ISSN:2231-0711
www.ijcset.net

Evaluation of Handover Process in WIMAX Networks

Firas Abdullah Thweny Al-Saedi[1], Wafa A. Maddallah[2]

[1,2]*Computer Engineering Department, Al-Nahrain University, Baghdad, Iraq*

[1]firas_alsaidi@yahoo.com

[2]wafajabar@yahoo.com

***Abstract* - Worldwide Interoperability for Microwave Access (WIMAX) is a technology based on IEEE 802.16 standards. WIMAX is to be used as the solution for the last mile access for both fixed and mobility applications (mobile users). IEEE 802.16 standard was developed to deliver Non Line of Site (NLOS) connectivity between a Subscriber Station (SS) and the Base Station (BS) with a typical cell radius of three to ten kilometers. Mobile communication is increasingly oriented towards the usage of all Internet Protocol (IP) networks. Mobile IP technology is one of the important supporting technical in the construction of pervasive computing environment. This paper is a study of several scenarios of the WIMAX mobility and scanning procedure using OPNET IPv4 model for an available channel by a mobile station. Mobile handover (HO) with vector and random direction of movement with different speed of vector direction were studied. The effect of different parameters, applications, movement, multiple BS's were taking into consideration. WIMAX mobility allows Mobile Node (MN) to remain reachable while moving around in the Internet and the scanning procedure is used to determine if it could acquire a connection with a more suitable BS.**

***Keywords* - Handover, WIMAX, Mobile WIMAX, Mobile IP, Mobile Node, Subscriber Station.**

I. INTRODUCTION

The mobile WIMAX standard has been developed to be the best wireless broadband standard for portable devices enabling a new era of high throughput and high delivered bandwidth together with exceptional spectral efficiency when compared to other Third Generation (3G+) mobile wireless technologies [1]. Compared to the complicated wired network, a WIMAX system consists only of two parts: the WIMAX BS and WIMAX SS also referred to as Customer Premise Equipment (CPE). Therefore, it can be built quickly at a low cost. Ultimately, WIMAX is also considered as the next step in the mobile technology evolution path. The potential combination of WIMAX and Code Division Multiple Access (CDMA) standards is referred to as Fourth Generation (4G) [2].

Users want to be able to enjoy all of the applications, including multimedia, voice, and data, while still being able to access them in a mobile and/or fixed environment. IEEE 802.16 and its WIMAX technology are part of the solution which will enable that sort of uncompromised data transmission in a wireless environment. This technology also has huge advantages over some of its alternatives as it was designed to support Quality-of-Service QoS as one of its major features [3]. Mobile WIMAX takes the fixed wireless application a step further and enables cell phone-like applications on a much larger scale. In addition of being the final leg in a quadruple play, it offers superior building penetration and improved security measures over fixed WIMAX. Mobile WIMAX will be very valuable for emerging services such as mobile TV and gaming [4].

II. WIMAX HANDOVER

The (HO) is an important process in mobile systems and it is defined by the migration of a Mobile Station (MS) between air-interfaces belonging to different BS. The reason for such a change could be that a cell is overloaded or that the MS gets out of the BS transmission range. The BS associated with the MS before the HO is often called the Serving Base Station (SBS) while the new BS is referred to as the target BS as shown in Figure (1).

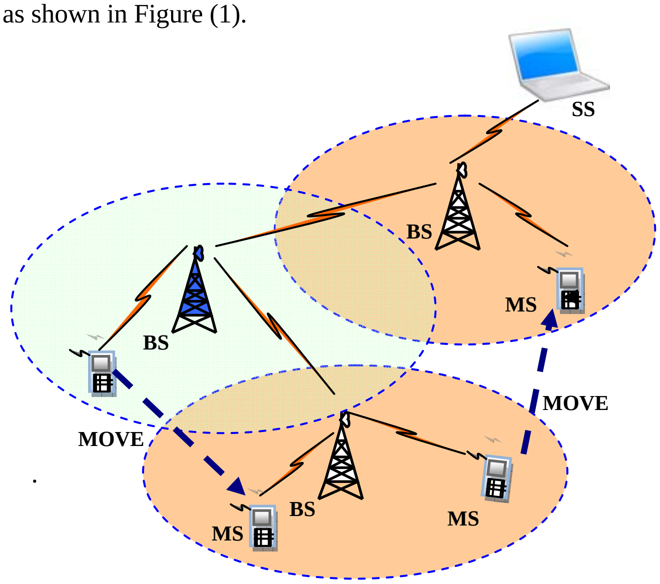

Fig.1 WIMAX handover

A handover can be divided into two parts, the pre-registration phase and the actual HO. The pre-registration phase includes messages such as a HO request and a list of possible target BSs. During this phase, the MS can also measure the signal strength from adjacent BSs to help in the decision about which BS to use as target BS. When the actual HO takes place, the MS will close the connection to the serving BS and open a new to the target BS [5].

