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Quality of Service (QoS) Policies Impact the Performance of VoIP Over WiMAX Networks

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Abstract-- Quality of Service (QoS) is an important concept, particularly when working with multimedia applications, such as video conferencing, streaming services, and VoIP (Voice over IP), require certain bandwidth, latency, jitter, and packet loss parameters. QoS methods help ensure that these requirements are satisfied, allowing for seamless and reliable communication. This work investigates the performance metrics such as Mean Opinion Score (MOS), end-to-end delay, jitter, and throughput, under varying conditions. The proposd WiMAX network was modeled using OPNET emulator and configuried as Handover (Mobility). Quening strategies; First-In-Frist-Out (FIFO), Priority Quening (PO) and Weigthed Fair Quening (WFQ) were applied to the modeled network. FIFO and PQ were found to be best for high performance, while WFQ provides a reasonable solution. The findings will contribute to improving the design and configuration of WiMAX networks to meet user demands for high-quality, reliable voice communication.

Keywords: WiMAX Network, Voice Over Internet Porotocol (VoIP), Quality of Service (QoS) and Mobility

1. Introduction

Quality of Services (QoS) is typically applied to networks that carry traffic for resource-intensive systems. Common services for which it is required include in Internet Protocol Television (IPTV), online gaming, streaming media, video conferencing, video on demand (VOD), and Voice over IP (VoIP) . Using QoS in networking, organizations have the ability to optimize the performance of multiple applications on their network and gain visibility into the bit rate, delay, jitter, and packet rate of their network [1]. This ensures they can engineer the traffic on their network and change the way that packets are routed to the internet or other networks to avoid transmission delay. This also ensures that the organization achieves the expected service quality for applications and delivers expected user experience. As per the QoS meaning, the key goal is to enable networks and organizations to prioritize traffic, which includes offering dedicated bandwidth, controlled jitter, and lower latency. The technologies used to ensure this are vital to enhancing the performance of business applications, wide-area networks (WANs), and service provider [2,4]. Handoover occurs when the quality or the strength of the radio signal falls below certain parameters (signal quality reason) it may also occur when the traffic capacity of a cell has reached its maximum or is approaching (traffic reason).

2. QoS in Networking

QoS is the use of mechanisms or technologies that work on a network to control traffic and ensure the performance of critical applications with limited network capacity. It enables organizations to

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adjust their overall network traffic by prioritizing specific high-performance applications. QoS networking technology works by marking packets to identify service types, then configuring routers to create separate virtual queues for each application, based on their priority. As a result, bandwidth is reserved for critical applications or websites that have been assigned priority access.

QoS technologies provide capacity and handling allocation to specific flows in network traffic. This enables the network administrator to assign the order in which packets are handled and provide the appropriate amount of bandwidth to each application or traffic flow.

3. Basic QoS Architecture

There are three fundamental aspects of QoS architecture [2]:

- **QoS identification**. In order to provide preferential service for a specific connection or a type of traffic, it must first be identified. To identify QoS packets, the header packet has to contain information about the class of QoS that it belongs to.
- **QoS within a single network element**. Routing, scheduling, buffering and flowcontrol provide QoS within a network element. When a packet arrives at a network node all those mechanisms have to meet the QoS demand to provide the required service for the connection.
- **QoS policy and management** is a set of methods to determine whether the current traffic characteristics of the network allow for a new QoS connection to be established. When a QoS technique has been deployed to target the particular traffic, QoS management has to test whether QoS goals have been reached. In local area networks (LANs) and wide area networks (WANs) this is an ongoing process while for on-chip networks QoS policy and management is usually conducted only once during the design process.

4. Parameters Measurements and Techniques for QoS

A network flow is a sequence of packets going from one device to another. To quantify the QoS in a network, one needs to measure the flow [3], see figure.1.a. There are several metrics for that.

Packet loss: This occurs when network connections get congested, and routers and switches begin losing packets.

Jitter: This is the result of network congestion, time drift, and routing changes. Too much jitter can reduce the quality of voice and video communication.

Latency: This is how long it takes a packet to travel from its source to its destination. The latency should be as near to zero as possible.

