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PERFORMANCE EVALUATION OF A CELL SITE IN CELLULAR NETWORKS USING WIMAX TECHNOLOGY

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Abstract

For the past few years, the scope of optimization techniques has been widened at a rapid rate in order to unravel a variety of design problems in cellular networks, with a clear vision to save cost as well as to improve the quality of the overall network. In real life scenario, we have varying geographic locations to set up a cellular network that include sparse as well as dense populated areas. WiMAX (Worldwide Interoperability for Microwave Access) is a cell-based technology specified by the IEEE 802.16 standard that supports quality of service (QoS) mechanisms and enables high-quality levels of applications such as VoIP. In this research paper, we have highlighted the results obtained through simulation carried out on OPNET modeler to deduce that IEEE 802.16 networks perform differently for different network traffic, number of mobile nodes, distance from base station and mobile speed. The measured performance metrics like throughput, delay etc will positively lend us a hand while implementing WiMAX for developed urban areas like suburbs of Punjab.

Index Terms - *Cell Site, Cellular Network, Geographic Location, WiMAX.*

1. Introduction

The development of newer generations of technology and increase in user mobility has created the need and demand for wireless networks that are generally implemented with some type of information transmission system by making use of electromagnetic waves, such as radio waves. During the past few years, there has been an unprecedented growth in the number of wireless users, applications, and network access technologies. Typical mobile users, nowadays, have access to various types of wireless networks that may be cellular networks, wireless local area networks (WLAN), metropolitan area networks (MAN), home networks, or even mobile ad-hoc networks.

In a cellular network, a high-capacity mobile system is assigned radio spectrum which is divided into discrete channels that are assigned in groups covering a cellular geographic service area. These cellular networks consist of mobile units linked via a radio network to an infrastructure of switching equipment interconnecting the different parts of the system and allowing access to the wired (fixed) Public Switched Telephone Network (PSTN). In such a cell-based wireless network, a geographic area is partitioned into zones called cells. Each cell has the equipment to switch, transmit and receive calls from any subscriber located within the borders of its radio coverage area. If cells were not used, the transmitter would need to use very high power to cover a large area. Using cells means that the area covered by a single transmitter is reduced, thereby reducing the need for high powered transmission. The cell shape is determined by the nature of the surrounding area, for example hills, tall buildings etc, and the pattern become more complex as the number of cells in the system increases. The number of cells in any geographic area is determined by the number of mobile subscribers who will be operating in that area and the geographic layout of the area (hills, lakes, buildings, etc).

A regular hexagon is chosen to represent a cell because it covers a larger area with the same centre-to-vertex distance (or radius) compared to a square or an equilateral triangle. Consequently,

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fewer hexagonal cells are required to cover a given geographical area. The cells are grouped into clusters. The entire block of frequencies is completely allocated to each cluster and the cells in each cluster use different frequencies. In this way, the limited block of frequency spectrum is reused.

2. Need of the Study

As the technology advances, the demand for better and faster communication systems also increases. Several schemes [2] for radio resource management have been proposed so far to make the efficient use of various geographic locations for cell sites [1]. Major implementation obstacle, which prevents a wide deployment of cellular location techniques, is the requirement of modifications of the existing network infrastructures. In many instances, a subscriber may not be able to complete a call due to limitations in topography (the surroundings), capacity (how many callers are communicating with the same cell site at a given time), and network architecture (where antennas are located).

Despite a significant amount of research on the cell site location problem, there are still unresolved aspects regarding applicable positioning solutions providing estimation accuracy. Typically, existing positioning solutions for cellular networks provide accurate location estimates, however, at the cost of a significant increase of network and terminal complexity. Therefore, need of the hour is to select the optimal cell site by providing better resource management schemes, which include channel assignment, power control, handoff control, call admission control, and continuous provision for uninterrupted service with multiple traffic types. There are many issues that must be addressed to ensure the maximum performance while choosing a cell site location [4] that include the terrain in our surrounding area, gain requirements, electrical type, ground plane availability, mounting style and placement, physical size, appearance, and surrounding environment. The aim is to design a feasible cell based network that incorporates both the urban and non-urban landscapes with optimal utilization of the resources.