The main target of HO in cellular mobile networks is to provide the continuity of services during a MS traveling across the cell boundaries of BS [6].

Handover mechanism handles SS switching from one BS to another. Different HO techniques have been developed. In general, they can be divided into hard handover and soft handover [7].

- ***Hard handover***

Within hard HO, the MS communicates with just one BS in each time as shown in Figure (2).

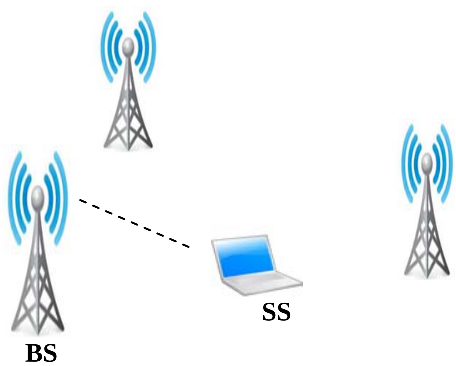

Fig. 2 Hard handover

All connections with the old BS (called SBS) are broken before the connection to a new BS (Target BS) is established. It means that there is a very short time when MS is not connected to any BS. Handover is executed after the signal strength from neighbor's cell exceeds the signal strength from the current cell [5].

The hard handover mechanism, shown in Figure (3), uses the principle of break before make. The MS will break the connection with the original BS before making a new connection with another BS. Although it may lower the HO quality, an improved handover mechanism must be used. When the MS moves from BS1 to BS2, it has to disconnect the original connection with BS1 before it can make a new connection with BS2 [8].

- ***Soft handover***

During a soft HO the MS will keep contact with both BS's throughout the second phase of the HO, often called make-before-break as shown in Figure (4)

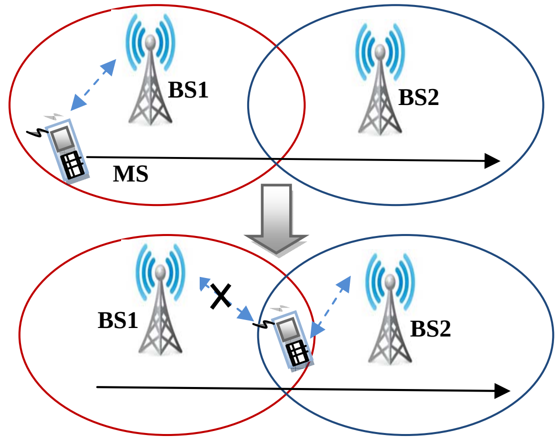

Fig. 3 Hard handover mechanism

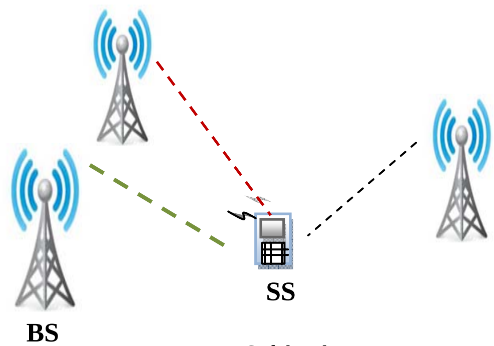

Fig. 4 Soft handover

The MS will always be connected during the HO. There are however some drawbacks with the use of two connections, the overhead in the system will increase and the MS will use more network resources since there will be several channels reserved.

When a MS is leaving the cell of the serving BS, it can make a request for a HO to find a better BS. If soft HO is being used, the MS will commence the registration phase with the target BS before aborting the connection to the serving BS. During the HO, the MS will receive signals from both BSs. When the setup of the new connection is completed, the transmissions from/to the serving BS will end [7].

III. HANDOVER PROCEDURES

The HO allows MSs to HO between neighboring BSs while moving across the corresponding coverage areas. Furthermore, the mechanism can be used by BSs to trigger a HO in order to optimally balance the traffic load of cells within a network. Figure (5) shows an example with three BSs. Each BS is connected to the operator's backbone network either by wired or by wireless connections. The MS is moving away from its SBS, where it is currently associated. The other two BSs are termed neighboring BSs. While crossing the cell boundary, the MS initiates a HO to the most favorable BS, the target BS [9].