Bandwidth: This is a network communications link's ability to transmit the majority of data from one place to another in a specific amount of time.

Mean opinion score: This is a metric for rating voice quality that uses a five-point scale, with five representing the highest quality.

Figure.1.b. depicts a very simple network comprising two logical LANs interconnected by a router based WAN. There are two applications communicating with QoS requirments on an end-to-end basis.

We can apply several mechanisms to improve the QoS in a network. They rely mainly on organizing data routing based on their sensitivity to real-time traffic [3,4].

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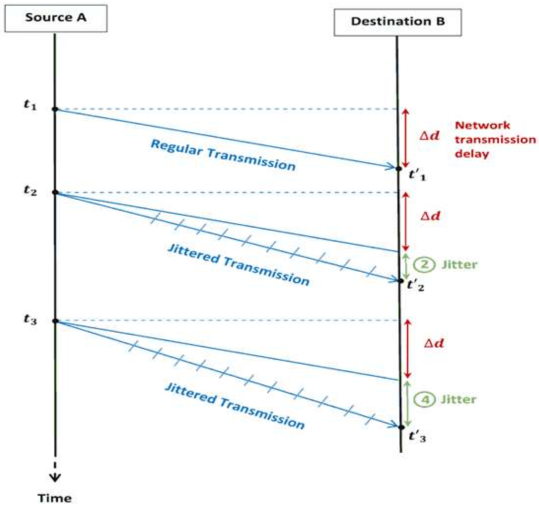

Figure.1.a. Delay and Jitter for Network Transmission

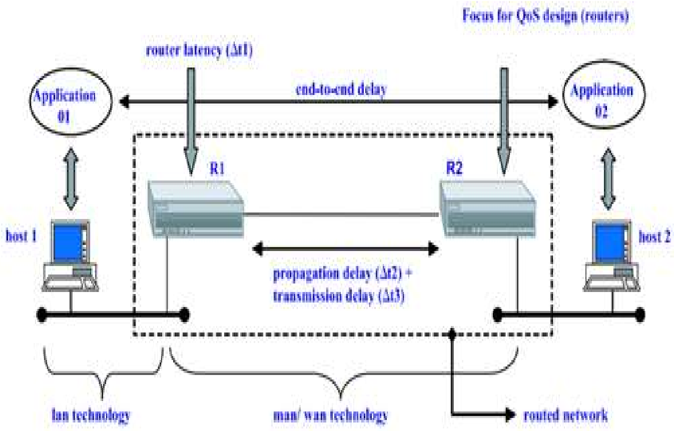

Figure.1.b. QoS Parameters in IP Network [2].

5. Techniques to Improve the QoS

I. Classification and Marking

Here, the network traffic is split into different classes. grouping distinct packets having the same class (video, audio, web browsing, etc.) helps to know what types of data streams flow across the network and how to assign priorities. Usually, traffic classes distinguish by their level of priority as sensitive traffic, such as VoIP and video conferencing), best-effort traffic like emailing, and undesirable traffic such as spam. Each packet labled with the appropriate class by changing a field in the packet header.This process is called marking, ensuring the network recognizes and prioritizes the sensitive ones. Classification is sorting the packets for labeling. Both are implemented within a router or a switch [5]

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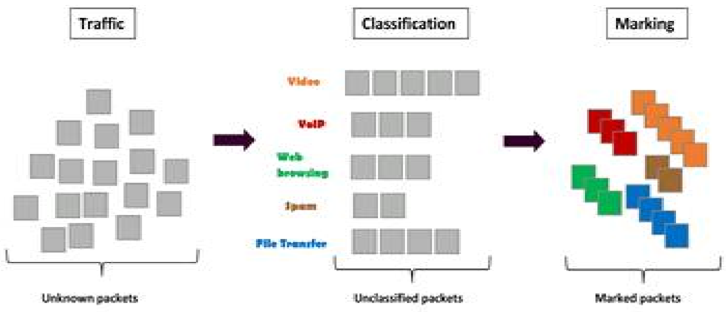
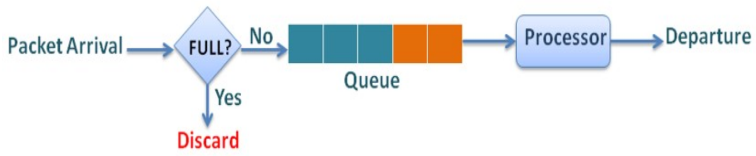