3. Historical Perspective

While planning a cellular system, the aim is to create a communication network that fulfills various requirements such as high frequency, efficiency, low cost, high grade of service, and improved capacity. It should provide maximum coverage in the middle of the town and minimum coverage at the town edges. There are many aspects that need to be considered while selecting a cell site location that includes the distance of the cell site from the state, national highway, high security zones, railway lines, airport etc.

The cell site selection process begins with traffic and coverage analysis that should produce information about the geographical area including population distribution, land usage data, cost of mobile stations, automobile usage distribution etc. Design of cell sites depend upon amount of radio bandwidth available [5] [7], services provided, and number of customers in an area. Based on these data, the designs determine size and location of cells so that radio channels can be reused in the cells. Several different designs of cellular networks exist [3].

Chung Chi Yeh has proposed that the time-varying population of each cell demonstrates the macro moving behavior of overall users in its cell [10]. This approach does not guarantee the network ability to ensure the availability of the service in the entire service area. The dimensioning exercise [6] is to identify the equipment and the network type required to provide coverage and quality. The more accurate the dimensioning is, the more efficient will be network rollout. In practice, network rollout very closely follows the output of network dimensioning or planning [8]. The question still remains to provide very realistic and accurate dimensioning for each cell site.

Ribeiro and Leila Zurba tried to achieve fairness in cellular networks and to design a cellular network that has a high survivability [9]. Still there are some issues that remain unanswered such as an economical network implementation when the service is established.

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4. Technology Used: WiMAX (Worldwide Interoperability for Microwave Access)

WiMAX plays an imperative role in both emerging markets as well as mature markets that enables continuous connectivity and offers wide coverage as shown in Figure 1. Once the 802.16-2004 standard (Air Interface for Fixed Broadband Wireless Access Systems) was inclusive, the IEEE committee set in motion to work further in order to evolve the standard to support mobile applications. The new 802.16e-2005 standard (Air Interface for Fixed *and Mobile* Broadband Wireless Access Systems) was concluded in December 2005 which is often referred to as *mobile WiMAX*. With WiMAX support of multiple antennas at a single base station, the coverage of a single base station can reach tens of kilometers and the data throughput can increase by four times to tens of Mbytes/sec, compared to only a few Mbytes/sec using the most advanced cellular 3.5G technologies.

