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Meliorate QOS of WIFI-WIMAXin Backhaul Networks

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Abstract: **Wireless access networks are developing at a very rapid rate. They are convenient in providing Internet access in remote inaccessible areas thatconfront for traditional wire-line service providers. Wireless communication provideslesser cost, wider support for massive users and conveniently accessible fordifferent users but on the other hand these are considered less efficient and irregular as compared to the wired networks that make end-to-end quality of service (QOS) provision a challenge for wireless networks.Wireless access networks are widely accepted and continuously advancing by expanding their coverage, bandwidth and QOS services. Commonly used wireless standards are IEEE 802.11 (Wi-Fi) and IEEE 802.16 (WiMAX). IEEE 802.11 (Wi-Fi) is a standard that provides high speed WLAN connectivity such as in buildings, homes, hotels, cafes and airports. Wi-Fi networks are possibly the most widely used and accepted technology by providing the highest transmission rate among standard wireless networking.IEEE 802.16 (WiMAX) is a standard to provide high speed transmission in both indoor and outdoor environments.Moreover, it is innovative and commercially viable alternative in last mile implementations to cable modems, DSL technologies and T1/E1 cables. This paper provides detailed technical differences between the 802.11 and 802.16 and also discusses the QOS Service classes of WiMAX network. The simulation consequenceshave been beholding with network simulator allinone-3 and investigating the performances of the overall network.**

Index Terms: **WiMAX, Wi-Fi, QOS, backhaul networks, Wireless Networks, Scheduling Algorithms.**

I. INTRODUCTION

Wireless networks connect various devices such as laptops, mobiles, PDAs and tablets to the Internet using radio waves. They are gaining popularity day by day as they are easy to set up and inexpensive. There are some inbuilt qualities of wireless communication systems like mobility, reachability, simplicity, maintainability, roaming services, new smart services etc [6].Wireless is a more modern alternative to traditional wired networking that relies on cables to connect networkable devices together. Wireless technologies are widely used in both home and business computer networks. Two major wireless techniques are IEEE 802.11x and IEEE 802.16x. WiMAX and Wi-Fi networks use IP-based technologies to provide connection services to the Internet.

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These technologies provide Internet access in countries without any wired network infrastructure and main aim is to provide convenient, affordable broadband wireless access to users in more areas.

A. Wi-Fi

The common name of the IEEE 802.11 is Wi-Fi (Wireless Fidelity). It is a synonym of Wireless Local Area Network (WLAN). It is the most widely used broadband wireless networking technology, providing the highest transmission rate among standard-based wireless networking technologies. Wi-Fi enabled devices (like Smartphones, tablets, video game consolers etc.) can connect to network resources like the Internet through a wireless network access point. Access points are also known as hotspots have a coverage area of about 20 meters indoor and even a greater range outdoors [7]. Wi-Fi standard 802.11a and 802.11g provides transmission speed up to 54 mbps. 802.11n can achieve speeds as high as 140 mbps and 802.11 ac is the newest standard, and can provide a transmission speed of 450 mbps.

Wi-Fi Standards: 802.11a was the first wireless networking standard, but IEEE 802.11b was the first widely accepted one, which is followed by IEEE 802.11g and IEEE 802.11n [11].

- IEEE 802.11a: It works in unlicensed 5GHz. It supports data rates from 6Mbps to 54 Mbps. It runs in the 5GHz range, so less interference from other devices. 802.11a does a great job of supporting multimedia applications and densely populated user environments.
- IEEE 802.11b: It is deployed in 2.4GHz range and supports a maximum raw data rate of 11Mbps. IEEE 802.11b is longest, well supported, stable and cost effective technique but security is the main disadvantage of this standard.
- IEEE 802.11g: 802.11g is an extension to 802.11b, but it operates at data rate of 54 Mbps within 2.4Ghz of spectrum band. IEEE802.11g is flexible because multiple channels can be combined for faster throughput, but limited to one access point and this is the main problem of IEEE 802.11g.
- IEEE 802.11n: 802.11n is an amendment made in 802.11g standard by adding multiple-input multiple-output antennas (MIMO). It supports data rate of 300 Mbps and deploys on both 2.4 GHz and the lesser used 5 GHz.
- IEEE 802.11 ac: It utilizes dual band wireless technology, supporting simultaneous connections on both the 2.4 GHz and 5 GHZ Wi-Fi bands and data rate

of up to 1300 Mbps on the 5 GHz band plus to 450 Mbps on 2.4GHZ.