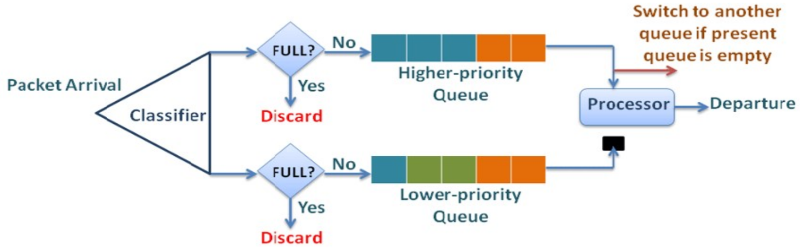
Figure.2 Techniques for improving of QoS

II. Queuing and Scheduling Strategies

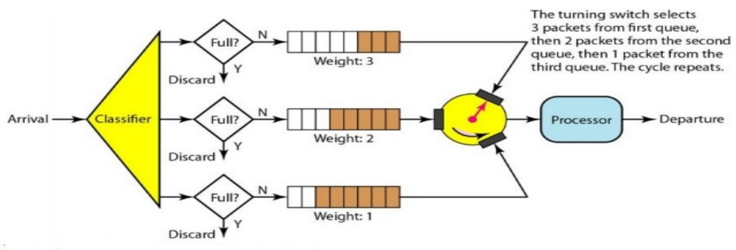
Queuing strategies determine the order in which packets are processed and transmitted across a network. First In, First Out (FIFO) is a basic approach where packets are processed in the order they arrive. However, more advanced strategies like Priority Queuing (PQ) allocate dedicated processing for high-priority traffic, ensuring that critical data bypasses queues filled with lower-priority packets. Weighted Fair Queuing (WFQ) is another method that assigns bandwidth proportionally based on the assigned priority, creating a balanced yet efficient system for handling diverse traffic types [6]. When a router (switch) receives packets from different flows, it stores them in different buffers these called queues, this digrammetically shown in figure.3, a, b, and c.



a) First In, First Out (FIFO)



b) Priority Queuing (PQ)



c) Weighted Fair Queuing (WFQ)

Figure.3. a, b, c. Illustrates the Queening Techniques

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The choice of queuing discipline impacts the performance of the network in terms of the number of dropped packets, latency, etc. When analyzing the effect of choosing the different schemes, a significant impacts on various parameters was observed [6], as shown in figure.4.

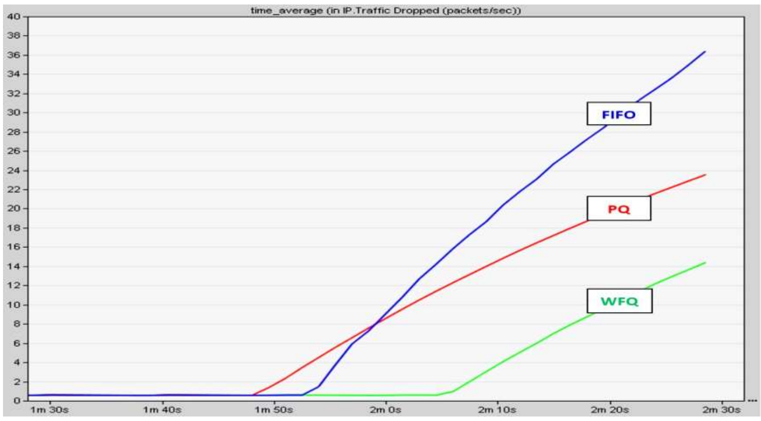

Figure.4. Number of packets dropped versus time
(different queuing disciplines)

5. Scenarios for Quality of Services (QoS)

Three scenarios were deployed to compare the types of QoS which are First In First Out (FIFO), PRIORITY Queuing (PQ), Weighted Fair Queuing (WFQ), then the applications VOIP, Video, HTTP were activated for each scenario, as shown in figure.5.

