Performance Analysis of a Mobile WiMAX Network in Node Mobility under Different Scenarios

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Abstract: Mobility is important in wireless network because internet connectivity can only be effective if it is available during the movement of node. Several works have been carried out in performance analysis of node mobility in horizontal handover, but none of those is carried out in multiple networks within the same technology, So this paper analysis the performance of mobile nodes during handover in single WiMAX network by comparing it with performance of node mobility in two WIMAX networks and to measure the performance there are number of parameters available like handover latency, end-to-end delay, MOS value, Throughput, Network Delay, etc. and we have used Network Throughput, Network Delay and MOS value which are involved in mobility management procedures

Keywords: Mobile Network, WIMAX, Handover, Throughput, Delay, VoIP, OPNET

I. INTRODUCTION

The world is moving to the age of velocity in every field especially the wireless networks field. To go along with it, it is needful to have faster facilities, more importantly in the wireless networks. The need is to provide mobile wireless with higher data rates, Quality of Service (QoS) and adaptability within the same network or among networks of different technologies and service providers and the rapid growth in the area of communication has generated the need of mobility during communication. [4] The mobility of a terminal is a requirements of great importance, supported by a procedure known as handover. Handover is a key element in maintaining air link to base station even when mobile node is moving with high velocity and changes its geographical position. The handover can be due to the movement of mobile subscriber or due to change in radio channel condition or due to cell capacity constraints. IEEE 802.16e support handovers for portability, simple mobility and full mobility of the users. [8]

II. QOS (QUALITY OF SERVICE)

Support for QoS is a fundamental part of the WiMAX network. To support a wide variety of applications, mobile WiMAX defines five scheduling services listed below

Table 1.Types of services [6]

Service Class	Application	QOS Specification
Unsolicited Grant Service (UGS)	VoIP	-Jitter Tolerance -Latency tolerance -Sustained rate
Real-time Packet Services (rtPS)	Streaming Audio/Video	-Traffic Priority -Latency tolerance -Reserved rate -Sustained rate
Extended real time Packet Services (ertPS)	VoIP (VoIP with Activity Detection)	-Traffic priority -Jitter tolerance -Latency tolerance -Reserved rate -Sustained rate
Non-real Time Packet Services(nrtPS)	FTP	-Traffic Priority -Reserved Rate -Sustained Rate
Best Effort (BE)	Data transfer, web Browsing	-Traffic priority -Sustained rate

III. PERFORMANCE METRICS

3.1 *Throughput*

In any communication networks, such as Ethernet or packet radio or mobile Wimax network, throughput or network throughput is the average rate of successful message delivery over a communication channel. So this means more message delivered over Channel will make network more reliable and fast. [3]

3.2 *Network delay*

Network delay is an important design and performance characteristic of a computer network or telecommunications network. The delay of a network specifies how long it takes for a bit of data to travel across the network from one node or endpoint to another. It is typically measured in multiples or fractions of seconds. Delay may differ slightly, depending on the location of the specific pair of communicating nodes.[12] There is a certain minimum level of delay that will be experienced due to the time it takes to transmit a packet, so this adds up more variable level of delay due to network congestion.

3.3 *MOS in VoIP*

A VoIP application typically works as follows, first, a voice signal is sampled, digitized, and encoded. The encoded data (called frames) is/are packetized and transmitted using RTP/UDP/IP. At the receiver's side, data is de-packetized and forwarded to a playout buffer, which smoothes out the delay incurred in the network. Finally, the data is decoded and voice signal is subjective and therefore is measured by mean opinion score (MOS). MOS is a subjective quality score that ranges from 1 (worst) to 5 (best) [5].

IV. SIMULATION MODEL

4.1 *Opnet Simulator*

Opnet Simulator is used to create the WiMAX Mobile environment and figure 1 represents the workflow of the OPNET Simulator.
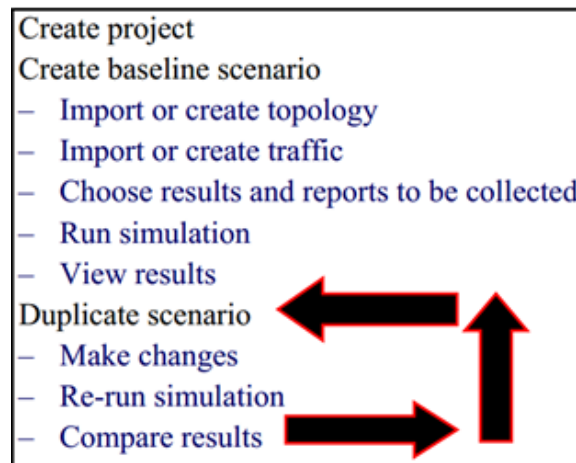