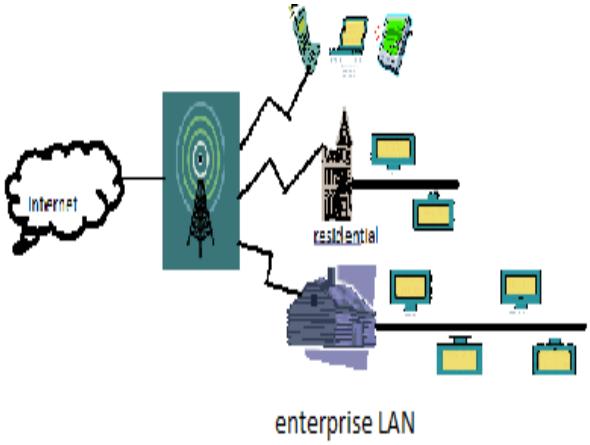

Fig. 1.Wi-Fi network

B. WiMAX

The IEEE 802.16 is commonly known as WiMAX (Worldwide Interoperability for Microwave Access) is a wireless communication system that allows computers and workstations to connect to high-speed data networks (such as the Internet) using radio waves as the transmission medium with data transmission rates that can exceed 120 Mbps for each radio channel. WiMAX is system that is primarily used as a wireless metropolitan area network (WMAN). WMANs can provide broadband data communication access throughout an urban or city geographic area. WiMAX broadband wireless can compete with DSL, cable modems and optical broadband connections. As wireless communication provides lower costs, ease of deployment and wider user support, they are widely used as backhaul networks rather than the traditional wired technologies. Backhaul networks transfer data between access points and gateway nodes, which in turn are connected to the wired Internet [4].

The name "WiMAX" was created by the WiMAX Forum, which was formed in June 2001 to promote conformity and interoperability of the standard [1]. The forum describes WiMAX as "a standards-based technology enabling the delivery of last mile wireless broadband access as an alternative to cable and DSL". The WiMAX Forum is a non-profit organization formed to promote the adoption of WiMAX compatible products and services. WiMAX Forum is doing what Wi-Fi Alliance has done for wireless LAN and IEEE 802.11 standard. WiMAX Forum certified products adhere to the IEEE 802.16 standards and offer higher bandwidth, lower costs and broader service capabilities than most of the proprietary solutions.

WiMAX Standards: The IEEE 802.16 group was formed in 1999 to standardize Local Multipoint Distribution System and address its issues [2].

- IEEE 802.16: First document was published in December 2001, supports the frequency range of 10-66 Ghz with a maximum bandwidth of 32-132 Mbps, transmission range of 50 kms and line-of-sight (LOC) transmission.
- IEEE 802.16 a: Modifications were made in IEEE 802.16 and a new standard IEEE 802.16 an approved in January 2003, supports the frequency range of 2-11 Ghz with a bandwidth of upto 75 Mbps and Non Line-of-sight (Nlos) transmission.
- IEEE 802.16 d: By making amendments in the IEEE 802.16 a new standard IEEE 802.16 d was formed. It is also known as the IEEE 802.16 2004. The standard provides technical specifications for the PHY and MAC layers for fixed wireless access and addresses the first or last-mile connection in wireless metropolitan area networks (WMANs).
- IEEE 802.16 e: This standard was approved in December 2005, adds mobility. This is generally referred to as mobile WiMAX.

