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RESEARCH ARTICLE

Comparisons of Delay, Load and Throughput in IEEE 802.16/WIMAX by Varying the Network Size

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Abstract

WIMAX is growing like rapid fire. It has become the most famous and competitive technology in the telecommunications industry, which offers variable and high data rate, QoS and seamless mobility in a network. For simulation of various types of wireless networks, a simulation program tool OPNET modeler is available. In this paper, three different WIMAX networks have been taken and evaluated. The modeler was used to study networks with 4, 18 and 30 mobile workstations. The results obtained were helpful in evaluating QoS attributes for WIMAX Network and it has been observed that by increasing the number of mobile nodes for WIMAX Network, an optimized value of QoS parameters could be obtained. Performance parameters denote the quality of services like Delay, Load, and Throughput which has been discussed.

Keywords: Delay, IEEE 802.16, Load, Throughout, WIMAX

Introduction

WIMAX is an acronym for "Worldwide Interoperability for Microwave Access". This wireless technology is based on the IEEE 802.16 standards. The WIMAX technology has been developed by a forum also known as WIMAX forum. WIMAX provides wireless broadband access to large areas and deploys easy and cost efficient services. It is available in many different versions on the basis of data rate such as version 2005, which has lesser data rate than the version that came out in 2011. Orthogonal Frequency Division Multiplexing is supported by WIMAX which is available in two versions as per the technical terminology. One is IEEE 802.16-2004 and the other is IEEE 802.16d. It is based on the adaptive modulation technique in non-line-of-sight (NLOS) environment. WIMAX falls in two major categories, one is FIXED and another one is MOBILE. The main difference between these two is support of Line of Sight (LOS) in fixed type and Non-Line of Sight (NLOS) in the mobile type (Bagoria *et al,* 2013).

Due to the standard of IEEE 802.16a and IEEE 802.16e, WIMAX is lucrative in many ways such as network coverage, frequency reuse, self installation, power consumption and bandwidth efficiency (Dong *et al,* 2009).

According to the WIMAX forum, WIMAX technology has emerged as an alternative for cable and DSL, and there are nearly 133 million WIMAX subscribers/users in the year 2012 (Farzin, 2010).

(Guma and Bilal, 2014) they focused on analysis of important QoS parameters (delay, Packet dropped Ratio (PDR) and throughput) in WIMAX network was done and was analyzed for (3-35) mobile nodes.

(Jakhar *et al,* 2014) this paper has examined cases of different QoS deployment over a WIMAX network and has investigated the capability of a WIMAX network to convey sufficient QoS to voice application.

(Jha *et al,* 2011) according to the author efficient scheduling was explained which is important for WIMAX systems. For Wireless networks like Round Robin, Proportional Fairness (PF) scheme and Integrated Cross-layer scheme (ICL) various algorithms are present on which they were focused. The main emphasis was on the performance of scheduling algorithms for WIMAX networks and they also studied the implementation of some existing scheduling algorithms.

OPNET Modeler

OPNET (Optimized Network Engineering Tool) can be defined as a network simulation package that has an advantage of using Graphical User Interfaces dexterously. OPNET provides performance analysis of computer networks and applications. Through this we can design;

- Network architecture
- Network management
- The traffic profiles

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of a traditional network and sees the effects of these changes (Using OPNET).

OPNET Modeler consists of a series of editors, related to each other in a hierarchical manner which is parallel to the structure of actual networks (Hammoshi and Al- Ani 2010) (Fig.1).

The model structure consists of group of editors as given below:

A. Network Editor (Project Editor)

Network editor is the first editor, also known as Project Editor. It expresses the topology of communication network which consists of node (switch/router, server etc.) and links model (Ethernet, ATM, FDDI etc.) which enables us to maintain networks with unlimited sub network nesting like country, city, building etc. (Hammoshi and Al-Ani 2010).

B. Node Editor

It helps in defining the behavior of each network object which can be described using distinct modules, where models have some internal aspect of node behavior like data creation etc. (Hammoshi and Al-Ani 2010).

C. Process Model Editor

The Process Editor helps in creating process models, which control functionality of the node models created in the Node Editor. (Hammoshi and Al- Ani 2010).