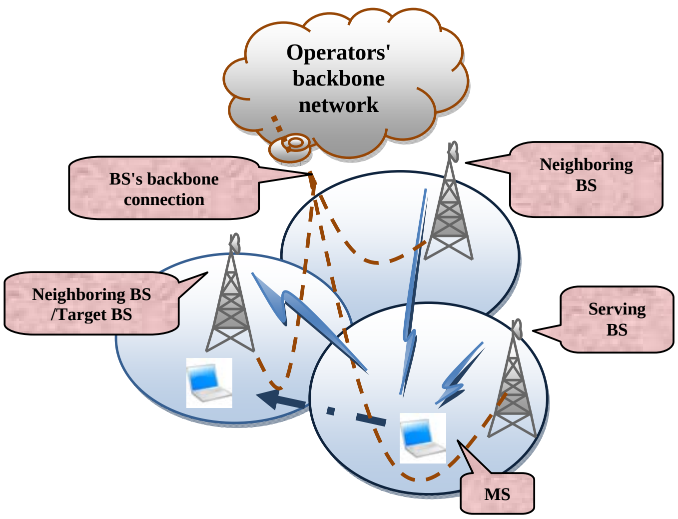

Fig. 5 Network model

The HO procedure can be divided in two stages shown in Figure (6). Stage that is executed before HO, called network topology acquisition, contains network topology advertisement and MS scanning. The results of scanning are used in the next stage of HO procedure, called HO Process [10].

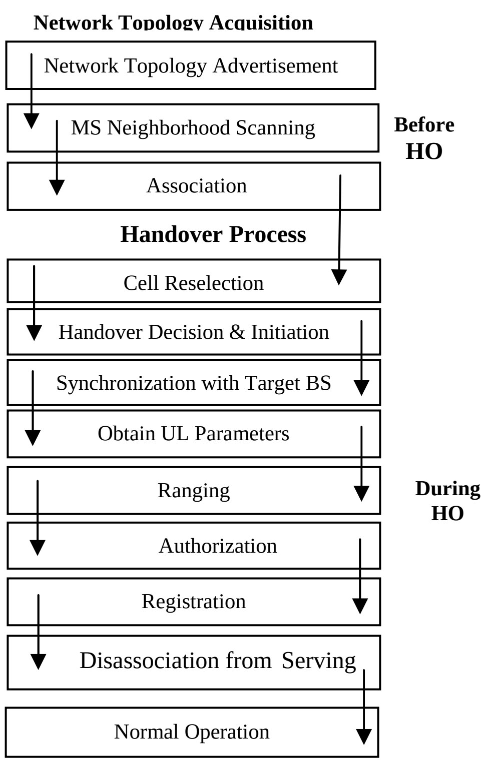

Fig. 6 Network model

1- NETWORK TOPOLOGY ACQUISITION

- ***Network topology advertisement***

SBS periodically broadcasts information about the current network topology using the Mobility Neighbor Advertisement (MOB-NBR-ADV) message. At least every 30s, the message provides channel information of neighboring BSs. The BSs obtain that information over the backbone by exchanging its own Downlink Channel Descriptor / Uplink Channel Descriptor (DCD/UCD) messages. Figure (7) shows the Message Sequence Chart (MSC) of the advertisement.

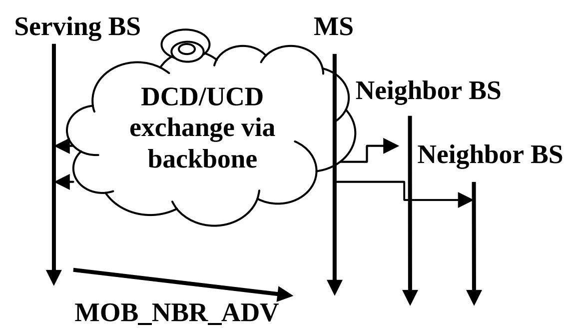

Fig. 7 Network topology advertisements

The channel knowledge facilitates an efficient MS synchronization with neighboring BS by removing the need to monitor transmission from the neighboring BS for DCD/UCD broadcasts [9]. Additionally, the NBR message includes the number of neighbors defined in the message, the Operator ID, trigger criteria for HO and settings that define what optional information is included. Optional information may include additional HO optimization and Quality of Service (QoS) information [11].

- ***Scanning of neighbor BSs***

While a WIMAX MS is moving, it constantly scans for neighboring BS's and transfers data between itself and the BS that it is currently connected with. The purpose of these scans is to determine if it could acquire a connection with a more suitable BS. This could be because of a better wireless Signal to Noise Ratio (SNR), a BS with lower traffic, etc.

