with different types of application and terrain to include measurement in real network environment.

References

[1] IEEE 802.16 Working Group, "IEEE Standard for Local and Metropolitan Area Networks, Part 16: Air Interface for Fixed Broadband Wireless Access Systems," IEEE Standard 802.16-2004, October 2004.

[2] IEEE 802.16 Working Group, "IEEE Standard for Local and Metropolitan Area Networks, Part 16: Air Interface for Fixed and Mobile Broadband Wireless Access Systems, Amendment 2: Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands," IEEE Standard 802.16e-2005, February 2006.

[3] WiMAX Forum Network Working Group, "WiMAX Forum Network Architecture—Stage 2: Architecture Tenets, Reference Model and Reference Points—Release 1, Version 1.2," WiMAX Forum, January 2008.

[4] WiMAX Forum Network Working Group, "WiMAX Forum Network Architecture—Stage 3: Detailed Protocols and Procedures—Release 1, Version 1.2," WiMAX Forum, January 2008.

[5] K. Pentikousis, "Wireless Data Networks," *Internet Protocol Journal,* Volume 8, No. 1, March 2005, pp. 6–14.

[6] IEEE 802.16 Working Group, "IEEE Standard for Local and Metropolitan Area Networks. Part 16: Air Interface for Fixed and Mobile Broadband Wireless Access Systems. Amendment 3: Management Plane Procedures and Services," IEEE Standard 802.16g-2007, December 2007.

[7] Pero Latkoski, Borislav, Popovski,Evaluation of Mobile WiMAX Handover Procedure, IEEE, 2010

[8] IEEE Std. 802.16-2004, IEEE Standard for Local and Metropolitan Area Networks, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, October 2004.

[9] IEEE 802.16-2001, “IEEE Standard for Local and Metropolitan Area Networks — Part 16: Air Interface for Fixed Broadband Wireless Access Systems”, Apr. 8, 2002.

[10] WiMAX : A wireless Technoly Revolution, G.S.V Radha Krishna Rao & G.Radhamani, Auerbach Publication, 2008

[11] Wireless Technology ; Protocol, Standard and Techniques, Michel Daoud Yacoub, CRC Press, 2002

[12] The Interner Protocol Journal, Mobile WiMAX, Jarno Pinola and Kostas Pentikousis

[13] Analysis of Handover Performance in Mobile WiMAX networks- MohdSidekPardi, MohdDani Baba, IEEE Control and System, 2011

[14] IEEE Std 802.16e-2005. Amendment to IEEE Standard for Local and MetropolitanArea Network-Part 16: Air Interface for Fixed Broadband Wireless AccessSystem –Physical and Medium Access Control Layers for Combined Fixed andMobile Operation in Licensed Bands, February, 2006

[15] WiMAX/ MobileFi , Advanced Research and Technology, Yang Xiao, Auerbach Production