# Comprehensive Study of Wireless Networks QoS Parameters and Comparing Their Performance Based On Real Time Scenario

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***Abstract* - The current world of information technology encompasses a surplus of variant wired and wireless communication technologies. The major arena in networking is now devised in the field of wireless communication technologies. In wireless technologies efficiency of the network is measured through a certain parameters namely delay time, jitter, end to end delay through put, packet loss etc. These parameters are classified as essential QoS parameters. The research aims to study the various QoS parameters associated with wireless technologies such as Wi-Fi, WiMAX, LTE which are the currently leading and promising technologies of wireless world. Comparison is portrayed for the above technologies by simulating and testing the environments. The results evidently show the variations of performance of the technologies. This study helps in choosing networks based on QoS parameters for real time scenarios.**

***Index terms* – Wireless networks, Wi-Fi, WiMAX, LTE, QoS parameters**

## I. INTRODUCTION

The development in network and communication technology is still going through in rapid pace because of the introduction of wireless communication technologies in the early-1990s and new developments are persistently intensifying its role in modern communication. The fact that every individual finds it tough to imagine his life without a smart phone proves that wireless networking has been ruling the planet for many years now. Wireless technologies have reached out to the rural and remote areas such that it has become an essential part in every communication device present there. [1] A few wireless communication technologies such as WiMAX, WiFi and LTE are those technologies that have been discussed in this study. WiMAX IEEE 802.16e is one of the propitious technologies designed to provide broadband access services at very high speeds over larger distances and for a greater number of users. Likewise LTE and WiFi have also been very promising. QoS parameters play an indispensable role with respect to the determination the efficiency of the network in various situations and infrastructure. However when comparison is made among the three technologies, LTE wins due to some extraordinary features.

Worldwide Interoperability for Microwave Access (WiMAX) aims to provide wireless data over long distances, in different ways; from point to point links to complete mobile cellular type access [2]. Wireless Fidelity (Wi-Fi) is the prevalent term for 802.11b wireless networks where they include both a Wi-Fi "hot spot" to transmit data as well as a Wi-Fi-enabled device to receive the data and commonly used to access the Web by some handheld devices with built-in Wi-Fi capabilities [3]. Long Term Evolution (LTE) sprouted out in the market which was one of the breakthroughs in the technologies. The basic parameters of any network technology are network size, bandwidth, network packet delay, reliability, maximum transmission unit (MTU). However people associated with network still do not know to choose a suitable network technology as per their network needs. There exists a lot of confusion in the thoughts of the people as they have no proper knowledge of the pros and cons of each network. They had least knowledge regarding the network QoS parameters of these wireless network technologies[4]. Due to wide use of heterogeneous devices, there are challenges faced when it comes to improvement with regard to services qualities. The era of forth coming generation broadband wireless network access has been in its way. A traditional Wi-Fi network does not seem much promising neither do they support sufficient coverage and mobility. Also it is a fact that it cannot satisfy today's demands. But in case of WiMAX and LTE, they have longer and efficient transmission distance, mobility, and wide coverage. These both technologies overcome the

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limits of last mile and is able to support all the users

## II. RELATED WORK

Wi-Fi has been comprehended as the integral part of everyone's life. The faster the technology improves, the better it is for the users. The scrutiny has been carried out where it deals with the future prospects of WiFi technology in the technological world. The challenges faced on the basis of crisis in spectrum and energy consumption that has been going up rapidly. [1] The key technologies of WiFi are discussed such as Tri-band WiFi, Recent Lifi over WiFi and advanced enterprise WiFi. The key technologies such as WiFi-Certified ac and WiFi- Certified Pass point have also been studied to suggest the solutions for major challenges. As an outcome of this study, the technology called super WiFi and WiFi Gigabit solution has been suggested where it consists of Wi-Gig beam management, High capacity, Power efficient. The main objective of studying the technologies was to understand the various problems related with these technologies [3] On understanding the various problem associated with the implementation has been analyzed and solutions have been suggested to overcome some problems. In order to mitigate the risks and problems faced, a system with a secured environment is suggested in the research.