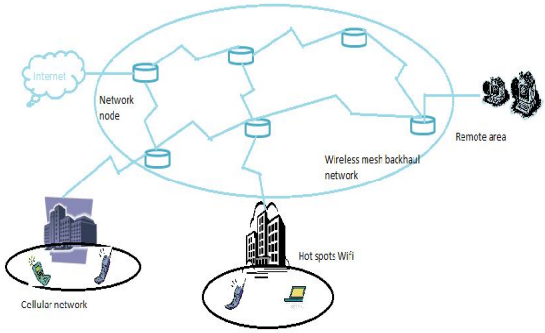

Fig. 2. Wireless backhaul network

C. Wi-Fi versus WiMAX

Although Wi-Fi and WiMAX are wireless technologies but both differ in many ways. The key characteristics which can be used to compare these two technologies are: efficiency, maximum range, dependability, security, mobility and radio transmission modulation techniques. Bandwidth efficiency refers to the number of bits per second that can be carried on one cycle of radio bandwidth (i.e. bps/Hertz) [15]. It is measured in terms of bandwidth and latency. Maximum range is the measured distance between two base stations. It must support hand-off between base stations without losing connection from the global world. Dependability or reliability try to minimize the loss packets and the number of disconnects. Security deals with the encryption and the device authentication supported by each technology. Mobility is the speed at which the technology can connect to the global world and remain connected. Wi-Fi operates in unlicensed frequency whereas WiMAX operates in both licensed and unlicensed frequency bands. Detailed comparison of the two technologies is shown in table 1.

Table 1. Wi-Fi versus WiMAX [15, 13]

Characteristics	Wi-Fi (802.11)	WiMAX (802.16)
Primary application	Wireless LAN	Wireless MAN designed for broadband wireless
Range and Coverage	Mainly designed for indoor Optimized for 100 metres	Designed for outdoor NLOS performance Optimized for 50 km
Scalability	MAC designed to support tens of users	MAC designed to support thousands of users
Frequency Band	Unlicensed Band 2.4 Ghz to 5 Ghz	Licensed and Unlicensed Band 2 Ghz to 11 Ghz
Channel Bandwidth	On the range from 20-25 Mhz	Adjustable range from 1.25 to 20 Mhz
Bandwidth Efficiency	0.44 to 2.7 bps/Hertz	<=5 bps/Hertz
Half/Full Duplex	Half	Full
Radio Technique	OFDM 64 channels and Direct Sequence Spread Spectrum	OFDM 256 channels
Security	Security is optional here. Better encryption technique like WPA and WEP available now	3 DES (128 bits)
Mobility	In Development phase now	Mobile WiMAX build in 802.16 e
Access Protocol	Contention based MAC (CSMA/CA)	Grant Request MAC
QoS	QoS is proposed in IEEE 802.11e	Mainly designed to support voice and video
Modulation	BPSK, QPSK, 16-, 64-QAM	BPSK, QPSK, 16-, 64-, 256-QAM

D. Quality-of-Service

Quality-of-Service (QoS) is defined as a network's ability to achieve maximum bandwidth and deal with other network performance elements like latency, jitter, packet error rate and uptime. It also involves controlling and managing networks by setting priorities for specific types of data (video, audio, files) on the network. Wireless networks are generally less efficient and irregular compared to wired networks, which make quality-of-service (QoS) provision a bigger challenge for wireless communication. Wireless technologies are expanding at a very fast rate and with the advent of standard IEEE 802.11 (Wi-Fi) or Wireless Local Area Networks (WLANs) bandwidth has increased resulting in QoS support to end users. The design constraints at several layers of the IEEE 802.11 restrict its capacity to delivered guaranteed QoS [6]. So a new standard IEEE 802.16(WiMAX) has emerged as the most promising broadband wireless technology, which provides guaranteed QoS to wireless application end users. To ensure QoS, the routing algorithm in use has to reserve and allocate radio resources for various competing data flows during selecting appropriate routes to them. [3]

The five QoS classes specified in the IEEE 802.16 Medium Access Layer are as follows: [10, 14]

- *Unsolicited Grant Access (UGS)* is designed to support real-time applications consisting of fixed-size data packets that are issued at periodic intervals. The BS issues fixed-size data grants without receiving explicit request from the SS, as in the case of T1/E1 and VOIP without silence suppression.
- *Real-Time Polling Service (rtPS)* is designed to support real-time applications consisting of variable-sized data packets that are issued at periodic intervals. The BS allows the SSs to make periodic unicast requests and allows them to specify the size of the desired grant, as in MPEG video or VOIP with silence suppression.
- *Extended Real-Time Polling Service (ertPS)* is designed to support real-time applications consisting of variable-sized data packets that are issued at periodic intervals and have data rate and delay requirements, like in the case of voice with activity detection (VOIP). It is a combination of UGS and rtPS.
- *Non Real-Time Polling Service (nrtPS)* is designed to support non real-time applications consisting of variable-size data packets on a regular basis. It supports delay tolerant applications such as in File Transfer Protocol (FTP).
- *Best Effort (BE)* is designed to support applications for which no minimum service guarantees are required, like the case in telnet or World Wide Web (WWW). The bandwidth request by such applications is granted on space-available basis.

