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Research Paper
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Performance Evaluation of Voice over Internet Protocol in WiMAX Access Network System

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Abstract — Wireless networks are growing day by day due to the increased demand of using it, so it has become very necessary to improve the quality of service (QoS). The aim of this paper is to study QoS of voice over internet protocol (VOIP) over WiMAX for fixed and mobile WiMAX networks in different power ranges. The basic parameters of QoS which were studied in this paper are the end to end delay , throughput and jitter. Different scenarios were created using computer simulator to evaluate the performance, the study used different numbers of nodes, for three and five cell. The analysis of the results shows that WiMAX networks give a high efficiency using both fixed and mobile nodes for all studied parameters. The influence of transmitter power on the results of end to end delay is approximately not noticed when cells number and mobile nodes increased. The results achieved the required goal of the study.

Keywords— WiMax; QoS; Delay; Throughput; Jitter

I. INTRODUCTION

Wireless communication is highly demand in many applications therefore to meet this demand a lot of efforts have been done recently to enhance the quality of service QoS [1]. Delays and jitter are the most factors that appears into the data transmission over internet protocol which led to use the concept of QoS.[2]. Basically there are two categories of WiMAX ; the fixed standard which based on IEEE 802.16d-2004 and mobile standard based on IEEE 802.16e-2005 [3]. The major layer in the structure of WiMAX system is MAC layer. WiMAX has the advantage of enabling connection for large numbers of users for each terminal [4,5].

There are four layer defined in the IEEE 802.16 structure[6[Convergence, MAC, transmission and physical Most of papers are often studied the QoS in either fixed or Mobile nodes ignoring the effect of transmitter power. In this paper we have been considered all these items together in different scenarios to evaluate the QoS for WIMAX network.. The objective of the proposed study is to evaluate the performance of voice over IP over WiMAX by using OPNET software.

II. RELATED WORKS

Recently there are many studies focusing on performance evaluation of VOIP in WiMAX network.Table.1 illustrates some of these works and provides general description of each paper. The novelty of this study comes in the term of studying the influence of the transmitter power on the overall performance parameters in addition of modeling various situations of the WIMAX networks.

Table.1. Summary of related works

Author	Year	Description
Awad [7]	**2015**	Study the performance of VOIP ,the results were only for delay time ,it doesn't refers to effects of power on the QoS parameters
Ojasvichhaniwal [8]	2015	Used NS2 to create WiMAX network with different routing protocols like DSDV, MADV and AODV with different number of node
Jalendry [9]	2015	Study VoIP in WiMax network with different codes (G.711, G.722, G.723, G.726, G.727, G.728, G.729) OPNET modeler 16.0.A was selected as the simulation tool
Mishra [10]	2015	Provides a general simulation to estimate the performance of WIMAX for supporting VOIP traffic using OPNET modeler ,they made comparison between QoS classes BE, ERTPS, NRPTS, RTPS, optimized ERTPS

III. METHODOLOGY

The performance of VOIP over WIMAX networks was planned and designed by OPNET software. Different scenarios have been assumed to evaluate the performance; the study used different types of nodes (mobile & fixed) using different numbers of nodes (5-10-15) for three and five cells, and the power (0.5-1),W, during 30 minutes. The delay of a network is the time that packet takes to travel from one node to another in the network. Delay should be within acceptable range not more few milliseconds. Delay can be calculated mathematically by:

$$Delay = \left[\sum_{t_n}^{t_n+1} DT - \sum_{t_n}^{t_n+1} \Delta T \right] / \sum_{t_n}^{t_n+1} RP \qquad (1)$$

Where : DT = Delivery time
AT = Arrival time
RP = Received packet

Arrival time is the time that the packet required to be received . Delivery time is the time of delivering the packet to the destination node. Received packets are the total number of packets received between the start time, t_n of frame n and the start time, t_{n+1} of the next frame . Throughput is the average data rate of successful message delivery over a communication channel.

$$Throughput = [\text{Number of } DP \times P_{size} \times 8] / T \qquad (2)$$

Where: DP = delivered packet,
T =Total simulation time
P_{size} packet size

Jitter: is a represents the changes of the packet over time across a network.it can be given by:

$$Jitter = \sum_{i} (PA_{i+1} - PS_{i+1}) - (PA_i - PS_i) / n-1 \qquad (3)$$

Where : PA= the packet arrival
PS = packet starts

The mathematical model where created and simulated in computer model using flowchart shown in Figure1.