The study was carried out on WiMAX IEEE802.16 where it deals with the outline of the WiMAX technology in this competitive world. The study on technology driving WiMAX is made and the deployment considerations are studied. The impacts of such factors have been on the distance that is covered by WiMAX. The coverage range of cell site according to various frequency bands are revealed in the form of simulation. The simulation shows the efficiency of the network with respect to various frequency bands and the cell site coverage differs according to the reform in the frequency band. The results are concluded with the description of various business models in this technology. [2]

In order to deal with the drawbacks of WiFi and WiMAX, Long Term Evolution (LTE) sprouted out in the market which was one of the breakthroughs in the technologies. Full-fledged study on Long term evolution developed by the 3GPP has been carried out according to their architecture, interfaces and protocols etc. The advantages of LTE with respect to cost, performance have been looked at on a deeper sense. One other merit of LTE is the seamless mobility that has been keeping LTE in its level now. The Air Interface Architecture has been defined in the paper. The protocol stacks such as X1, X2 have been described and depicted by the author where GPRS Tunneling Protocol-User is utilized to transmit relay packets. As to conclude, LTE technology has continually been in helping in converting the complex architecture to simpler flat architecture [5]. Various researches were carried out with regard to LTE technology where several security issues of LTE and LTE-A networks has been discussed. In this paper, the LTE Architecture has been instigated with regard to all the factors influencing the network's efficiency. Secondly, the security factor in the LTE Architecture has been depicted in the research as well. The limitations of Security framework are also being taken into discussion. As a result the authors observed that increase in the operational overhead as well as delays should not occur in order for the security to be implemented in the LTE Network. It was found that further improvements are to be made in the LTE Architecture and its security feature and there by mend the performance of this network. [6] The performance study on WiMAX and LTE was carried out with the help of NS-2 Simulator. The Observations of the simulations depicts the manner by which several performance parameters namely throughput, delay and jitter are affected by change in factors like number of nodes, modulation scheme, distance between base station and subscriber station In WiMAX, Line of sight is necessary for the propulsion of data packets but LTE doesn't need any line of sight. Without Line of sight it can propagate the data packets [7]. A brief overview of WiMAX and LTE technology was explicated with reference to characteristics, architecture, standards, modulation techniques, protocols and security threats. With introduction of WiMAX and LTE technology it is anticipated that next generation 4G networks would rule the world with an extremely promising wireless broadband connectivity, these networks assures wonderful mobility with great speed in data rate, high capacity and application with backward compatibility. In this research, many practical parallels and differences that benefit one wireless technology over the other are analyzed for it to help us determine which of these factors should have added to LTE endearing. The factors that are not technical and which are of viable and ancient nature are analyzed which may be advantageous over another technology. Finally, current actions in the regularization of both the WiMAX and LTE technologies are offered with a viewpoint on the projections of both technologies. The factors that caused LTE to win over other technology as the technology for one of the most efficient networks are also discussed. Elements that prejudiced the competition are not only technical. The final outcome is that WiMAX people realized the necessity to blend and assimilate with LTE rather than continue surpassing it. In this paper the author say that LTE will triumph as one standard in the upcoming technology world for serving public networks as WiMAX has decent prospects in dedicated and corresponding segments. [8] A system has been proposed that describes a transceiver simulator having two different configurations, one parallel to LTE standard and other to Mobile WiMAX. Both these transceiver configurations contain all the information with reference to baseband signal treatment blocks, communication and reception architectures, RF Front-End and channel models. This entire transceiver simulator perceives BER for various configurations, links and spots the comparison existing between the two models of systems with reference to performances. In that particular research, point of view of the transmitter architecture, the point of view from the