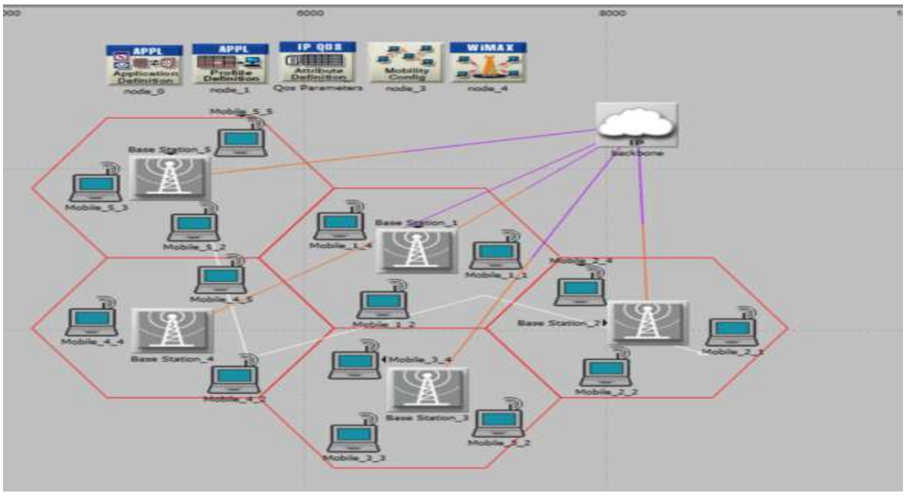

Figure.5 The deployed WiMAX network for QoS

a. Configuration of the Applications

Right click on the Application node ➔ Edit Attributes ➔Select Application Definitions ➔ Set Number of rows 3.
Application1 Go to Enter Application Name ➔ Name ➔ VoIP ➔ click on Description ➔ voice ➔ Select IP Telephony.
Application2 Go to Enter Application Name ➔ Name ➔ Video ➔ click on Description ➔ video Conferencing ➔High Resolution Video

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Application3 Go to Enter Application Name ➔ Name ➔ Http ➔ click on Description ➔ Http ➔ Select Heavy Browsing, see figure.5.

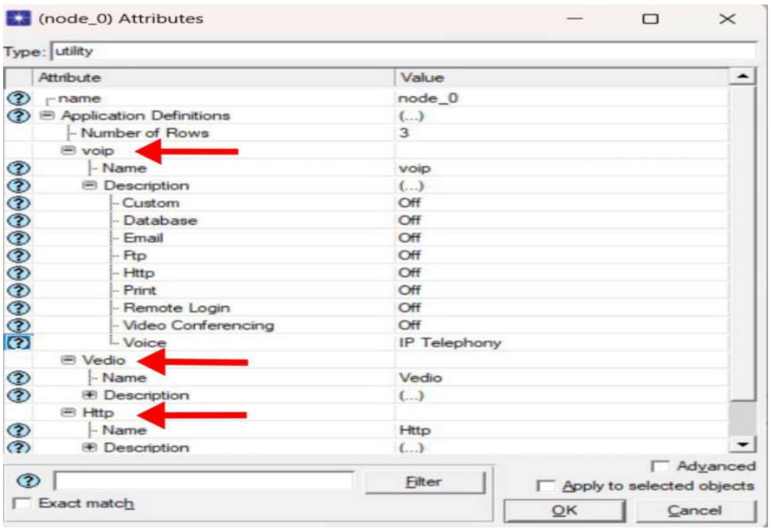

Figure.5. Configuration of the Applications

b. Configuration of QoS

The proposed scenario was configured for three types of QoS, namely, FIFO WFQ and PQ, as an example, WFQ type is shown in figure.6.