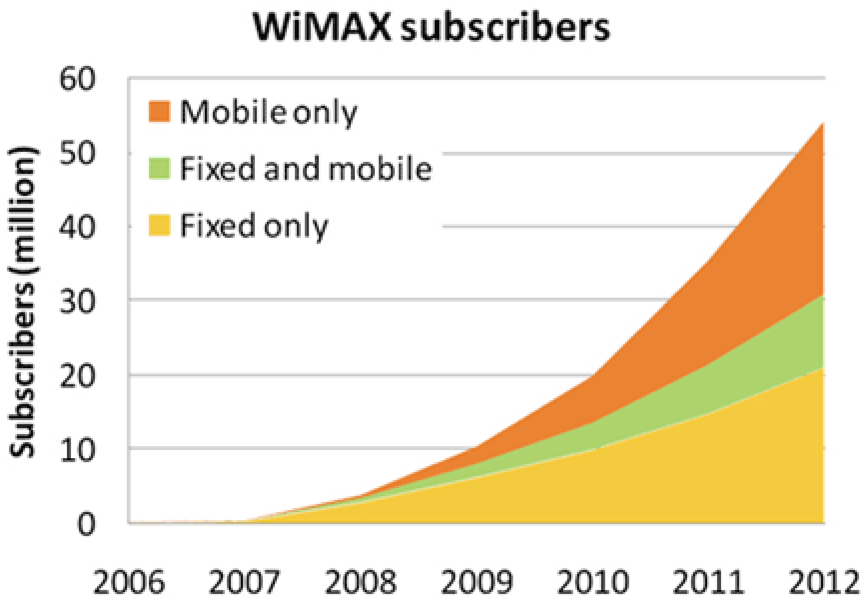

Fig 1 WiMAX subscribers forecast

There are more than 262 WiMAX operators covered in 91 countries. Many companies, from large communications equipment companies to smaller companies, are involved in developing and manufacturing WiMAX. Asia Pacific accounted for 26% of deployments, Europe 34%, the Middle East 16%, North America 11%, and the Caribbean and Latin America for 13%. Although these growth numbers are quite good for a new technology, they have a long way to go to catch up to the 3 billion subscribers currently using mobile cellular service. WiMAX as a leading broadband technology is opening to make its niche in this market. At the end of 2007, there were 1,650,000 WiMAX subscribers; currently WiMAX subscribers are estimated at 1.9 million.

5. Simulation Scenario

5.1 Simulation Software

The software used in this study is OPNET Modeler. OPNET is a network and application management software designed and distributed by OPNET Technologies Inc. Among other things OPNET Technologies Inc. model communication devices, technologies, protocols, and architectures, and provide simulation of their performance in a dynamic virtual network environment.

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5.2 Simulation Model

We design network model where a particular geographic location has been divided into various cells of hexagonal shape. WiMax performance measurement for the following three simulations were performed:

- Varying number of mobile nodes.
- Placement of mobile nodes at varying distances.
- Mobile nodes with varying speeds.

The various parameters used during simulation are described below:

Initial Parameters	Value
Total Number of Cell(s)	1
Total Number of Base Stations	1
Number of subscribers in each Cell	Varying
Radius of Cell	500 metre
X and Y dimensions	Varying
Simulation Time	3600 seconds
Seed Value	128
Data Rate	11 Mbps
Default Power	0.005 watts
Source Nodes	Varying
Destination Nodes	Varying
Traffic Pattern	TCP agent with FTP traffic
Interface Type	OFDM
Channel Type	Wireless Channel

Table 1: Wireless node and topology parameters

6. Performance Metrics

The different performances 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:

6.1 Delay

The packet end-to-end delay is the average time that packets take to traverse the network. This is the time from the generation of the packet by the sender up to their reception at the destination's application layer and is expressed in seconds.

6.2 Load

Represents the total load (in bits/sec) transmitted on the network.

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6.3 Throughput

The ratio of the total amount of data that reaches a receiver from a sender to the time it takes for the receiver to get the last packet is referred to as throughput. It is expressed in bits per second or packets per second.

7. Performance Analysis

In this research paper, we have presented three simulation scenarios, where scenario 1 depicts the performance of WiMAX cell when the number of mobile nodes was increasing; scenario 2 represents the measurement of WiMAX performance over different distances of WiMAX subscriber stations from the base station and finally scenario 3 portrays the effects of mobility on WiMAX network by taking into account the speed of the node as an independent variable. All these simulations have been successfully performed on OPNET modeler.

Scenario 1: By making use of TCP/FTP traffic for WiMAX networks, we have described six varying cases with 50, 100, 20, 150, 300 and 200 mobile nodes. The end-to-end delay for TCP/FTP traffic has been shown in the Figure 2 which concludes that delay time increases as the topology grows bigger and bigger.

Scenario 2: Different test cases have been examined when 300 mobile nodes are placed at different distances from the base station. The different distance schemes followed are 500, 400, 300, 200 and 100 meters. It is observed from the results shown in Figure 3, that the performance graph is almost constant regardless of the distance of mobile node from base station until that node is situated within the coverage area or zone.

Scenario 3: This scenario determines the effects of node’s speed on the network performance and for this we have used different test cases for speed as 10, 50 100,150 and 200 m/s to provide the results for end-to-end delay as shown in Figure 4.