receiver and a comparison of available architectures has been presented. A comparison start point is provided by the classical homodyne architecture. It provides decent performances, although it does not take care of the issues of flexibility, configurability and power efficiency which is needed for green radio and cognitive radio applications. This architecture is a substitute so as to advance the power efficiency of the transmitter. A controlled spectrum folding is induced by this architecture and it also permits recovering two transmitters simultaneously. [9] A relative study of WiMAX and LTE was proposed on the basis of QoS. This paper addresses the upcoming leading technologies of wireless broadband. These technologies intend to support the existing and forthcoming Quality of Services. The arrangement of QoS and feature of next-generation 4G mobile broadband technologies such as LTE, IEEE 802.16E and IEEE 802.16M (WiMAX) is to withstand numerous applications of QoS needs. It describes these two wireless broadband technologies in accordance to the architecture, characteristics, radio access technologies, security and QoS structure. LTE is introduced after WiMAX hence LTE provides innovative features namely SC-FDMA, Multiple Input Multiple Output (MIMO) and System Architecture Evolution (SAE) architecture. In comparison to LTE, WiMAX is beforehand set up but LTE delivers enhanced and efficient solution with reference to quality of service (QoS) parameters. LTE makes it possible for a better-quality combination of performance and it requires minimum cost to reach forthcoming requirements of users for wireless broadband services [10]. An enhanced study of numerous scheduling algorithms in subsequent generation networks that is built on the basis of Quality of Services (QoS) parameters is carried out. The WiMAX hybrid scheduling algorithm provides a definite preference to QoS traffic instead of BE demands from the subscriber (EDF + WFQ + F I F O ). This might incur starvation when the amount of non-real time Poling Services and BE is extraordinary. Results show a reasonable establishment of bandwidth and starvation prevention for BE traffic. A new solution has been offered where in the uplink bandwidth is segregated into class based threshold standards prior to running the scheduling algorithm. In this altered logic it assigns the bandwidth within the existing classes by utilizing sliding window protocol and estimating the requirements. In further study it may include a standard simulation platform to authenticate the outcomes of the algorithms and computing the jitter or packet losses met by the numerous classes so as to launch the objectivity and acquiescence to the QoS guarantees. [11]

## III. FEATURES

### *A. Features of WiFi*

One of the main features of WiFi technology appears to be its convenience with regard to installation and usage. WiFi networks are very much easier to establish as there is no requirement of any professional installation such as WiMAX network which would otherwise make a tedious task. WiFi technology is robust and scalable as well. Wifi has been designed to cater to the needs of a specific group of users such as household requirements and corporate sector for interconnectivity. Using WiFi technology, it is possible to connect devices like printers to computer and game consoles can be connected to routers as well.

### *B. Features of WiMAX*

WiMAX is one of the excellent wireless broadband access technologies offering access to wireless network which is similar to WiFi technologies. The progressive characteristics of radio are espoused to reduce the costs of all the radios and all the companies coming under WiMAX confirm interoperability by carrying out testing. The IEEE 802.16 supports the duplexing schemes which are Time Division Duplexing (TDD) and Frequency Division Schemes (FDD). The basis of WiMAX is the orthogonal frequency distribution due to which it provides data transmission through the approach of multipath data transmission. Coming to the range of WiMAX technology, it covers up to 30 miles. However when implemented practically 6 km of range coverage has been possible till now [12]. The Quality of Services of WiMAX plays a vital role in supporting a certain number of users, where the users might be associated with multiples connections in a single terminal. WiMAX supports a vast number of users with regard to the above mentioned point.

### *C. Features of LTE*

One of the main characteristics of LTE is the feature of Orthogonal Frequency Division Multiple Access (OFDMA) where the data is carried over various narrow band carriers and LTE uses this technology for downlink. [13] As for the technology used in the uplink, SC-FDMA plays its role in the transmission. Talking about the spectrum flexibility, LTE has the flexibility to work in both FDD and TDD where the band flexibility is well-adapted by this technology. [14] Dynamic Spectrum Assignment has been utilized to optimally avail the radio spectrum. One other important feature of LTE is the Multiple Input Multiple Output (MIMO) where the data is transmitted using multiple antennas. [15] There is several transmission and receiver devices (antennas) which helps in speeding up the transmission help it win over other technologies. LTE uses a state where various nodes aggregate and work with each other dynamically to get rid of the intrusion from other signals in transmission.