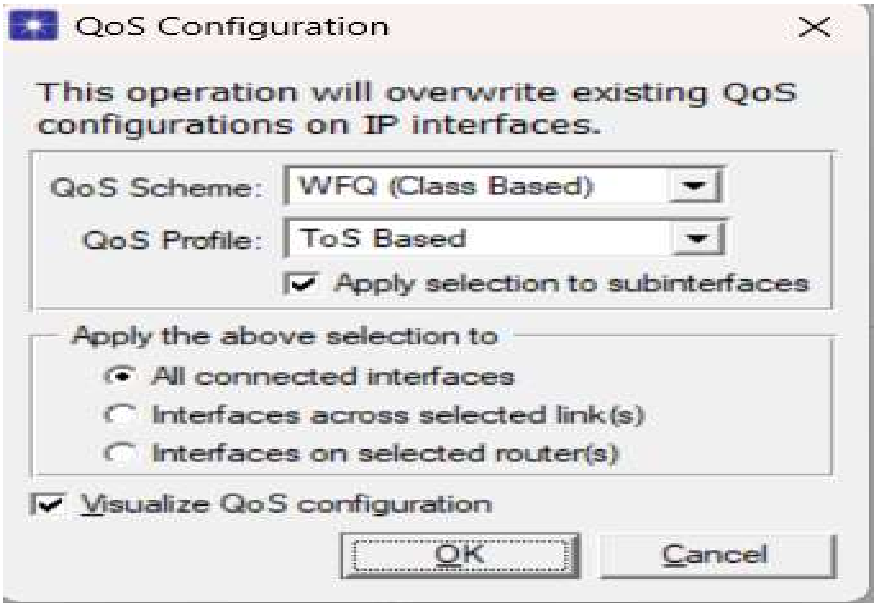

Figure.6 QoS Configuration as WFQ Type

6. Results and Discussion

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Figure.8. shows the time average of voice jitter in seconds for different Quality of Service (QoS) configurations in a WiMAX handover scenario. All configurations start with a high jitter, particularly noticeable in the (WFQ), all configurations stabilize the jitter values, converging to a similar range around zero.

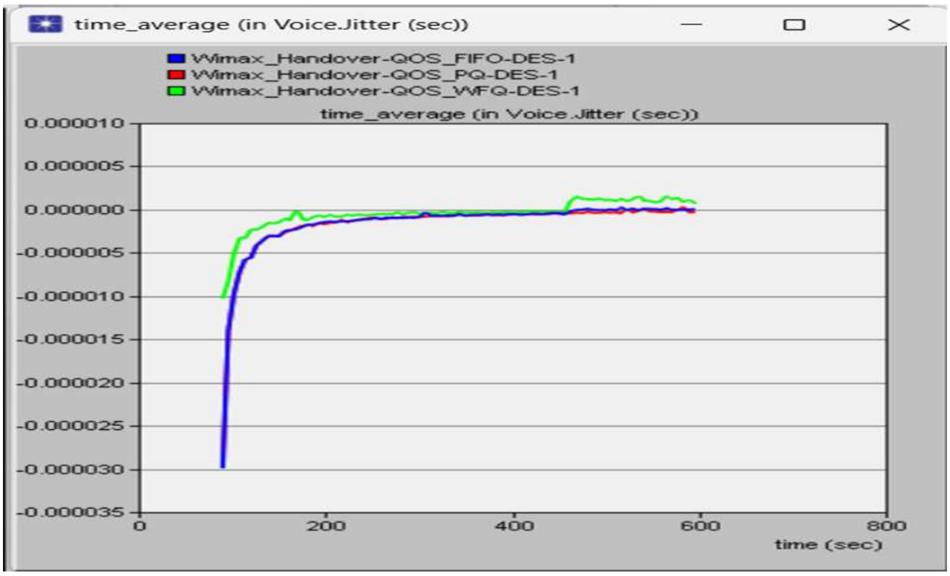

Figure.7. Jitter (sec) in scenarios QoS

Figure.9, depicts the time average of Voice Packet End-to-End Delay in seconds for different QoS configurations during a WIMAX handover. PQ shows a slight decrease in delay over time, indicating improved performance