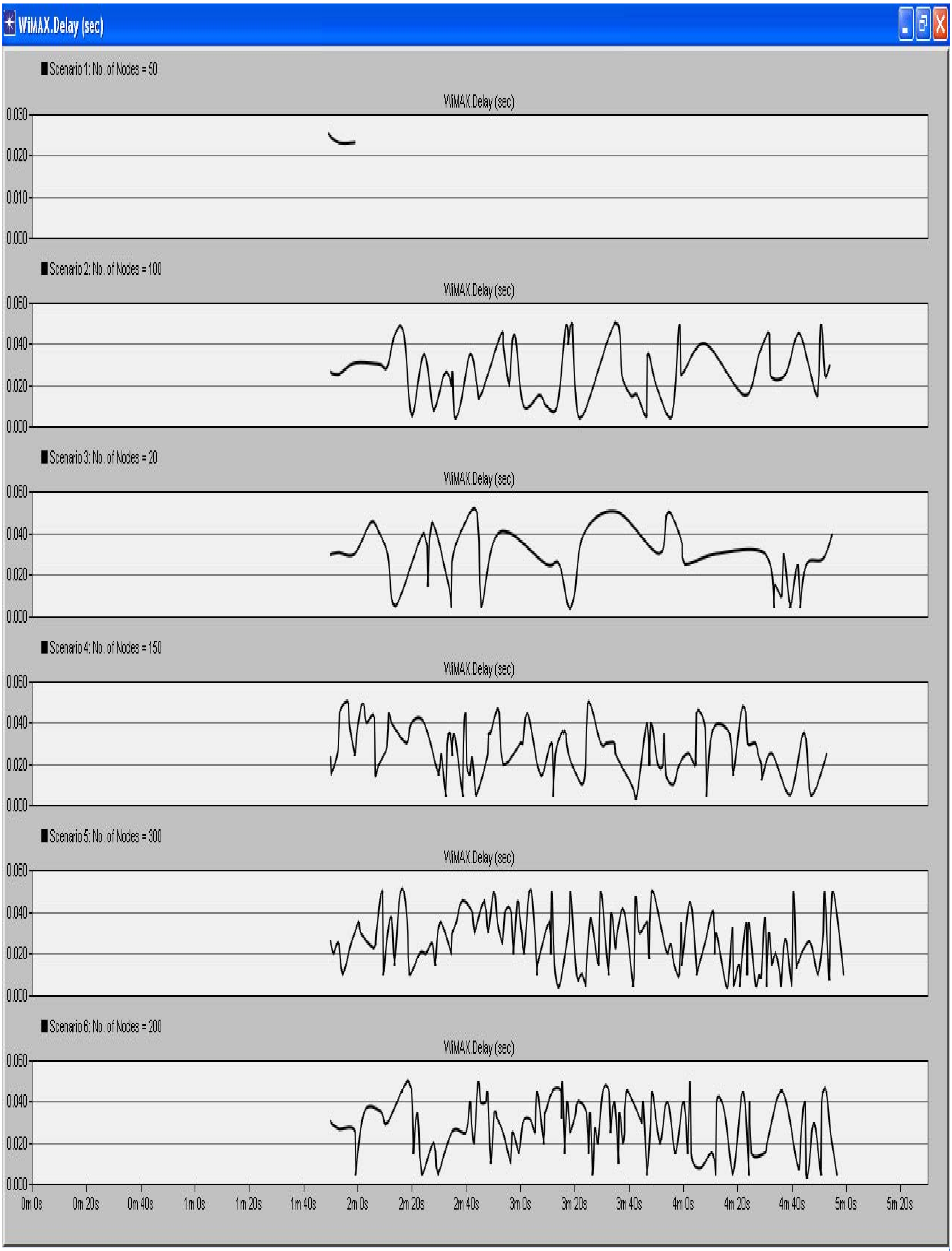

Fig. 2 Number of nodes vs end-to-end Delay

