OPNET BASED SIMULATION AND INVESTIGATION OF WIMAX NETWORK USING DIFFERENT QoS

Kamini Jaswal[1], Jyoti[2], Kuldeep Vats[3]

[1]*M.tech, Department of electronics and communication, South point institute of engineering and technology, Sonepat, Haryana, India*

[2]*Assistant professor, Department of electronics and communication, South point institute of engineering and technology, Sonepat, Haryana, India*

[3]*B.E. Honors, M.tech, Department of computer science engineering, Sonepat, Haryana, India*

Abstract

IEEE 802.16 WiMAX network is designed for providing high speed wide area broadband wireless access. WiMAX is an emerging wireless technology which is used for creating multi-hop mesh networks offering variable and high data rates, QoS, seamless mobility within a network. OPNET modeler is a simulation program tool used to simulate the different types of wireless networks. In this paper, simulation and evaluation of three different sized networks (small, medium, large) is carried out. We are using the modeler to study networks with 15, 25 and 40 mobile workstations. In each network, group of five WiMAX workstations connect and call each other through one WiMAX base stations during 1000sec. Performance of parameters that indicate the quality of services such as initial ranging activity, delay, total transmission power and PHY path loss have been studied.

Keywords *– WiMAX, IEEE 802.16, OPNET, QoS*

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1. INTRODUCTION

IEEE standard Board in 1999 introduced and worked on Broadband Wireless Access Standards which aimed for global deployment of broadband Wireless Metropolitan Area Networks. The family of 802.16 is known as Wireless MAN which is also known as "WIMAX" or wireless broadband. IEEE 802.16-2004 is known as 'fixed WiMAX' and IEEE 802.16-2005 or 802.16e is known as 'mobile WiMAX'. WiMAX is abbreviated as "Worldwide Interoperability for Microwave Access" which provides broadband connectivity by connecting to the Internet Service Provider even when you are roaming outside home. WiMAX network is a proficient alternative to 3G or wireless networks for providing connectivity over large coverage area with low cost of deployment and high speed data rates. It supports data rates of 70Mbps over ranges of 50km with mobility support at vehicular speeds. WiMAX technology is the only wireless system capable of offering high QoS at high data rates for IP networks. One of the top applications for the 802.16 is Voice over Internet protocol (VoIP) service to support bidirectional voice conversation [1]. In upcoming era, WiMAX will substitute other broadband technologies competing in the same segment and will become an excellent solution for the deployment of the well-known last mile infrastructures in places where it is very difficult to get with other technologies, such as cable or DSL, and where the costs of deployment and maintenance of such technologies would not be profitable [2][3].

The main parts of a WiMAX system are the subscriber station (SS) and the base station (BS). A BS can have one or more than one nodes that is subscriber units connected to it. These base stations (BS's) and Subscriber stations (SS's) can form a cell with point to multipoint (P2MP) structure. Multiple BS's can be configured to form a cellular wireless network. WiMAX based systems generally use fixed antenna at the subscriber station site, mounted on heights. A Base Station can use either directional or Omni directional antennas. A stationary Subscriber unit uses directional antenna while mobile or portable Subscriber unit can use an Omni-directional antenna. The 802.16 standard also can be used in a point to point topology with pairs of directional antennas. This increases the effective range of the system [4][5].

This paper provides an overview of 802.16 followed by one of most widely used tool for studying the performance of existing systems. It is known as Optimized Network Evaluation Tool (OPNET). The purpose of this study was to examine cases of different QoS deployment over a WiMAX network and to investigate the capability of a WiMAX network to deliver adequate QoS to voice applications.