Figure 1. The Project/Scenario Workflow in OPNET

4.2 *Network model*

The network consists of three cells in two different Networks and an IP backbone. Cell radius is set to 2 km. Each cell has 5 nodes. The green bidirectional dotted lines represent the generic routing encapsulation (GRE) tunnels and white arrow lines represents the trajectory set for mobile nodes to move around the network while simulation.[1][2] Figure 2 shows the implementation of Wimax mobile environment using OPNET Simulator.
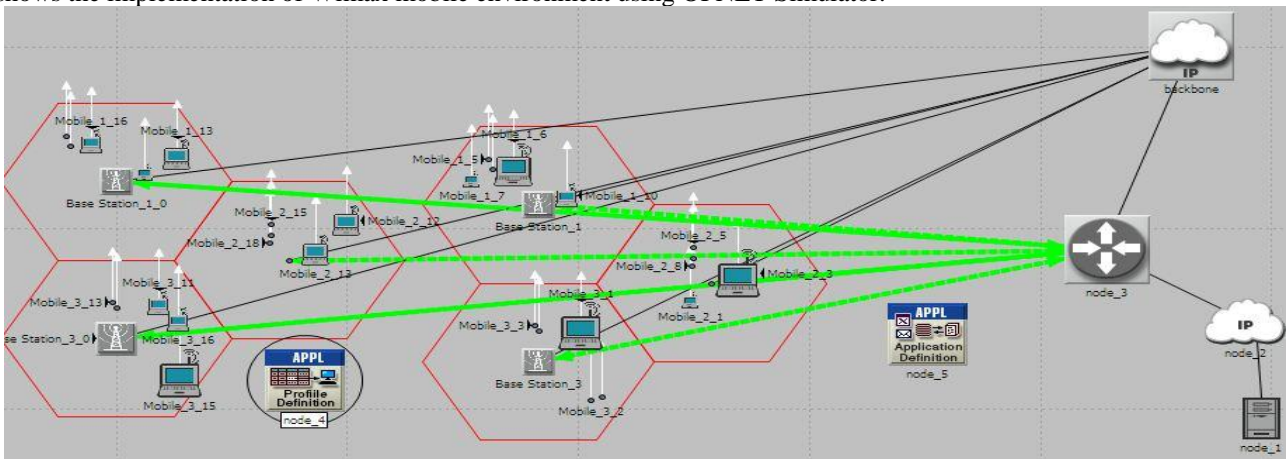

Figure 2. WiMAX Network Topology showing two Different Networks

4.3 ASN Gateway

The Access Service Network (ASN), which comprises one or more base stations and one or more ASN gateways that form the radio access network at the edge. The ASN gateway typically acts as a layer 2 traffic aggregation points within an ASN. Main functions that the ASN gateway include are intra-ASN location management and paging, radio resource management and admission control, caching of subscriber profiles and encryption keys, AAA client functionality, establishment and management of mobility tunnel with base stations, QoS and policy enforcement, and foreign agent functionality for mobile IP, and routing to the selected Network [1].

4.4 Node Mobility Experiment Scenarios

4.4.1 Scenario 1:

Scenario 1 is proposed to investigate the impact of node mobility on the performance of VoIP application in a single mobile WiMAX network at node speed of 20km/h. Moreover, results from Scenario 1 will also be used to analyze the effect of handover in the two WiMAX networks when compared with results from Scenario 4.

4.4.2 Scenario 2:

Scenario 2 is used to investigate the impact of node mobility on the performance of single mobile WiMAX network at node speed of 40km/h. Moreover, results from Scenario 2 will also be used to analyze the effect of handover in more than one network by comparing them with results from Scenario 5.

4.4.3 Scenario 3:

Scenario 3 is used to investigate the impact of node mobility on the performance of single mobile WiMAX network at node speed of 60km/h. Moreover, results from Scenario 3 will also be used to analyze the effect of handover in more than one network by comparing them with results from Scenario 6.

4.4.4 Scenario 4:

Scenario 4 is used to investigate the impact of handover on two same networks on the performance of VoIP application in a mobile WiMAX network at node speed of 20km/h.

4.4.5 Scenario 5:

Scenario 5 is used to investigate the impact of handover on two same networks on the performance of VoIP application in a mobile WiMAX network at node speed of 40km/h.