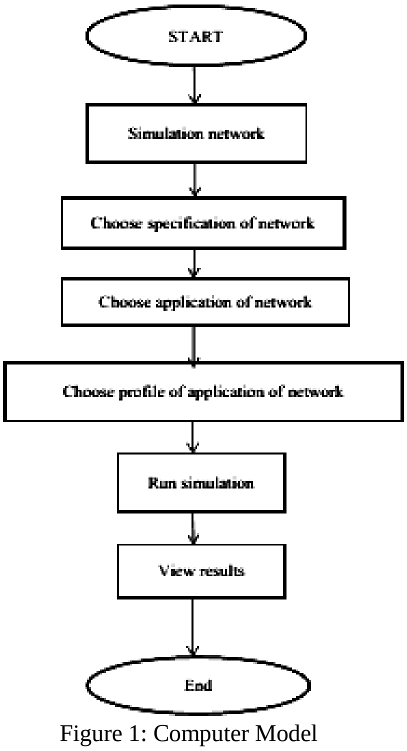

Figure 1: Computer Model

IV. Simulation Models

This paper study the performance via different scenarios in each case the parameters of QoS such as delay ,throughput and jitter were shown. The parameters which have been taken in to consideration of evaluation of QoS of WIMAX network were shown in table .2.

Table 2. Basic Parameters

Parameter	Type
Type of WIMAX Network	Fixed ,mobility
Application	VoIP
Nodes	5,10 and 15
Simulation time	1 hour
Number of cell	3 OR 5
Coding	G7.23
Transmitted Power	0.5W OR 1.0W

A) Mobile Nodes Models

The first scnerio up to six scenario were caried out to study the QoS of wimax network assuming mobile nodes.The first scenario as shown in Figure2 assumed three cells with 15 mobile nodes with power 0.5 watt.

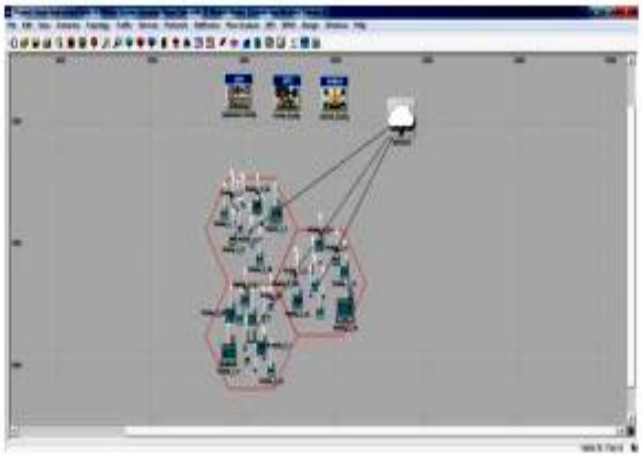

Figure 2: First scenario

The second scenario assumed three cells with 10 mobile nodes with power 0.5 watt.

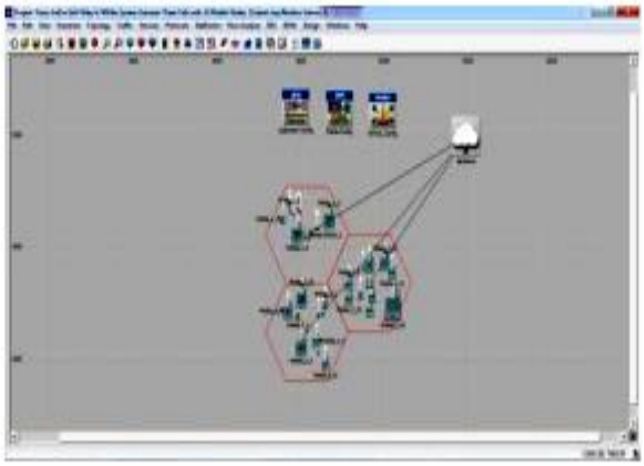

Figure 3: Second scenario

The third scenario as shown in Fig.4 three cells with five mobile nodes with power 0.5 watt, next scenario change the power to 1 watt.