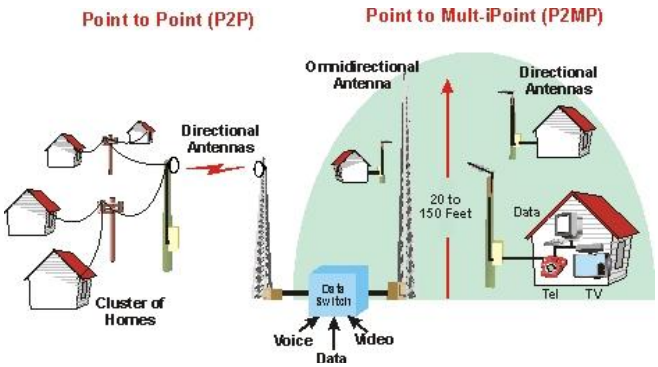

Fig1. P2P and P2MP antennas with WiMAX network

2. OPNET MODELER

We are using the Optimized Network Engineering Tool (OPNET v14.5) for simulation of our networks which is one of the most powerful simulation tools regarding wireless communications. OPNET is a research oriented network simulation tool which provides a development environment for modeling and simulation of deployed wired as well as wireless networks and also provides multiple solutions for managing networks and applications e.g. network operation, planning, research and development (R&D), network engineering and performance management. OPNET 14.5 is designed for modeling communication devices, technologies, protocols and to simulate the performance of these technologies. User can create customized models and simulate various network scenarios [6]. It is possible to simulate various wireless communication technologies such as MANET, 802.11, 3G/4G, Ultra Wide Band, WiMAX, Bluetooth, ZigBee using OPNET tool.

The OPNET modeler is object oriented and employs a hierarchical approach to model communication networks as shown in fig below. The OPNET usability can be divided into four main steps.

1. Modeling : This module is used to build or create a network model
2. Choose and select statistics: We can choose different statistics to collect from each network.
3. Simulate the network.
4. View and analyze results.

The OPNET Modeler comprises a series of hierarchical user interfaces including Project, node, process, link model, path, and project editors [7] as shown in figures 2, 3, 4.