## IV. QOS STUDY OF WIFI AND WIMAX

The Quality of Parameters plays a significant role in the decision making factor, where the efficiency of the network is being analyzed. In this research, QoS study of all the three technologies has been studied. Having studied the parameters of these technologies, improvements are suggested in order to help in the efficiency of the network. The QoS parameters in every network are those factors that are behind these wireless technologies driving their performance and hence efficiency. Some of the QoS

parameters for wireless network technologies like Wifi, WiMAX, and LTE are Average End-to-End delay, Jitter, Packet loss, throughput, transit delay, priority, protection. [16] The table below shows the QoS study of Wifi and WiMAX and traffic specifications.

TABLE I. WIFI AND WIMAX QOS STUDY

<table>
<tr><th>WIFI QOS Study</th><th>WIMAX QoS Study</th></tr>
<tr><td>WiFi IEEE 802.11 had 2 types of exchanges initially:<br>• DCF (Distributed Coordination Function)<br>• PCF (Point Coordination Function)<br>IEEE 802.11e familiarized two schemes<br>• Enhanced DCF Channel Access (EDCA)<br>• Hybrid Coordination Function Channel Access (HCCA)<br>Basic QoS parameters Jitter, Latency, Bandwidth are well-defined by the TSPEC parameters.<br><br><table><tr><th>TSPEC Parameters</th></tr><tr><td>Element ID</td></tr><tr><td>Length</td></tr><tr><td>TS info</td></tr><tr><td>Normal MSDU Size</td></tr><tr><td>Maximum MSDU size</td></tr><tr><td>Minimum Service Interval</td></tr><tr><td>Maximum Service Interval</td></tr><tr><td>Inactivity Interval</td></tr><tr><td>Minimum data rate</td></tr><tr><td>Mean Data rate</td></tr><tr><td>Maximum burst size</td></tr><tr><td>Minimum PHY Rate</td></tr><tr><td>Peak Data Rate</td></tr><tr><td>Delay Bound</td></tr><tr><td>Surplus Bandwidth Allowance</td></tr></table><br>The most important in the QoS stream is the knowledge of<br>For EDCA<br>• Nominal MSDU size<br>• Mean Data Rate<br>For HCCA<br>• Maximum Service Interval</td><td>There are few important parameters that influence the network performance and the QoS of the WiMAX network<br>• Latency<br>✓ User to base station<br>✓ Over the IP Network<br>✓ Base station to end user<br>• Jitter<br>• Packet Loss<br>As for the deeper study into QoS of WiMAX, it was released that there were classes of QoS that were used to classify the type Quality of Service.<br>✓ Unsolicited Grant Service<br>Used for real time services such as VOIP<br>✓ Real-time Packet Services<br>Used for real-time services with video streaming.<br>✓ Extended Real Time Packet Services<br>Used where packet size varies – Eg. Skype.<br>✓ Non real time Packet Services<br>Utilized where guaranteed bit rate is necessary but the latency is not of that importance. Eg. File Transfer<br>✓ Best Effort<br>DP carried as space is available. Delay and Jitter are is not a critical issue. Eg. Internet services</td></tr>
</table>

## V. LTE QOS STUDY

The QoS study of Long Term Evolution (LTE) has been carried out in this paper where it is necessary to comprehend a few other concepts so as to understand the QoS parameters and the efficiency of the network. The types of bearers and characteristics of each bearer determine the way the LTE QoS works. The types of bearers are mentioned below.

- Dedicated Bearer
  - ➢ Guaranteed Bit Rate(GBR)
    - ▪ Minimum GBR
    - ▪ Maximum GBR
  - ➢ Non-Guaranteed Bit Rate(GBR)
    - ▪ APN-AMBR
    - ▪ UE-AMBR
- Default Bearer
  - ➢ Non-Guaranteed Bit Rate
    - ▪ ARP
    - ▪ TFT
    - ▪ IP Address

Talking about dedicated bearer, it has been classified into Guaranteed Bit Rates and Non Guaranteed Bit Rates where GBR is further classified into its types such as Minimum Guaranteed bit rate and Maximum Guaranteed bit rate. The parameters of Non-GBR are namely APN Aggregate Maximum Bit Rate and UE Aggregate Maximum Bit Rate. Under the type of Default bearer, it comprises only of Non-Guaranteed Bit Rate bearers. The further classification encompasses important terms such as Allocation and Retention Priority, Traffic Flow Template and IP Addresses. Some of the vehicular Adhoc Networks are efficiently supported with LTE due to its mobility rate which is extraordinary and it is unique QoS parameters for LTE. [17]

## VI. BASIC IMPLEMENTATION OF WIFI

The implementation shown below depicts the basic working of WiFi technology using Network Simulator 3.