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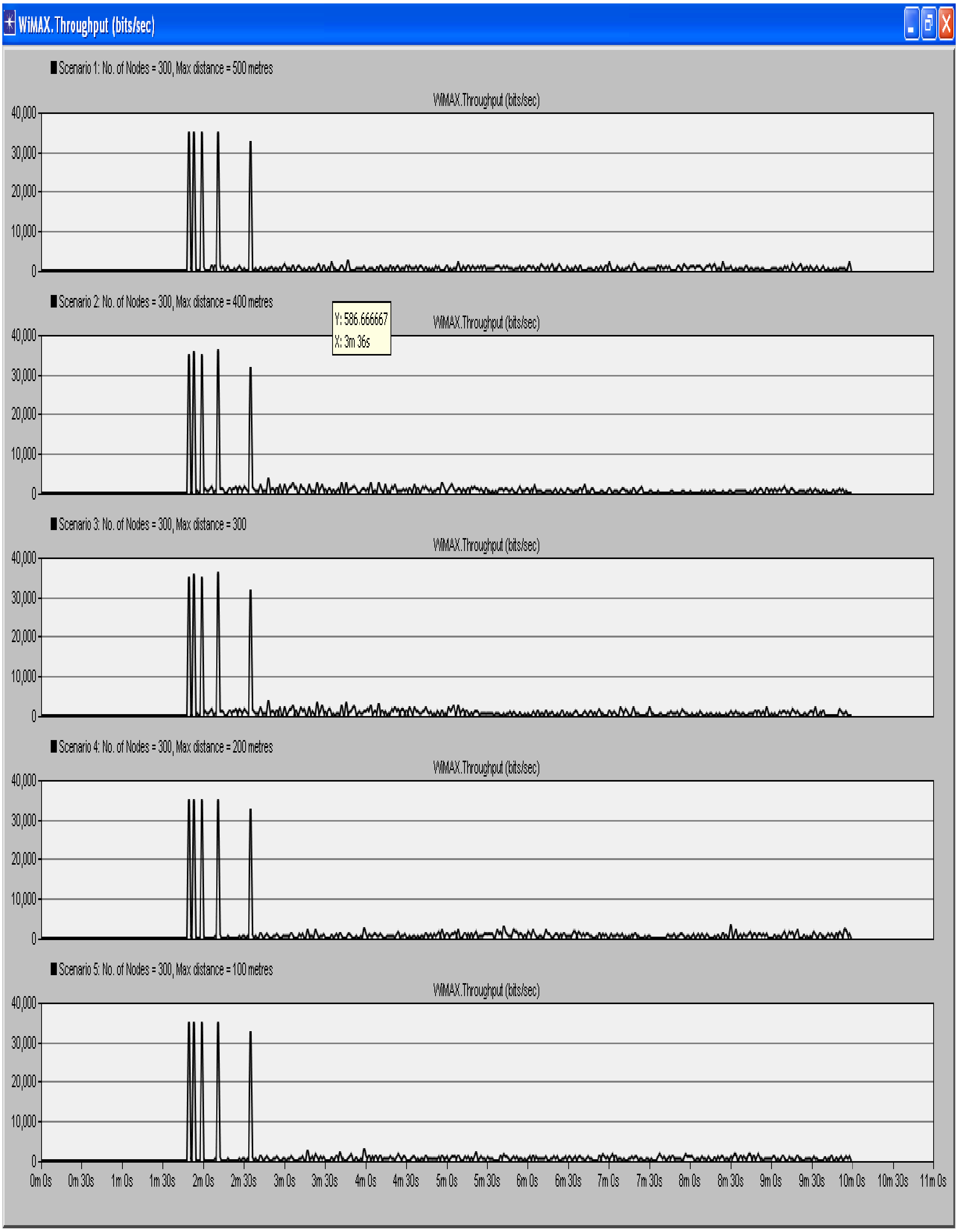