4.4.6 Scenario 6:

Scenario 6 is used to investigate the impact of handover on two same networks on the performance of VoIP application in a mobile WiMAX network at node speed of 60km/h.

V.   SIMULATION RESULTS AND ANALYSIS

Each scenario`s experimental result is summarized in a separate graph. Therefore, the graphs will clearly indicate how system performance has been influenced by increasing node speeds with handover in single Network as well as in two networks.

5.1 Throughput Results at 20 km/h

Throughput is one of the most important performance analysis parameter used in the research. From the graph shown in the Figure 3, it can be concluded that the throughput of the data packets flowing in the scenario which supports node mobility with handover in Single networks is 20% more than the node mobility with handover in two networks.
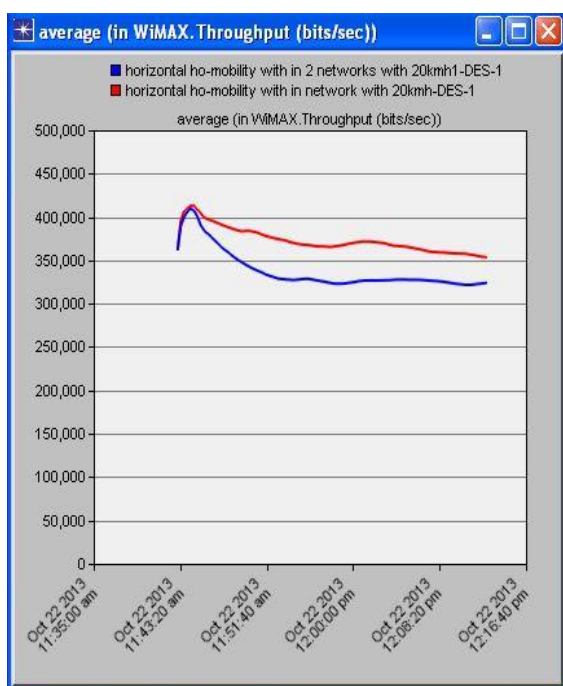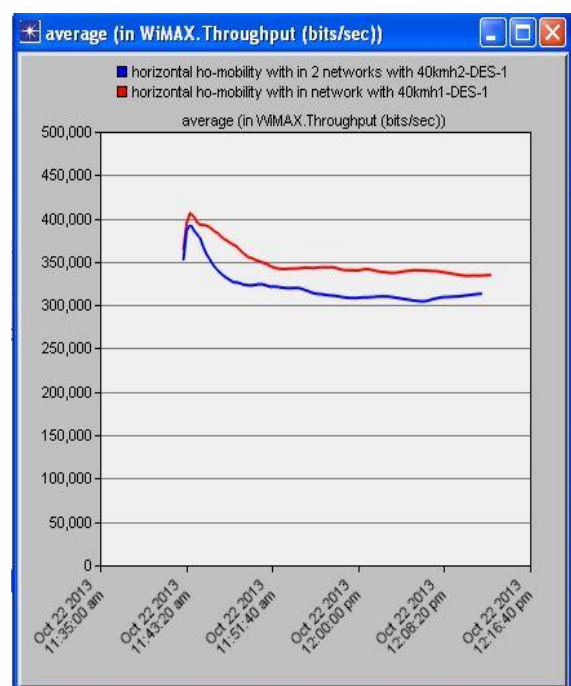

Figure 3: Throughput at 20km/h	Figure 4: Throughput at 40km/h

5.2 Throughput Results at 40 km/h

It can be depicted from the graph shown in the Figure 4 that throughput of the scenario which supports node mobility in Single network is 10-15 % more than the scenario in which node mobility occurs in two networks.
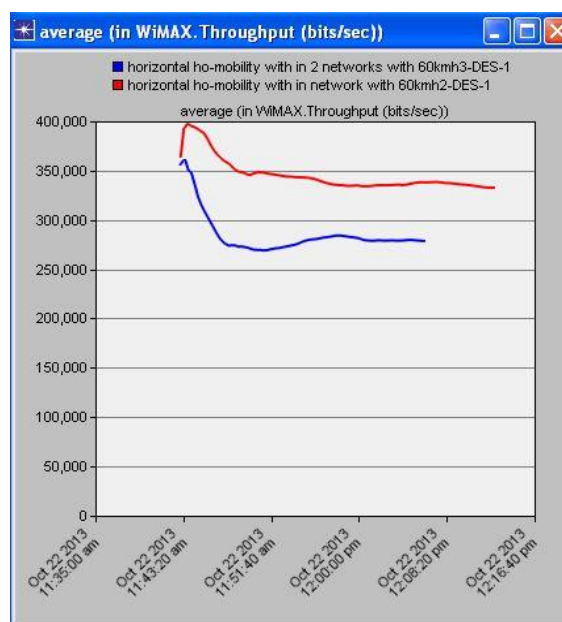