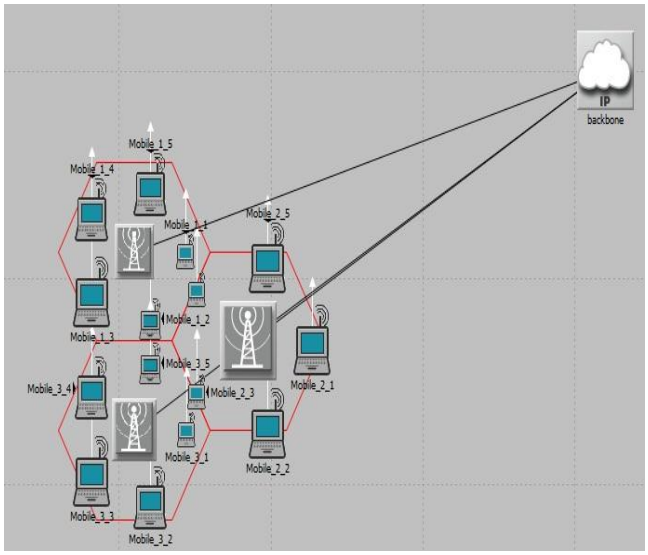

Fig 2 The Network model

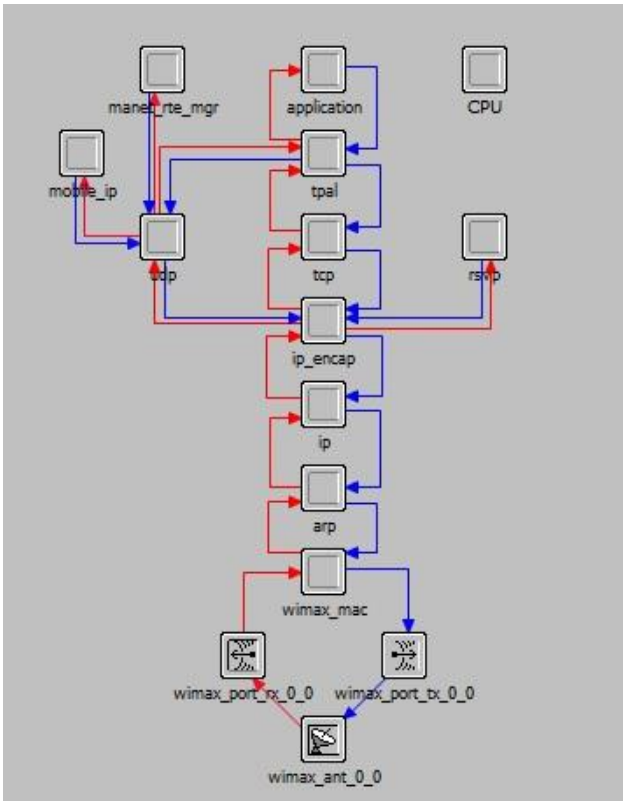

Fig 3 The Node model

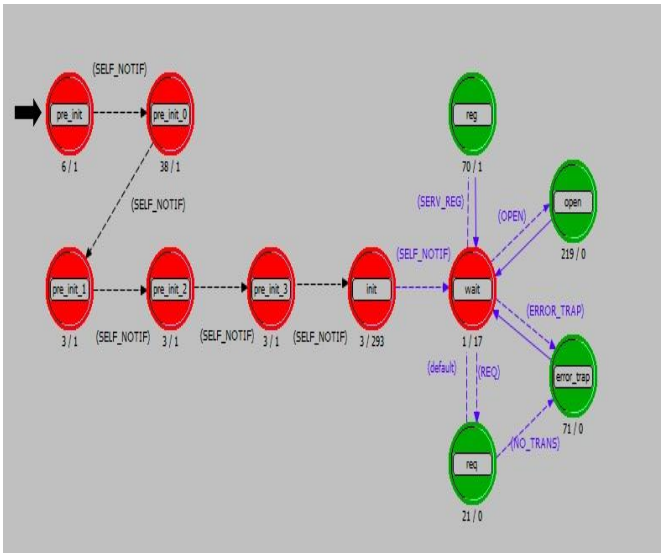

Fig 4 The Process model

3. SIMULATION INFRASTRUCTURE AND SCENARIOS FOR WiMAX NETWORK

3.1 Simulated Test Bed Infrastructure

The test bed infrastructure consists of simulated WiMAX network, which is interconnected with real devices defined as nodes. The network topology of our test bed network is given in Figure. We have created three network models with different number of nodes and base stations. These models consist of a circular placement of nodes in a hexagon pattern

with variable no. of WiMAX Base Stations each consisting 5 mobile Subscriber Stations (SS).

Three Opnet models developed for investigating the performance of WiMAX network resides in a small-scale network of area (1km x 1km). The first scenario consists of 3 base stations and 5 nodes per base station. The second scenario consists of 5 base stations and 5 nodes per base stations. The third scenario consists of 8 base stations, each having 5 nodes as shown in table 1

Table 1 Network model size

Network model	No. of base stations	No. of nodes per base station	Total No. of nodes
Small	3	5	15
Medium	5	5	25
Large	8	5	40

3.2 Simulation Parameter Setup

The Wimax parameters used in the simulation are shown in table 2.

Table 2 WiMAX Parameters

Parameters	**Value**
Simulation speed	182,370 event/sec
Node Position	Circular
Antenna gain(dBi)	-1
PHY profile	Wireless OFDMA 20 MHz
Simulation Time	1000 sec
Seed	128
Value per Statistic	100
BS MAC address	Distance based
Maximum Base station transmission power	0.50W
No. of subscriber stations	15,25,40
MS handover retransmission	30

4. OPNET SIMULATION RESULTS

This paper investigates the performance of WiMAX network using different quality of services (QoS) which are explained below.

4.1 Quality of Service (QoS)

Quality of service (QoS) shows the overall performance of a WiMAX network, seen by the users of that network[8]. To quantitatively measure quality of service, several related aspects of the network service are often considered, such as error rates, bandwidth, throughput, load, transmission delay, availability, jitter, transmission power etc.

4.2 Performance Metrics

The different performance metrics used in the evaluation of simulation represent the different characteristics of the overall WiMAX network performance. We evaluate the following metrics used to study their effect on the overall network performance. These metrics are:

4.2.1 Initial Ranging Activity

Initial Ranging activity is one of the most important processes in the WiMAX standard. Synchronization between a Base Station (BS) and all users within a cell and transmission power adjustments are done using the initial ranging activity.