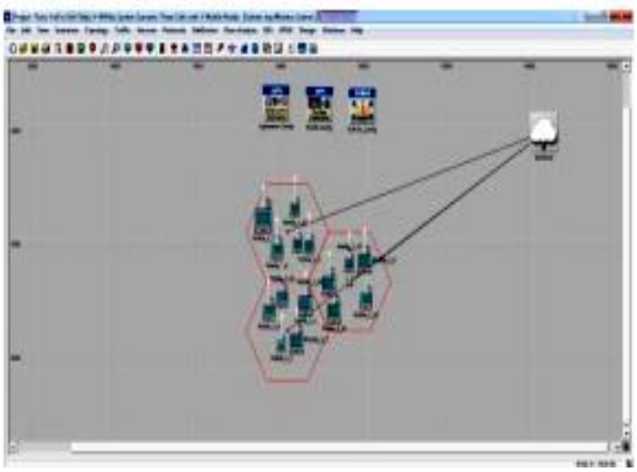

Figure 4: Scenario Three

Scenario four as shown in Figure 5 assumed five cells with 15 mobile nodes with power 0.5 watt, next scenario change the power to 1 watt.

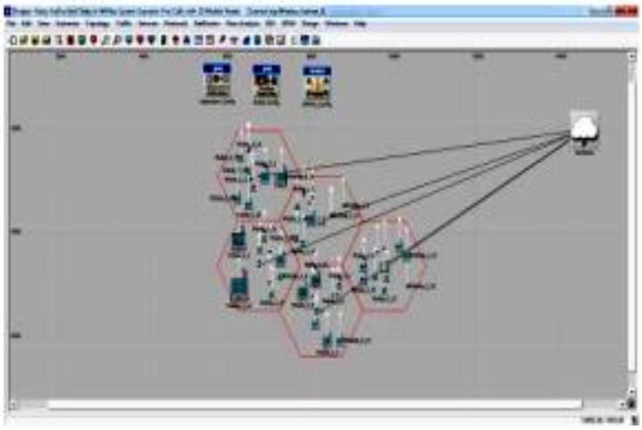

Figure 5: Scenario four

Scenario five as shown in fig.6. assumed five cells with ten mobile nodes and power of 0.5 watt.

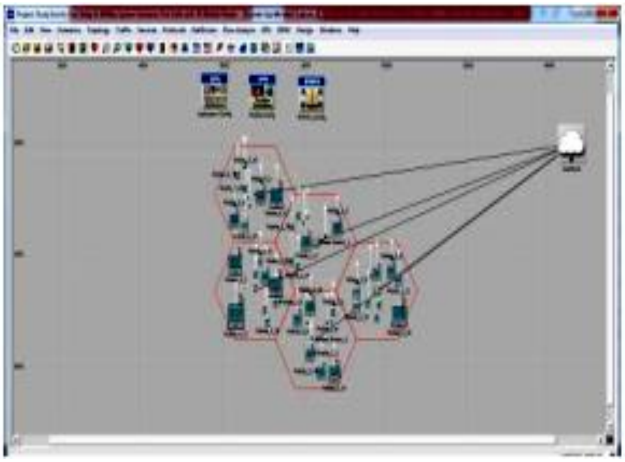

Figure 6: Scenario Five

Scenario six as shown in Fig.7 assumed five cells with five mobile nodes and power 0.5 watt. This scenario environment was examined by change the power to 1 watt.

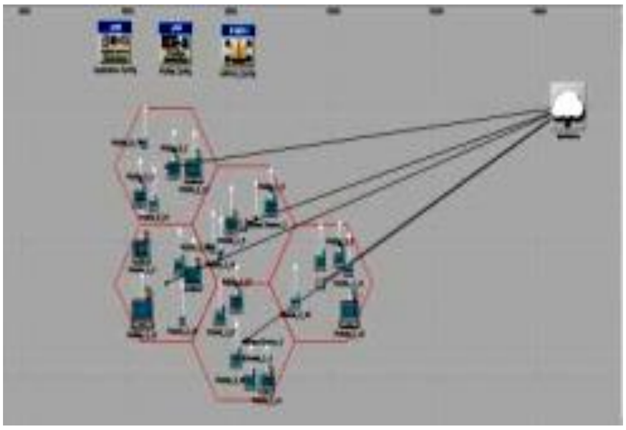

Figure 7: Scenario six

B) Fixed Nodes Models

Starts from scenario seven up to scenario number 13 were caried out to study the QoS of wimax network assuming Fixed nodes. Figure.8. illustrates the model of scenario seven which assumed three cells with 15 fixed nodes for transmitter power of 0.5 watt, this scenario also examined by changing the power to 1 watt.