Fig. 3 Distance of mobile node from base station vs Throughput

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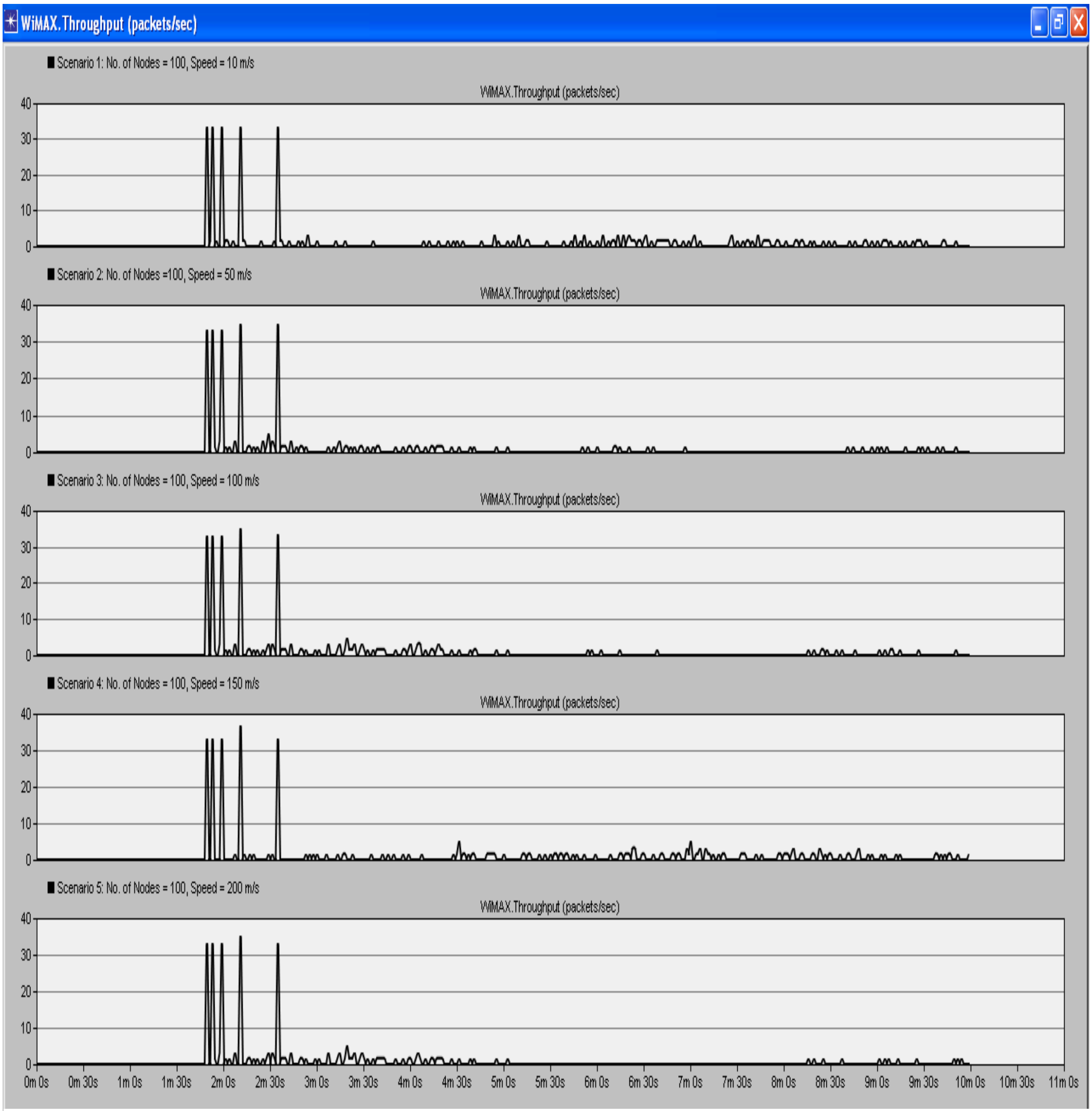

Fig. 4 Speed of mobile node vs end-to-end Delay

8. Conclusions

This research paper lends us a hand to conclude that 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. Significant loss in throughput occurs if a mobile node is placed at a distance greater than 500 meters (maximum coverage range of a cell used in simulation). Finally it is concluded that the varying speed of the mobile nodes does not affect the network performance until they lie within the coverage range but the same speed factor affects the network performance greatly, once the handover concept is involved. This research can auxiliary be enhanced to the UDP traffic applicable for WiMAX network to be deployed in urban areas. The network performance can further be improved with proper changes made to the positioning of cell in varying geographic locations, i.e. the location for base station can be chosen optimally in such a manner so as to achieve better solution techniques.

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