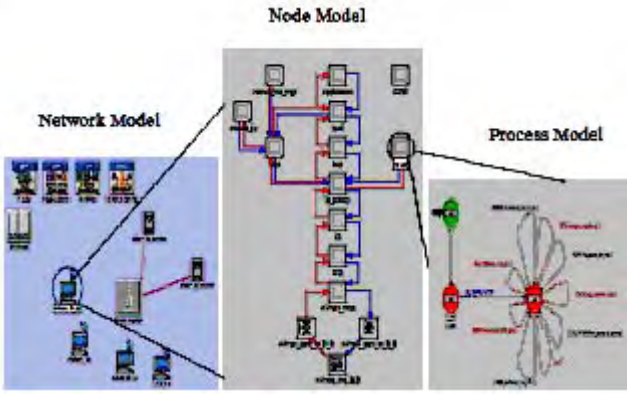

Fig. 1. OPNET Graphic Editors for Network, Node, and Process Models

QoS Service Classes in WIMAX

On the basis of applications and services, there are four main service classes namely UGS, rtPS, nrtPS, BE. Also, there is a service known as: ertPS. All of these services are prioritized in decreasing order. Generally in IEEE; the QoS is decided by the network on its own and also with the help of different objective parameters basically known as QoS parameters which affect the performance of WIMAX. The meaning of QoS is to meet certain requirements like throughput, packet error rate, delay, and jitter etc. (Mehta and Gupta, 2012).

Simulation Model

We have created three network models with different number of nodes and base stations and used different components (Application Config, WIMAX Config, and Profile Config) to configure the performance parameters. The models consist of a circular placement of nodes in a hexagonal pattern where the cell radius is set as 1 km. Each Base Station (BS) is linked to the IP backbone. Subscriber Node and Base Station Transmission Power is set to 0.50 W. The Pathloss and Multipath Model are set to vehicular. The simulation time is taken as 30 minutes. OPNET modeler 14.5 for simulation is used to create these network models.

In Scenario 1, a service area is designed for WIMAX network. A wireless topology (WIMAX) is deployed, and 4 mobile nodes are configured with 2 cells as given in Fig 2. The modulation technique selected is adaptive modulation.

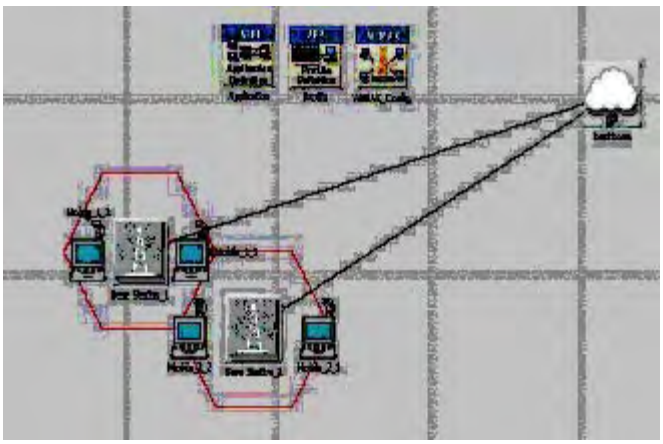

Fig. 2. Scenario 1 WIMAX Network with 2 cells and 4 mobile nodes

In scenario 2, a similar service area is designed but the number of cells and mobile nodes are increased to 6 cells with 18 mobile nodes as given in Fig 3.

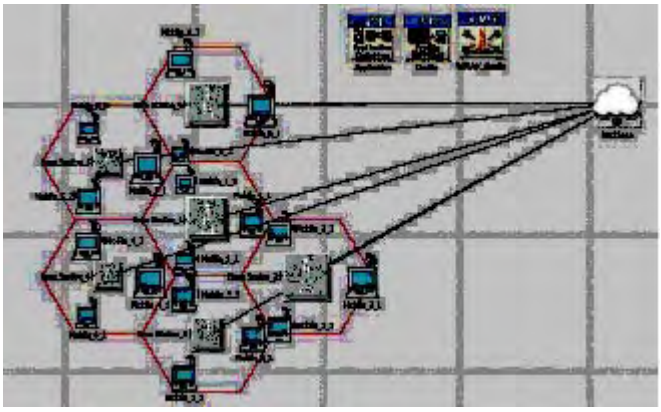

Fig. 3. Scenario 2 WIMAX Network with 2 cells and 18 mobile nodes

Scenario 3 provides a wireless network with the same parameters and 30 mobile nodes are randomly selected for 6 cells as given in Fig 4. Similar modulation technique is used like in scenario 1.