When a MS first communicates with a BS, it is responding using Mobile Scan Request (MOB_SCN-REQ) message to an advertising message that is sent out periodically by the information clients of various conditions of the BS. A MOB_SCN-REQ message may be transmitted by an MS to request a scanning interval for the purpose of seeking available BSs and determining their suitability as targets for HO. The MOB_SCN-REQ message includes three key parameters that were modified and measured the impact of: scan duration, interleaving interval, and number of iterations. The process of sending the request is shown in Figure (8) [12].

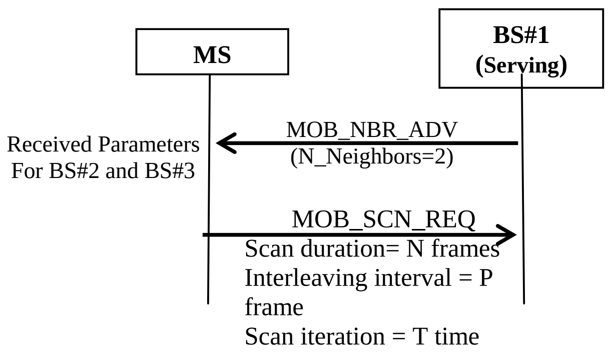

Fig. 8 Mobile station requests

The scan duration is a period of N frames during which the MS scans neighboring BS's and acquires information about them. The interleaving interval is a period of P frames during which the MS handles normal data transmission between itself and the BS it is currently connected to. It repeats pairs of N scan frames and P interleaving interval frames T times [12].

At that point, it must reconnect to the current BS or to a new BS. This is illustrated in the Figure (9).

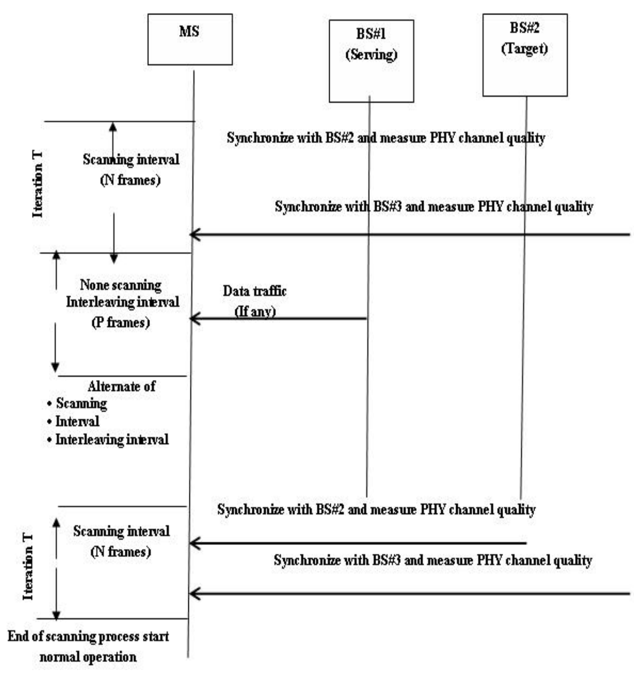

Fig. 9 Activity between mobile and base station

In Figure (9), the leftmost side Iteration 1 contains a scanning period, and a non-scanning interleaving interval. This is continuing until the connection is terminated by the BS and the MS must request a new connection [12].

2. HANDOVER PROCESS

The HO process consists of six different stages, cell reselection, HO decision and initiation, synchronization to target BS downlink, ranging, termination of service and HO cancellation [5].

- ***Cell reselection***

The cell reselection is the stage where the MS acquire information about BSs in the network. The information is used in evaluation of the possibility to perform a HO. This can be done by using the information in the network topology advertisements or require a scanning interval to obtain the needed information. The cell reselection phase does not need to occur in relation to a HO decision [5].

- ***Handover Decision and Initiation***

The initiation of a HO is the decision to migrate the MS from the serving BS to a target BS. This decision can be triggered in the MS as well as in the BS. To commence the actual HO the requesting party sends a HO request which will trigger a sequence of HO specific messages to be sent between MS and BS [5].

- ***Synchronization***

To establish communication with the target BS, the MS needs to synchronize to its downlink channel. During this phase, the MS receives downlink and uplink transmission parameters. If the MS previously received information about this BS (through the network topology acquisition), the length of this process can be shortened [5].

- ***Ranging***

When the MS is synchronized to the channel, it needs to perform initial ranging or HO ranging. Ranging is a procedure where the MS receives the correct transmission parameters, e.g. time offset and power level [5]. Ranging is necessary because SS's may be moving or have been moved, and their radio waves' arrival time at the BS depends on their changing distance from the BS. The greater the distance, the more delay in the signal's arrival time [13].