Figure 5: Throughput at 60km/h

5.3 Throughput Results at 60 km/h

In Figure 5, it has been concluded that throughput of the scenario in which mobile nodes moves in single network is more then node mobility in two networks by 30%
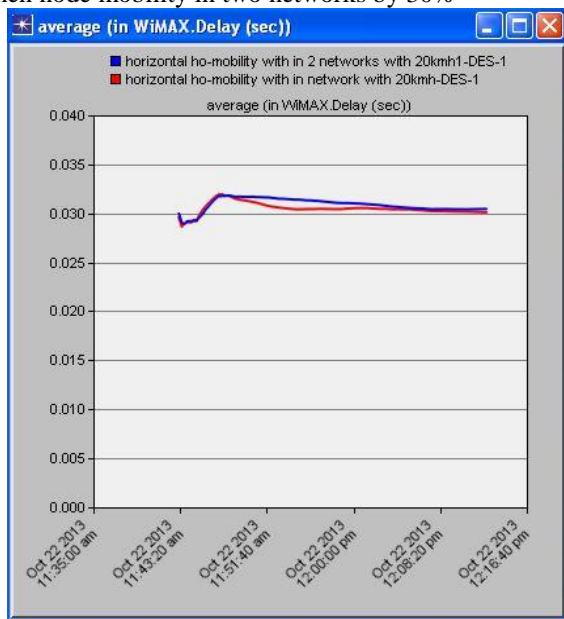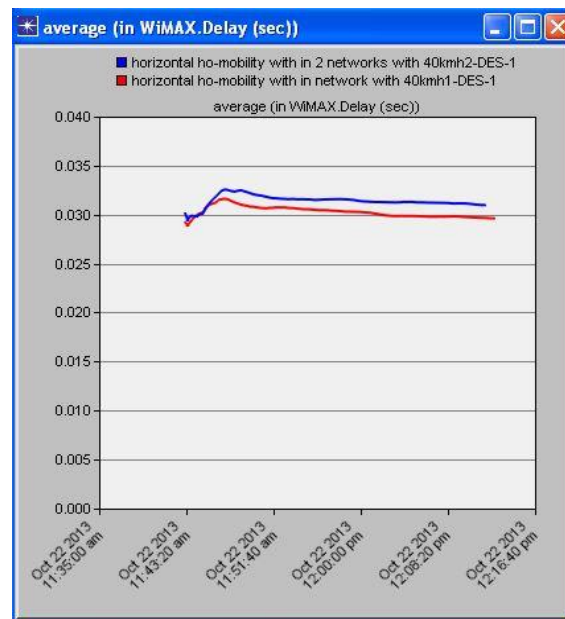

Figure 6: WiMAX Network Delay at 20km/h

Figure 7: WiMAX Network Delay at 40km/h

5.4 Network Delay Results at 20 km/h

From the given Figure 6 it can be analyzed that network delay is more in case of handover in two networks as compared to a node mobility in single network by 7-8 %. Whenever a handover occurs, it involves some basic steps like scanning, ranging, network re-entry and registration. There is no data transfer during scanning and transmission, it is further delayed due to ranging, network re-entry and registration process. So, all these factors sum up to increase the network delay during handover in two networks as compared to single network.

5.5 Network Delay Results at 40 km/h

It can be concluded from the graph shown in Figure 7 that network delay caused by data packets flowing in scenario where mobile nodes moves in two networks is 10% more than those nodes that perform handover in single network as they move away from their serving base station.
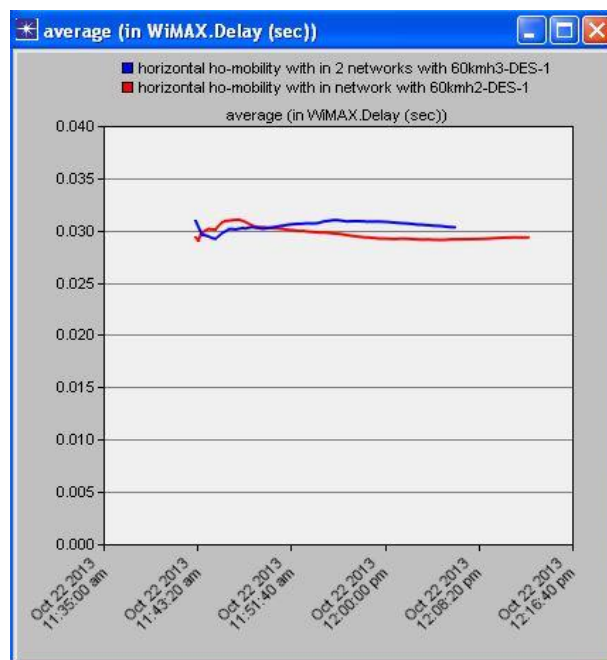
Figure 8: WiMAX Network Delay at 60km/h