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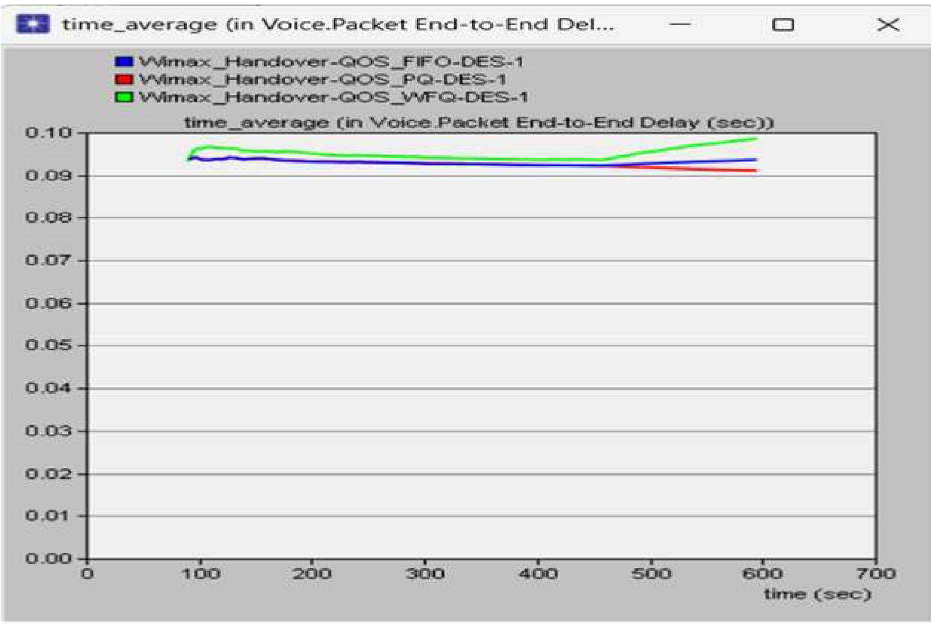

Figure.8. Time average of Voice Packet End-to-End Delay (sec).

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The FIFO remains relatively stable with a slight increase. WFQ shows a noticeable increase in delay towards the end. For minimizing end-to-end delay, the Priority Queuing (PQ) configuration is the most effective. FIFO remains a stable option but may not be optimal under increasing network load. WFQ shows less favorable performance in terms of delay.

FIFO and PQ show similar performance, with slightly lower jitter as compared to WFQ. WFQ scheme initially has higher jitter, but stabilizes close to the other two. The choice of QoS configuration may depend on other factors such as network load and specific application requirements, but in terms of jitter, FIFO and PQ seem preferable, see figure.9. This analysis can guide decisions on which QoS strategy might be most effective for minimizing jitter in a WiMAX handover scenario.

The FIFO shows a slightly delayed start compared to the others, but quickly catches up. WFQ initially dips before aligning with the others. PQ displays consistent performance throughout. All three QoS configurations FIFO, PQ, and WFQ perform similarly in terms of WiMAX delay after the initial increase and stabilization.

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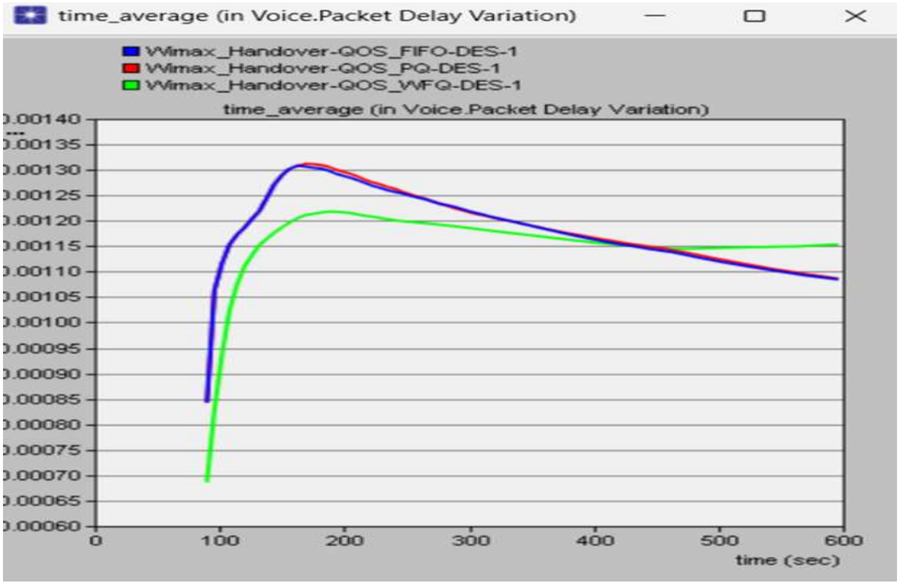

Figure.9. Delay Variation (sec) in scenarios QoS

Figure.10. shows the time average of WiMAX throughput in bits per second over time, comparing three different Quality of Service (QoS) schemes: FIFO, PQ, and WFQ. FIFO scheme achieves the highest throughput initially and maintains it throughout the time period.