The WIMAX system uses two types of ranging: initial ranging and periodic ranging. Initial ranging is used to determine the transmit power requirements of the MS in order to reach the BS. During initial ranging, the WIMAX SS transmits a brief ranging request message that allows the system to send back a ranging response message with the amount of timing offset that the SS must use when it begins transmitting. After the SS has attached to the system, the BS will continually send time alignment messages (periodic ranging) to the SS to adjust (fine tune) its timing advance as it moves in the radio coverage area [13].

- ***Authorization and registration***

After the ranging, the MS and the target BS negotiate their basic capabilities, e.g., the modulator / demodulator capabilities. Authentication of the MS and encryption key exchange follows. After its authorization, the MS performs registration where the MS informs, e.g., about its ARQ and CRC support. Now, the MS successfully re-entered the network and proceed with the connection establishment [9].

The pre-registration, in which target BS obtains the service flow and authentication information of this MS through backbone networks before HO, is deployed to reduce the overhead [10].

- ***Disassociation from serving BS***

Termination of services at the serving BS is the last step in the HO process. The serving BS will terminate all connections associated with the MS and remove all information in queues, counters etc.

During the HO, the MS have the right to cancel the HO and resume normal communication with the serving BS. The only condition is that the MS do not try to cancel after a specified time have elapsed [5].

IV. MOBILE WIMAX MODEL OVERVIEW

In order to perform mobility operation scenarios, the OPNET MIPv4 model was used.

The main topologies were simulated mobile HO with vector and random direction of movement, mobile HO with different speed of vector direction. The effect of different parameters, applications, movement, multiple BS's were taking into consideration for the mentioned scenarios. The simulation strategy was made to examine the possible topologies and configuration for the network.

Figure (10) and Figure (11) shows the simulated scenarios.

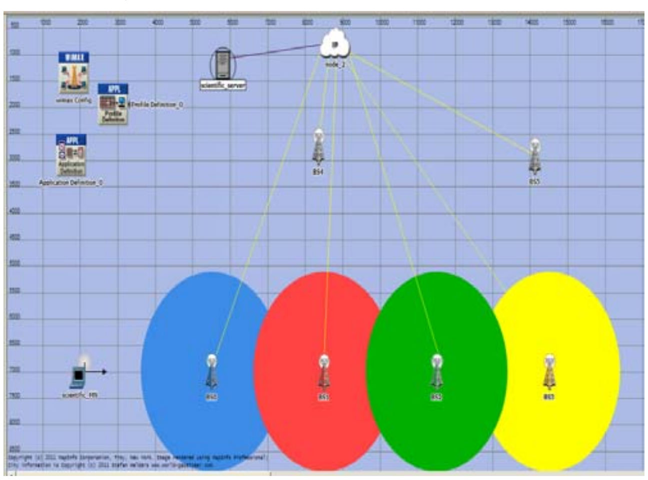

Fig. 10 Mobile handover with vector direction of movement

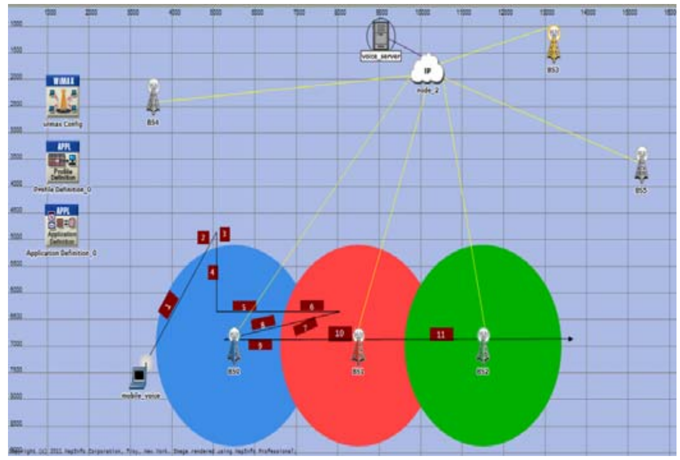

Fig. 11 Mobile handover with random direction of movement

The arrangement of objects in these scenarios contains multiple objects which are explained below:

- MN: a node was moved from a specific location through different numbers of BS's to simulate HO in the network.
- BS: Multiple BS's were connected with IP cloud object which was used to represent a collection of routers viewed as a "black box." Packets enter the cloud at a well-defined entry points and later exit at a well-defined exit points. In principle, all of the routers within a cloud are internally connected.
- WIMAX configuration: the global configuration object is used to configure parameters such as PHY profiles, efficiency mode and MAC service class definitions are chosen. The efficiency modes will be used in these scenarios, the Mobility and Ranging Enabled mode. The simulation accounts for mobility and ranging effects.
- Servers: to complete the designed network, server with different supported Profile (Engineer, Multimedia, Researcher) was used.
- Application Definition: to define multiple application configurations.
- Profile Definition: to define multiple profile configurations.