5.6 Network Delay Results at 60 km/h

Figure 8 presents that at a speed of 60km/h, network delay is 5-7% more if mobile devices require handover on their move from one network to another as compared to those situations when devices move in the range of single network only.
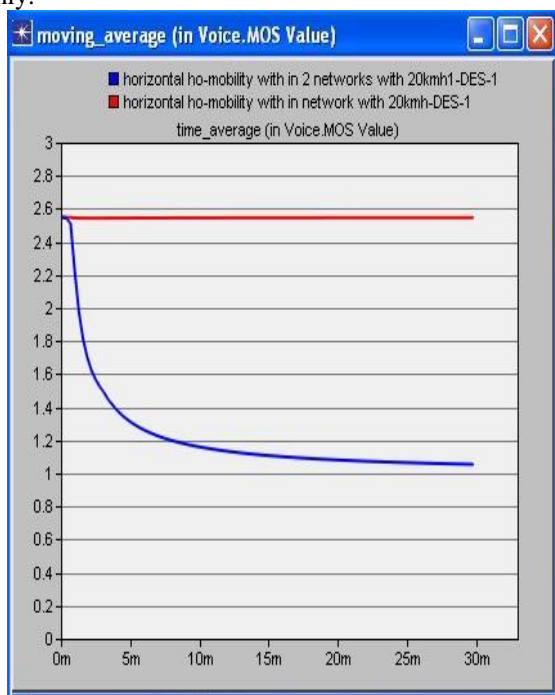

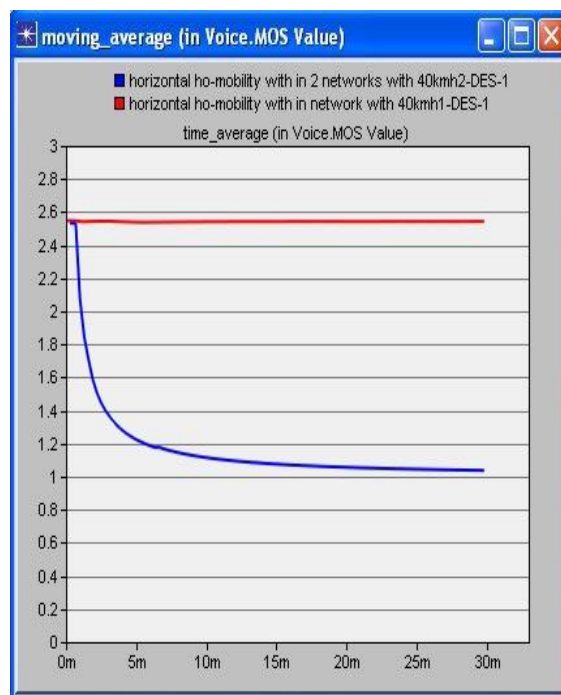

Figure 9: Mean Opinion Score (MOS) at 20km/h   Figure 10: Mean Opinion Score (MOS) at 40km/h

5.7 MOS value Results at 20km/h

From Figure 9, it can be concluded that MOS value of the scenario which supports node mobility in single network is more than the MOS value in case of node mobility in two networks by 47.70 %. This is due to the fact that number of packets is dropped and end-to-end delay is increased in the case of changing the network. Moreover, we can see that MOS value remains constant with the time elapse in both the cases.