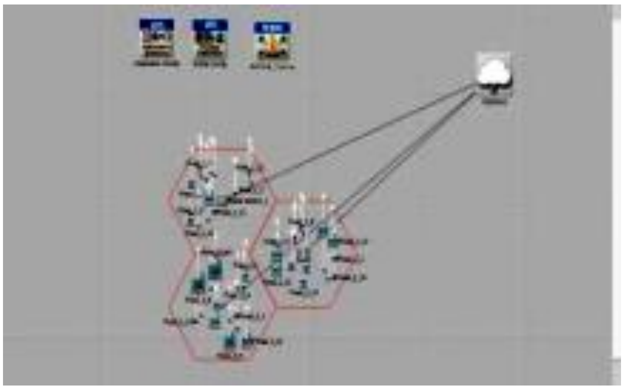

Figure 8: Scenario seven

Figure.9 illustraes the model design of scenario eight which assumed three cells with ten fixed nodes with power 0.5 watt, next scenario change the power to 1 watt.

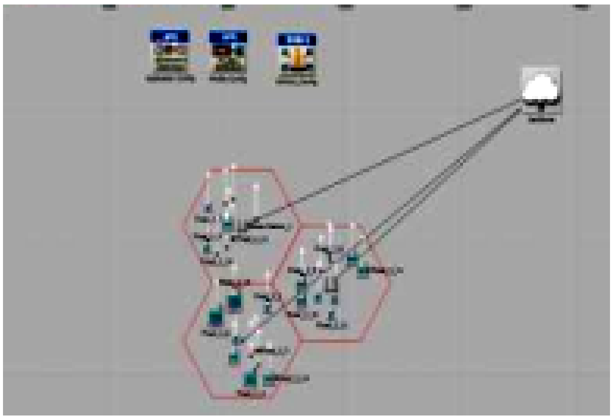

Figure 9: Scenario eight

Figure.10 shows the model design of scenario nine which assumed three cells with 5 fixed nodes with power 0.5 watt,

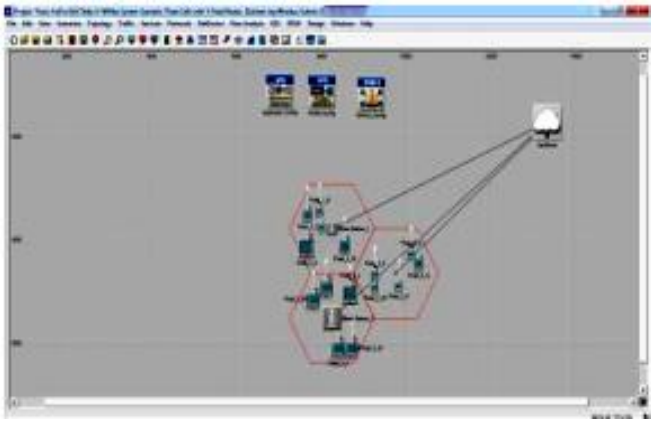

Figure 10: Scenario nine

The computer model design of scenario ten is shown in Figure11. in this scenario five cells have been created. It contained fifteen fixed nodes with power 0.5 watt, the same model environment on this scenario was tested by changing the power to 1 watt.

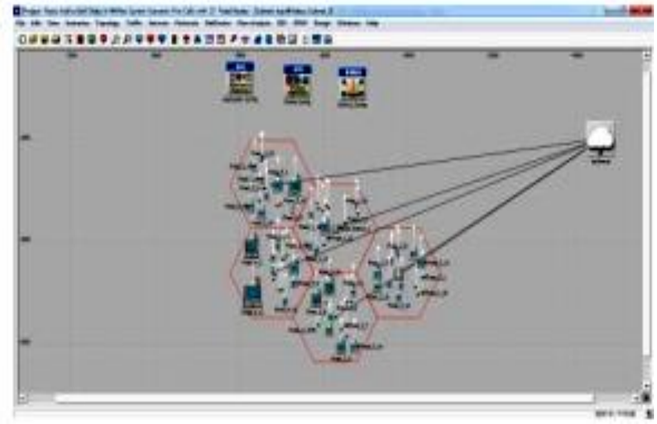

Figure 11: Scnerio ten

Figure 12 shows scenario number eleven used five cells with 10 fixed nodes with power 0.5 watt,