WFQ shows a slightly lower throughput than FIFO but remains close to it, suggesting effective load balancing.

PQ similar to FIFO, FIFO and PQ offer the highest throughput, making it efficient for applications that require maximum bandwidth utilization. WFQ provides a balance between throughput and fairness, suitable for environments with mixed priority traffic

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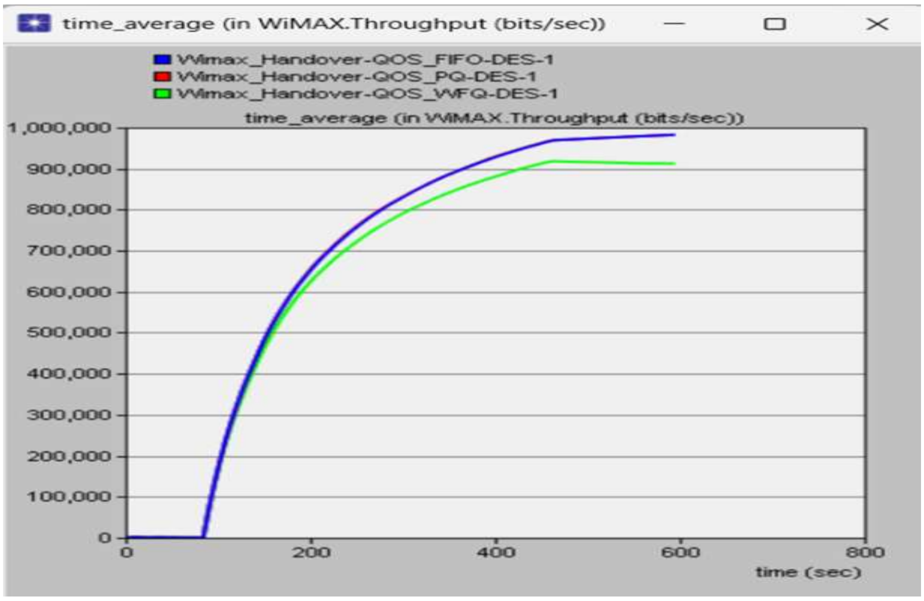

Figure.10 Throughput(bits/sec) in scenarios QoS’

Table.1. Comparison of Results (QoS),

`	Parameters VoIP	FIFO	FWQ	PQ
VOICE	Jitter (sec)	0.72×10^{-7}	0.725×10^{-6}	0.273×10^{-6}
	Packet end-to-end delay (sec)	0.09358	0.09855	0.09104
WiMAX	Delay (sec)	0.016718	0.0166936	0.0167156
	Throughput (bits/sec)	0.983×10^{6}	0.913×10^{6}	0.983×10^{6}

Conclusion and Future Work.

Quality of Service (QoS) serves as a critical tool in managing network performance, ensuring that diverse traffic types are handled efficiently and with precision. By prioritizing vital applications like real-time communication, streaming, and enterprise operations, QoS plays a central role in delivering reliability and seamless user experiences.

QoS can be improved if these resources are reserved before hand, and a flow of data needs resources such as buffer, bandwidth, CPU time and son on.

To fulfill the distinct requirements of various forms of network traffic, QoS is implemented using a combination of categorization, prioritization, resource reservation, and traffic management techniques. The choice of QoS technique depends on network and application requirements; FIFO and PQ are best for high performance, while WFQ provides a balanced solution.

Further, Traffic Shaping Strategies, such as Leaky Bucket and Token Bucket should be applied and QoS impacts on performance of VoIP over WiMAX network should be analysised.

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