Table 2. Summary of QoS Classes [3]

QoS Category	Applications	QoS Specifications
Unsolicited Grant Service (UGS)	Voice over IP (VOIP) without silence suppression, T1/E1	Maximum sustained rate Maximum latency tolerance Jitter tolerance
Real-Time Polling Service (rtPS)	MPEG video	Minimum reserved rate Maximum sustained rate Maximum latency tolerance Traffic priority
Extended real-time Polling Service (ertPS)	Voice with activity etection (VOIP)	Minimum reserved rate Maximum sustained rate Maximum latency tolerance Jitter tolerance Traffic priority
Non real-time Polling Service (nrtPS)	File Transfer Protocol (FTP)	Minimum reserved rate Maximum sustained rate Traffic priority
Best Effort Service (BE)	Data transfer, web browsing etc.	Maximum sustained rate Traffic priority

II. LITERATURE SURVEY

The overview of the mobile WiMAX technology and the evolution from 802.16 to 802.16d for fixed wireless access and to the new IEEE 802.16e standard with mobility support is discussed in this paper. Bo Li discusses the QoS provisioning and mobile WiMAX Specification [3].

The author uses a mesh networks to backhaul data traffic from access networks to the wired Internet. Yun Hou proposes a novel distributed scheduling algorithm composed of a framework and a new utility function definition for wireless backhaul networks. The algorithm converges to the desired throughput allocation in a long run, which can be specified by the routing protocol in use to guarantee quality of service [4].

Study of the computational complexity of finding the optimal link schedule for the wireless mesh networks with time-division-duplexing (TDD) operations is done in this paper. The author proposes a heuristic distributed scheduling algorithm and a link utility function for wireless mesh networks. Framework maintains strong temporal correlation of interference, which is required to ensure proper channel predictions for distributed scheduling and power control. Compare the tree scheduling and a centralised ideal scheduling [5].
The explanation of the various wireless technologies and the comparison of WiMAX technology with Wi-Fi and 3G technologies are purposed by the author in this paper [6].

We can study a comparison and technical analysis of alternatives for implementing last mile wireless broadband services. Provides detailed technical differences between Wi-Fi (802.11) wireless networks with WiMAX (802.16) a new technology that solves many of the difficulties in last mile implementations [7].

Author proposes the Combined Distributed and Centralised (CDC) scheme to combine the distributed scheduling and the centralized scheduling mechanisms so that the minislot allocation can be more flexible, and the utilisation is increased in the paper. Two scheduling algorithms, Round Robin (RR) and Greedy, are proposed as the baseline algorithms for the centralised scheduling mechanism [8].

This paper presents an integrated architecture utilising a novel WiMAX/Wi-Fi Access Points (W^2-AP) device to effectively combine the WiMAX and Wi-Fi technologies. The proposed architecture, the Wi-Fi hotspots work as that of WiMAX system and can support connection oriented transmissions and QOS in a similar fashion to the WiMAX and thus an improvement in the delay performance is obtained [9].

Author presents a novel architecture for integration of WiMAX and Wi-Fi technologies. In proposed architecture, they provide mesh connectivity between WiMAX Wi-Fi Routers (WWRs) in the WiMAX segment and their performance is compared and discussed in terms of not only throughput and delay but also packet loss[12].

III. CORRECTING PROBLEM

- In this research, work will be done on backhaul networks. Backhaul networks are those networks that collect the data from the access points and transfer them to the gateway nodes, which are connected to the wired Internet [4]. Traditionally, backhaul networks are based on wired technologies such as ADSL, T1 and optical fibre but now because of the ease of deployment and the cost factors, wireless networks such as standards IEEE 802.11 and IEEE 802.16 are being considered to provide the backhaul capability.
- For the research, hexagonal layout for the arrangement of the nodes is used because in the previous studies [4, 5] tree layout has various shortcomings such as the links established in the network does not communicate in the horizontal manner.