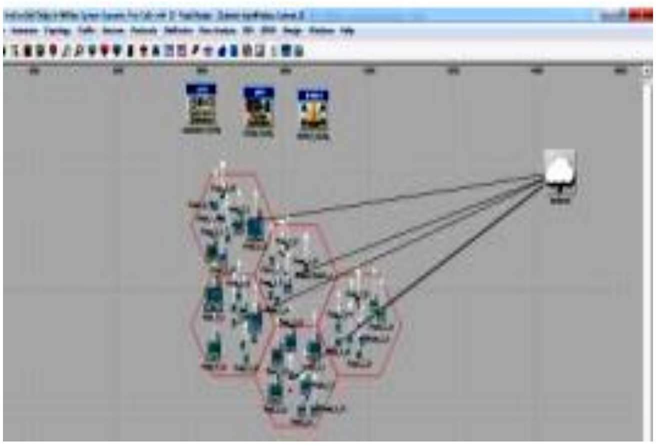

Figure 12: Scenario eleven

Scenario number twelve is shown in Fig.13.It used five cells with ten fixed nodes with power 0.5 watt. The scenario was also studied by changing the power to 1 watt.

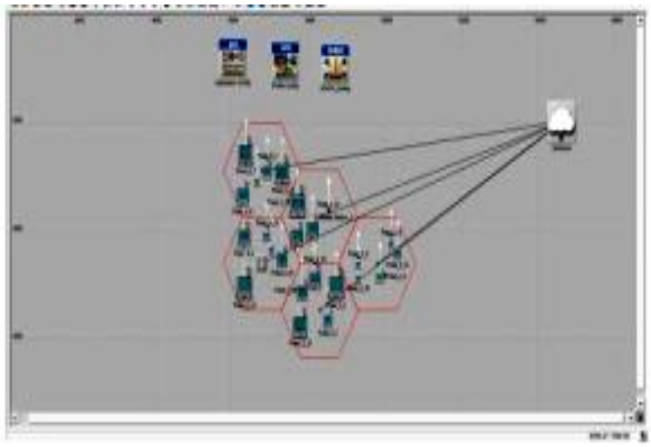

Figure 13:Scenario twelve

Scenario thirteen as shown in Figure14. used five cells with five fixed nodes with power 0.5 watt . the model design environment of this scenario studied by changing the power to 1 watt.

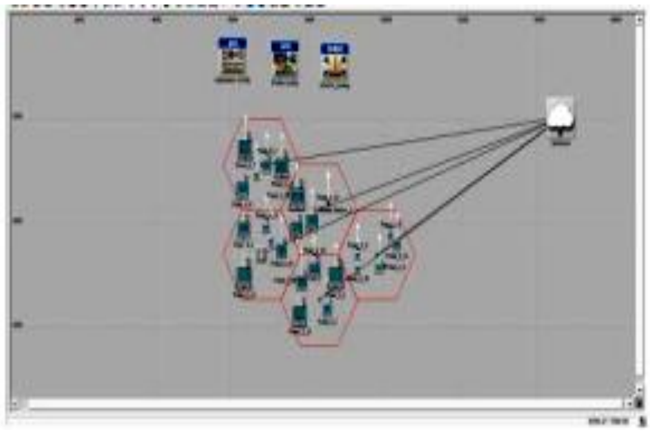

Figure 14: Scneario Thirteen

V. RESULTS AND DICUSSIONS

The results in this paper were carrird out using OPNET software. The results were shown in tables forms for mobile nodes and fixed nodes.

A-Results of Mobile Nodes Models

The simulation results of QoS parameters for mobile nodes were obtained in different scenarios as shown in table.3 to table7.

Table 3: Mobile nodes in three cells

Number of mobile nodes	Delay (sec)	
	Power (0.5 watt)	Power (1 watt)
15	0.0187	0.0187
30	0.0163	0.0192
45	0.0177	0.0179
Average	0.0176	0.0186

Table 4 : Mobile nodes in five cells

Number of mobile nodes	Delay(sec)	
	Power (0.5 watt)	Power (1 watt)
25	0.0026	0.0027
50	0.003	0.0029
75	0.0034	0.0031
Average	0.003	0.0029

Table 5 summarized the obtained results of the average delay in three cells and five cells with mobile nodes..