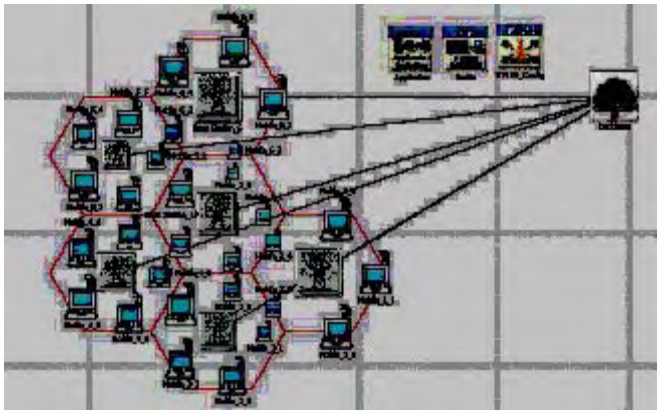

Fig. 4. Scenario 3 WIMAX Network with 6 cells and 30 mobile nodes

Simulation Parameter Setup

In Table 1 and Table 2, the parameters of Subscriber Station and Base Station are shown respectively.

Table 1. Subscriber Station Parameters

Parameters	Value
Antenna Gain (dBi)	-1 dBi
Type of SAP	IP
Jvlatch Value	Interactive Voiced6)
Serv ice das s Name	Gold
Modulation and Coding	Adaptive
Max Transmission Power	0.5 W
PHY Pro file	Wireles s OFDMA 2 0 MHZ
PHY Profile Type	OFDM
Multipath Channel Mode	ITTJ Pedestrian A
Pathloss Model	Vehicular Emifonrnaits
Terrain Type	Terrain Type A

Table 2. Base Station Parameters

Farameia-s	**Value**
Antenna Gain'dBi)	**15 dBi**
Match Value	**Interactive Voiced6)**
Service Class Name	**Gold**
Modulation and Coding	**Adaptive**
Max Transmission Po'.ver	**0.5 W**
PHY Profile	**Wireless OFDMA20MHZ**
PHY Profile Type	**OFDM**
Perm Has e	**3**

Simulation Results and Discussion

This paper investigates the performance of WIMAX network using different quality of services (QoS) which are explained below (Jaswal *et al,* 2014).

A. Quality of service (QoS)

Quality of service (QoS) represents the whole performance of a WIMAX network, witness by the users of that network. To evaluate the quality of service, various related aspects of the network service are often considered, for example error rates, bandwidth, throughput, load, transmission delay, availability, jitter, transmission power etc. (Jaswal *et al,* 2014).

B. Performance Parameters

The performance parameters are used to analyze simulation which represents the characteristic of the overall WIMAX network performance. These attributes are (Jaswal *et al,* 2014):

1) *Delay:* It denotes the end-to-end delay (in terms of sec.) of all packets received by the WIMAX MACs of all WIMAX nodes in the network and is forwarded to the upper layer.

   As observed from the results, the maximum delay is 0.01744(sec.) in scenario 1, when the mobile nodes are less. In scenario 2, with the increase in number of mobile nodes to 18, the maximum delay also increases to 0.01956 (sec.). Scenario 3 exhibit the maximum delay of about 0.01984 (sec.) as there is increase in mobile nodes to 30 which is maximum number of mobile nodes in the analysis. From the above results the inference can be drawn that the average value of delay increases when the number of mobile nodes increases as depicted in Fig 5.

2) *Load:* Load is used to denote the total load (in terms of packets/sec) which is submitted to WIMAX layers by all higher layers of the WIMAX nodes of the network.

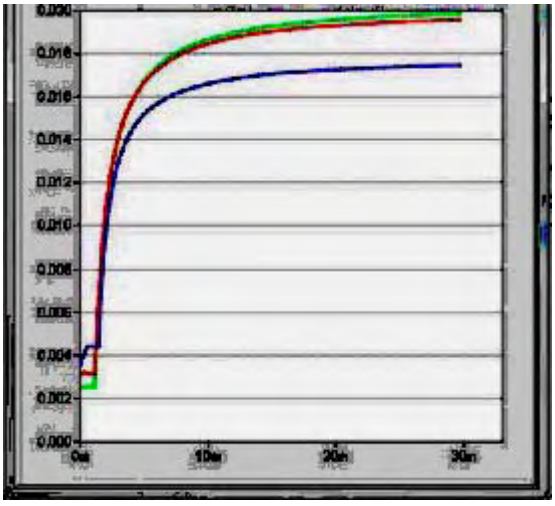

Fig. 5. WIMAX Delay (sec)

As observed from the results, in scenario 1, which has comparatively less number of mobile nodes, the maximum load is 1119.74 (Packets/sec) .In scenarios 2, when the number of mobile nodes increases to 18, the maximum delay also increases to 3493.33 (Packets/sec).Scenario 3 exhibit the maximum delay of about 5956.09 (Packets/sec) with an increase in mobile nodes to 30 which is maximum number of mobile nodes. From the above results, it is analyzed that the average value of load increases when the number of mobile nodes increases as observed in Fig 6.