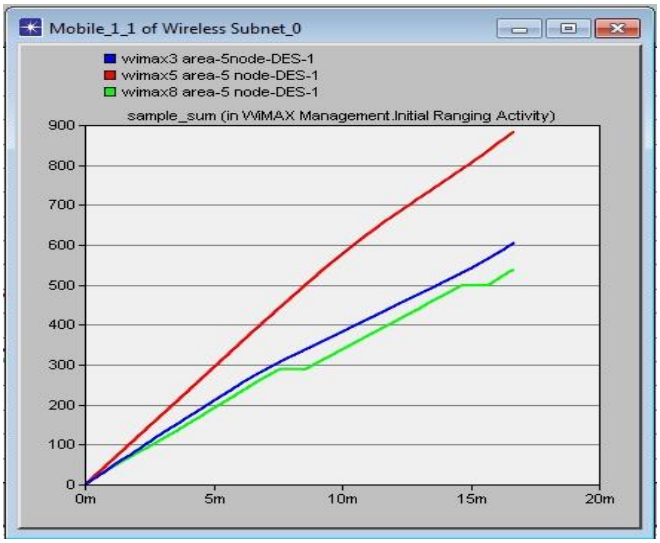

Fig 5 WiMAX management initial ranging activity

As shown in fig 5, initial ranges for small, medium and large networks are 609.1dBm, 889.30dBm and 532.10dBm respectively.

4.2.2 Delay (sec)

The packet end-to-end delay is the time of generation of a packet by the source up to the destination reception. So this is the time that a packet takes to go across the network. This time is expressed in sec. Hence all the delays in the network are called packet end-to-end delay [9].

$$d_{end-end} = N[d_{trans} + d_{prop} + d_{proc}] \quad \text{(i)}$$

Where

$d_{end-end}$ = End to end delay

d_{trans} = Transmission delay

d_{prop} = Propagating delay

d_{proc} = Processing delay

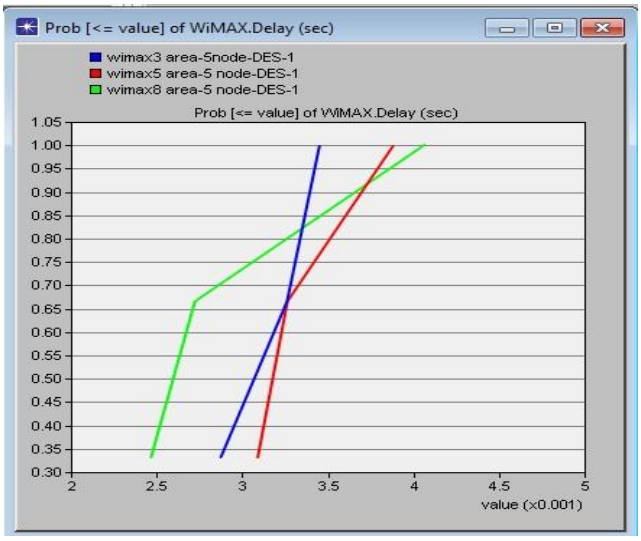

Fig 6. WiMAX delay(sec)

If the size of the topology is small then there is no significant delay but as the number of nodes increases in any particular geographic area then end-to-end delay becomes noticeably higher.

4.2.3 Total Transmission Power

Transmission power gives the total power transmitted from a base station to all of the subscriber stations. As shown in fig 7, total transmission power for small, medium and large network are 89756dBm, 57010dBm and 82000dBm respectively.

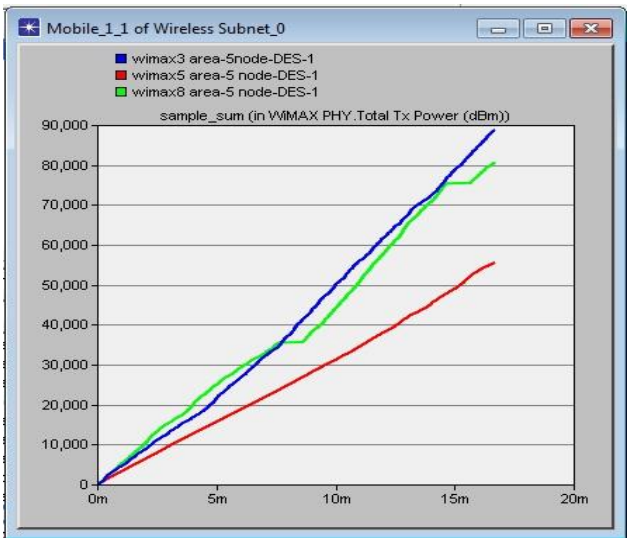

Fig 7 WiMAX PHY total transmission power (dBm).