V. CONFIGURATION

A. *WIMAX CONFIGURATION*

The WIMAX simulation parameters were chosen based on 20MHz bandwidth, the base frequency was set to 3.5 GHz and the MAC Service Class Definition parameters as shown in Table 1.

Table 1 MAC service class definition parameters

Service Class Name	Scheduling Type	Maximum Sustained Traffic Rate(bps)	Minimum Reserved Traffic Rate(bps)	Maximum Latency (milliseconds)
Gold	UGS	96000	96000	10
Silver	rtPS	1Mbps	1Mbps	30
Bronze	BE	384Kbps	384Kbps	30

B. MOBILE NODE CONFIGURATION

The parameters of MN in these scenarios are summarized in Table 2. In MN, the global IP address should use the same network prefix as the IP address of SBS, and the other parameters are set as default.

Table 2 MN configuration parameters

		Parameters	Value
1	DL	Classifier Definition	Bronze
		Modulation and Coding	Adaptive
2	UL	Classifier Definition	Bronze
		Modulation and Coding	Adaptive
3		Application	- Http – Email – FTP - Telnet
4		Max transmission power	0.5 W
5		Antenna gain	-1 dBi
6		MS Pathloss model	Vehicular Environment
7		Terrain Type	Terrain Type B
8		Shadow Fading	10 dBm

The distance between MN and BS0 is 3500 m and the distance between BS's is 3000 m.

C. BS's CONFIGRATION PARAMETERS

The MAC address of BS is used, which represents BS ID and is set to 0, 1, 2 and 3 for BS0, BS1, BS2 and BS4 respectively. The other settings and parameters of each BS are explained in Table 3.

Table 3 BS's paramerters

	Parameters	Value
1	Antenna gain	15 dBi
2	Classifier Definition	Silver ,Gold, Bronze
3	Max transmission power	0.5 W

D. TRJECTORY CONFIGURATION

Trajectory was configured to control the MN movement and it can be configured with different ways such as vector movement, also there movement and there speed can be changed during the simulation. The important parameters of the scenario of Figure (10) are shown in Table 4 while the parameters of the scenario of Figure (11) are shown in Table 5.

Table 4 Trajectory paramerters of MN of Figure (10)

Parameters	Value
Position (X,Y)	(2000,7000)
Trajectory	Vector
Bearing	90 (to move from left to right)
Ground speed	5 m / sec

Table 5 Trajectory paramerters of MN of Figure (11)

	X Pos (m)	Y Pos (m)	Distance (m)	Traverse Time(sec)	Ground Speed (m/sec)
1	0	0	n/a	n/a	n/a
2	1,830.750	-2,629.123	3,203.738	640.75	5
3	1,830.750	-1,128.733	1,500.389	300.08	5
4	4,803.999	-1,128.733	2,973.249	594.65	5
5	2,009.696	-605.661	2,842.840	568.57	5
6	9,566.704	-619.426	7,557.021	1511.4	5
7	10,420.137	-619.426	853.43263	17.07	50

VI. RESULTS ANALYSIS

Full study for the MN HO that took place in the first scenario is presented in Figure (12). The throughput for the MN and the HO behavior with vector direction of movement is explained.

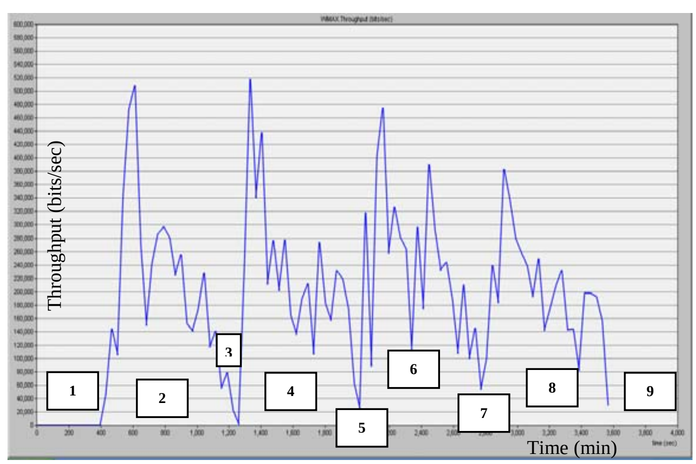

Fig. 12 MN throughput curve for vector movement

Where the points attached in Figure (12) represent:

1. At the beginning of simulation process, the MN moves 1584 m outside coverage area.
2. After 396 sec, MN enters BS0 coverage area and moves 3456 m in it.
3. HO between BS_0 and BS_1.
4. MN enters BS_1 area and moves 3024 m in it.
5. HO between BS_1 and BS_2.
6. After the HO process between BS_1 and BS_2, MN enters and moves 3024 m in the coverage area of BS_2.
7. HO between BS_2 and BS_3.
8. BS_2 is the last area the MN enters and moves 3168 m in it.
9. MN exits from the coverage area of BS_2 at the end of simulation time.