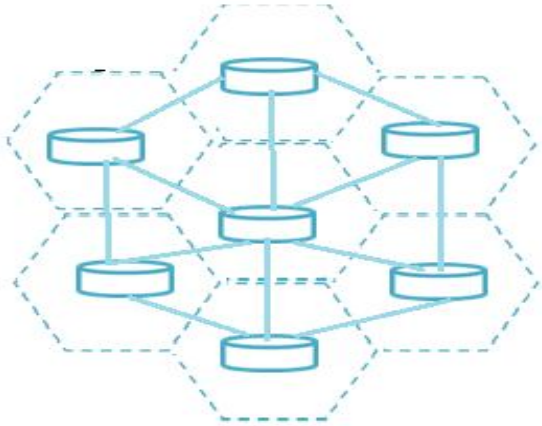

Fig. 3. Hexagonal Layout

- Time-division-duplexing is used in which proper allocation time to each node is given. In TDD system each node can only transmit to/receive from its neighbouring node in a single time slot.
- Now our work is to improve the Quality-of-Service (QOS) of the WiMAX network for proper utilization of link capacity by linking each node with the other neighbouring node in the hexagonal layout.
- In this propose solution, we are removing the conflict situation when say a node i wants to send data to the node k and the neighbouring node j wants to send data to the node i. Due to TDD, node i cannot receive and sent at the same time. The transmission (solid arrow) from node i will be more beneficial than the incoming transmission because it is the only reason why node i choose the transmission rather than the reception of data.

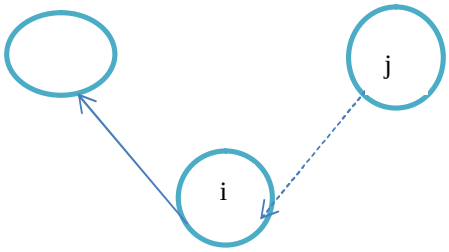

Fig. 4.conflict situation

- Buffers are maintained at the nodes and access points as if any node is not active it can store it's data in the buffer and wait for some time for the node to become active and when the node become active, it sends the data again to the node.

IV. SCENARIO USED

Wi-Fi provides high speed broadband connectivity in local area networks whereas WiMAX provides last mile broadband connection over larger areas- metropolitan, suburban or rural. Integration of WiMAX and Wi-Fi lead the service providers to deliver convenient, affordable broadband Internet services in more places. By combining WiMAX and Wi-Fi access together service providers can deliver high-speed Internet connectivity that users desire in more places. These days vendors are integrating WiMAX and Wi-Fi in a single Customer Premise Equipment where WiMAX provides the backhaul and Wi-Fi provides the in

building coverage. Instead of providing the interconnection of Wi-Fi mesh networks, the same WiMAX network can also allow the service providers to offer a two tier service to users, where users connect based on their mobility, bandwidth and QoSrequirements.The inter-working capabilities between WiMAX and Wi-Fi enable service providers to deliver consistent, transparent, and user-friendly broadband services to their subscribers. Achieving this transparency requires two key elements:

- Multi-mode subscriber devices that can communicate on both WiMAX and Wi-Fi networks.
- The ability to provide service across WiMAX and Wi-Fi networks when users move between them. This is generally implemented through a controlling Access Service Network Gateway (ASN GW) and common Authentication, Authorization, and Accounting (AAA) service functionality located in the service provider network.The proposed network configuration is shown in the fig. 5.

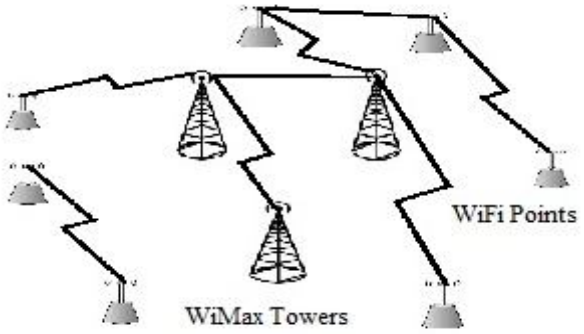

Fig. 5. WiMAXandWiFi Network

Among the available tools for networks simulation, NS-3 Simulator is used in order to evaluate the performance of WiMAX and Wi-Fi network. Various simulation parameters used are given in table 3.