Table 5: QoS for mobile models

Power (watt)	Delay (sec)	
	Three cells	Five cells
0.5	0.0176	0.003
1	0.0186	0.0029

The throughput average versus the mobile nodes numbers in three cells is shown in Table.6.

Table 6 : Throughput results in three cells

Number of mobile cells	Throughput (Packet/s)	
	Power (0.5 watt)	Power (1 watt)
15	517.7323	517.7323
30	454.5618	457.6253
45	531.4609	435.1242
Average	501.2517	470.1606

Table 7 :Throughput results in five cells

Number of mobile cells	Throughput (Packet/sec)	
	Power (0.5 watt)	Power (1 watt)
25	0.0933	0.1005
50	0.1989	0.2174
75	0.2895	0.2823
Average	0.1939	0.2001

Table 8 : Summary of throughput results for mobile models

Power (watt)	Throughput (Packet/s)	
	Three cells	Five cells
0.5	501.2517	0.1939
1	470.1606	0.2001

Table 9: Jitter results in three cells

Number of mobile cells	Jitter (sec)	
	Power (0.5 watt)	Power (1 watt)
15	-0.0000006	-0.00000062
30	-0.00000022	0.0000004
45	-0.00000048	0.00000015
Average	-0.00000043	-0.00000002

For a transmitter power of 0.5W and three cells the delay was increased when the number of nodes is increased For a power of 1W the delay is semi-fixed when the number of nodes is increased from 15 to 30, while it decreased when the number of the nodes is increased from 30 to 45 node.

For five cells network with transmitted power of 0,5W the performance shows small increasing of delay. By increasing the number of nodes and using a transmitted power of 1W; the delay gives approximately similar results. For mobile nodes with transmitted power of 0.5 W the throughput was increased when the number of nodes was increased.

B) Results of Fixed Nodes Models

The obtained results in the fixed scenario models are shown in Table10to Table 15 of the paper .The results illustrate all the measured values of QoS parameters using different transmitter power ranges.

Table 10: Fixed nodes in three cells

Number of nodes	Delay (sec)	
	Power (0.5 watt)	Power (1 watt)
15	0.0033	0.0035
30	0.0028	0.0028
45	0.0039	0.0041
Average	0.0033	0.0035

Table 11: Fixed nodes in five cells

Number of nodes	Delay (sec)	
	Power (0.5 watt)	Power (1 watt)
25	0.027	0.0273
50	0.0313	0.0323
75	0.035	0.0363
Average	0.0311	0.032

Table 12 :Summary of Delay

Power (watt)	Delay (Sec)	
	Three cells	Five cells
0.5	0.0033	0.0311
1	0.0035	0.032

Table 13 :Throughput results in three cells

Number of Fixed cells	Throughput (Packet/s)	
	Power (0.5 watt)	Power (1 watt)
15	0.061	0.0682
30	0.1123	0.1247

45	0.1493	0.1735
Average	0.3225	0.1221

Table 14 : Throughput Results in Five Cells

Number of Fixed cells	**Throughput (Packet/s)**	
	Power (0.5 watt)	Power (1 watt)
25	506.1826	548.8229
50	1010.079	1036.2419
75	1443.4014	1590.5357
Average	986.5543	1058.5335

Table 15: Throughput in Fixed Models

Power (watt)	**Throughput Packet/s**	
	Three cells	Five cells
0.5	0.3225	986.5543
1	0.1221	1058.5335

The delay was decreased when the number of nodes is increased from 15 to 30, while it is increase when the number of nodes is increased from 30 to 45, when the power value is 0.5W. Similar results has been found, when the power value increased to 1.0W.Throughput was increased when the number of nodes was increased when the power value is 0.5W. Similarly it increased when the power change to 1W. The throughput for five cells give similar results where throughput increased by increasing the number of fixed nodes.

VI. Conclusion and Future Scope

In this study the performance of WIMAX was studied in different operating scenarios. The overall results have been proven that when number of nodes is increase the delay is unstable. And when transmitted power is increase the end to end delay decreased in mobile nodes, but it was constant in fixed nodes. It was shown that when the number of cells in network was increased the end to end delay decreased for mobile nodes, but it was increased in fixed nodes.

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