4.2.4 Neighbor Advertisements Sent

The neighbor advertisement contains information required by nodes to determine the type of neighbor advertisement message, the sender's role on the network, and typically the link-layer address of the sender. As shown in fig 8, neighbor advertisements sent for small, medium and large networks are 1,300,247 bits/sec, 2,460,010 bits/sec and 4,099,000 bits/sec respectively.

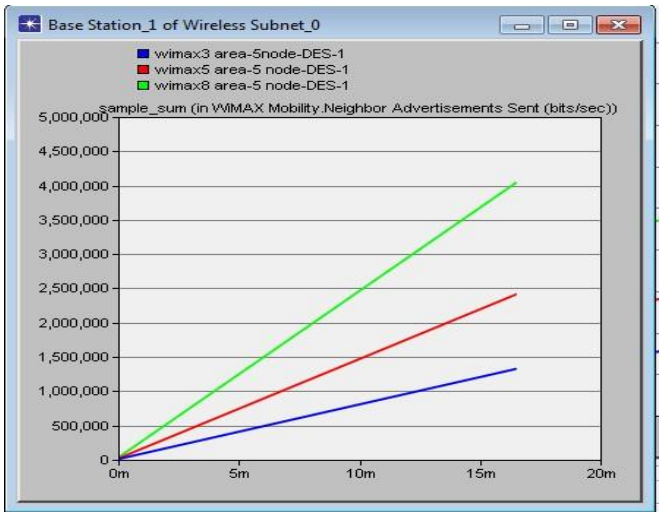

Fig 8 WiMAX mobility neighbor advertisements sent(bits/sec)

4.2.5 PHY Path Loss

The path loss gives the difference (in dB) between the transmitted power and the received power. It represents signal level attenuation caused by free space propagation, reflection, diffraction and scattering. After simulation of 1000 sec. WiMAX PHY path loss values in three models with 802.16 are show in figure 9.

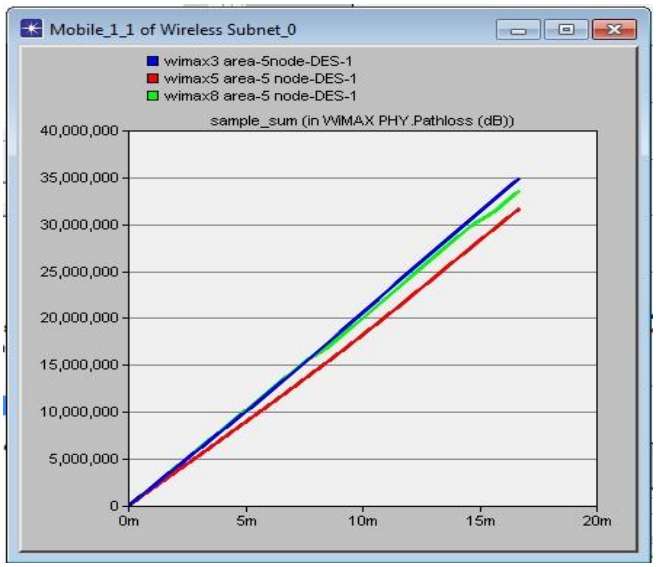

Fig 9 WiMAX PHY path loss (dB)

5. CONCLUSIONS

In this paper various QoS attributes based on the scheduler of IEEE 802.16 are elaborated and compared on three different WiMAX scenarios, showing after simulations the performance of such networks, initial range activity is maximum in medium network with 25 nodes and minimum in large network with 40 nodes. Queuing delay is highest in large geographic area or with large no. of users and lowest in small users' area. WiMAX PHY Path loss and Total transmission power of base stations is lowest in medium network and highest in small network that is with lesser no. of nodes. Neighbor advertisements sent are maximum in densely populated area and minimum in less populated area.

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BIOGRAPHIE

Kamini Jaswal has obtained her Bachelors degree with distinction in Electronics and communication engineering from MDU, Rohtak and presently she is pursuing her M.tech from SIET, Sonepat. Currently, her work focuses on performance of faster growing WiMAX technology.