Table 3. Simulation Parameters

Parameter	Values
Simulator	NS-3
Standards	802.16a, 802.11b
RX-Power	15dbm
TX-Power	15 dbm
Path loss	Two Ray Ground
Mode	Full Duplex
Channel	Orthogonal
Data Bytes	512 bytes

V. RESULTS AND DISCUSSION

To evaluate the performance of the network, Quality of service is the most important metric i.e. throughput and end-to-end delay.The throughput can be calculated by the size of the packet move from one network to another network and the total time is calculating by the difference between the last packet arrivesatthe destination end via the source side. The solution (fig.6) improves the overall throughput of the proposed network. The Throughput increases with the network size without any higher fluctuations. At 60 Mbps, 90 Mbps and 120 Mbps it was assumed that the congestion occurs. This congestion may be occurring due to delay and interference but this delay was negligible because WiMAX wraps the performancesdegradation of Wi-Fi networks.

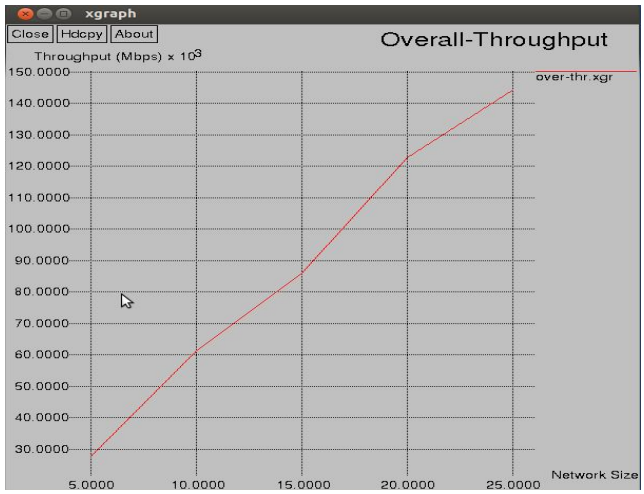

Fig. 6. Throughput of the network

Delay varying with simulation time and it was observing that higher the delay more will be packet loss. Figure 7 depicts delay at the starting simulation time 0.0 seconds and then stable after the simulation time continuously increases step by step. Whenever,it was assumed that if traffic load will be inclusively added in Wi-fi networks without the use of WiMax networks then itstumble the performances of the network.

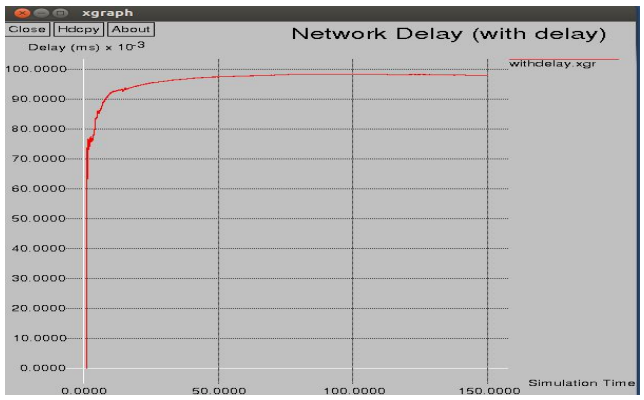

Fig. 7. Delay of the network

The delay increases due to multi-flow and the issue resolves when we implementing strong routing decisions strategy (these decisions make by AdHoc on demand distance vector routing protocol (AODV)) [16].Here, we found that the simulation time 30 seconds thegraphline goes to.095 milliseconds and then it maintained stability this is due to the hexagonal approach mentioned in this paper.

VI. CONCLUSION

This paper has studied the two wireless access technologies Wi-Fi (IEEE 802.11) and WiMAX (IEEE 802.16) and the detailed difference between these technologies. QOS service classes of WiMax are also discussedin detail. WiMAX extends the benefits of WiFi networks to deliver the next-generation Internet services. Integrating WiMAX and Wi-Fi promises convenient and affordable broadband connectivity that brings new deployment models for service providers, as well as new usage models for subscribers.Throughput and Delay of WiMAX and Wi-Fi network is calculated and it is observed that overall throughput of the network is improved because WiMaX covers up the degradation caused by Wi-Fiand delay in the network becomes stable with the use of hexagonal approach. Our future work will depict the working of the wimax network and its throughput.

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