5.8 MOS value Results at 40km/h

It can be depicted from the graph shown in the Figure 10 that MOS value of the scenario which supports node mobility in single network is 60% more than the scenario in which node mobility occurs in two networks. It is because of the increased end-to-end delay and data drop of the devices during network change.
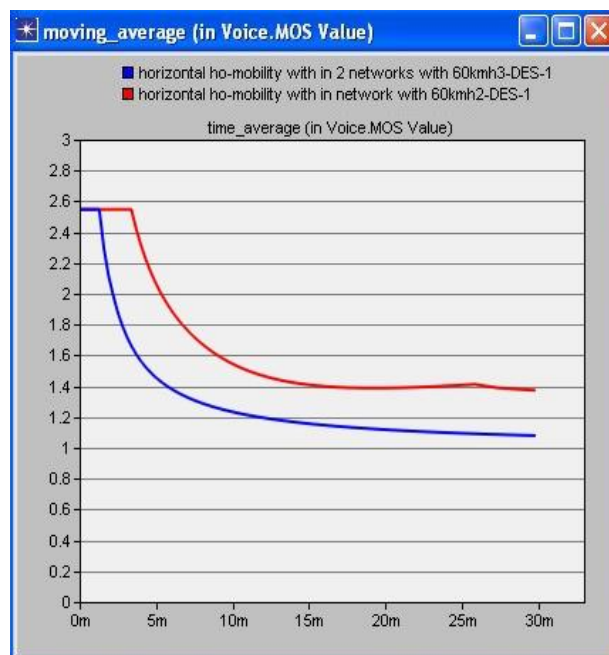
Figure 11: Mean Opinion Score (MOS) at 60km/h

5.9 MOS value Results at 60km/h

Figure 11 also shows the same that MOS value is more in Single network than in two networks. Moreover, we can see that MOS value is decreased considerably with the increase in speed of mobile nodes.

5.10 Serving Base Station ID Analysis

In order to analyze that handover is taking place in the mobile nodes, change in the serving BS ID of mobile node has been shown in the figure 12.
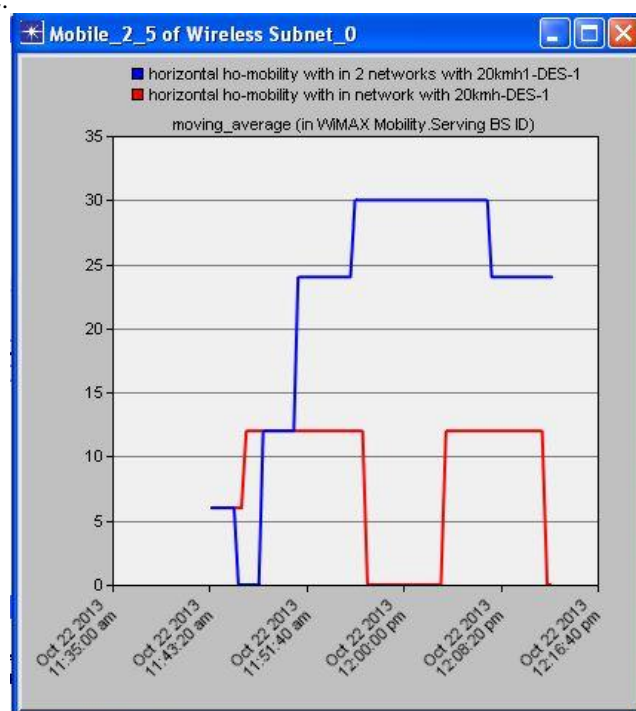

Figure 12: Serving BS ID

From Figure 12, we can clearly depict that the mobile node is changing its Serving BS Id while it moves from one location to another i.e. it moves from the cell coverage of one base station to that of another base station. Whenever a mobile node exhibit handover its base id is changed from the serving base station to the target base station. And as in single network BS Id changes to maximum of three values as there are only three base stations but in handover in two networks base ID changes rapidly to maximum of six different values as there are total six base stations in two networks so base Id changes as mobile node moves from one network to the other. Figure 12 also shows that the mobile node moves from one Cell to other and perform handover. This is the reason the serving base ID Changes as the mobile node enters the other cell. So Figure 12, Clearly Shows that Handover Actually Occurred.

VI. CONCLUSION

In above results it has been shown that performance of node mobility during handover is higher in the single WIMAX network than node mobility during handover in two WIMAX networks. Above results has been analyzed using OPNET simulator and to measure the performance we took three parameters Network Throughput, Network Delay and MOS Value, and after examining the simulation in mobile environment ,It shows that the performance of node mobility in single WIMAX network is much more than that of performance of node mobility in two WIMAX networks due to the fact that End-to-End Delay increases while changing the network so performance degrades in handover of mobile nodes in two networks ,And for future work different handover related WiMAX research issues need to be analyzed to support high-speed mobility in different scenarios.

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