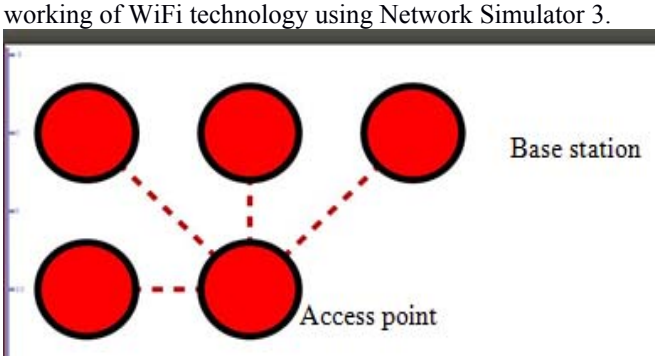


Fig. 1. Nodes displayed in NS3 visualizer

Fig. 1 displayed above shows the nodes in NS3 simulator where the node at the middle where all the other nodes are connected to is the access point of the Wi-Fi based connected network with five nodes inclusive of access point.

Fig. 2. Nodes communicating with each other: Access point and Base station

Figure 2, that is displayed above the communication between the nodes that is the base stations and the access point where the access point sends the packet to all the base stations.The communication takes place at the rate of 183.70 kbps from the access point to the base stations. The number of packets has been set to 2. The location and the IP Addresses of nodes have also been displayed in the terminal. The communication takes place in a time of 2.00721 seconds where the server sends the packets and the client receives it and the client also communicates with the server.

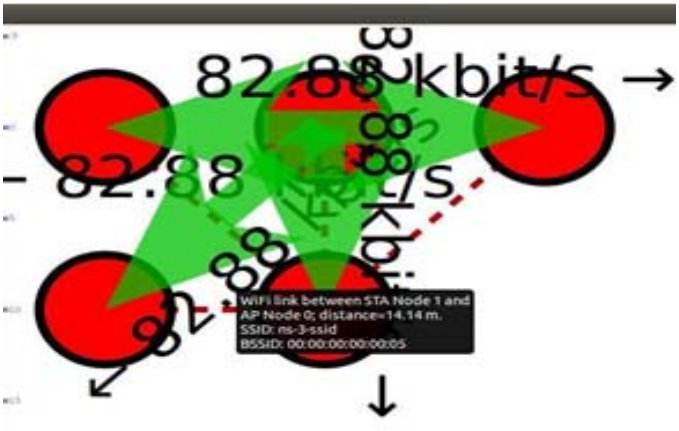


Fig. 3. Wifi link between nodes and access point shown with communication

The figure 3 above shows the communication where the base stations communicate with the access point. The communication between them takes place at the rate of 82.88 kbps. The above implementation has been made for a few numbers of nodes where the nodes receive packets from access point. The number of packets to be transmitted has been set to 2.The simulation shows the transmission of packets, the time and speed in which it happens. The result obtained in the base paper is that confidence being 95 percent, the maximum end to end delay was 2.05ms in the presence of zero packet loss.

TABLE II. OBSERVATIONS

| Parameters | Value |
|---|---|
| Maximum No of packets | 1200 |
| Rss value | 80 dBm |
| Packet size | 1000 |
| No of wifi nodes | 5 + 1 |
| Interval | 3.0 seconds |

## VII. BASIC IMPLEMENTATION OF WiMAX IEEE802.16

Figure 4 and 5 shows the network with 6 subscriber stations and one base station that are connected through WiMAX technology. The communication takes place between the subscriber stations and the base station. The base station communicates with the subscriber station at the rate of 146.21 kbps.