The scanning and power control results of MN that occured during the simulation are explained in Figure (13) with a brief description about each effect in the simulation.

- Graph A represents the WIMAX throughput of MN.
- Graph B indicates the initial ranging activity. Whenever MN connects to a BS, it performs an initial ranging activity to confirm if the threshold power is enough to stop scanning process.
- Graph C shows the HO delay. The HO interruption time is caused by switching of mobile node form the serving BS to the target BS.
- Graph D indicates the serving BS ID, since mobile will be served by four BS's 0, 1, 2 and 3 .The ID of BS represents the MAC address for each BS.
- Graph E shows the SNR at the physical layer of the model. One important measurement parameter is the SNR that is to be monitored along the way. When the MN is moving, there is a circle of a certain radius that defines a minimum threshold of SNR outside of which the SNR is too low. As seen from the graphs, the maximum SNR is attained when the MS is closest to the BS and the minimum SNR is attained when MS is scanning for a BS.

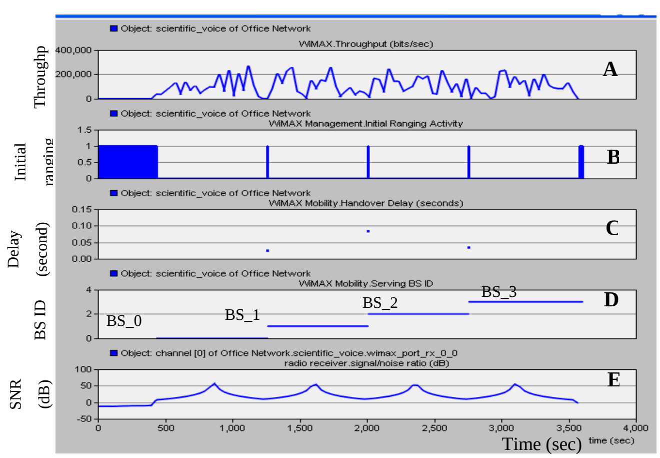

Fig. 13 MN scanning and handover

In the case of mobile HO with random direction movement which is presented in the scenario in Figure (11), the results and analysis was displayed for the VoIP application.

Figure (14) shows the throughput for MN which is configured to move in a speed of (5 m/sec) in a random direction of arrow from specific location through three BS's (BS_0, BS_1 and BS_2) to implement WIMAX HO in the network.

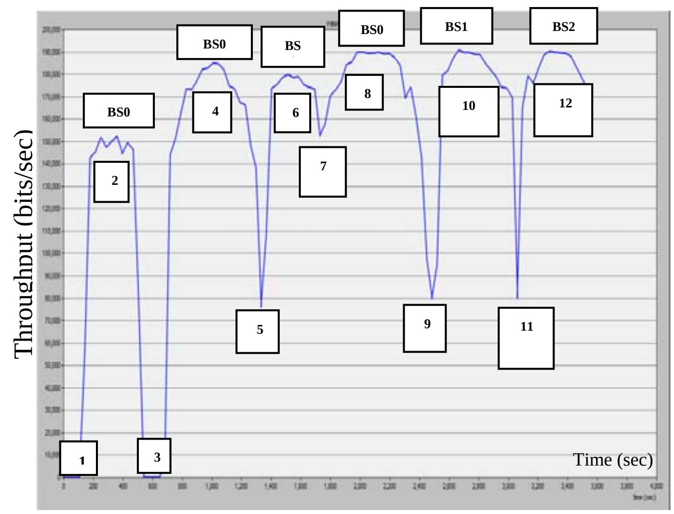

Fig. 14 MN throughputs with random direction movement

Where the points attached in Figure. 14 represent:

1. MN move 540 m outside coverage area.
2. BS_0 is the first BS where the MN enters its coverage area and moves 2000 m in it.
3. MN exit from the area of BS_0 and move 540 m outside coverage area.
4. MN will again enter BS_0 area and move 3240 m in it.
5. HO between BS_0 and BS_1.
6. The distance where the MN stays in the BS_1 coverage area is 1980 m.
7. HO between BS_1 and BS_0.
8. For the third time, the MN enters BS_0 coverage area and move 3600 m in it.
9. MN decides to come back to BS1 area during its movement, so the HO between BS_0 and BS_1 will be occurred.
10. MN move 2700 m in the coverage area of BS_1.
11. HO between BS_1 and BS_2.
12. For the rest of simulation time, the MN will move in the coverage area of BS2.