3) *Throughput:* It denotes the total data traffic (in packets/sec) forwarded from WIMAX layers to higher layers in all WIMAX nodes of the network.

The value of throughput should be high. In scenario 1, when the mobile nodes are low, the average throughput is minimum that is 874.86 (Packet/second). For scenario 2, the average throughput increases to 1,585.69 (Packet / second). Scenario 3 presents the highest value of average throughput of about 2,176.23 (Packet /second) because it contains the largest number of mobile nodes as depicted in Fig. 7. The results show that one of the major advantages of WIMAX network is that the average throughput increases with the increase in the number of mobile nodes.

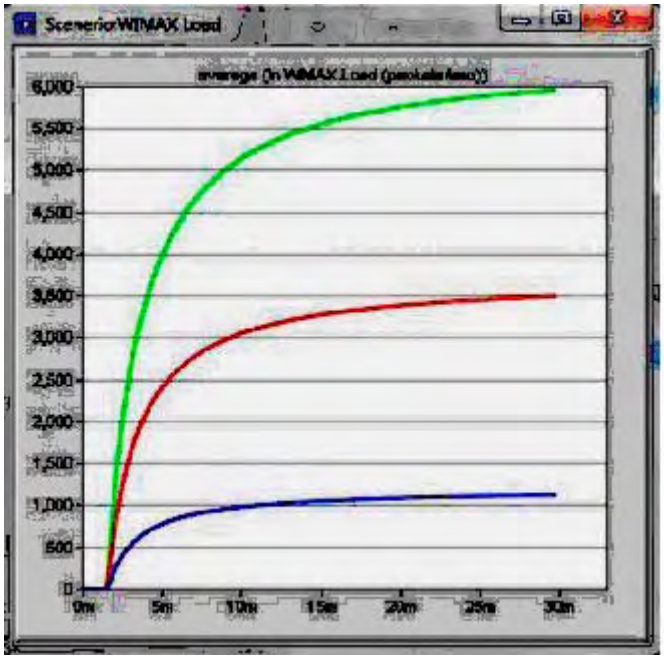

Fig. 6. WIMAX Load (Packets/Sec)

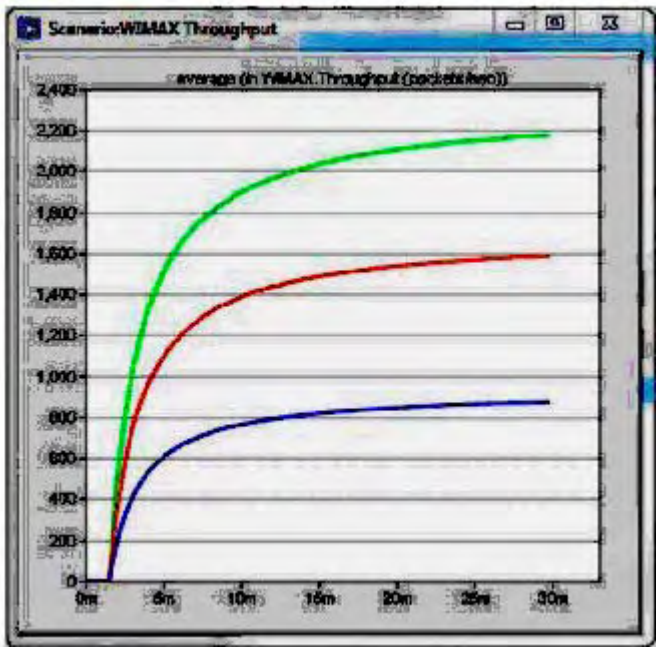

Fig. 7. WIMAX Throughput (Packets/Sec)

Conclusion

In this paper, various performance parameters of QoS such as Delay, Load and Throughput, are analyzed on different WIMAX scenarios. These parameters play an important role for any WIMAX or any broadband wireless communication to satisfy the needs of the users. With the help of the observations obtained from different WIMAX scenarios, it was found that as the no. of mobile nodes increases, the value of QoS parameters (load, delay and throughput) also increases and by increasing the number of mobile nodes for WIMAX Network, an optimized value of QoS parameters is obtained.

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