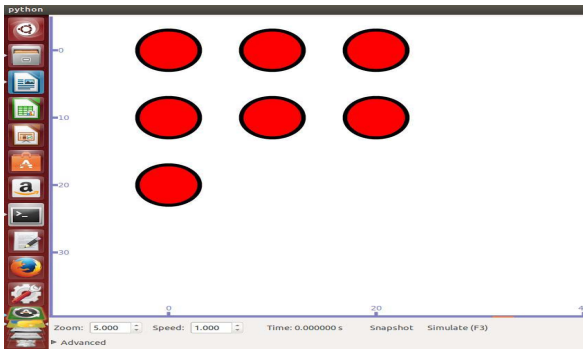


Fig .4. WiMAX Nodes and the base station

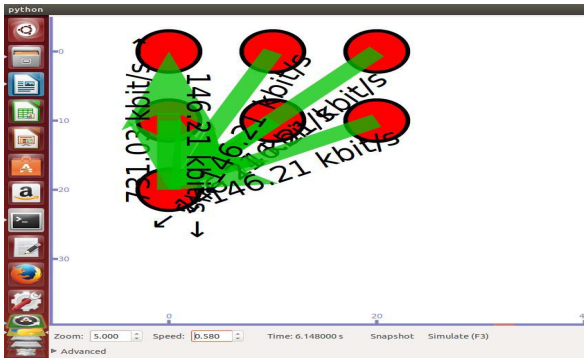


Fig. 5. Communication

The above simulation in the figure 4 and 5 shows a network of 6 nodes of subscriber station and one base station where the communication among these nodes takes place through WiMAX technology. The results are such that it shows the parameters such as trace delay, time, delay, Uid, sequence number, RXtime, Txtime. This shows that the communication takes place with 6 seconds, that is the request from subscriber station and response from the base station takes place within 6 seconds in the simulation. The output parameters such as trace delay, time, delay, Uid, sequence number, RXtime, Txtime. This shows that the communication takes place with 6 seconds, that is the request from subscriber station and response from the base station takes place within 6 seconds in the simulation.

TABLE III. OBSERVATIONS

| Parameters | Value |
|---|---|
| Maximum no. of packets | 1200 |
| Service station nodes | 6 |
| Packet size | 1024 |
| Duration | 7 |
| Interval | 0.5 seconds |

## VIII. AN OVERALL COMPARISON

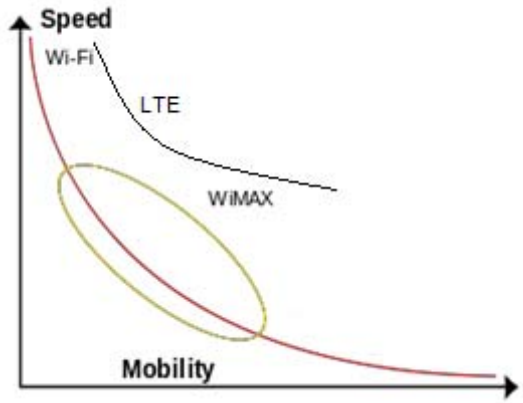


Fig. 6. Graph depicting WiFi, WiMAX and LTE

The above graph depicts the perofmace of WiFi, Wimax and LTE with respct to its speed and mobility. When the speed is high it seems that mobility of WiFi is considerably less. As for WiMAX, it shows a medium level of effecieny in accordance to speed and mobility as WiMAX has a obility rate than WiFi.As for LTE , it performs much better than both the above mentioned technologies. As the mobility ranges upto 350 km in the case for LTE , thus helping it perform better.

## XI. CONCLUSION

With the progress of technology rapidly in this competitive world, energy efficient network are always the required kind of communication models. However there are some elements which can't be compromised on. For instance Wi-Fi can cover only up to a certain distance. The only step is to improve the Wi-Fi in reference to the quality of services; such improvements had been done in the papers that were published later. Wireless technologies have always been a part of everyone's day today life. The enterprises have always found it tedious to decide on the network technology that should be preferred while setting up their own infrastructure. There is least knowledge regarding the quality of services and parameters of the various technologies such as WiFi, WiMAX and LTE in the minds of people.

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