Figure (15) shows the BS's throughput. The MN passes three times through BS0 during its trip and twice through BS1 and passes only one time through BS2. During the HO, the MS will receive signals from both BSs. When the setup of the new connection is completed, the transmissions from/to the serving BS will end i.e. when the MN crosses a boarder of cells between the serving BS and target BS, the connection with the serving BS is closed. After that, a new connection with the target BS is established.

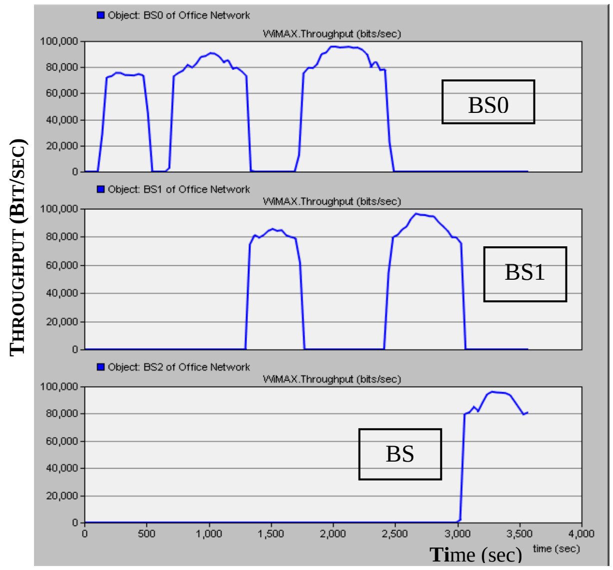

Fig. 15 BS's throughputs

VII. CONCLUSIONS

HOs play a critical role for mobility in mobile WIMAX networks. The mobile WIMAX specification 802.16e provides a variety of hard and soft HO techniques.

There is a decrease in the throughput as the mobile station moves out of coverage area of BS, and also during the HO process no packets are transferred. After the HO, the packets are transferred through the neighbor BS

At the point where MN changed its location (HO), there were some data dropped, happened without making disconnection for data from MN to servers and vice versa.

REFERENCES

[1] A. Ahmadzadeh, "Capacity and Cell-Range Estimation for Multitraffic Users in Mobile WIMAX", University College of Borås School of Engineering, September 2008.

[2] S. ILYAS, "WIMAX Applications", Boca Raton London New York, 2008.

[3] P. Staub, "An Analysis Of IEEE 802.16 and WIMAX Multicast Delivery", Naval Postgraduate School, Monterey, Califoria, September, 2007.

[4] M. Saini, " Analysis of Handover Schemes in IEEE 802.16 (WIMAX) ", Thapar University, Patiala, JUNE – 2008.

[5] M. Lax and A. Dammander, "WIMAX - A Study of Mobilityn and a MAC-layer Implementation in GloMoSim", University Department of Computing Science SE-901 87 UME°A SWEDEN, April 6, 2006.

[6] M. Hempel, W. Wang, H. Sharif, T. Zhou, P. Mahasukhon, "Implementation and Performance Evaluation of Selective Repeat ARQ for WIMAX NS-2 model", Computer and Electronics Engineering, University of Nebraska – Lincoln, USA, 2008.

[7] "Handoff Mechanism in Mobile WIMAX", http://www.conniq.com/WIMAX/handoff.htm, Last Visited 19 May 2011.

[8] D. Kumar, N.Nagarajan, "Simulation of Hard Hand over (HHO) Mechanism in IEEE 802.16j Transparent Mode networks", International Journal of Computer Applications, Volume 14– No.2, January 2011.

[9] C. Hoymann, M. Grauer, "WIMAX Mobility Support", RWTH Aachen University, Faculty 6, Chair of Communications Network, Germany,http://fireworks.intranet.gr/Publications/itgAachen06_WIMAXMobility_hoymann.pdf, Last Visited 26 May 2011.

[10] A. Ulvan, R. Bestak, "The Analysis of Scanning Time in IEEE802.16m's Handover Procedure", Czech Technical University, Prague, 28 December 2009, http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=5367702, Last Visited 19 May 2011.

[11] "Missing Neighbor Analysis for WIMAX networks", Wireless logix, E2E Network Solution, http://www.remopt.com/whitepaper1.php, 28/07/2008, Last Visited 19 May 2011.

[12] S. Sarai, D. Carter, B. Jazizadeh, "WIMAX Mobility", Spring 2009.

[13] K. Kalaichelvan, L. Harte, "WIMAX Explained", USA, 2007.